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REMEDIAL ACTION PLAN AND SITE CONCEPTUAL DESIGN FOR STABILIZATION OF THE INACTIVE URANIUM MILL TAILINGS SITES AT RIFLE, COLORADO

APPENDIX D

FINAL

Appendix B of the
Cooperative Agreement
No. DE-FC04-85AL16257

February 1992

DISCLAIMER

NOTE

The redlined pages at the end of this document show the latest changes in the text. To facilitate comparison between the revised document and the changed pages, a bar in the left margin of the revised copy indicates the locations of these changes in the text.

APPENDIX D
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D.1 INTRODUCTION

This appendix assesses the present conditions and data gathered about the two designated inactive uranium mill tailings sites near Rifle, Colorado, and the proposed disposal site six miles north of Rifle in the area of Estes Gulch. It consolidates available engineering, radiological, geotechnical, hydrological, meteorological, and other information pertinent to the design of the Remedial Action Plan (RAP). The data characterize conditions at the mill, tailings, and disposal site so that the Remedial Action Contractor (RAC) may complete final designs for the remedial actions.

For ease of reading, figures, then tables, are grouped at the end of each section of this appendix.

D.1.1 SITE DESCRIPTION

D.1.1.1 Location

The Rifle, Colorado, sites consist of two separate tailings sites adjacent to the city of Rifle in Garfield County, Colorado (Figure D.1.1). The eastern site, known as the Old Rifle site, is approximately 0.3 mile from the center of Rifle. The western site, known as New Rifle, is approximately two miles from the center of Rifle. The Colorado River is immediately south of both sites.

The designated Rifle processing sites (Figures D.1.2 and D.1.3) are in Sections 15 thru 18, Township 6 South, Range 12 East, Sixth Meridian. The designated disposal site for the Rifle uranium mill tailings is the Estes Gulch site, approximately six miles north of Rifle (Figure D.1.4). The Estes Gulch site is approximately six road miles north of the Old Rifle tailings site and approximately nine road miles north of the New Rifle tailings site.

D.1.1.2 Physical description

The Old Rifle site covers approximately 22 acres, between U.S. Highway 6 to the north and the Denver & Rio Grande Western (D&RGW) Railroad and the Colorado River to the south. It is on young (late Holocene), unconsolidated alluvial deposits approximately five feet above the normal level of the Colorado River. Soils beneath and adjacent to the tailings are classified according to the Soil Conservation Service (SCS) classification system as coarse-loamy, mixed, mesic Fluvaquensic Haplustolls (SCS, 1985).

The 22-acre site consists of a 13-acre tailings pile on the south and western half of the site, and a nine-acre mill area that includes the former ore storage and milling facilities. The only remaining mill structure is the concrete block assay building. The foundations of other mill structures are exposed or buried at the east end of the mill area. Buried conduits, including electrical and water lines, are in the vicinity of the assay building. Remnants of a septic system are also on site.

The relatively flat tailings pile is at the base of a cliff below U.S. Highway 6. The pile is approximately 1300 feet in the east-west direction and 650 feet in the north-south direction. The tailings pile has an average thickness of 17.3 feet. The pile contains approximately 333,000 cubic yards (cy) of tailings. The characteristics of the tailings pile are described in detail in Section D.4, Tailings Geotechnical Data.

The Old Rifle tailings pile was partially stabilized by Union Carbide in 1967 in accordance with applicable state of Colorado regulations. The southern edge of the pile was moved to the north away from the railroad tracks, and the entire pile was covered with six inches of soil. The pile was then fertilized and seeded with grasses, and a sprinkler system was installed to promote vegetation. Water is drawn from the Colorado River for irrigation. Approximately 85 percent of the pile is vegetated with grasses common to the area. The entire tailings site is fenced to control access.

The New Rifle tailings site covers approximately 142 acres between the D&RGW Railroad and U.S. Highway 6 to the north and Interstate 70 (I-70) and the Colorado River to the south. It is on unconsolidated river alluvium approximately 10 feet above the normal level of the Colorado River. Soils beneath and adjacent to the tailings are classified according to the SCS classification system as Fluvaquensic Haplustolls (SCS, 1985).

The 142-acre site consists of a 31.2 acre tailings pile approximately in the west-central portion of the site, and a mill area north and east of the pile. The mill area contains the mill facilities, water retention ponds, and two ore storage areas. The majority of the mill facilities are in standby condition. Utilities include buried conduits for water, gas, and electricity. A spur of the D&RGW Railroad also parallels the northern edge of the processing site, just south of the main tracks for the D&RGW Railroad.

The tailings pile contains approximately 2,415,000 cy of tailings. The tailings pile measures approximately 1600 feet in the north-south direction and approximately 1150 feet in the east-west direction. The pile has two distinct heights. The northeast portion of the pile is approximately 55 feet high and contains older tailings. The southwestern portion is approximately 41 feet high and contains more recent tailings. The tops of the two portions of the pile are relatively flat; the sides are steep with one-to-one (one horizontal to one vertical) slopes in many places. The pile is separated from the Colorado River by a dike on the east side of the site and by the I-70 embankment on the south.

Union Carbide has partially stabilized the tailings pile. Approximately 1000 tons of mulch and fertilizer were applied to the pile, and native grasses were planted. An irrigation system was installed to promote the vegetation. The lack of soil cover, the steep slopes, and strong winds in the Colorado River valley have caused some erosion of the tailings pile. Breaks in the vegetative cover have been patched with soil, and windbreaks such as snow fences have been installed in an effort to minimize the erosion (FBDU, 1981).

The tailings site is fenced to control access except along the east and south sides next to the Colorado River.

The Estes Gulch disposal site is approximately six miles north of Rifle, above the Colorado River valley. The site is between the Grand Hogback to the northeast and State Highway 13 to the south. The terrain of the site slopes gently upward to the north toward the Grand Hogback. The site is presently on Federal land administered by the Bureau of Land Management (BLM).

D.1.1.3 History

The uranium mill at the Old Rifle site was owned and operated by the Union Carbide Corporation (Union Carbide) from 1924 to 1932 and from 1942 to 1958. From 1932 to 1942, the mill was idle for economic reasons. The mill produced vanadium during both operating periods and uranium during the latter period. Ore was shipped to the mill by truck and railroad from eastern Utah and from the Uravan Mineral Belt, and Meeker and Rifle Creek mines in Colorado. The mill operated under a contract to the U.S. Atomic Energy Commission (AEC) from 1947 to 1958. Records kept by the AEC show that during that period, 761,000 tons of ore were processed and over 2000 tons of uranium concentrate were sold to the AEC. After 1958, most of the Old Rifle tailings were reprocessed and deposited at the New Rifle site (FBDU, 1981).

The New Rifle mill replaced the Old Rifle mill in 1958 and was also owned and operated by Union Carbide. The mill was constructed as part of a complex which included the upgraders at Slick Rock, Colorado, and Green River, Utah. Ore and the upgrader products from Slick Rock and Green River were shipped to the mill by truck and railroad. From 1958 to 1973, the mill produced uranium and vanadium, and AEC records show that 2.7 million tons of ore, upgrader products, and Old Rifle tailings were processed. Over 5000 tons of uranium concentrate were sold to the AEC, and additional uranium and vanadium products were sold commercially. From 1973 to 1984, a portion of the mill was used to produce vanadium; this operation involved processing vanadium solutions and did not produce tailings (FBDU, 1981).

Process

The Old Rifle mill recovered vanadium from roscoelite-type ores by salt roasting, water leaching, and adding sulfuric acid to the water solutions to precipitate a sodium hexavanadate red cake. In 1947, acid leaching and subsequent process steps to recover uranium were added to the Old Rifle plant.

At the New Rifle plant, low-vanadium ores were acid leached, and high-vanadium ores were first salt roasted and then water leached to remove the soluble sodium vanadate. The residue was then acid leached and both uranium and vanadium recovered by solvent extraction. Products received from Slick Rock and Green River were fed to the process at various points depending on the uranium and vanadium content.

At the conclusion of uranium ore milling operations (early 1973), vanadium concentrate was processed in the New Rifle mill. About 20 percent of the capacity of the mill was used for vanadium processing.

Ownership

Both mills (Old Rifle and New Rifle) were constructed and operated by Union Carbide Corporation or its predecessor, the United States Vanadium Corporation. Both sites are currently owned by the State of Colorado.

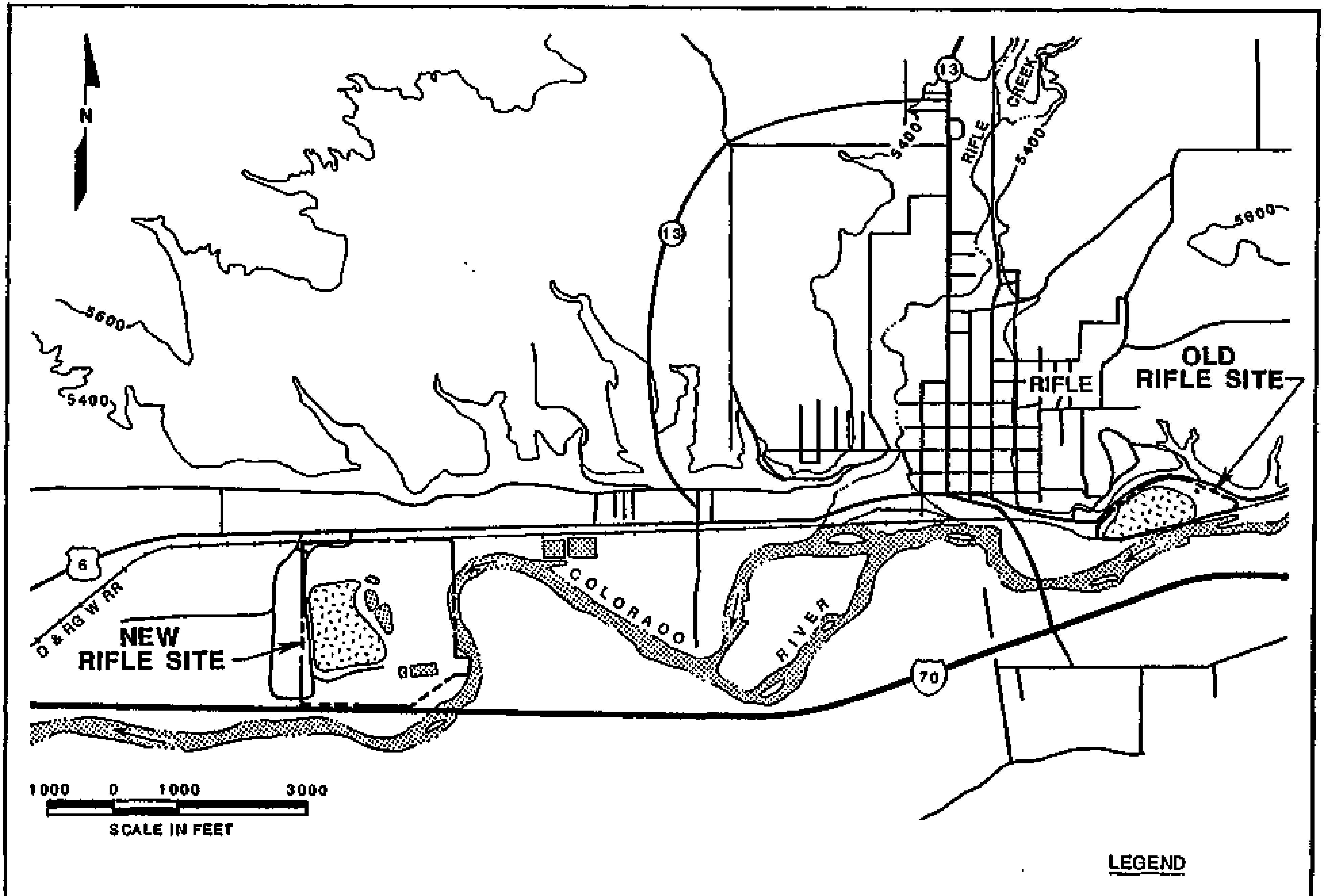


FIGURE D.1.1
OLD AND NEW RIFLE SITES

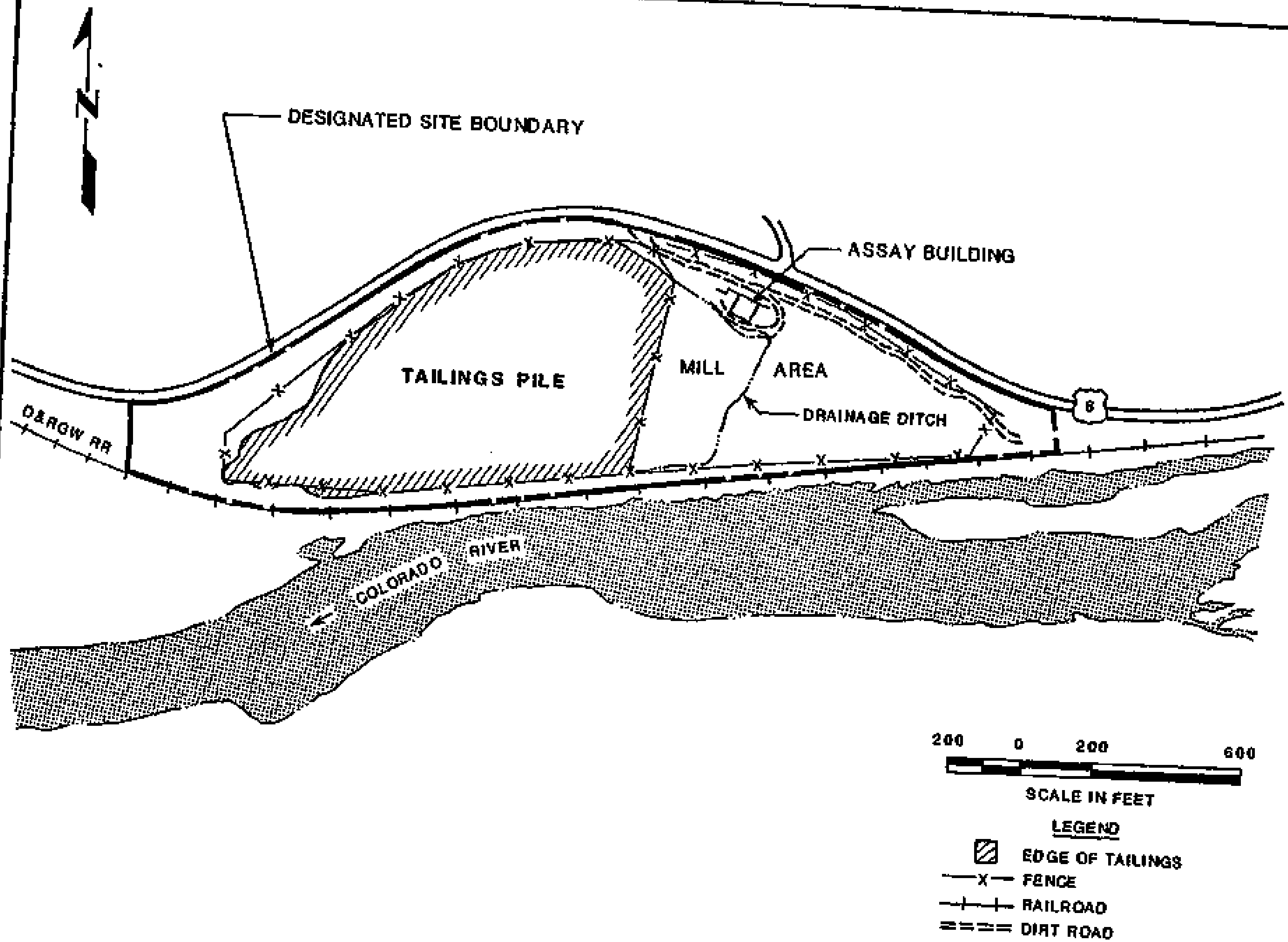


FIGURE D.1.2
OLD RIFLE PROCESSING SITE

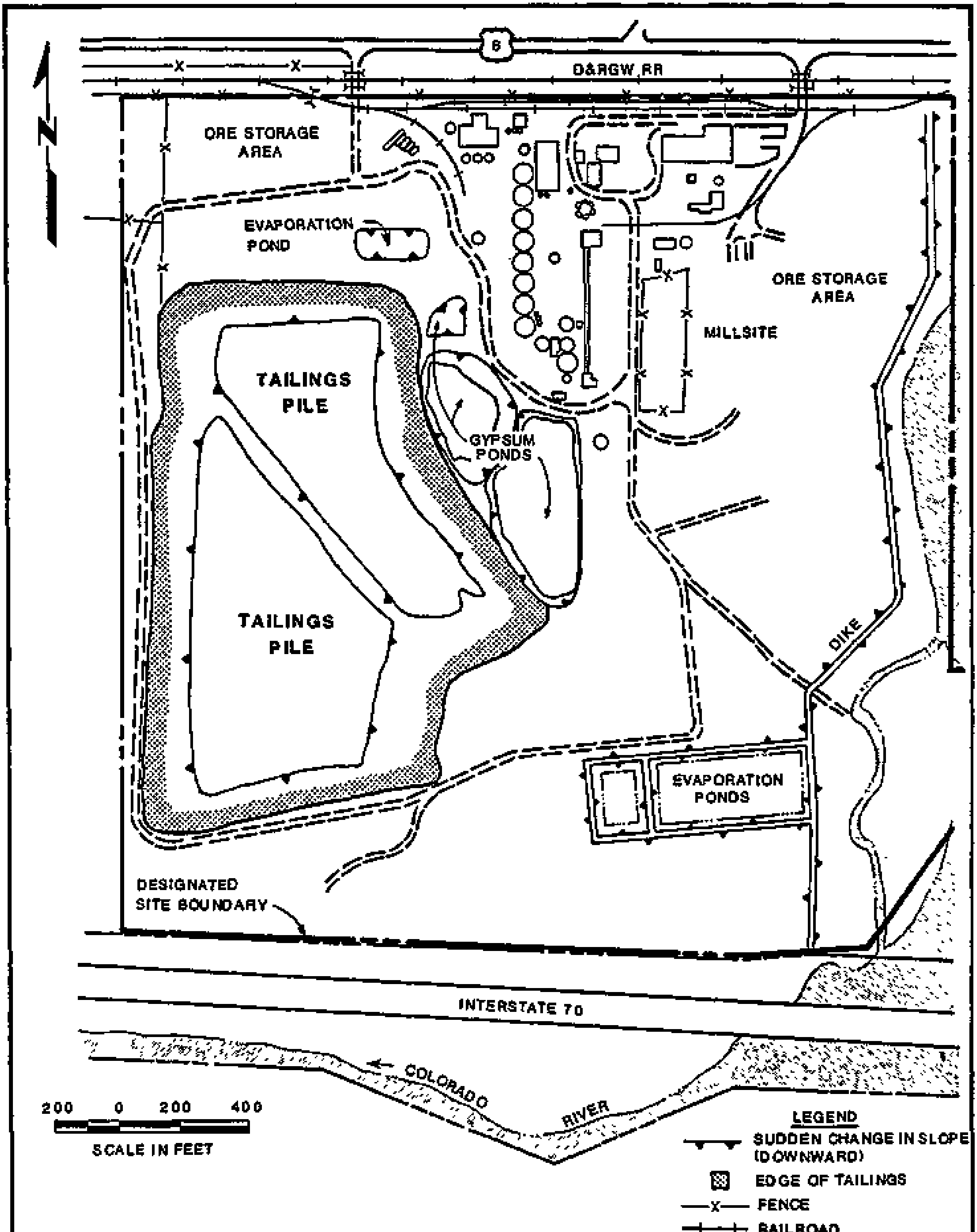


FIGURE D.1.3
NEW RIFLE PROCESSING SITE

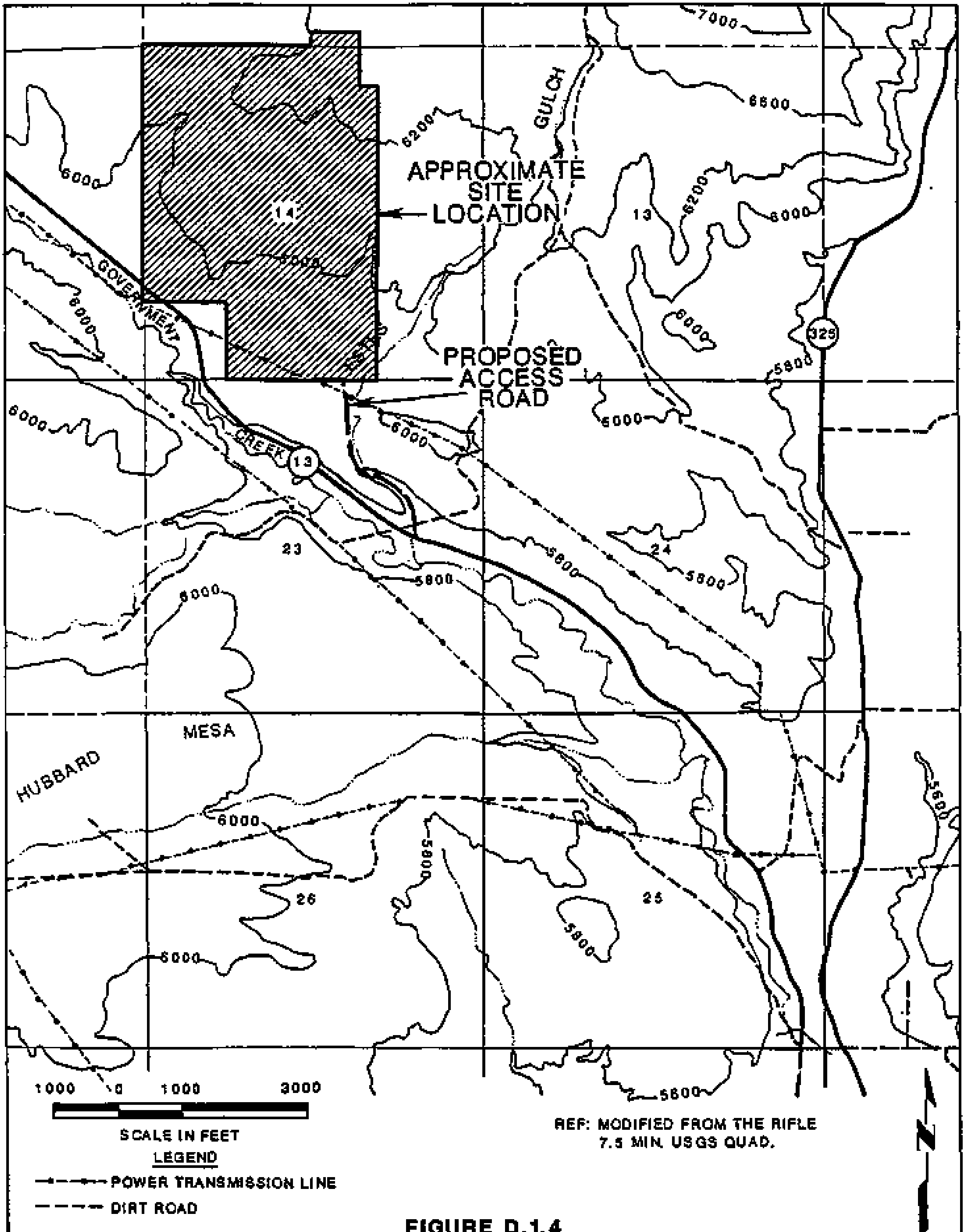


FIGURE D.1.4
ESTES GULCH SITE

D.2 RADIATION DATA

This section describes the magnitude and characteristics of the radioactive materials at the Rifle uranium mill tailings sites. Radiological data from the vicinity of the sites have been collected by numerous investigators since 1962. All have contributed to an understanding of the radiological condition of the site; however, each has concentrated on a certain aspect of the site contamination and the results have not been combined to give an overall description of the extent of contamination.

The first radiological data collection was completed in May 1976. Oak Ridge National Laboratory (ORNL), in cooperation with Ford, Bacon and Davis, Utah (FBDU), conducted radiological surveys that included measurements of background external gamma exposure rates and background radionuclide concentrations in surface soil samples; external gamma exposure rates at the sites and in the area immediately around the sites; radionuclide concentrations in surface soil, sediment, and water samples; subsurface distribution of Ra-226 in tailings and soil as a function of depth; and radionuclide concentrations in airborne particles (ORNL, 1980). Radon concentration measurements at background locations, in locations influenced by the site, and on the tailings pile have been performed by FBDU (1981). Similar radon concentration measurements have been performed by the Technical Assistance Contractor (TAC) as part of the one-year pre-remedial action radon monitoring program (TAC, 1988).

A systematic sampling of the pile at the Rifle sites was performed by Mountain States Research and Development (MSRD) to evaluate the economic viability of reprocessing for residual uranium, molybdenum, or vanadium (MSRD, 1982a,b). Some of these MSRD samples were analyzed for radium-226 (Ra-226) by Bendix Field Engineering Corporation (BFEC, 1985b; BFEC, 1984).

Finally, an extensive survey of the limits of contamination off the pile was performed in 1984 by Bendix Field Engineering Corporation (BFEC, 1985a). The BFEC data form the primary basis for the current understanding of the distribution of contamination in off-pile areas. The MSRD study forms the basis for current knowledge of on-pile and subpile conditions.

Data from all major sources listed above are presented in this section, along with other data, in an interpretation of the distribution of contamination around and beneath the Rifle sites. This section does not assess the health risks from this contamination, or recommend a course of remedial action. Its purpose is to present the current understanding of the radiological conditions associated with the inactive uranium mill tailings sites.

D.2.1 BACKGROUND RADIATION

The purposes of measuring background radiation near the sites are to provide a reference point to which levels of contamination on the sites can be compared and to assess the affects of construction on the surrounding population and the environment. Measurements of background radiation near the Rifle sites have resulted in the determinations discussed in the following paragraphs.

D.2.1.1 Background gamma exposure rates

Bendix Field Engineering Corporation conducted their radiological characterization near the two inactive uranium mill sites in the Rifle area between October 1 and November 16, 1984. Using a gamma Scintillometer and taking measurements three feet above ground surface, the average background external gamma radiation exposure rate in Rifle was determined to be approximately 15 microroentgens per hour (microR/hr) (BFEC, 1985a). Measurements were cross checked using a pressurized ionization chamber (PIC). Data from each sample point are presented in Table D.2.1.

An aerial radiological survey of the Rifle area was conducted in 1979 to determine background gamma radiation levels (EGBG, 1980). The average gamma exposure rate was calculated to be 13 microR/hr within the Rifle city limits and 13 to 14 microR/hr in the areas east and west of the city. Cosmic rays (radiation from the sun and other sources external to the earth) contribute approximately 5.6 microR/hr (43 percent) of the total 13 microR/hr exposure rate.

D.2.1.2 Background radionuclide concentrations in soils

Background soil radionuclide measurements were collected at the same locations as the measurements for gamma exposure rates (BFEC, 1985a). Four sites (north, south, east, and west of the city of Rifle) were sampled and analyzed for radionuclide concentrations in soils. The results are contained in Table D.2.1. The surface samples (zero to six inches) averaged 1.2 picocuries per gram (pCi/g) Ra-226 and 10.6 parts per million (ppm) thorium-232 (Th-232). The background concentrations of the widely spaced sample sites were quite uniform.

D.2.1.3 Background radon concentrations in air

A quarterly radon monitoring program was conducted from April 4, 1987 through April 27, 1988, in the Rifle area (TAC, 1988). This program monitored background and site related radon concentrations using integrating film-type radon detectors. The results are contained in Table D.2.2. The annual average background radon concentration was 0.4 picocuries per liter (pCi/l).

D.2.2 DISTRIBUTION OF CONTAMINATION

The uranium mill tailings at Rifle are at two distinct sites, Old Rifle and New Rifle, approximately two miles apart. The Old Rifle site is just east of the city limits of Rifle, in Garfield County, Colorado. U. S. Highway 6 and 24 runs along the north side of the site and the D&RGW Railroad tracks are on the south side. The Colorado River is immediately south of the railroad tracks. The New Rifle site is west of Rifle and is bordered on the north by the D&RGW Railroad tracks. The Colorado River is both east and south of the site. Interstate 70 is to the south between the site and the river. The valley containing the tailings sites is at an elevation of approximately 5300 feet. Steep cliffs and mesas up to elevations of 9300 feet are to the north of the Rifle sites, and long sloping mountains on the south rise to the Grand Mesa and elevations of 10,000 feet.

D.2.2.1 On-pile and subpile contamination

Mountain States Research and Development (MSRD 1982a,b) sampled each of the Rifle tailings piles through the physical interface. Supplemental sampling of the tailings piles through the physical interface was also performed (MK-E, 1988). All information presented here on the depth and magnitude of the on-pile contamination is based on the results from these programs. As part of the MSRD study to investigate the economic viability of reprocessing the Rifle tailings piles for additional uranium, vanadium, and molybdenum, 162 holes across both piles were sampled using the split barrel technique. Samples were collected in 2.5-foot increments down to the physical interface between tailings and subbase material. These samples were archived and some were recently analyzed for radium content (BFEC, 1984). The analytical results allow an estimate of the distribution of Ra-226 within the pile. The results also give an estimate of the depth below the physical interface at which the U.S. Environmental Protection Agency (EPA) standard of 15 pCi/g Ra-226 in soil is met. These provide the volumes of material which will be excavated, as well as the radon source term used for cover design.

The approximate MSRD hole locations on both piles are shown on maps in the MSRD reports (MSRD, 1982a,b) (Figures D.2.1 and D.2.2). The hole locations shown on these maps are probably within 20 to 30 feet of their actual positions. In order to estimate the volumes of contaminated material on each pile, uniform grid systems were superimposed over the drill hole patterns. Additional grid cells were added to approximate the relatively large amounts of retaining berm material not sampled in the MSRD programs. To estimate the depth to the physical interface for these cells, the slope of the underlying topography was approximated, and extrapolation from the nearest cells with existing data was used.

By inspection of the 2.5-foot sample results and the Sandia National Laboratory (SNL, 1982) estimates of selected samples, the depth to the level at which 15 pCi/l is reached can be estimated for some grid cells. To estimate the depth to the 15 pCi/g interface for those cells where data did not allow an objective determination, a different method was used. The average difference between the physical interface and the 15 pCi/g interface for holes where data existed was calculated. This average distance was then added to the depth to the physical interface for those cells with missing depth to the 15 pCi/g interface data.

Finally, missing values of concentrations at all depths were estimated from an average of the nearest neighbor's sample concentrations. This was done by using existing data from the nearest lateral neighbors at the same height above the physical interface for a given grid cell. The resulting three-dimensional grid is the best current estimate of the radium concentration distribution within the piles based on existing data. Tables D.2.3 and D.2.4 summarize measured depths to the physical interface and 15 pCi/g interface for MSRD boreholes at Old and New Rifle. A summary of the volumes of the two piles and average concentrations is presented in Tables D.2.5 and D.2.6.

The layer-by-layer average Ra-226 concentration was determined over the entire surface area of each pile. This "cookie cutter" approach provides the average Ra-226 concentration, which affects the diffusion of radon-222 (Rn-222) from the surface. For cells with a shallow depth to the 15 pCi/g interface, the contribution to the average for a layer below the interface was a constant value of 15 pCi/g. This overestimates the layer average only slightly for the bottom few layers, and insignificantly for the top layers. The natural tendency is to average only radium values measured in the tailings. However, this results in a profile higher in value than the true average, which contains uncontaminated material at the boundaries. All that is known is that this material is less than 15 pCi/g, so this value is conservatively used for all uncontaminated regions in the layer-by-layer averages.

Old Rifle site

As part of the MSRD study to investigate the economic feasibility of reprocessing the Old Rifle tailings for uranium, vanadium, and molybdenum, 67 boreholes were drilled into the tailings piles. Tailings and sub-pile samples were analyzed for radium content (BFEC, 1984). These data were supplemented with additional field investigation data collected by Morrison Knudsen-Ferguson (MK-F). The data were used to determine the average radium concentration of the tailings and sub-pile materials; the supplemental data are repeated in the Final Design for Review (MK-E, 1988).

The average Ra-226 concentration of the tailings material is 704 pCi/g as determined from 111 samples. The estimated volume of tailings material is 333,000 cy. The average radium concentration of the sub-pile is 505 pCi/g as determined from 102 samples. The estimated volume of sub-pile material is 168,000 cy. The average radium concentration for the tailings, the existing 0.5-foot-thick cover, and the sub-pile contamination is 637 pCi/g. The sub-pile material exceeds the EPA standard of 15 pCi/g Ra-226 to an average depth of 4.8 feet. The total volume of tailings, cover, and sub-pile is approximately 501,000 cy.

New Rifle site

As part of the MSRD study to investigate the economic feasibility of reprocessing the New Rifle tailings for uranium, vanadium, and molybdenum, 95 boreholes were drilled into the tailings pile. Tailings and sub-pile samples were analyzed for radium. These data were supplemented with additional field investigation data collected by MK-F, and were used to determine the average radium concentration of the tailings and sub-pile materials; the supplemental data are repeated in the Final Design for Review (MK-E, 1988).

The average Ra-226 concentration of the tailings material is 636 pCi/g as determined from 238 samples. The estimated volume of tailings material is 2,415,000 cy. The average radium concentration for the sub-pile is 244 pCi/g as determined from 102 samples. The estimated sub-pile volume is 375,000 cy. The average radium concentration for the tailings and sub-pile contamination is 585 pCi/g. The sub-pile exceeds the EPA standards of 15 pCi/g to an average depth of 4.3 feet. The total volume of tailings and sub-pile materials is approximately 2,790,000 cy.

D.2.2.2 Off-pile contamination

Old Rifle site

Volume estimates of Old Rifle off-pile contamination were determined from BFEC (1985) and MK-F (1987) field data. A figure representing the vertical and horizontal extent of contamination may be found in the Final Design for Review (MK-E, 1988). An additional 160,000 cy of contaminated materials are estimated to exist in off-pile areas. The contaminated areas include the mill area east of the tailings pile, the previous ore storage area on the bluff north of the tailings site, and windblown tailings on the bluff northeast of the tailings site. Figures D.2.3 and D.2.4 illustrate the off-pile contaminated areas in relation to the Old Rifle tailings pile. The average radium concentration of the off-pile contaminated materials is estimated to be 245 pCi/g.

Gamma exposure rates in the windblown tailings area to the northeast decrease below 20 microR/hr at distances beyond 2000 feet from the edge of the tailings pile. In all other directions, gamma exposure rates decrease below 20 microR/hr at distances of 500 feet from the edge of the tailings pile (BFEC, 1985a).

New Rifle site

Volume estimates of New Rifle off-pile contamination were determined from BFEC (1985) and MK-F (1987) field data. A figure representing the vertical and horizontal extent of contamination may be found in the Final Design for Review (MK-E, 1988). An additional

442,000 cy of contaminated materials exist in areas adjacent to the New Rifle tailings pile. The contaminated areas include the mill and previous ore storage area north and east of the tailings pile. Some windblown and waterborne tailings are present west of the tailings pile. Figures D.2.5 and D.2.6 illustrate the off-pile contaminated areas in relation to the New Rifle tailings pile. The average radium concentration of the off-pile contaminated materials is estimated to be 63 pCi/g. In addition, approximately 216,000 cy of contaminated vicinity property materials and 34,000 cy of demolition debris from the processing sites are to be included into the stabilized pile. The Ra-226 concentration in the vicinity property materials varies considerably, and ranges from slightly greater than background levels (1.2 pCi/g) to 2000 pCi/g.

Gamma radiation levels have been found to decrease rapidly with distance from the New Rifle tailings pile. Gamma exposure rates decrease to below 20 microR/hr at distances of 1500 feet in all directions from the edge of the tailings pile (BFEC, 1985a).

D.2.2.3 Building contamination

Buildings on both Rifle sites were surveyed for gamma and alpha contamination by BFEC. The complete survey results are in their report (BFEC, 1985a). All structures on Old and New Rifle were demolished during the Phase I remedial action.

Old Rifle site

The only building on the Old Rifle site was the old assay laboratory. Elevated exposure rates were recorded throughout the building. Alpha contamination was detected on surfaces at several locations within the building. The highest total and removable alpha were in a discolored area on the floor in room J. This building was demolished as part of the interaction.

New Rifle site

All buildings at New Rifle had elevated exposure rates and surface alpha contamination. The redcake building and the solvent extraction building contained the highest levels of overall contamination. The main office/shop building was not grossly contaminated.

D.2.2.4 Waterborne contamination

Old Rifle site

Stream sediment samples were collected at 16 locations on or surrounding the Old Rifle site to determine whether contamination was transported off of the site by surface drainage (BFEC, 1985a).

Radium-226 concentrations ranged from three pCi/g in the dry stream channel near the hospital (located approximately 1.25 miles north of the site) to 247 pCi/g in the small drainage ditch running across the site at a point five feet above its junction with the Colorado River. The Old Rifle site is approximately 100 feet north of the Colorado River, so sediment-transported contamination would have been diluted upon reaching the Colorado River.

New Rifle site

Stream sediment samples were collected at 17 locations on the New Rifle site to determine whether contamination was transported by surface drainage (BFEC, 1985a). Radium-226 concentrations ranged from one to 149 pCi/g. Elevated Ra-226 concentrations were found in the swampy area west of the tailings pile, suggesting that contamination is moving off the site via this pathway. Thorium-230 (Th-230) was generally found at higher concentrations than Ra-226, again suggesting surface drainage transport of contamination. In general, off-pile sediment and soil samples indicated Th-230 concentrations exceeding Ra-226 concentrations by a factor of approximately three.

D.2.3 OTHER RADIOLOGICAL PARAMETERS

D.2.3.1 Emanating fractions

Old Rifle site

To determine the emanating fraction for the Old Rifle tailings and sub-pile material, a total of 33 samples were collected from seven boreholes on the Old Rifle tailings pile (MK-E, 1988). Twenty samples were collected of tailings material and had an average emanating fraction of 0.29. The average emanating fraction of the sub-pile material was 0.35 and was determined from 13 samples. A total of 27 samples were collected from 17 boreholes in the Old Rifle off-pile area to determine the off-pile emanating fraction (MK-E, 1988). The average emanating fraction of the off-pile material was 0.34.

New Rifle site

To determine the emanating fraction for the New Rifle tailings and sub-pile material, a total 39 samples were collected from eight boreholes on the New Rifle tailings pile (MK-E, 1988). Thirty-three samples were collected of tailings material and had an average emanating fraction of 0.37. The average emanating fraction of the sub-pile was 0.41 and was determined from six samples. Thirty-two samples were collected from 21 boreholes in the New Rifle off-pile area to determine the off-pile emanating fraction (MK-E, 1988). The average emanating fraction of the off-pile material was 0.45.

D.2.3.2 Diffusion coefficients

Radon diffusion coefficient measurements were made on tailings samples from five test pits, two on the New Rifle pile and three on the Old Rifle pile, and supplemental field data were collected by MK-F (1988). Radon diffusion coefficient data are contained in the Final Design for Review (MK-E, 1988) and plotted in Figures D.2.7 through D.2.10. These figures show the relationship between moisture content and diffusion coefficient. Diffusion coefficient measurements were also made from 10 test pits at the Estes Gulch disposal site. The results of these measurements are contained in the Final Design for Review (MK-E Vol. IV, 1988) and plotted in Figure D.2.11.

D.2.3.3 Ambient radon concentrations

Radon concentrations as a function of distance from the Old Rifle and New Rifle processing sites were determined quarterly as part of the one-year pre-remedial action radon monitoring program. The results of this monitoring program are presented in Table D.2.2 with sample locations in Figure D.2.12. Similar sampling programs are planned for during remedial action and one year after remedial action.

D.2.3.4 Gamma exposure rates

Old Rifle site

Using Schiager's (1974) estimate of 2.5 microR/hr per pCi/g, the bare tailings gamma exposure rate would be 1760 microR/hr, based on the average tailings pile Ra-226 concentration of 704 pCi/g. The 1760-microR/hr gamma exposure rate is considered to be conservatively high, as the existing cover on the tailings pile reduces the pile surface gamma exposure rate to an average of less than 250 microR/hr (EG&G, 1983). Gamma traverse measurements across the pile indicated an average gamma exposure rate of 160 microR/hr on the pile with a maximum of 292 microR/hr (ORNL, 1980).

New Rifle site

Using Schiager's (1974) estimate of 2.5 microR/hr per pCi/g, the bare tailings gamma exposure rate would be 1590 microR/hr based on the average tailings pile Ra-226 concentration of 636 pCi/g. The 1590 microR/hr gamma exposure rate is considered to be conservatively high, as the average pile surface gamma exposure rate under existing conditions is less than 500 microR/hr (EG&G, 1983). Gamma traverse measurements indicated an average gamma exposure rate of 430 microR/hr with a maximum of 888 microR/hr (ORNL, 1980).

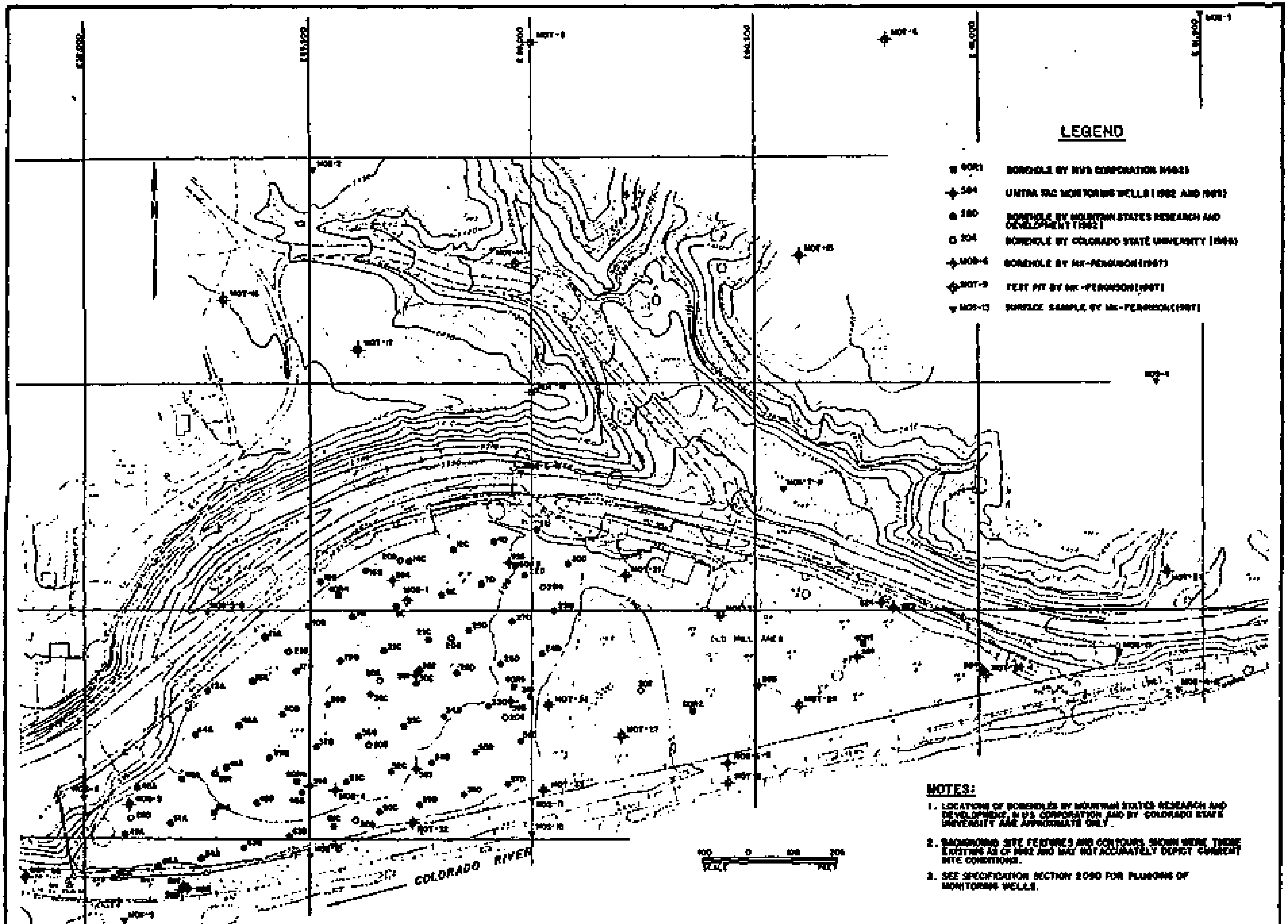
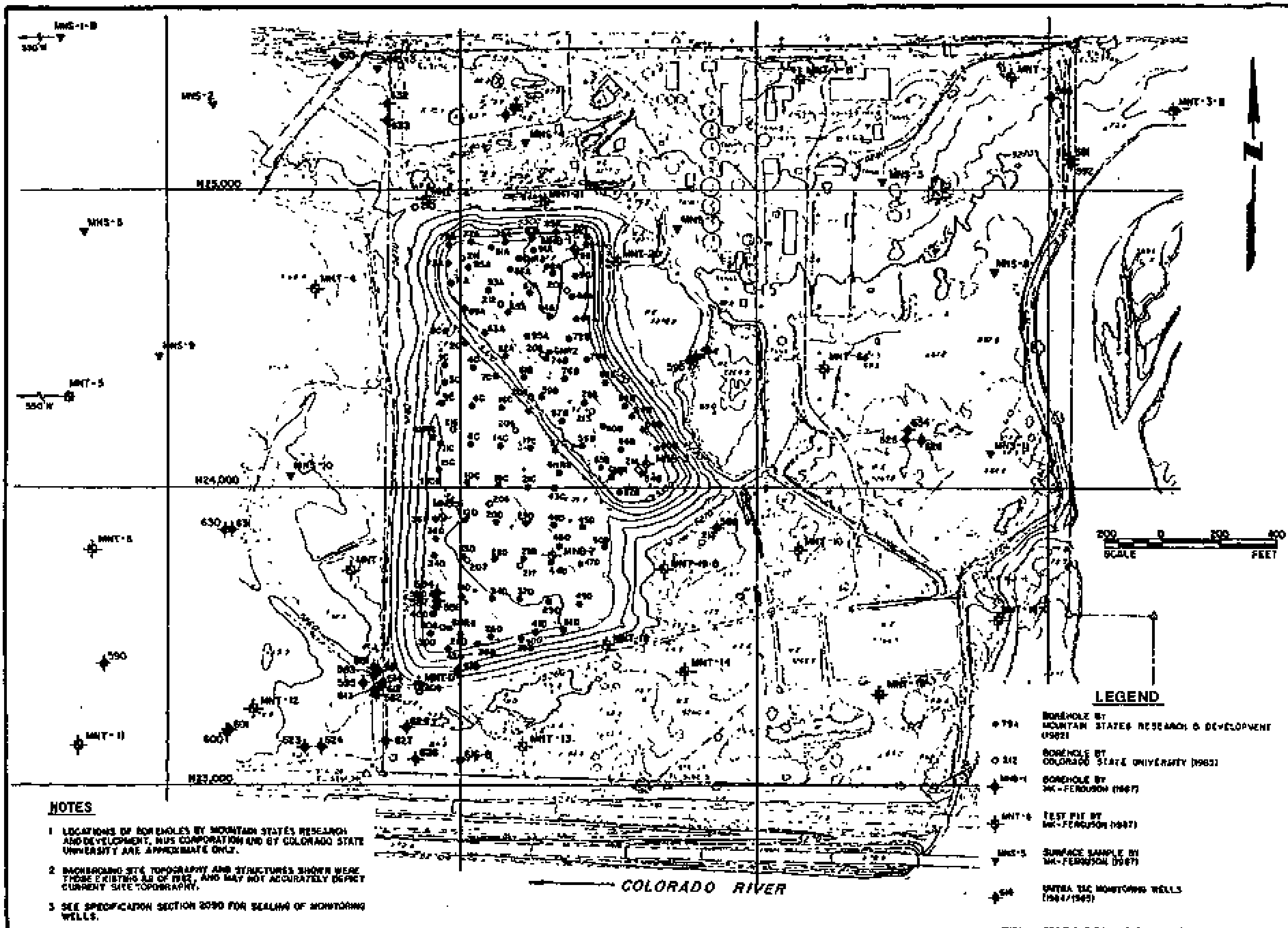


FIGURE D.2.1

LOCATIONS OF BORINGS ON THE OLD RIFLE TAILINGS PILE

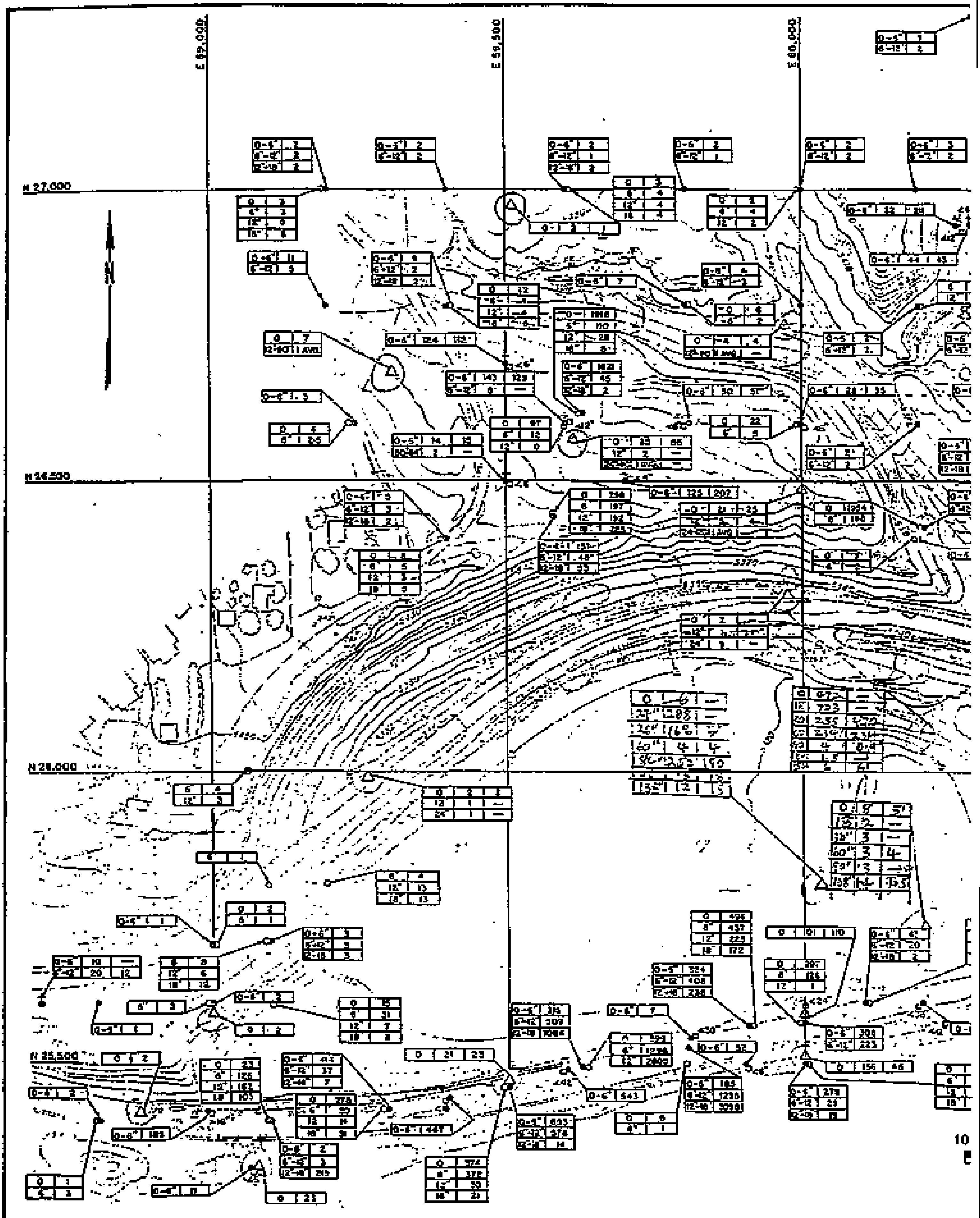


NOTES

1. LOCATIONS OF BOREHOLES BY MOUNTAIN STATES RESEARCH AND DEVELOPMENT, NUS CORPORATION AND BY COLORADO STATE UNIVERSITY ARE APPROXIMATE ONLY.
2. BACKGROUND SITE TOPOGRAPHY AND STRUCTURES SHOWN WERE THOSE EXISTING AS OF 1982, AND MAY NOT ACCURATELY DEPICT CURRENT SITE TOPOGRAPHY.
3. SEE SPECIFICATION SECTION 2090 FOR SEALING OF MONITORING WELLS.

FIGURE D.2.2

LOCATIONS OF BORINGS ON THE NEW RIFLE TAILINGS PILE


E 59,000
E 59,500
E 60,000
N 27,000
N 26,500
N 26,000
N 25,500

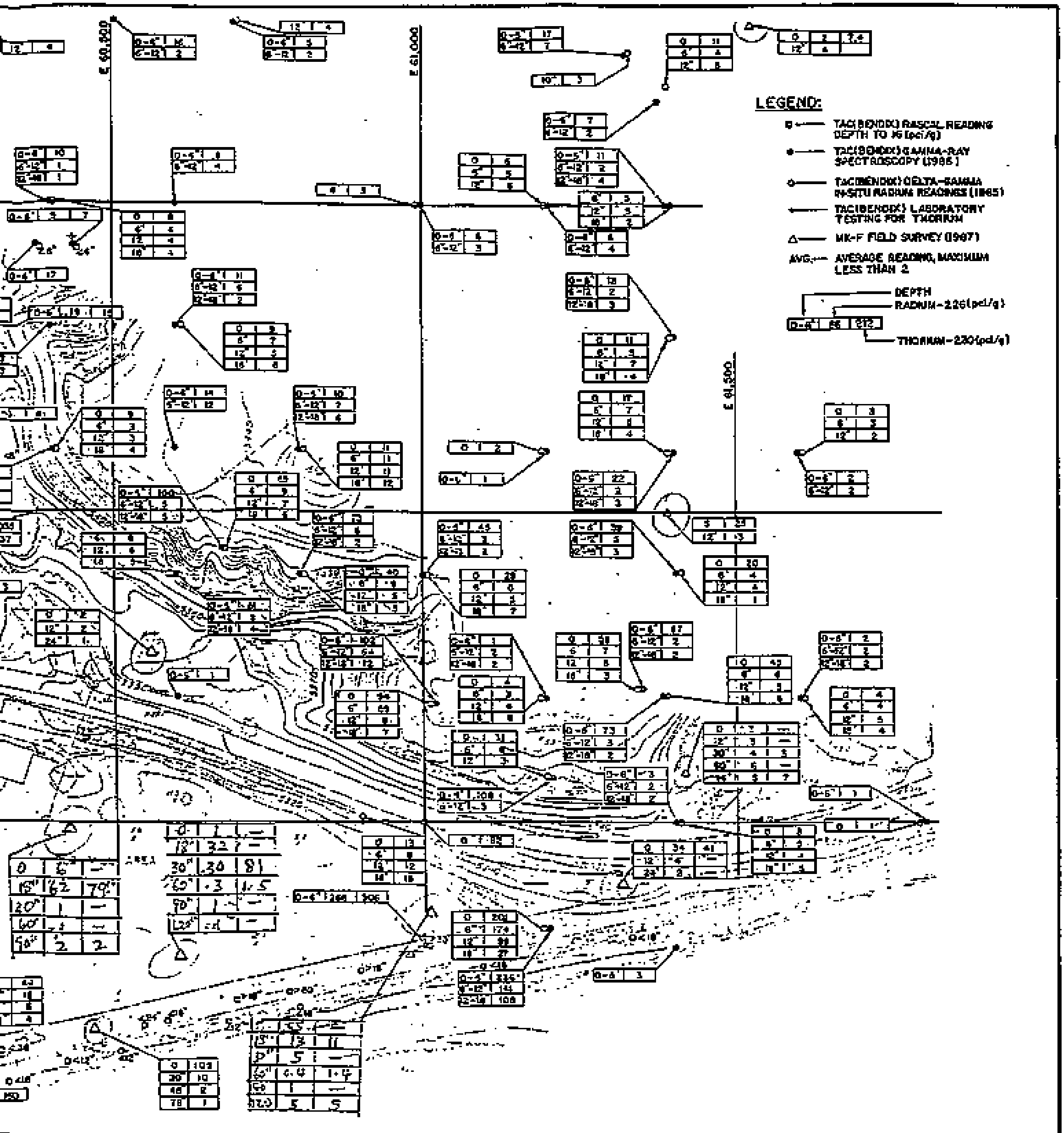


FIGURE D.2.3

VERTICAL AND HORIZONTAL EXTENT OF OLD RIFLE OFF-PILE CONTAMINATION

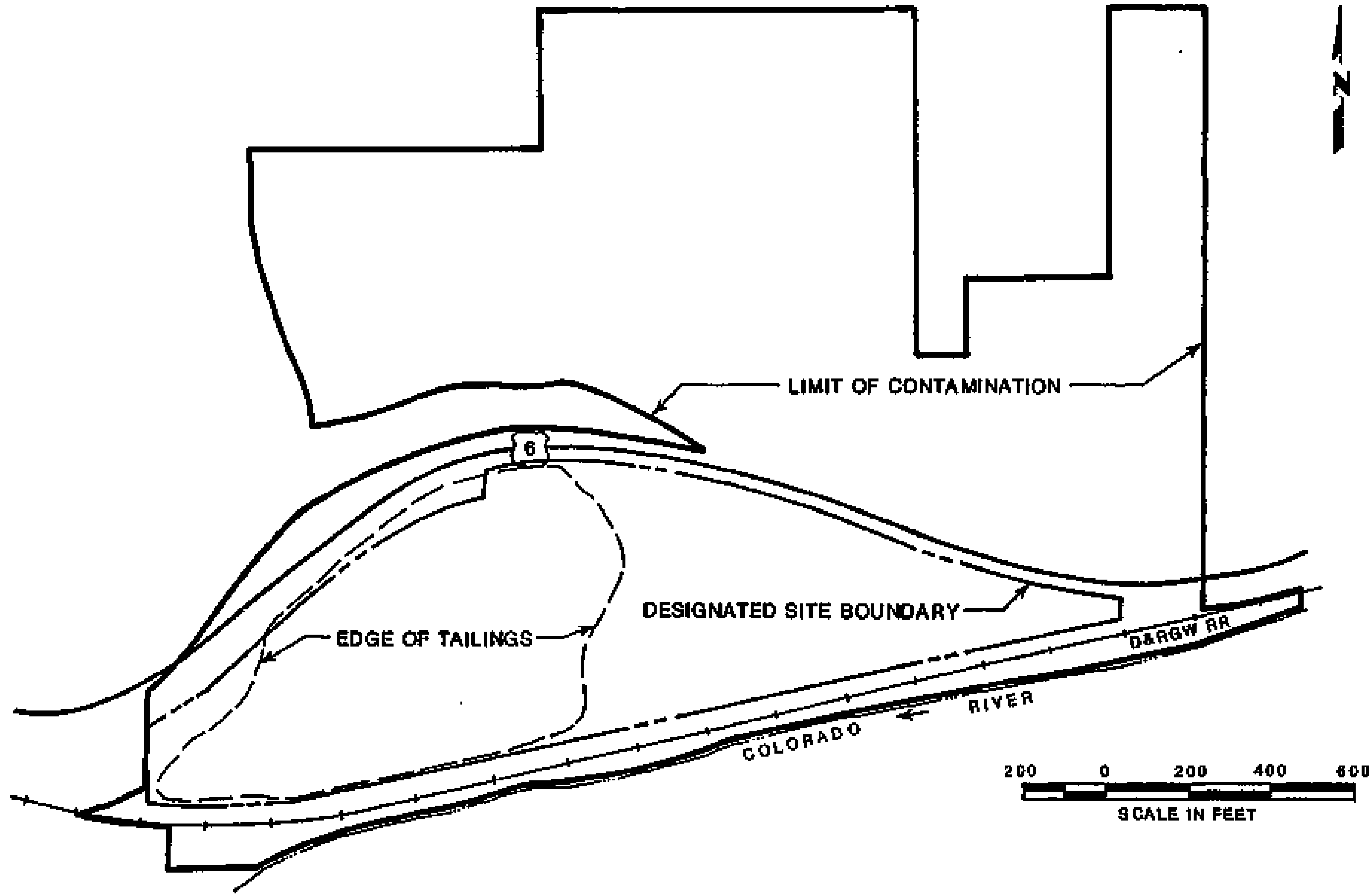
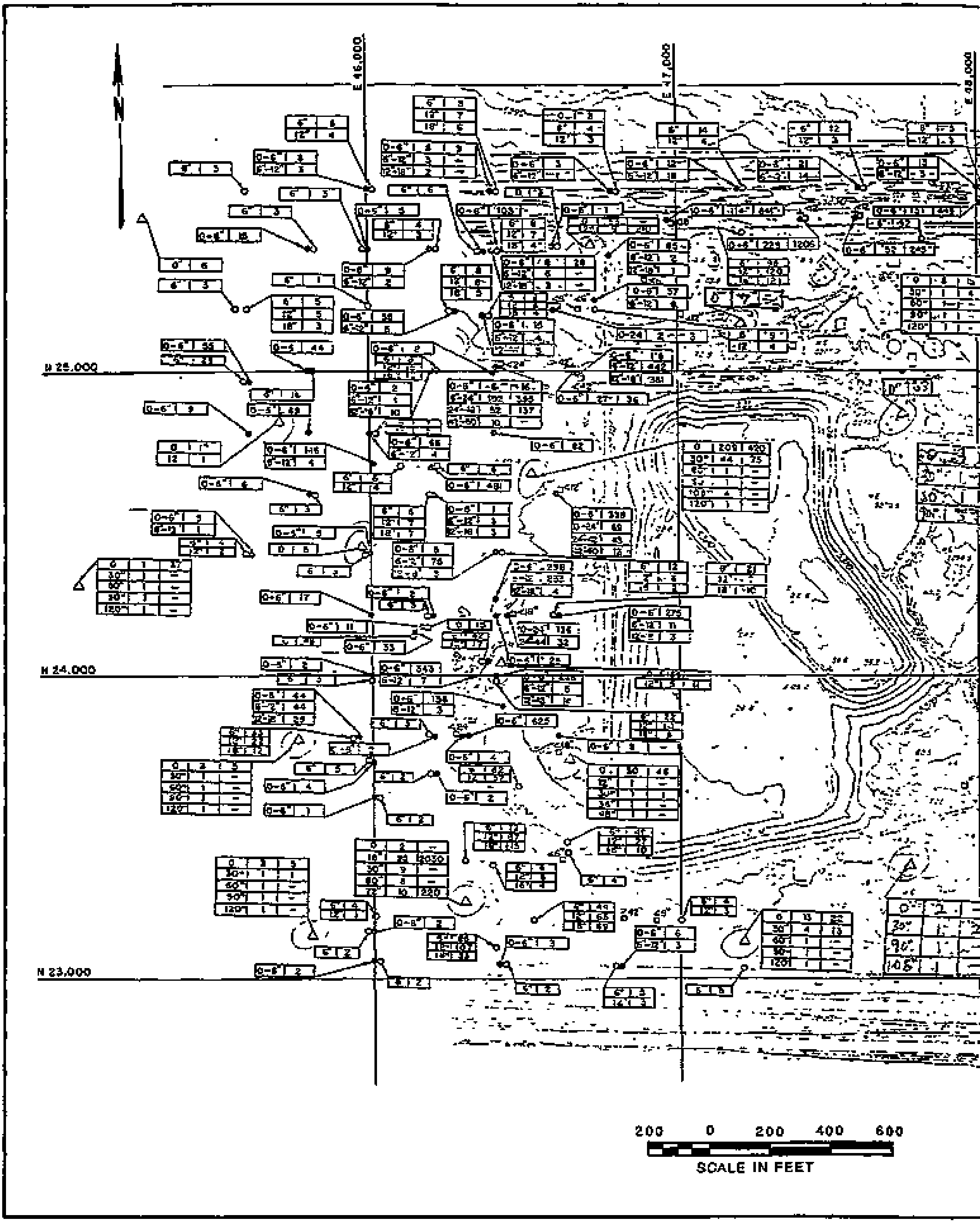


FIGURE D.2.4
OFF-PILE CONTAMINATION, OLD RIFLE SITE


N
E 46,000
E 47,000
E 48,000
N 25,000
N 24,000
N 23,000
200 0 200 400 600
SCALE IN FEET

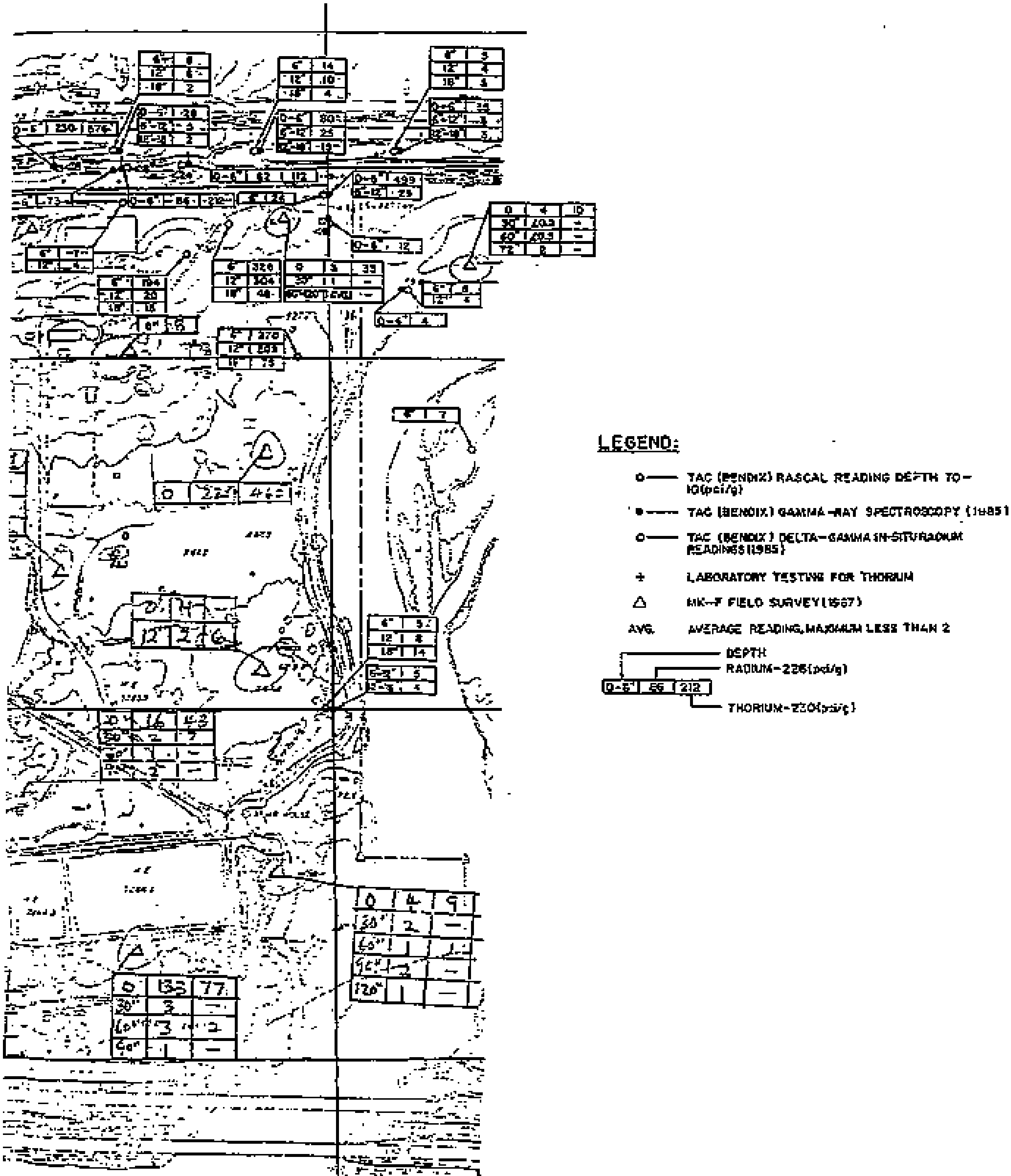


FIGURE D.2.5

VERTICAL AND HORIZONTAL EXTENT OF NEW RIFLE OFF-PILE CONTAMINATION

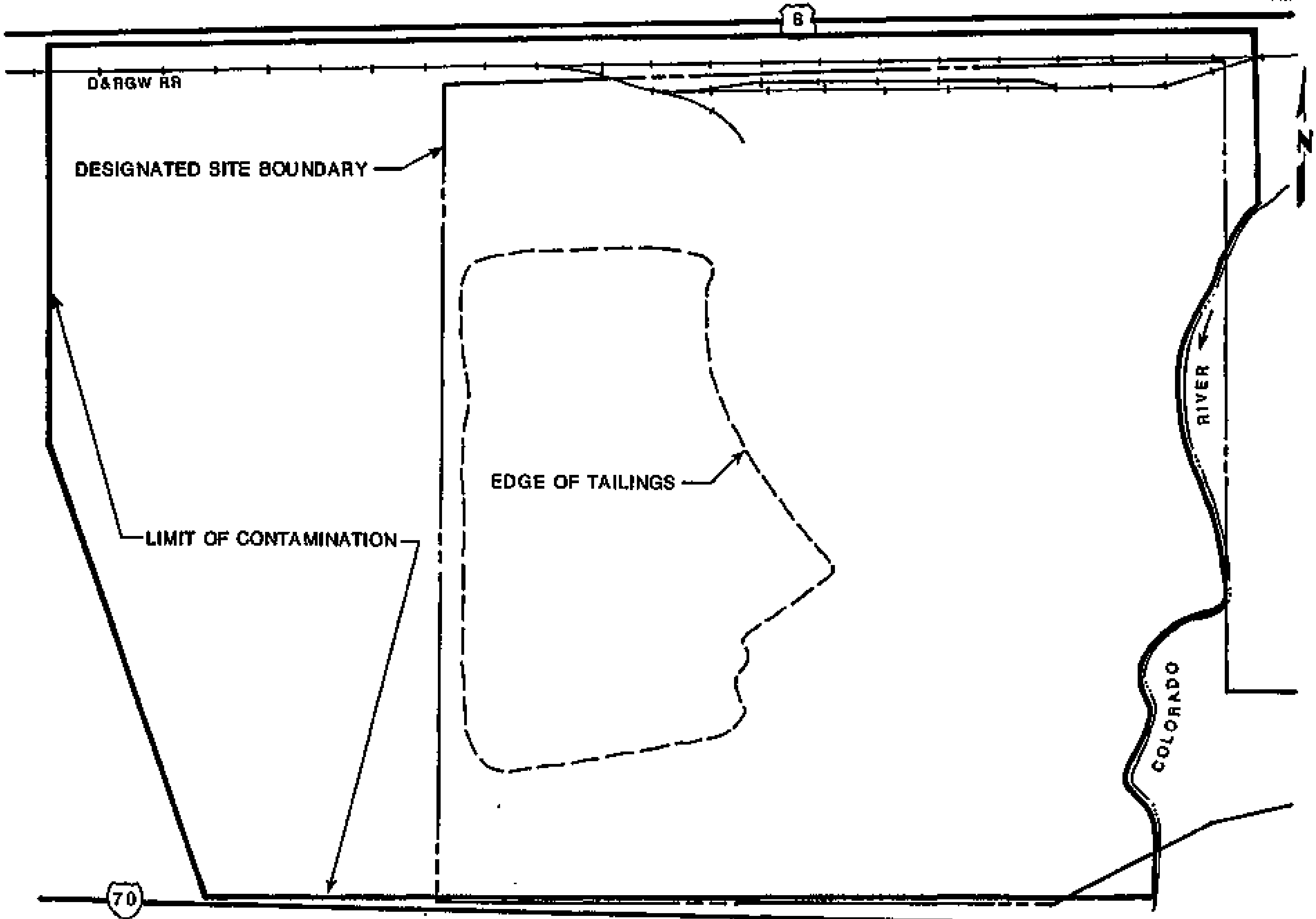


FIGURE D.2.6
OFF-PILE CONTAMINATION, NEW RIFLE SITE

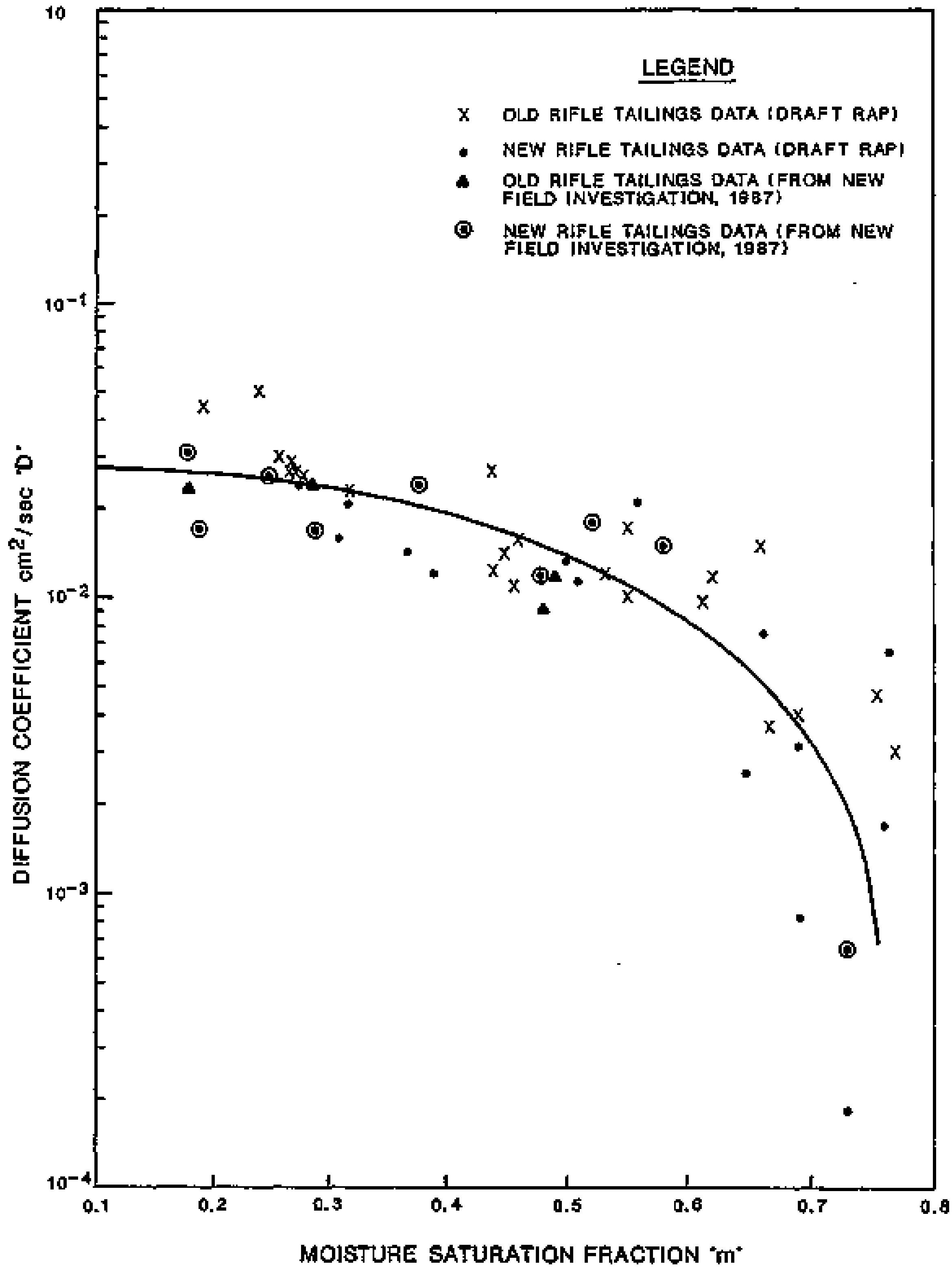


FIGURE D.2.7

RADON DIFFUSION COEFFICIENTS FOR TAILINGS MATERIAL OLD AND NEW RIFLE

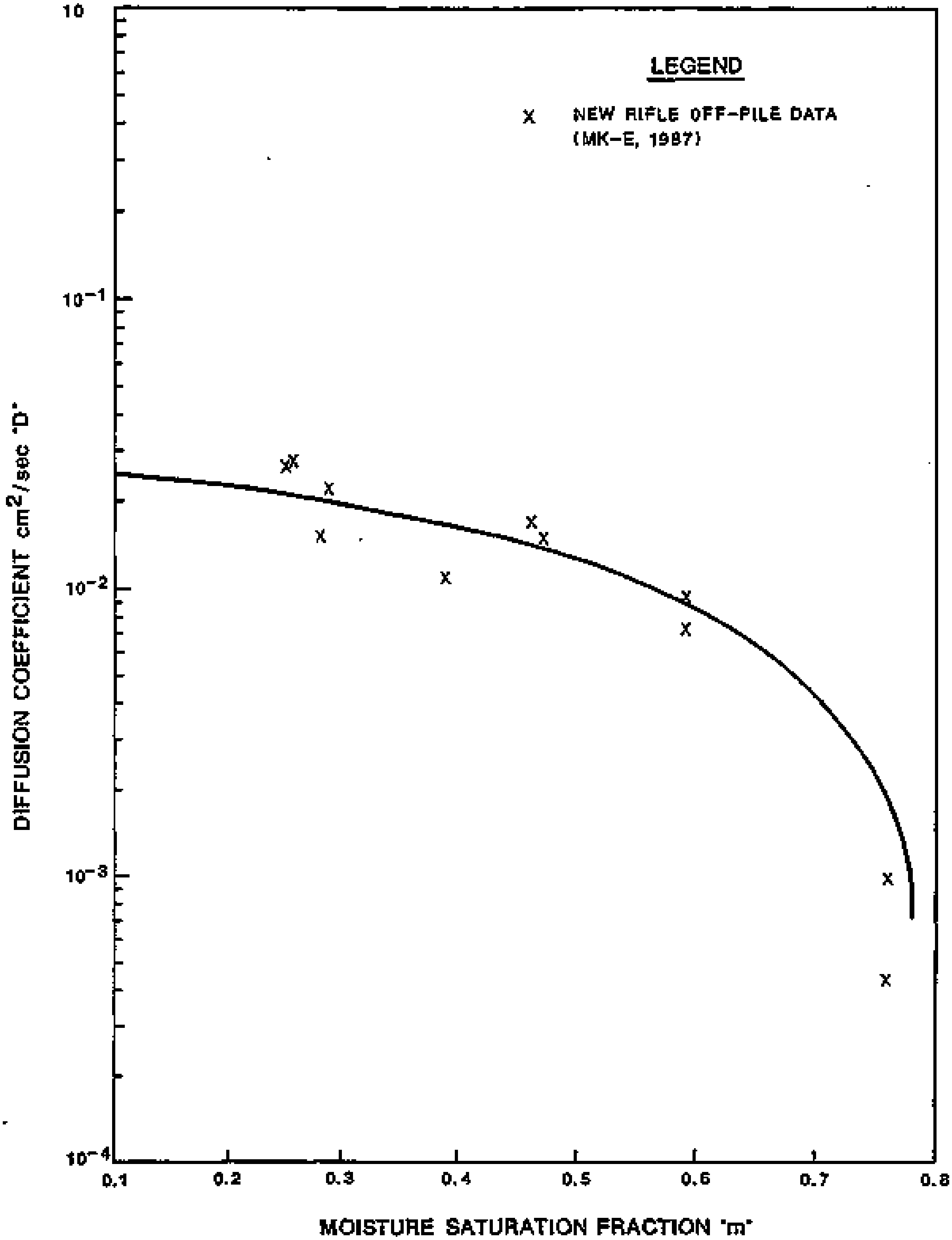


FIGURE D.2.8

RADON DIFFUSION COEFFICIENTS FOR NEW RIFLE OFF-PILE MATERIAL

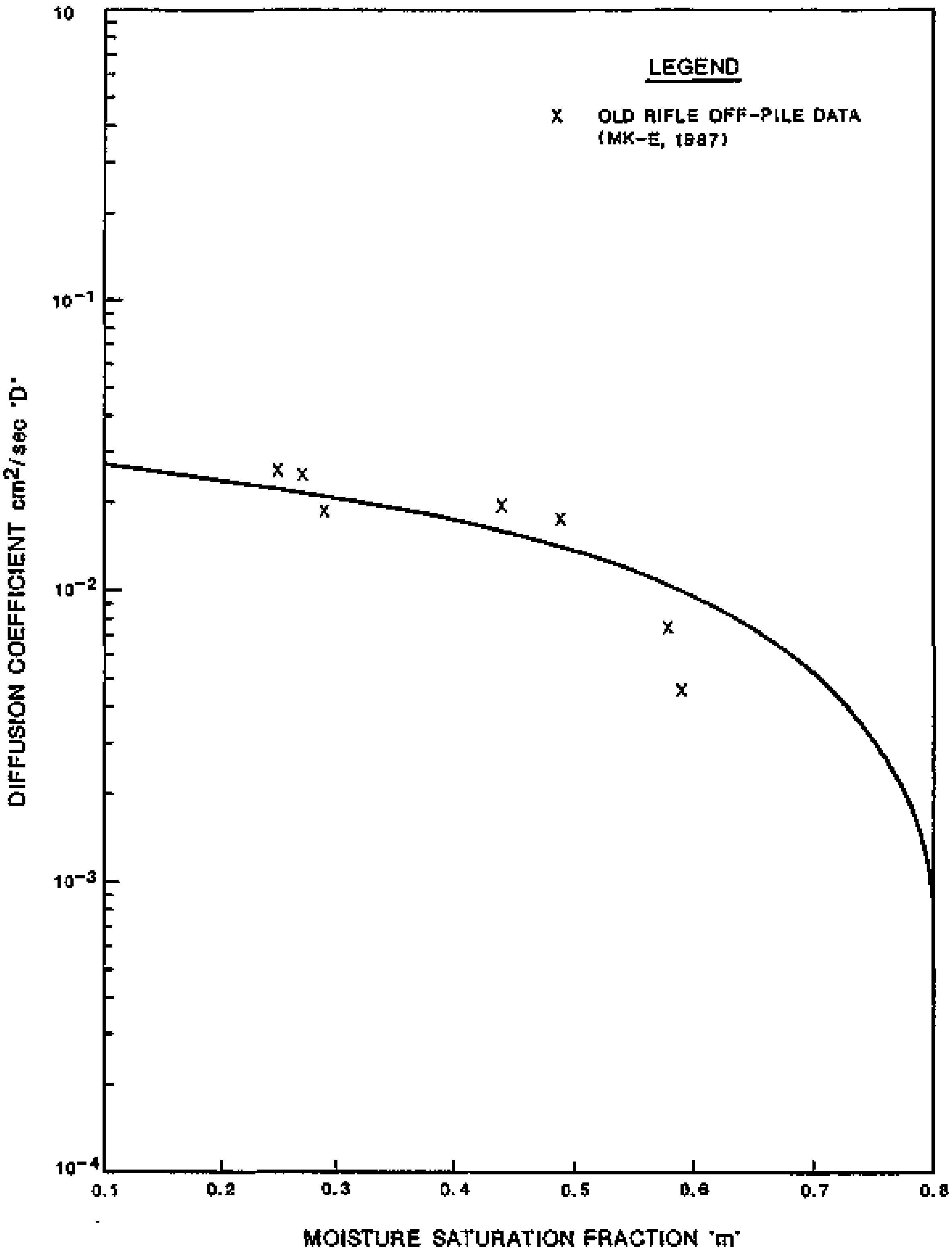


FIGURE D.2.9
RADON DIFFUSION COEFFICIENTS FOR OLD RIFLE OFF-PILE MATERIAL

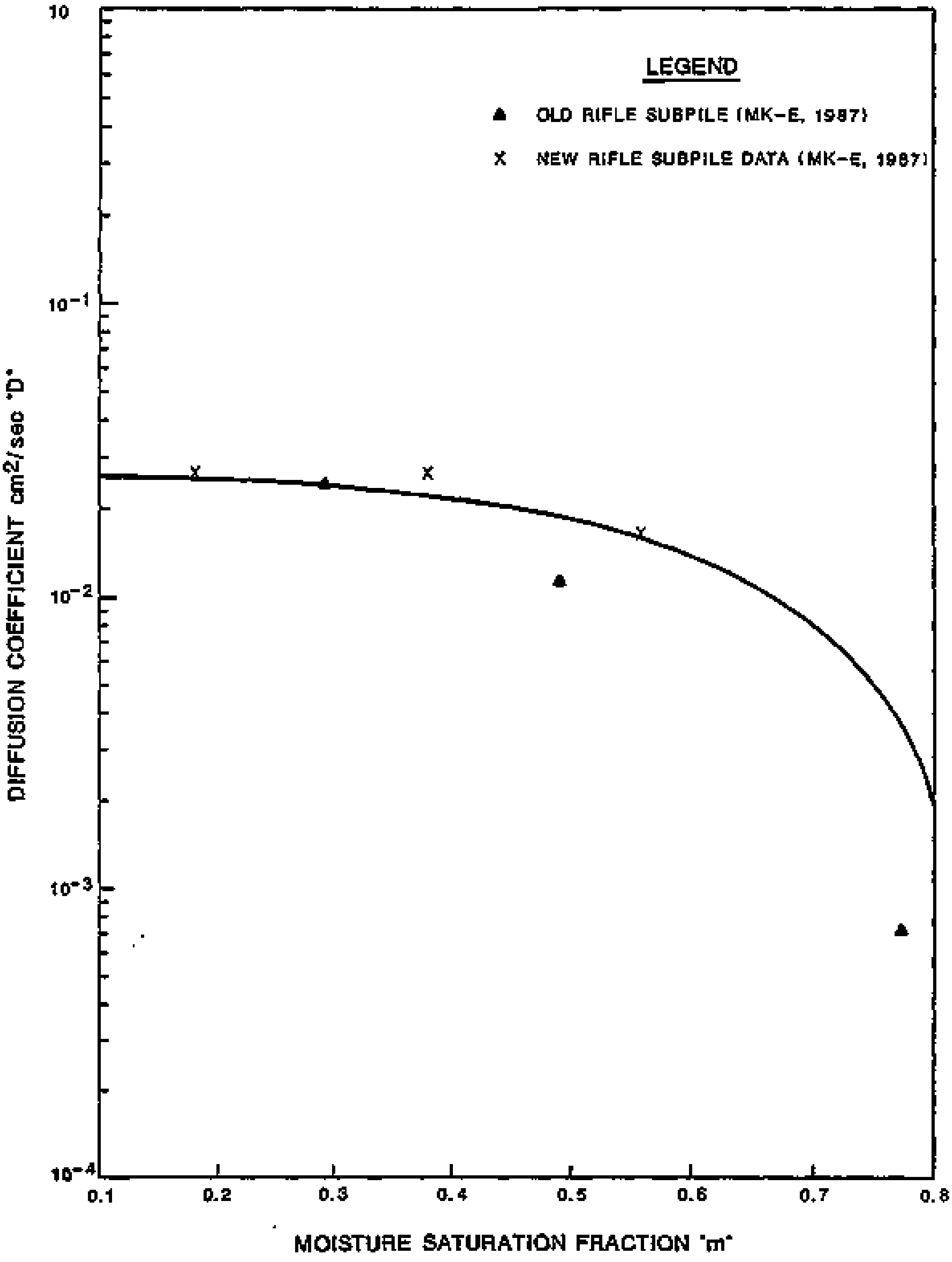


FIGURE D.2.10

RADON DIFFUSION COEFFICIENTS FOR OLD RIFLE AND NEW RIFLE SUBPILE MATERIAL

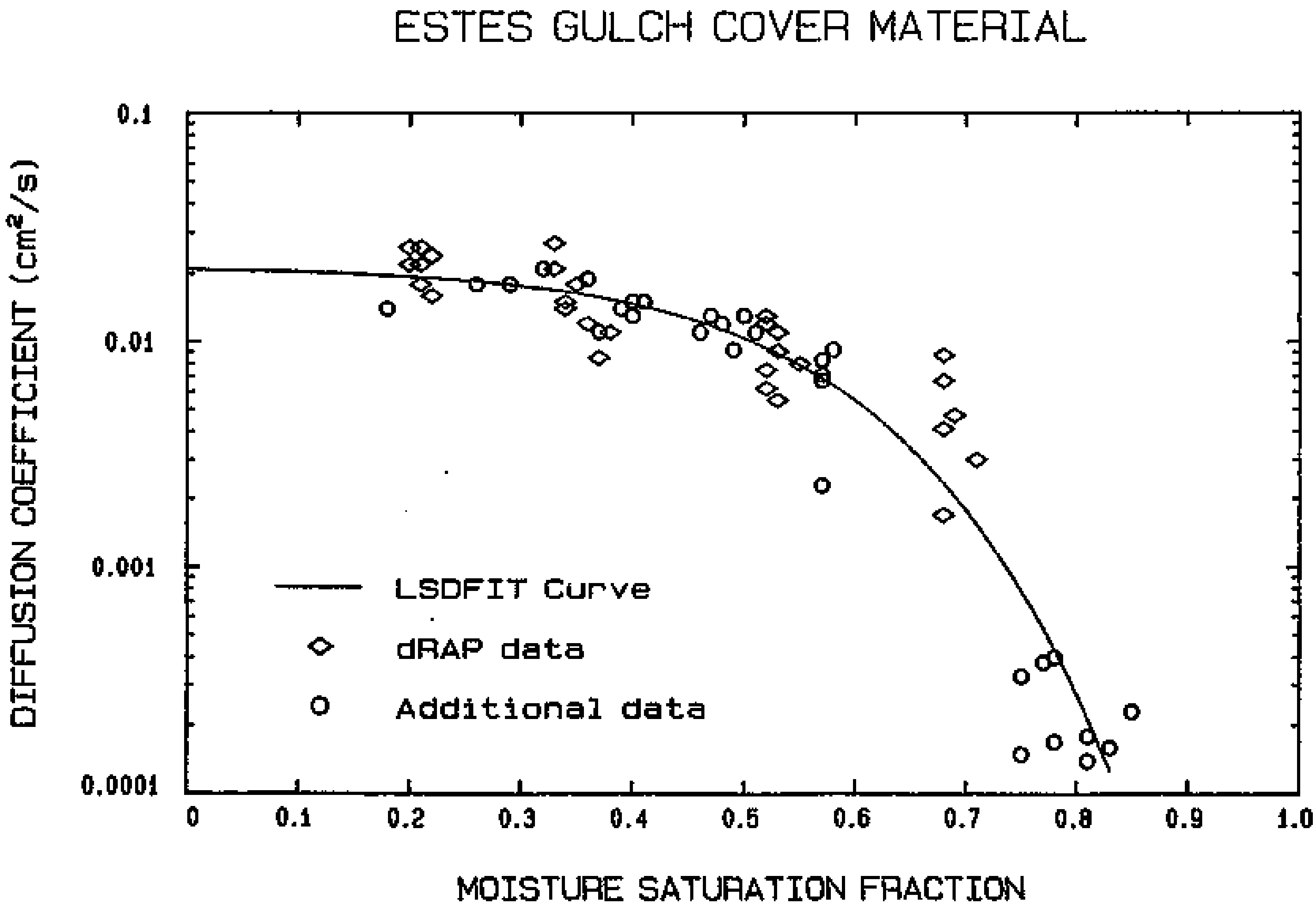


FIGURE D.2.11
RADON DIFFUSION COEFFICIENTS FOR ESTES GULCH COVER MATERIAL

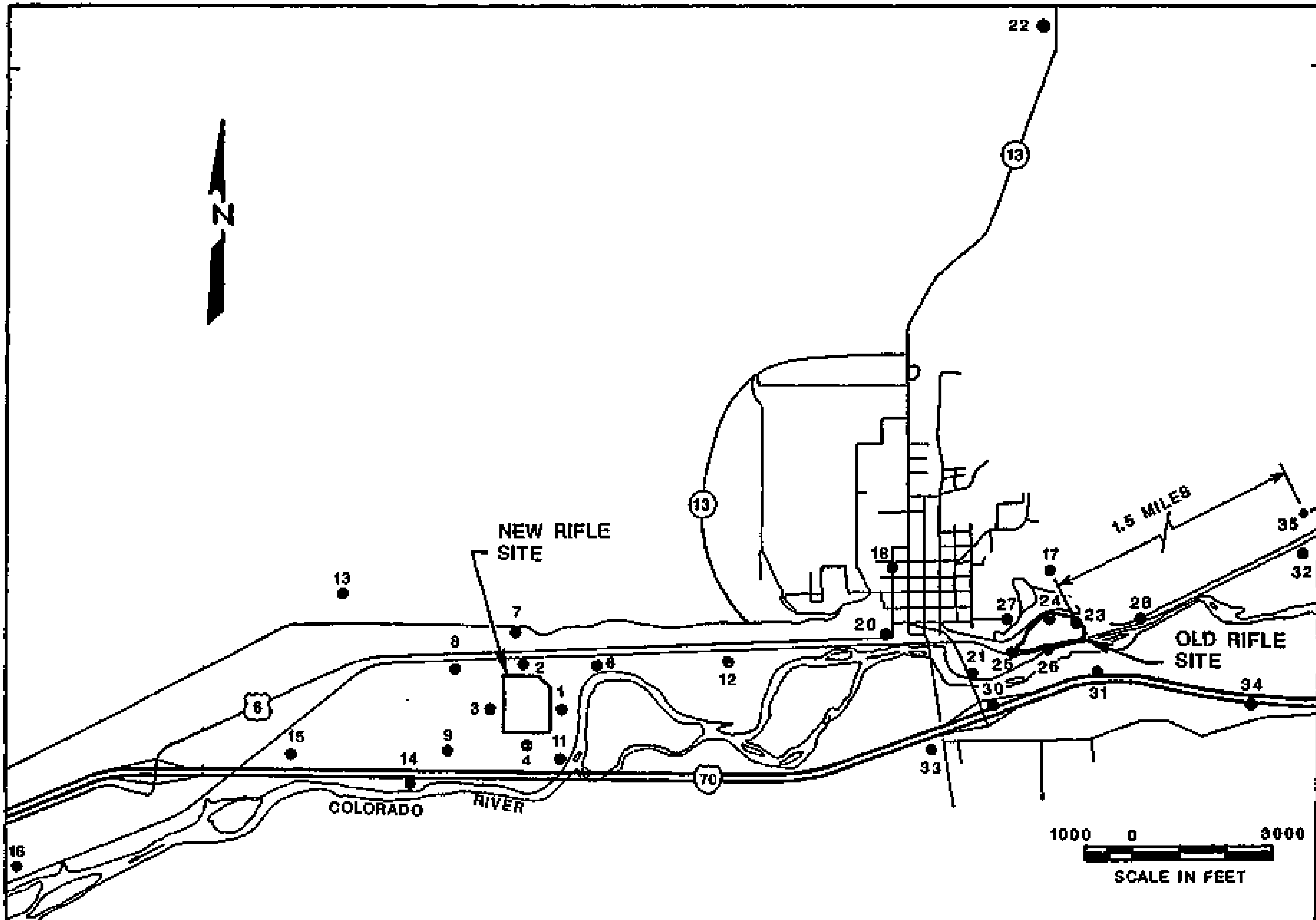


FIGURE D.2.12
OLD AND NEW RIFLE SITES RADON MONITORING NETWORK AT RIFLE, COLORADO

Table D.2.1 Background radiation levels and concentration of radionuclides in surface soil near Rifle, Colorado

Sample identification	Description of sample location	External exposure rate[a] (microR/hr)	Radionuclide concentration Ra-226 (pCi/g)	Radionuclide concentration Th-232 (ppm)
BG-1	South of I-70 ~5 km east of Old Rifle	15.3	1±1	11±3
BG-2	South of Colorado River ~3 km west of New Rifle	15.3	1±1	10±3
BG-2	(Duplicate soil samples)	–	2±1	10±2
BG-3	West of state Hwy 13 ~2.5 km north of Rifle	14.8	1±1	11±2
BG-4	~1.6 km south & ~1.2 km east of New Rifle	15.0	1±1	11±3

[a]Three feet above the ground.

Table D.2.2 Annual average radon concentration as a function of distance from the processing sites for pre-remedial action monitoring around the Rifle, Colorado, UMTRA Project sites

Location	Number of locations	Average radon concentration (pCi/l)	Maximum radon concentration (pCi/l)
New Rifle pile perimeter	4	20.0	22.8
0.25 mile from New Rifle	5	2.7	5.9
0.5 to 1 mile from New Rifle	4	1.0	1.6
2.25 miles from New Rifle	1	0.7	0.7
Old Rifle pile perimeter	4	34.1	50.9
Old Rifle maximally exposed individual	1	2.5	2.5
0.25 mile from Old Rifle	5	1.4	3.1
0.75 mile from Old Rifle	3	0.7	0.8
1.5 miles from Old Rifle	1	0.5	0.5
Town of Rifle	4	1.7	3.1
Rifle background	1	0.4	0.4
Estes Gulch background	2	0.5	0.5

Table D.2.3 Measured depths (feet) to the physical interface and 15 pCi/g interface for MSRD holes at Old Rifle

Hole I.D.	Tails depth	Subbase depth	15 pCi/g interface depth	Hole I.D.	Tails depth	Subbase depth	15 pCi/g interface depth	Hole I.D.	Tails depth	Subbase depth	15 pCi/g interface depth	Hole I.D.	Tails depth	Subbase depth	15 pCi/g interface depth
A-11	23.0	--	--	B-10	21.0	--	--	C-21	22.0	3.0	25.0	D-26	17.5	--	--
A-13	25.0	--	--	B-16	16.3	--	--	C-23	15.0	--	--	D-27	19.0	1.0	20.0
A-15	23.0	--	--	B-17	22.0	3.0	25.0	C-30	21.0	--	--	D-28	16.0	--	--
A-41	21.5	--	--	B-18	26.0	4.0	30.0	C-32	17.0	--	--	D-31	3.0	--	--
A-42	20.0	--	--	B-19	20.0	--	--	C-35	17.0	--	--	D-33	15.5	--	--
A-43	18.5	--	--	B-37	18.5	--	--	C-36	17.5	7.5	25.0	D-34	16.0	6.5	22.5
A-44	18.7	5.0	22.5	B-38	22.0	--	--	C-52	17.0	5.5	22.5	D-54	16.0	--	--
A-45	16.0	--	--	B-39	21.0	6.5	27.5	C-53	20.0	--	--	D-55	15.0	5.0	20.0
A-47	14.0	--	--	B-40	27.0	3.0	30.0	C-60	16.0	--	--	D-56	11.0	4.0	15.0
A-49	22.5	--	--	B-46	18.0	--	--	C-61	15.0	7.5	22.5	D-57	8.0	--	--
A-50	21.5	--	--	B-48	23.5	--	--	D-2	14.0	3.5	17.5	D-58	12.0	3.0	15.0
A-51	22.0	--	--	B-62	21.0	6.5	27.5	D-4	16.0	--	--	D-59	14.0	3.5	17.5
A-64	22.2	--	--	B-63	20.5	--	--	D-7	12.5	--	--				
A-65	14.5	5.5	20.0	C-6	17.0	--	--	D-20	14.0	--	--				
A-66	17.5	--	--	C-8	19.0	8.5	27.5	D-22	17.0	--	--				
A-67	9.5	8.0	17.5	C-12	16.0	--	--	D-24	3.5	--	--				
B-8	24.0	--	--	C-14	16.0	--	--	D-25	15.0	--	--				

Table D.2.4 Measured depths (feet) to the physical interface and 15 pCi/g interface for MSRD holes at New Rifle

Hole I.D.	Tails depth	Subbase depth	15 pCi/g interface depth	Hole I.D.	Tails depth	Subbase depth	15 pCi/g interface depth	Hole I.D.	Tails depth	Subbase depth	15 pCi/g interface depth	Hole I.D.	Tails depth	Subbase depth	15 pCi/g interface depth
A-62	71.5	6.0	77.5	B-53	72.4	--	--	C-8	48.0	--	--	D-33	45.0	2.5	47.5
A-63	71.0	4.0	75.0	B-54	72.2	--	--	C-9	46.0	--	--	D-34	49.5	--	--
A-65	68.0	--	--	B-55	72.0	5.5	77.5	C-10	45.0	0.0	45.0	D-36	48.0	4.5	52.5
A-67	65.0	--	--	B-56	70.0	--	--	C-11	49.0	--	--	D-37	45.5	--	--
A-69	71.0	6.5	77.5	B-57	70.0	5.0	75.0	C-13	47.0	3.0	50.0	D-38	52.0	--	--
A-71	72.0	8.0	80.0	B-58	71.5	3.5	75.0	C-14	42.0	--	--	D-39	49.0	2.4	51.4
A-75	69.8	7.7	77.5	B-59	71.0	--	--	C-15	46.0	--	--	D-40	53.0	--	--
A-73	72.0	--	--	B-60	72.0	--	--	C-17	44.2	--	--	D-44	42.5	--	--
A-77	68.0	--	--	B-61	72.0	5.5	77.5	C-18	43.0	2.2	45.2	D-45	44.5	--	--
A-81	69.0	--	--	B-64	69.0	--	--	C-19	42.0	--	--	D-46	41.0	--	--
A-83	67.0	--	--	B-66	70.0	--	--	C-21	42.0	5.5	47.5	D-47	42.0	--	--
A-84	69.3	--	--	B-68	69.0	--	--	C-27	44.5	--	--	D-49	43.5	--	--
A-85	67.6	--	--	B-70	71.5	--	--	C-43	44.5	--	--	D-51	49.0	3.4	52.4
A-86	69.0	--	--	B-72	70.0	--	--	D-12	45.2	2.8	48.0				
A-87	69.0	--	--	B-74	71.3	--	--	D-20	43.0	--	--				
A-88	67.6	--	--	B-76	70.5	--	--	D-22	45.2	--	--				
A-89	68.2	--	--	B-78	70.5	--	--	D-23	44.6	2.9	47.5				
A-90	69.0	--	--	B-80	75.0	--	--	D-24	49.3	6.7	56.0				
A-91	70.7	--	--	C-1	46.5	--	--	D-25	44.5	--	--				
A-92	66.0	--	--	C-2	44.3	8.2	52.5	D-26	48.0	--	--				
A-93	68.0	--	--	C-3	46.5	6.0	52.5	D-28	51.2	--	--				
A-94	68.0	--	--	C-4	45.5	7.0	52.5	D-29	42.5	--	--				
A-95	70.8	--	--	C-5	49.0	--	--	D-30	52.0	--	--				
B-44	--	--	--	C-6	43.0	--	--	D-31	47.0	--	--				
B-52	72.0	5.5	77.5	C-7	48.5	--	--	D-32	52.0	--	--				

Table D.2.5 Summary of on-pile volumes and concentrations at Old Rifle

	Old Rifle pile
Volume above physical interface (cy)	333,000
Average depth to physical interface (ft)	17.3
Area (acres)	13.2
Radium concentration above physical interface (pCi/g)	704
Volume above 15 pCi/g interface (cy)	501,000
Average depth to 15 pCi/g interface (ft)	22.1
Average difference between physical and 15 pCi/g interface (ft)	4.8
Concentration above 15 pCi/g interface (pCi/g)	637

Table D.2.6 Summary of on-pile volumes and concentrations at New Rifle

	New Rifle pile
Volume above physical interface (cy)	2,415,000
Average depth to physical interface (ft)	57
Area (acres)	31.5
Concentration above physical interface (pCi/g)	636
Volume above 15 pCi/g interface (cy)	2,790,000
Average depth to 15 pCi/g interface (ft)	61.3
Average difference between physical and 15 pCi/g interface (ft)	4.3
Concentration above 15 pCi/g interface (pCi/g)	585

D.3 GEOLOGY, GEOMORPHOLOGY, AND SEISMICITY

D.3.1 INTRODUCTION

Detailed investigations of geologic, geomorphic, and seismic conditions at the Estes Gulch site were conducted by the U.S. Department of Energy (DOE). The purpose of these studies was basic site characterization and identification of potential geologic hazards which could affect long-term site stability. Subsequent engineering studies, such as analyses of hydrologic and liquefaction hazards, used the data developed in these studies. The geomorphic analysis was employed in the design of effective erosion protection. Studies of the regional and local seismotectonic setting, which included a detailed search for possible capable faults within a 65-km (40 mile) radius of the site, provided the basis for seismic design parameters.

The scope of work performed included the following:

- o Compilation and analysis of previous published and unpublished geologic literature and maps.
- o Review of historical and instrumental earthquake data.
- o Review of site-specific subsurface geologic data, including logs of exploratory boreholes advanced in the site area.
- o Photogeologic interpretations of existing LANDSAT and conventional aerial photographs.
- o Low-sun-angle aerial reconnaissance of the site region.
- o Ground reconnaissance and mapping of the site region.

The Estes Gulch site itself and the immediately surrounding area, out to a radius of about 1.6 km (one mile), are referred to in this section as the site area. The surrounding region, encompassing west-central Colorado and adjoining eastern Utah, will be referred to as the site region. The following topics relevant to the stabilization of mill tailings at the Estes Gulch site are discussed:

- o Characterization of the regional geologic setting and its correlation to site geology.
- o Identification of geomorphic hazards and suggestions for mitigative measures.
- o Seismotectonic evaluation to provide initial design earthquake and acceleration parameters. Subsequent engineering analyses fully assess the liquefaction potential and slope stability.
- o On-site fault rupture potential.

- o Potential for damage by earthquake-induced natural slope failure.
- o Potential impact of geothermal and volcanic activity, subsidence due to tectonic causes, and reservoir-induced seismicity.
- o Analysis of mineral resource potential and the possible impact on site stability of future mineral resource development.

D.3.1.1 Criteria and definitions

This section presents definitions and criteria used to perform site hazard evaluations. These are presented to standardize usage throughout this section, and are pertinent to the seismic hazard evaluation because of the wide range of interpretation or usages of certain seismological terms.

Design life. As specified by the EPA-promulgated standards for remedial actions at inactive uranium processing sites (40 CFR 192), the controls implemented at the Uranium Mill Tailings Remedial Action (UMTRA) Project sites are to be effective for up to 1000 years, to the extent reasonably achievable, and, in any case, for at least 200 years. In the case of assessing seismic and geomorphic hazards, the criteria established and the methodologies applied seek to ensure that the stabilized embankment will not be damaged by earthquake ground motions, related ground rupture, or erosional encroachment for up to 1000 years.

Design earthquake. The magnitude of the earthquake which produces the largest on-site peak horizontal acceleration is the magnitude of the design earthquake. This controlling earthquake could be the floating earthquake or an earthquake whose magnitude is derived from a relationship between capable fault rupture and/or fault length and maximum magnitude.

Capable fault. A capable fault is defined as a fault which has exhibited one or more of the following characteristics:

- o Movement at or near the ground surface at least once within the past 35,000 years or movement of a recurring nature within the past 500,000 years.
- o Macro seismicity instrumentally determined with records of sufficient precision to demonstrate a direct relationship with the fault.
- o A structural relationship to a capable fault such that movement on one fault could be reasonably expected to cause movement on the other.

This definition is essentially the one adopted by the NRC for the siting of nuclear power plants (10 CFR 100, Appendix A, 1975).

Acceleration. Acceleration is defined as the mean of the peaks of the two horizontal components of an accelerogram record. The exact term used is "peak horizontal acceleration." The design accelerations are determined from the constrained attenuation relationship based on distance and magnitude developed by Campbell (1981). The mean-plus one standard deviation (84th percentile) values are adopted. The design value is considered a nonamplified peak horizontal acceleration in the free field.

Magnitude and intensity. Magnitude was originally defined by C. F. Richter as the base-10 logarithm of amplitude of the largest deflection observed on a torsion seismograph located 100 km (62 miles) from the epicenter. This local magnitude value may not be the same as the body-wave and surface-wave magnitudes derived from measurements at teleseismic distances. Unless specified otherwise, Richter magnitude values are used in the seismic hazard evaluations.

Intensity is the index of the effects of an earthquake on the human population and structures. The most commonly applied scale is the 1931 Modified Mercalli (MM) Intensity scale, which is used in these studies.

Because pre-instrumental earthquakes are reported in intensity and more recent instrumental records are in magnitude, there may be a need to relate these values. Several equations have been proposed. Unless otherwise specified, the relationship developed by Gutenberg and Richter (1956) is applied. This equation is as follows:

$$M = 1 + 2/3\, I_o$$

where M = magnitude in the Richter scale and I_o = Modified Mercalli (MM) intensity in the epicenter area.

It is generally acknowledged that some confusion prevails in the use of various magnitude scales in the engineering and seismic literature. This results from the lack of instrumental data in many places, such as the Colorado Plateau, limitations of the instruments themselves, the complex nature of seismic phenomena, and the fact that different scales are used for different purposes.

The definition of magnitude is restricted to local magnitude (M_L) for design earthquakes in the UMTRA Project studies. This is because the M_L (and m_b) scales are proportional to the ground motion amplitudes near one second period, which is the part of the ground motion spectrum of most interest to engineers (Nuttli and Herrmann, 1982). The surface wave magnitude (M_s and M_o) measures very long period ground motion amplitudes which are generally only of interest in the determination of the dimensions of fault rupture. Magnitudes of design earthquakes will continue to be specified in terms of M_L.

An exception to this rule occurs where maximum earthquakes (MEs) of potential design faults or distant seismotectonic provinces are determined. The ME value, calculated using the relationships of Bonilla et al. (1984), as stated above, is an M_S value. This is specifically stated wherever appropriate. No error is introduced into design acceleration estimates using Campbell (1981), since ME values of potential design faults generally are significantly greater than 6.0. This agrees with the methodology used by Campbell (1981) to determine acceleration/attenuation relationships:

$M = M_S$ for magnitudes equal to 6.0 or greater

$M = M_L$ for magnitudes less than 6.0

Derivations of the various seismic design parameters are dependent on published sources, which employ the magnitude scale most appropriate for their particular purpose. For example, the fault length versus magnitude relationship is taken from Bonilla et al. (1984), who compiled statistical relationships of surface rupture length and fault displacement to surface wave magnitude (M_s). The following relationship of Bonilla et al. (1984) is used for plate interiors:

$$M_s = 6.02 + 0.729 \log L$$

where L = mapped fault rupture length

Floating earthquake. A floating earthquake (FE)is an earthquake within a specific seismotectonic province which is not associated with a known tectonic structure. Before assigning the floating earthquake magnitude, the earthquake history and tectonic character of the province are analyzed. The term "floating earthquake" is used to define the largest event within a specific province not associated with a known structure. The magnitude of the floating earthquake within each province will not be less than the largest event not associated with a known structure.

In accordance with the seismic design procedures developed in agreement with the NRC and DOE staff (DOE, 1989), the more conservative value of $M_L = 6.2$ is recommended for the maximum magnitude of the FE in the Colorado Plateau. Within the province of the site, the floating earthquake is placed 15 km from the site.

Maximum Earthquake (ME). The maximum earthquake is the earthquake associated with specific seismotectonic structures, source areas, or provinces that would cause the most severe vibratory ground motion or foundation dislocation capable of being produced at the site under the currently known tectonic framework. It is determined by judgement based on all known regional and local geological and seismological data.

Duration of strong earthquake ground motion. For the purposes of UMTRA Project studies, duration is defined, after Krinitzsky and Chang (1977), as the bracketed time interval in which the acceleration is greater than 0.05g.

The methodology of Krinitzsky and Chang (1977) is applied in estimating the duration of strong ground motion at a particular site.

Geomorphic evaluation

The purposes of the geomorphic evaluation of UMTRA Project sites are to characterize the current geomorphic conditions and to assess the impact of geomorphic processes on the long-term stability of the uranium mill tailings piles. These evaluations are restricted to the assessment of natural geomorphic processes and the geomorphic effects of past land-use activities, but do not address future human activities or potential hazards related to site hydrology.

Schumm and Chorley (1983) have prepared a detailed publication presenting a theoretical discussion of geomorphic processes which may affect a tailings site. Nelson et al. (1983) present a handbook approach to specific methods for site assessment, engineering procedures for mitigation, and confidence levels for hazard predictions over periods of 200, 500, and 1000 years. The methodologies and criteria presented in these publications were used as guides for the geomorphological investigations of UMTRA Project sites.

D.3.1.2 Scope of work

Compilation and analysis of previous work

A review of all pertinent stratigraphic, lithologic, tectonic, seismologic, geophysical, geomorphic, mineral resource, and soils literature and maps of the site region was performed by the DOE. A GeoRef data search was employed to ensure complete coverage of all published information. The GeoRef data search is available on request from the DOE UMTRA Project Office in Albuquerque, New Mexico. References used during this study are listed in the reference section at the end of this appendix.

The study region is completely covered by published geologic maps of the U.S. Geological Survey at 1:250,000 scale (Tweto et al., 1976; Cashion, 1973). Several 7.5- and 15-minute quadrangles and other areas in the region are also covered by published geologic quadrangle maps and open-file reports at various scales. Other significant publications of the U.S. Geological Survey dealing with the geology of the study region include Lohman (1965), Donnell (1961a), and Fischer (1960). Structural geology of the Uncompahgre Uplift has been discussed in recent papers by Heyman (1983), White and Jacobsen (1983), and Jamison and Stearns (1982). Regional studies of Colorado Plateau geology and physiography include works by Keller et al. (1979), Hunt (1974, 1956), and Kelley (1955).

The Quaternary geology and geomorphic history of the study region have been discussed by Cole and Sexton (1981), Epis et al. (1980), Sinnock (1981a,b; 1978), Yeend (1969), and Richmond (1965). Field trip guidebooks to the site region have been published recently by the American Association of Petroleum Geologists (Chenoweth, 1980), the New Mexico Geological Society (Epis and Callender, 1981), the Grand Junction Geological Society (Robinson and Dea, 1981), and the Rocky Mountain Association of Geologists (Dunn, 1974; Murray and Haun, 1974).

Copies of all published maps and open-file reports within a 65-km (40-mile) radius of the site were obtained and employed in the fault compilation. All faults identified during the survey were compiled onto a single base map, at 1:250,000 scale, for use in subsequent analyses. A search was also made for other unpublished seismic evaluations for large engineered structures (dams, power plants, waste disposal areas, and the like). An unpublished seismic hazard evaluation for Ridgway Dam site (Sullivan et al., 1980) was obtained. It provided useful data on the Ridgway fault and other structures at the southeast end of the Uncompahgre Uplift.

Personal communications were established with experts on seismic evaluation and researchers active in the study region to supplement the literature whenever possible. Dr. David B. Slemmons of the McKay School of Mines, University of Nevada, was consulted for his professional opinion on the value of the ME for the Colorado Plateau. Dr. Carl Von Hake of the National Geophysical Data Center in Boulder, Colorado was consulted on the reliability of the historical seismic record. Contacts were made with various personnel of the Bureau of Reclamation concerning seismic studies at Ridgway Dam site, Rifle Gap Dam, Vega Dam, Fruitgrowers Dam, and other dams and water projects in western Colorado.

Earthquake data compilations

Historical earthquake data for the area within a 200-km (124-mile) radius of Estes Gulch were obtained for the initial phase of this study (SH&B, 1985). The complete data file is included in Addendum D4. Additional seismic data for the Ridgway Dam and reservoir site (Sullivan et al., 1980) were obtained from the Bureau of Reclamation.

Published probabilistic seismic hazard studies for the United States (Algermissen et al., 1982; Coffman et al., 1982; Applied Technology Council, 1978; Algermissen and Perkins, 1976; Liu and DeCapua, 1975) were also reviewed.

Maximum earthquake values for remote seismotectonic provinces, such as the Intermountain Seismic Belt and Rio Grande Rift, were taken from published studies. In addition, two regional epicentral compilations were also obtained from the National Geophysical Data Center for use in calculating the ME value and recurrence interval for the Colorado Plateau and in compilation of the regional seismic map. Copies of the regional epicentral data compilations are available on request from the DOE UMTRA Project Office, Albuquerque, New Mexico.

Subsurface geologic data

Subsurface geologic data obtained in the site area for this study by the Technical Assistance Contractor (TAC) consist of logs of 42 boreholes and 16 backhoe test pits advanced on the site during 1985, 1986, and 1988. Boreholes were drilled to depths ranging from 17 to 543 feet to install wells, assess vadose zone conditions, subsurface stratigraphy, and engineering characteristics. Additionally, the Remedial Action Contractor (RAC) drilled core holes within the area of the proposed toe of the cell in 1992 to evaluate local stratigraphy. Test pits were advanced to depths of three to 12 feet. Logs of all boreholes and test pits were compiled. Samples were obtained from the boreholes using standard sampling and penetration techniques. Disturbed bulk samples were obtained from the test pits.

Ground reconnaissance and mapping

Ground reconnaissance and mapping for the Estes Gulch site were conducted in 1985 and 1986 (SHB, 1985; TAC, 1985b). Local geology and geomorphic hazards were evaluated on the site in 1985 and 1986. Previous studies located during the reference literature compilation yielded geologic maps of the bedrock and surficial geology of the site area. Subsurface geologic cross sections were constructed from borehole logs of the site. Geologic, geomorphic, and site hazards investigations were conducted at the site by DOE representatives on May 23 and September 29 to October 3, 1986 and in spring, 1988.

A fault map compiled from published literature sources and augmented by photogeologic studies was used as a basis for field reconnaissance of potentially active faults. All faults within a five-mile radius of the site were studied and potentially active faults within a 65-km (40-mile) radius of the site were investigated for recent activity. Faults within a 65-km radius of the site are shown on Plate D.3.1. Field investigation of faults was conducted by DOE representatives from September 29 to October 3, 1986, and in spring, 1988.

These studies resulted in an evaluation of geologic features, geomorphic processes, and hazards at the site. The evaluation of the capability of faults in the site region resulted in seismic information which would affect seismic design parameters at the site.

Photogeologic interpretation

Studies of existing remote sensing imagery for the Rifle/ Estes Gulch area include review of satellite images, high-altitude aerial photographs, and low-altitude stereopair aerial photographs. The LANDSAT images of the area are black-and-white prints at a scale of 1:250,000 and consist of the following images: (1) flight line 035-033, scene 84036117195, July 12, 1983; and (2) flight line 035-032, scene 85019117194, September 8, 1984. National High Altitude Photography Program stereopair, black-and-white prints at a scale of 1:80,000, taken in 1982, were inspected for a radius of about 50 miles of the Estes Gulch site. Stereopair aerial photographs at a scale of 1:24,000 covering a 65-km radius of the site were examined at the offices of the BLM in Denver, Colorado.

Information from the aerial photograph inspection was transferred to topographic maps at scales of 1:24,000, 1:62,500, and 1:250,000.

Low-sun-angle aerial reconnaissance

Glass and Slemmons (1978) indicate the most definitive indication of active faulting is oversteepened land surfaces (fault scarps). They also indicate that the single most effective method of detecting and delineating fault scarps is to conduct aerial reconnaissance and remote sensing using low solar irradiation angles to produce shadows or highlights on scarps. Slemmons (1977) indicates the use of low-sun-angle methods can greatly aid in delineating very subtle geomorphic features associated with active faulting.

The natural degradation of fault scarps in unconsolidated material has been described by Wallace (1977) and Bucknam and Anderson (1978) and occurs as a result of mass wasting and erosional processes. This slowly reduces the slope angle of the scarp over a period of several hundreds of years to a few million years. These scarp degradation studies, performed in the Basin and Range physiographic and structural province, are believed to be applicable to the site region because of similar erosional processes and climate. They indicate that any major surface faulting of late Quaternary age (the last 500,000 years) should be readily detectable using low-sun-angle methods of observation.

Low-sun-angle methodology has been discussed by Glass and Slemmons (1978), Slemmons (1977, 1969), Cluff and Slemmons (1972), and Clark (1971). They indicate low-sun-angle aerial reconnaissance in areas of low to moderate terrain is best conducted when the sun is between 10° and 25° in elevation above the horizon. These sun illumination angles occur in the approximate 2.5-hour time interval beginning 0.5 hour after sunrise or ending about 0.5 hour before sunset. Glass and Slemmons (1978) recommend a "multi" approach, i.e., using multiple observers, multiple times of day (morning and evening), and multiple season missions.

Missions flown for this study included multiple observers and multiple times of day. Multiple-season observations were not conducted in the site region. Low-sun-angle aerial reconnaissance was flown by DOE representatives in the morning and evening of May 22, 1986.

During the low-sun-angle aerial reconnaissance missions, all known faults within 9.3 miles (15 km) of the site were inspected and an intense low-altitude search for undetected faults within 10 km (6.2 miles) of the site was made. All faults of over a few miles in length within a 65-km radius of the site were inspected and any topographic structures which could result from faulting were inspected. All regional structures which could be capable of large or great earthquakes within 200 km (125 miles) of the site were also examined.

D.3.2 GEOLOGIC SETTING

D.3.2.1 Physiographic setting

The Rifle/Estes Gulch site area is on the northeastern edge of the Colorado Plateau physiographic province, near its boundary with the Southern Rocky Mountains province (Figure D.3.1). The Wyoming Basin physiographic province lies to the north of the site area. In the Rifle area, the Colorado Plateau province is divided into two sections: the Canyonlands section to the south, and the Uinta Basin section to the north (Hunt, 1967). These two sections are separated from one another by the Book Cliffs, a prominent topographic escarpment formed by the Mesaverde Group outcrop. The Canyonlands section in the site area is characterized by monoclinal folds, upwarped plateaus, and lava-capped mesas. The Uinta Basin section exhibits a mature stream-eroded upland surface known as the Roan Plateau. The basin forms an embayment between the Middle and Southern Rocky Mountains physiographic provinces. Little faulting is associated with the structural upwarps and basins except in the northwest-trending basin south of and parallel to the Uncompahgre Upwarp (Hunt, 1967). Principal physiographic elements within the study region include the Colorado River Valley, Uncompahgre Plateau, Grand Mesa, Battlement Mesa, Roan Plateau, White River Plateau, and the Grand Hogback (Figure D.3.2).

Along the Colorado River Valley, the narrow DeBeque Canyon portion separates the broad, open Grand Valley to the west from the steep-walled, flat-bottomed valley to the east between the Roan Plateau and Battlement Mesa. East of Rifle, the Colorado River cuts through the Grand Hogback monocline after passing around the south side of the White River Plateau. Grand Valley is bounded by the Book Cliffs on the north and northeast, by the Uncompahgre Plateau on the south and southwest, and by Grand Mesa on the east. The valley is about 12 miles wide. The northern half of the valley is characterized by several levels of long, deeply dissected pediments which extend from the base of the Book Cliffs toward the Colorado River (Sinnock, 1981a,b). The southern half of the valley contains Colorado River terraces composed of alluvial gravels. South of the Grand Valley, the Uncompahgre Plateau forms a dome-shaped topographic high, sloping to the northwest. Parts of the plateau rise more than 4000 feet above the Colorado River. East and southeast of Grand Valley lies Grand Mesa, a basalt-capped plateau about 10,000 feet above sea level. The edges of Grand Mesa are characterized by steep escarpments that grade to multi-level, gravel-capped pediments which slope downward toward the Gunnison and Colorado Rivers.

The Grand Hogback monocline forms the western boundary of the Southern Rocky Mountain physiographic province. The steeply tilted hogback forms a drainage barrier between the steep canyon and mountain region northeast of the White River Plateau and the broad, flat valleys of the Colorado River basin. The Estes Gulch site lies on a gently sloping pediment between the Grand Hogback and the Government Creek Valley, a tributary to Rifle Creek and the Colorado River.

The region is drained by the Colorado River and its tributaries, including the Gunnison River. Principal tributaries of the Colorado River in the site area are Rifle Creek and Government Creek, both perennial streams. Most other creeks within the site area are ephemeral.

D.3.2.2 Regional geology and stratigraphy

The regional dip of rock layers in the Grand Junction-Rifle area is to the north and northeast. The oldest rocks, therefore, are exposed to the southwest and become progressively younger to the northeast. The oldest rocks exposed in the area are the complexly-folded Precambrian schists and gneisses found along the Colorado River in the Uncompahgre Plateau (Lohman, 1981). These rocks are, in turn, covered by a sedimentary section many thousands of feet thick (Table D.3.1). The oldest of the sedimentary formations, the Triassic Chinle Formation, is found southwest of Grand Junction unconformably overlying Precambrian rocks. The large time interval missing between the Precambrian and Triassic rocks supports the premise that the Uncompahgre Plateau was uplifted and eroded some 250 to 220 million years ago, then subsequently buried by a thick sequence of sedimentary rocks. The lower part of this sequence in the Grand Junction area has a thickness of over 500 feet and includes the Triassic Chinle formation, Wingate Sandstone, and Kayenta Formation.

Overlying these layers are approximately 800 feet of Jurassic rocks, including the Entrada Sandstone, Summerville, and Morrison Formations. Of the approximately 7000 feet of overlying Cretaceous rocks present in the Grand Junction-Rifle area, the Mancos Shale comprises about 4000 feet. It is wedged between the underlying Burro Canyon Formation/Dakota Sandstone and the overlying Mesaverde Group. Two formations comprise the Mesaverde Group, the Williams Fork and the Iles Formations. This group is about 4950 feet thick.

The Wasatch Formation, an interbedded sequence of shale, siltstone, and sandstone of early Tertiary age, overlies the Mesaverde Group. In some areas, the basal part of the Wasatch Formation is mapped as a separate formation, the Ohio Creek Conglomerate. The Wasatch Formation has been divided into three members by Donnell (1961b). Shale and claystone dominate the lower and upper members, whereas the middle member is primarily sandstone. Overlying the Wasatch Formation is the Tertiary Green River Formation, storehouse of the world's richest oil shale deposits (Lohman, 1981). This formation forms much of the impressive Roan Cliffs, exposed along the Colorado River near Rifle. Recently, the upper sandstone and siltstone member of the Green River Formation, the Evacuation Creek Member, has been named the Uinta Formation (Tweto et al., 1978).

Grand Mesa, to the south and east of the study area, is capped by a sequence of basaltic lavas approximately 10 million years old that attain a maximum thickness of 800 feet. These lavas are thought to have filled the valleys and lowlands that existed during Miocene time. The basalt now forms the resistant cap on Grand Mesa. Isolated remnants of these lava flows are also present on Battlement Mesa (Schwochow, 1978).

Along the Grand Hogback and northward to the interior of the White River Plateau, rock units of Precambrian to Cretaceous age are exposed. Cambrian to Permian beds of sandstone, siltstone, shale, limestone, and conglomerate crop out in increasingly steeply-dipping layers to the north edge of the Grand Hogback monocline. The steeply dipping monocline itself consists of siltstone, sandstone, shale, and coal beds of Triassic to late Cretaceous age (Tweto, 1978).

The Colorado River valley at Rifle is cut into Wasatch Formation bedrock. The valley is bordered to the north by outcrops of the eastern section of the Book Cliffs and to the south by an eastern extension of the Roan Cliffs. The thick sequence of sedimentary rocks that forms the cliffs and the valley lies within a structural downwarp known as the Piceance Basin. The bedrock generally slopes toward the axis of the basin, although in the Rifle area, the general structural trend has been modified by the White River Uplift and the strata dip approximately five to 10° toward the west-southwest. The transition between the Piceance Basin and the White River Uplift is marked by the Grand Hogback, which is less than 10 miles northeast of Rifle and is associated with faulting of Cretaceous and Tertiary Age rock units (Tweto et al., 1978).

The Wasatch Formation bedrock at Rifle consists of a series of interbedded shales and lenticular sandstone units that were deposited in riverbeds and lakes during the Tertiary period. Although the Wasatch Formation contains some resistant beds that form cliffs, most of the formation is easily weathered and forms lowlands. The more resistant

Green River Formation overlies the strata of the Wasatch Formation, forming the prominent cliffs and capping the plateau north of the Colorado River and Rifle. The Wasatch Formation varies in thickness, but is over 5000 feet thick where it has been measured 10 miles northwest of Rifle. The interbedded shales of the formation act as barriers to the downward and upward migration of groundwater. A generalized cross section of the Rifle area geology is shown in Figure D.3.3. A brief description of the bedrock units at Rifle in order of increasing depth down to the Mancos Shale follows:

Wasatch Formation--a single stratigraphic unit divided into an upper member, the Shire; a middle member, the Molina; and a lower member, the Atwell Gulch. The Shire Member consists of variably colored claystones and siltstones with minor units of lenticular, brown sandstones. The thickness of the Shire Member near Rifle is probably about 1600 feet, although some of it may have been removed by erosion. The Molina Member consists mainly of sandstone and thin, interbedded claystones and siltstones. It is probably about 500 feet thick. The Atwell Gulch Member, probably about 600 feet thick, is a series of drab brown and gray shales and sandstones with several thin, discontinuous interbeds of lignite and carbonaceous shale.

Ohio Creek Member of the Mesaverde Formation--a single massive light-gray to white carbonate cemented kaolinitic sandstone unit of late Cretaceous Age. This unit overlies the Mesaverde Group and was formerly known as the Ohio Creek Formation due to its distinctive color and the presence of chert pebbles (Johnson and May, 1980).

An exposed portion of this unit occurs at Estes Gulch approximately one mile northeast of the disposal site. This unit consists of a light-gray clayey sandstone with conglomeratic lenses having clasts with a maximum nominal diameter of up to 12 inches. This unit was approximately 75 feet thick. The rock exhibited a low permeability by not allowing fluid to infiltrate the matrix upon wetting.

Mesaverde Group--a composite of light-brown-to-white sandstone, gray-to-black shale, and coal beds of the Williams Fork Formation (maximum thickness: 4500 feet). Also included are massive beds of light-brown-to-white sandstone and interbedded shale and coal of the Iles Formation (maximum thickness: 1600 feet) (Tweto et al., 1978).

Mancos Shale--a gray marine shale with a few thin limestone beds and a few beds of sandstone. The Mancos Shale is approximately 6000 feet thick near Rifle (Murray and Haun, 1974; Tweto et al., 1978).

The total thickness to the bottom of the Mancos Shale is about 14,600 feet in the Rifle area (Dunn, 1974). No detailed discussions of fracturing and weathering are available in the literature for the Rifle area; however, it is likely that the more brittle formations are extensively fractured. Dunn (1974) points out that most of the oil and gas production in the area is associated with fracturing, including production from fractured sandstones in the middle and upper Wasatch Formation.

Quaternary deposits are represented by sediments consisting of pediment gravels of several ages, glacial drift and outwash, landslide deposits, fluvially deposited alluvium, and colluvium. Four levels of river terraces and associated pediments formed during two glacial advances are present in the Rifle area (Sinnock, 1981a). Pediment deposits consist of coarse gravel, cobbles, and boulders in a clayey-silt matrix. Thickness of the pediment deposits exceeds 30 feet on the flanks of some mesas south of the Colorado River (Schumm and Harvey, 1983). Unconsolidated fluvial alluvium is present along the Colorado River channel and along major tributaries such as Rifle Creek. Near Rifle, the alluvium thickness is approximately 16 to 25 feet (DOE, 1983). Landslide deposits occur on steeply dipping rock surfaces of the Grand Hogback monocline.

An abundance of mineral resources occurs within the Grand Junction-Rifle area. The Piceance Basin contains oil, natural gas, coal, uranium, sand, gravel, and a high percentage of the world's oil shale. The principal petroleum-bearing formations include, in order of increasing age, the Wasatch Formation, Mesaverde Group, Dakota/Burro Canyon Formations, Morrison Formation, and Entrada Sandstone. At least one of these formations underlies the entire study area.

Economically significant coal deposits are known to occur in only one formation in the area, the Mesaverde Group. The Mesaverde Group is found north and northeast of the Book Cliffs, and east of the western base of Grand Mesa. The Dakota Sandstone locally contains thin coal beds, but nowhere in the study area are there known Dakota coal beds of economic interest. The Estes Gulch site is not underlain by important, shallow coal deposits.

Thick oil shale deposits occur in the Parachute Creek Member of the Green River Formation. A majority of the known oil shale reserves in the United States occurs in this formation in the Piceance Basin. The Estes Gulch site is not underlain by important oil shale deposits.

Uranium and vanadium deposits are known to occur in the Burro Canyon Formation, Dakota Sandstone, Morrison Formation, Entrada Sandstone, Wingate Formations, and Navajo Sandstone (Schwochow, 1978; Fischer, 1960). No deposits have been recognized beneath the Estes Gulch site.

Sand and gravel resources are relatively abundant in the study area. Such resources occur in terraces and modern alluvium along the Colorado and Gunnison Rivers, and in pediment deposits along the Book Cliffs, Grand Mesa, and Battlement Mesas. In general, the most sound sources of riprap are pediment deposits shed from Battlement and Grand Mesas. These deposits contain well-indurated clasts of basalt that have excellent engineering characteristics (CGS, 1982). Pediment gravels from the Book

Cliffs, or river terraces and modern alluvium, often contain an abundance of shale and sandstone clasts. High-quality aggregate could also be obtained by quarrying the basalt cap on Grand Mesa or the small basalt-cap remnants on top of Battlement Mesa. In some areas, acceptable materials may also be obtained by quarrying various sandstone formations.

D.3.2.3 Regional structural setting

The regional structure in the Grand Junction-Rifle area consists of broad uplifts and deep structural basins (Schwochow, 1978). The Uncompahgre Uplift, which trends northwest-southeast, is the most obvious structural feature. On the southwest, it is bounded by the Paradox Basin and on the northeast by the Piceance Basin. The area southeast of Grand Junction, including Grand Mesa, has been influenced by the Gunnison Uplift. Figure D.3.4 shows uplifts and basins developed in Colorado during Laramide time.

These uplifts and basins have smaller-scale folds and faults associated with them. For example, the northeast margin of the Uncompahgre Uplift is bounded by normal faulting monoclinal folding. In Grand Valley, the Mancos Shale generally dips two to nine degrees to the north and northeast into the Piceance Basin. The Grand Hogback monocline to the northeast and east of Rifle marks the boundary between the Colorado Plateau and White River Uplift. The Rifle, Colorado, area lies on the extreme northeastern edge of the Colorado Plateau, near the boundary with the Rocky Mountain Foreland and White River Uplift.

The Colorado Plateau is a structurally unique area in the western United States in that it has been only moderately deformed in comparison with the more intensely deformed and tectonically active regions which surround it. The most distinctive structural features of the plateau are monoclines along the edges of major uplifts. Most of the structural deformation has occurred along these features (Kelley, 1955). The major tectonic divisions of the Colorado Plateau are defined by geographically widespread uplifts and structural basins. Each of the major uplifts are bounded on one side by a major monocline. Structural and tectonic divisions along the northeast edge of the Colorado Plateau are shown on Figure D.3.5.

The regional structural setting of the Colorado Plateau is influenced by the Cordilleran foldbelt to the west and south (Figure D.3.6). The foldbelt is characterized by flatlying thrust faults that have yielded toward the foreland to the east and northeast. The zone of frontal breakthrough of the thrust parallels and nearly coincides with the older zone of transition between the Cordilleran geosyncline and the platform along the western edge of the craton. Locally, traces of the thrusts appear to bend eastward into Arizona and New Mexico. Uplifts and basins of the Rocky Mountain foreland lie east and north of the Colorado Plateau. The intensely deformed regions noted above contrast markedly with the vast expanses of gently dipping strata and scattered monoclines of the Colorado Plateau.

During the late Cretaceous and throughout the Laramide orogeny (early Tertiary) the Colorado Plateau was subjected to compressional stress, producing folds usually expressed by east-dipping monoclines. Other structural elements developed during this time include the Rocky Mountain foreland and the basins and the uplifts of the Colorado Plateau interior. A change in the stress regime to one of regional tension during the Miocene initiated the development of a system of highangle normal faults superimposed on the earlier Laramide folds to the west, south, and southeast of the plateau. Epeirogenic uplift of the entire plateau apparently occurred late in Cenozoic time and may be related to the synchronous development of the Basin and Range structures. Injection of laccoliths and other intrusions occurred after Laramide time, producing domes and other minor modifications of some of the older structures. The stable intracontinental subplate of the Colorado Plateau interior has experienced about two millimeters per year of uplift since the late Tertiary (Gable and Hatton, 1980).

En echelon folding along the eastern and northern regions of the Colorado Plateau indicates a northeastward direction of yielding relative to the surrounding areas. This northeastward direction of yielding appears to be related to the sharp bend in the Cordilleran foldbelt in southeastern California (Figure D.3.6) where the foldbelt cuts into the crystalline basement rocks. East-west compression in the Nevada segment of the Cordilleran foldbelt and nearly north-south compression in the foldbelt in Arizona and New Mexico gives a resultant vector which trends northeast. Therefore, the northeast yielding of the Colorado Plateau appears to be related to the compressional forces in the foldbelt to the south and west. It seems likely that primary horizontal compression deep within the crust beneath the plateau resulted in local secondary stress fields near the surface having strong vertical components. This implies a strong crust which was capable of transmitting horizontal stresses over long distances without intense deformation (Woodward, 1973).

Northeastward compressional tectonism in the Colorado Plateau and Southern Rocky Mountains during the Laramide resulted in enhancement of pre-existing basement structures in western Colorado. The Colorado Plateau acted as a semi-rigid plate, rejecting intense deformation and thrust faulting along its western and southern margins, but forming generally north-oriented monoclines over Precambrian basement faults (Baars and Stevenson, 1981). Major uplifts and basins in western Colorado, including the Uncompahgre Uplift, the White River Uplift, the Piceance Basin, and the Grand Hogback, were formed as a result of the westerly compressive stresses during the Laramide. Major structures resulting from Laramide tectonism in the Rifle area are the Uncompahgre Uplift, the Piceance Basin, and the White River Uplift.

The Uncompahgre Uplift is a northwest-trending asymmetrical feature, cored with Precambrian rocks with flanks composed of Mesozoic rock units (Kelley and Clinton, 1960). The north- western edge plunges toward the Uinta Basin and is characterized by numerous small anticlines and synclines. The southwestern side is modified by numerous high-angle faults, most of which are downthrown to the south or southwest (Kelly and Clinton, 1960). The uplift is a remnant of an older, much larger highland that was a prominent structural feature during the late Paleozoic. The Uncompahgre Uplift is one of the few tectonic features within the stable Colorado Plateau interior which is potentially active. Considerable movement has occurred along bounding faults and monoclines during the Pliocene and Quaternary and may be continuing to the present time (Kirkham and Rogers, 1981).

The Piceance Basin is an asymmetric structural downwarp, elongated northwest-southeast, and lying between the Uncompahgre Uplift to the south and the White River Uplift to the north and east. The surface rocks of Upper Cretaceous shales, mudstones, and sandstones dip gently on the south and west, and more steeply on the north and east (Donnell, 1961a). The portion of the basin near Rifle, Colorado, is characterized by numerous subparallel northwest-trending anticlines and synclines (see Figure D.3.5). Several northwest-trending normal faults with small displacements are also present in the northeastern part of the basin (Donnell, 1961a). The Grand Hogback monocline forms the eastern boundary of the Piceance Basin. A fault zone indicated by a prominent topographic lineament trends roughly east-west about 40 miles northwest of Rifle. Geomorphic investigations of this fault zone have revealed features suggestive of Holocene faulting (McGuire et al., 1982).

The White River Uplift is a roughly circular structural high occupying part of the northwest-trending deformational zone between the ancestral Rocky Mountain Front Range and the Uncompahgre-San Luis highland. The steeply-dipping Grand Hogback monocline forms the western and southern boundary of the uplift. Major uplift of the feature occurred during the Laramide. The White River Uplift appears to lack a pre-Laramide structural expression; however, the border of the uplift may be controlled by older basement faults (Tweto, 1980a). Numerous faults cutting Precambrian to Tertiary bedrock units occur along and north of the Grand Hogback monocline (Tweto et al., 1978). Neogene tectonism in western Colorado resulted in widespread block faulting and elevation of the White River Uplift at least 2000 feet higher than the surrounding areas (Tweto, 1980a).

D.3.2.4 Regional geomorphology

Geomorphic features and Quaternary deposits in the Rifle area reflect the interaction of geologic and climatic variables. The physiography and topography and the Quaternary deposit record attest to the predominance of fluvial and eolian erosion and mass movement processes operating in a semiarid to temperate climate during Quaternary time. Climatic fluctuations are indicated by the abundance of glacial deposits adjacent to high elevation mesas. Since about 10,000 years ago, fluvial erosion processes have been the dominant geomorphic force in the region. Late Cenozoic uplift of the Colorado Plateau has been the major driving force in the evolution of the landscape, triggering landscape rejuvenation, stream channel incision, and removal of massive amounts of sedimentary bedrock. At least 5000 feet of regional downcutting of major rivers into sedimentary rocks of early Tertiary to Late Cretaceous age has occurred since uplift began (Yeend, 1969). Downcutting has produced long, steep slopes, oversteepened cliffs, and narrow canyons. Extremes in elevation, slope exposure, and range of bedrock types allowed varied geologic processes to operate through time and produce very different effects on the landscape.

A number of geologists have investigated the development of drainage patterns, terraces, pediments, and glacial moraines in the site region. The following discussion is excerpted from articles by Hunt (1956), Lohman (1981, 1965), Yeend (1969), and Sinnock (1981a,b; 1978). For a broader understanding of the Cenozoic and Quaternary geomorphic history of Colorado, the reader is also referred to Epis et al. (1980), Meierding and Birkeland (1980), Larson et al. (1975), and Richmond (1965).

Until perhaps Pliocene time, the Grand Junction and Rifle areas and adjacent parts of the Colorado Plateau were undergoing erosion by the ancestral Colorado River. The course of the Colorado River may have been established by the end of the Miocene. Differential uplift of the Uncompahgre Plateau was renewed during the Pliocene, causing major changes in the drainage patterns of the Colorado and Gunnison Rivers.

Some disagreement exists between various investigators on the question of whether tectonic activity essentially stopped before, or shortly after, the end of the Pliocene, or has continued up to the present time. The evolution of the modern drainage systems is also controversial. For example, Lohman (1981, 1965) presented evidence that the ancestral Colorado and Gunnison Rivers once flowed through Unaweep Canyon and that the present pattern evolved from successive stages of stream piracy by tributary streams cutting Mancos Shale north and west of the Uncompahgre Uplift (see Figure D.3.2). The more rapid rate of stream downcutting in the Mancos shale than in the Precambrian granitic terrain of the Uncompahgre Uplift was the determining factor. Sinnock (1981b), on the other hand, believes that Unaweep Canyon was formerly occupied by the Gunnison alone, and that the Colorado River has been in essentially the same position relative to the Uncompahgre Uplift since the Miocene. He attributes the diversion of the Gunnison away from Unaweep Canyon to successive stages of uplift of the Uncompahgre Plateau.

The development of the present landforms of the river valleys was strongly influenced by Pleistocene glaciations. Sinnock (1978, 1981a) identified four sets of glacial moraines of Bull Lake (?) and Pinedale (?) age in the Ridgway area. He correlated these with glacial episodes in the San Juan Mountains to the south. Evidence for successive periods of Pleistocene glaciation were also recognized on Grand Mesa and Battlement Mesa by Yeend (1969) and Cole and Sexton (1981). The glacial stages have been tentatively correlated with alluvial terraces along the Uncompahgre, Gunnison, and Colorado Rivers. Episodes of significant erosion and incision of the rivers occurred during major readvances of the ice. A general equilibrium exists during interglacial periods. Hence, it appears that the level of the Colorado River and tributaries near Rifle may have been fairly constant since the end of the Pleistocene.

Landslides, slumps, and mudflows have greatly influenced the topography in the area flanking Battlement Mesa, Grand Mesa, and the Grand Hogback. The presence of rapidly eroding sedimentary units beneath the durable Grand Mesa basalts has been responsible for widespread mass wasting, particularly slumping. Extensive slumping of large blocks of basalt has greatly reduced the aerial extent of Grand Mesa and Battlement Mesa throughout the Quaternary. Breakup of the basalt flows facilitated rapid removal of the high, originally more extensive surface of Grand Mesa by glacial and colluvial processes. Solifluction, slumping, frost breakup of basalt, landslides, and mudslides moved debris from the high parts of the mesa onto the surrounding slopes and stream valleys (Yeend, 1969). Stream downcutting has been the dominant process since the disappearance of the last glacier at the close of Pinedale (?) time. Large, localized debris flows along the Grand Hogback monocline attest to the formerly unstable slope deposits.

Landforms indicative of glacial processes are abundant at higher elevations throughout the region. Glacial, alluvial, and colluvial deposits associated with two major glaciations occur in high elevation areas of the White River Plateau and on Battlement and Grand Mesas south of the Colorado River (Cole and Sexton, 1981; Tweto et al., 1978). Glacial deposits are represented by till, moraines, outwash gravels, and alluvial terrace and fan gravels on the flanks of mesas. At Grand Mesa, ice reached levels as low as 5800 feet and outwash deposits reach to the level of the Colorado River (Yeend, 1969).

Extensive slope failure deposits of Pleistocene and Holocene age occur on the flanks of Grand and Battlement Mesas and in the areas west of DeBeque and north of Rifle. These deposits are the result of slumping, rock and debris falls and flows, rockslides, and solifluction movements. These movements occurred throughout the Pleistocene. Some of these processes are continuing today. A dominant factor in the formation of the landslides around Grand and Battlement Mesas is the presence of rapidly eroding claystones stratigraphically underlying durable basalt flows. The intensive jointing in the basalt, relatively abundant water, and common freezing temperatures are other important factors. Elsewhere, the presence of rapidly eroding early Tertiary sandstones, siltstones, and shales are major factors. Debris flow deposits of probable late Pleistocene age along the steep flanks of the Grand Hogback consist of clasts of these lithologies.

Talus deposits and rock glaciers are also present on steep slopes in the area. Numerous gravel-veneered pediment surfaces occur on the flanks of Grand and Battlement Mesas (Cole and Sexton, 1981). Multiple episodes of localized slope failures and debris flows are indicated by stabilized, eroded deposits along the Grand Hogback monocline.

Since the disappearance of the last glaciers, stream downcutting has been the dominant geomorphic process. Arroyos are common features of the more arid slopes. Quaternary age gravel and sand deposits are present along the Colorado River and major tributary streams. Most talus slopes appear to be stable, but small, active slumps, earthflows, and landslides are present adjacent to Grand Mesa (Yeend, 1969). Permanent streams are currently cutting into their floodplains. Active eolian processes are depositing fine-grained sand and silt over most bedrock terraces and pediment surfaces. Stream aggradation is not a common process along perennial, through-going streams. Climatic change would probably result in continued downcutting, perhaps at more accelerated rates than at present.

D.3.2.5 Rates of denudation

In reference to the possible influence of the long-term erosion processes upon reclamation design, a discussion of the rates of denudation and stream downcutting is provided below. The rates of denudation are the rates at which a land surface is being lowered as a result of erosional processes. These rates vary with climate and the amount of precipitation. As pointed out by Schumm (1963), it is obvious that no surface is lowered in a uniform manner; however, rates of denudation and downcutting have been estimated, generally for a period of 1000 years.

Evidence of the long-term predominance of erosional processes on the Colorado Plateau since the late Tertiary time is provided by canyon topography and the great amounts of Tertiary and Cretaceous strata (3500 to 13,000 feet) that have been removed from much of the plateau surface. The relatively low strength of Tertiary and Cretaceous bedrock facilitates the late Tertiary and Quaternary erosion (Schumm and Chorley, 1966). Features of the landscape of the upper Colorado River Basin that suggest continuing erosion at moderate rates include high relief, deep, narrow, vertical-walled canyons, badlands and dissected pediments (Sinnock, 1981a), and continuing scarp retreat along major cliffs (Sinnock, 1981b). Since late Miocene time, erosion rates have been controlled by the Colorado River, which acts as the regional base level for streams. Potassium-argon dates of basalt flows indicate that the Colorado River drainage above Grand Junction was established about 10 million years ago (Larson et al., 1975), whereas drainage integration through the Grand

Canyon occurred by about five million years ago (Damon et al., 1978; McKee and McKee, 1972).

Relatively rapid erosion has resulted from the combination of mechanically weak bedrock (Schumm and Chorley, 1966) and rapid tectonic uplift (Larson et al., 1975; Luchitta, 1972; Hunt, 1969). Broad spatial and temporal variations in erosion rates are due to differences in local rock type, changes in uplift rate, and climatic fluctuations.

Potential amounts of erosion at the Estes Gulch site during the next 1000 years were estimated from several types of data. Average stream channel incision and scarp retreat rates, calculated for periods on the order of millions of years, reflect the progressive development of major geomorphic features such as valleys and canyons. Modern denudation rates have been calculated from sediment yield and reservoir sedimentation rates for large sections of the Colorado Plateau and for small test watersheds on the Mancos Shale. Future erosion rates at and near the site were estimated from local geomorphic features. These types of data represent greatly differing scales of space and time and, therefore, are not directly comparable. Moreover, each data type involves simplifications and measurement problems, so that the resulting erosion rates are approximations. However, these data collectively indicate that future erosion at the Estes Gulch site will be relatively low.

<u>Regional erosion rates</u>

Average incision rates (Table D.3.2) were calculated for most sites in the northeastern Colorado Plateau where radiometrically dated units are closely associated with stream channels (Figure D.3.7). However, a few sites have minimum ages based on reversed paleomagnetic polarity (Johnson, 1982) or estimated age ranges based on geomorphic relationships. The maximum long-term incision rates are about one foot per 1000 years, but most of the rates fall between 0.3 and 0.7 foot per 1000 years. Some regional variation is apparent when rates for the same time interval are compared. The rates also are subject to change with time in a single area, as illustrated by the Roaring Fork River, where the average incision rate varied as follows: 0.98 foot per 1000 years (10 to 8 million years before present) (m.y.b.p.); <0.1 foot per 1000 years (1.5 to 0.62 m.y.b.p.); and 0.52 foot per 1000 years (0.62 m.y.b.p. to present). Changing rates over the past 400 years have also been observed in the Piceance Basin. The average erosion rate in this area appears to be slowly increasing. The erosion rate of 5.8 feet per 1000 years determined for the Piceance Basin using data for the past 100 years (Carrara and Carroll, 1979) is anomalously high due to accelerated erosion caused by cattle grazing since the 1880s. The average erosion rate for the preceding 300 years is 1.1 feet per 1000 years.

Channel incision rates also vary on shorter time scales, as indicated by pediments and terraces which occur at several levels above the

Colorado, Gunnison, Uncompahgre, and Dolores Rivers (Cole and Sexton, 1981; Yeend, 1969; Sinnock, 1981a, 1978; Yeend, 1969; Shawe et al., 1968; Lohman, 1965). These surfaces probably formed during glacial intervals when larger sediment loads temporarily prevented channel incision. No incision rates were calculated from the heights of these surfaces, because their ages are not well known. However, the presence of these surfaces indicates that incision rates have been more variable than the long-term averages indicate, and perhaps were several times higher during times of postglacial drainage adjustment.

Long-term average rates of scarp retreat are less well known than channel incision rates, due to greater difficulties in dating, the episodic nature of the retreat (Schumm and Chorley, 1966), and local variations in rate for salients, reentrants, and tributary mouths (Haman, 1983). Most of the calculated rates (Table D.3.3) are on the order of a few feet in 1000 years. An exceptionally rapid rate for the Book Cliffs at the northwestern end of the Uncompahgre Plateau, 74 feet per 1000 year (Hunt, 1969), may be erroneously high. Possibly valley widening at this location began earlier than assumed, along the tributary stream that later captured the Colorado River (Lohman, 1965).

Historic denudation rates for large parts of the Colorado Plateau (Table D.3.4) are based on sediment yield and reservoir sedimentation measurements. Rates which include all components of sediment load (suspended, dissolved, and bed) mostly range from 0.3 to 0.8 foot per 1000 year. These rates are similar to long-term average channel incision rates; however, the similarity must be partly fortuitous because the different time scales should reflect the controls of climate and tectonics in very different ways.

Erosion rates in the Estes Gulch area

Within the Grand Junction-Rifle region, rates of downcutting and scarp erosion are similar to average rates for the Colorado Plateau. Measurements of hillslope erosion on the Mancos Shale near Grand Junction show that the upper portion of the slopes were lowered about 0.25 inch during four years (Schumm and Chorley, 1966). Long-term hillslope erosion rates over the past 400 years in the Piceance Basin range from 5.8 to 8.7 feet per 1000 years. Rates over the past 100 years, however, are anomalously high due to the effects of cattle grazing. Rates over the previous 300 years average 1.1 feet per 1000 year on bedrock surfaces of sandstone, siltstone, and claystone. Near Grand Mesa, the average rate of downcutting by the Colorado River is 0.5 feet per 1000 years (Yeend, 1969). Tributaries to the river show current aggradation along small ephemeral streams, but are experiencing degradation along major perennial streams. Consequently, downcutting is occurring even at low elevations. Schumm and Chorley (1983) suggest that the Colorado River at Rifle is not incising as a result of uplift and conclude that Pleistocene uplift responsible for the Uncompahgre Plateau has ceased.

They also conclude that degradation of the Colorado River is controlled locally by resistant metamorphic and igneous bedrock and that degradation should not exceed about one foot during a 1000-year period if renewed uplift occurs. Periods of climatic change, whether to warmer and drier conditions or cooler and wetter conditions, would probably result in increased initial rates of downcutting in the Rifle area (Yeend, 1969). A long period of cool, wet conditions would ultimately result in increased sediment yield at higher elevations and stream aggradation at lower elevations.

Valley and hillslope erosion rates have not been specifically measured in the Estes Gulch area. Nevertheless, erosion rates calculated for similar lithologies and climates in the Piceance Basin area can be generally applied to the Estes Gulch area. Surface erosion rate studies in the Piceance Creek area, about 25 miles northwest of Estes Gulch, determined the rates over the past 400 years for south-facing slopes in a pinyon-juniper ecosystem on sandstone, siltstone, and claystone lithologies (Carrara and Carroll, 1979). These site conditions are roughly analogous to those of the Estes Gulch area. As previously stated, erosion rates ranged from 0.7 to 5.8 feet per 1000 years. Data for the 300 years prior to the introduction of cattle into the area give an average rate of erosion of 1.1 feet per 1000 years.

The formation of gullies and subsequent surface erosion in the Piceance Basin area has been shown to depend, in part, on the relationship between valley slope and drainage basin area (Patton and Schumm, 1975). In addition to this relationship, north-facing drainage basins are more stable at higher slopes than south-facing basins. The increased vegetation on north-facing slopes results in an increased stability for a given slope angle. The significance of the valley slope and drainage basin relationship is overshadowed by the slope aspect factor for basins with areas less than four square miles. Basins in the Estes Gulch area are generally less than 0.5 square mile; thus, slope-area relations are difficult to apply as predictors of gully formation. The relationships presented by Patton and Schumm (1975), however, suggest that these valley basins can be expected to develop gullies, as indeed most of them have. Increases in valley slopes as the result of alluvial fan development would be expected to result in the initiation of more rapid development of gully systems.

D.3.3 CLIMATE AND VEGETATION

Details of the site meteorology are presented in other sections of this appendix. Rainfall in the site region averages about 11 inches per year and average temperatures range from 23° to 71°F (Yeend, 1969). Snowfall averages 37 inches per year. Although there is no well-defined wet season, summer rainfalls occur as intense, scattered thunderstorms. The climate of the upper Colorado River Basin is semiarid, except in the higher elevations where precipitation is moderately heavy.

The vegetation types are controlled by local topography. A spruce-fir vegetation zone extends from high elevations down to about 8700 feet, with aspen stands extending to 8100 feet and to lower elevations in stream valleys. An oak-juniper zone ranges from 8500 feet to 5000 feet. Sagebrush, desert grasses, and cottonwoods occur within the oak-juniper zone to elevations of about 5000 feet. The effects of slope aspect cause lower elevation vegetation zones to extend higher on south-facing slopes than on north-facing slopes (Yeend, 1969). Ponderosa pine is absent in the area and only scattered pinon pines occur. At the Estes Gulch site (elevation 6100 feet), vegetation along the basin of Government Creek consists of sagebrush, juniper, pinon pine, greasewood, and a sparse cover of native grasses and forbs.

Very little direct information exists regarding the frequency, duration, and intensities of winds in the Estes Gulch site area. At the Garfield County Airport, south of Rifle, winds are strongest and most frequent from the north, southwest, and south (FBDU, 1981). Along the Colorado River Valley, winds are channeled in an east-west direction up and down the valley.

Postglacial climate

Climatic changes during the next 1000 years in the Rifle, Colorado, area will probably be smaller in magnitude than the major climatic shift that followed the last full glacial period. Little quantitative information on paleoclimate is available for northwestern Colorado; however, the last glaciation may have brought average temperatures 9° to 12°F cooler than present. Mean annual precipitation may have been about the same as now, or perhaps slightly greater. Runoff probably increased to several times the present values. In contrast, the broader shifts in post-glacial temperature were probably on the order of +4°F (Knox, 1983) and fluctuations in mean precipitation were probably less.

Because few paleoclimatic data are available for the Estes Gulch area, the following summary of late-glacial and post-glacial climates is based on recent reviews of data for surrounding areas in the northern Great Basin, Colorado Plateau, Rocky Mountains, San Juan Mountains, La Sal Mountains, and the Henry Mountains (Dohrenwend, 1984; Baker, 1983; Barry, 1983; Smith and Street-Perrott, 1983; Spaulding et al., 1983; Curry and James, 1982; O'Connell and Madsen, 1982; Mehringer, 1977; Richmond, 1965, 1962; Atwood and Mather, 1932). Glacial deposits and periglacial features in La Sal Mountains indicate the presence of mountain glaciers during the middle and late Pleistocene (Shroder et al., 1980; Richmond, 1962). Rock glaciers and block fields in the Abajo Mountains indicate the presence of periglacial conditions during the Pleistocene (Witkind, 1964). These deposits and features in the western Colorado and eastern Utah region provide evidence that the Estes Gulch area experienced similar climatic fluctuations to those documented in the western United States during the Pleistocene.

Although major paleoenvironmental changes on the time scale of millenia are relatively well known, the magnitudes of associated climatic changes are less certain (Curry and James, 1982). Several studies have shown that large regions of the western United States do not behave the same way during climatic fluctuations at different time scales: the last century or so represented by instrumental records (Kay, 1982; Bradley, 1976), the last several centuries represented by tree ring indices (Fritts, 1971), and the last 2500 years represented by various geologic and biologic data (Mehringer, 1977). Therefore, this summary of data provides only a general indication of major climatic trends in northwestern Colorado. The magnitude and timing of climatic changes throughout this region must have varied, depending on site elevation, local topography, storm tracks, airmass boundaries, and local rain shadow effects.

<u>The Late Pleistocene Climate</u>

In the western United States, the last full glacial occurred roughly 18,000 to 14,000 years ago (Madsen, 1982). In the Rocky Mountains, the time of deglaciation varied with altitude (Porter et al., 1983). Low mountain ranges with ice caps or transection glaciers were deglaciated by 15,000 to 14,000 years ago. Glaciers in mountain valleys disappeared progressively between about 14,000 and 12,000 to 11,500 years ago. In high alpine sites, small glaciers persisted longer, but were gone by 9000 years ago. Considering the low elevation of Grand Mesa, it appears that deglaciation probably occurred around 15,000 years ago, as it did in the San Juan Mountains (Carrara et al., 1984).

Paleoclimatic reconstructions for the last full glacial period differ in their interpretations of temperature and precipitation with respect to the present. Many workers propose a climate characterized by increased precipitation, cooler summer temperatures, and milder winters in the desert areas (Spaulding et al., 1983). Other workers suggest that precipitation amounts were similar to today's, but that summers and winters were much colder (Brakenridge, 1978).

Recent studies suggest that precipitation did increase; however, the percentage was less than initially thought. For example, paleoclimatic reconstructions that call for more than a 25 percent increase in full glacial mean annual precipitation are difficult to reconcile with fossil plant species from packrat middens in the Great Basin (Spaulding et al., 1983). Furthermore, the rain shadow effect of the Pacific Coastal Mountains may have increased during glaciations (Porter et al., 1983; Dohrenwend, 1984).

The following studies suggest that the full glacial, mean annual temperature in the Estes Gulch site area may have been about 9° to 12°F lower than the present. Mean annual precipitation may have been the same as now or perhaps slightly higher. The net effect of the combined temperature and precipitation conditions was a significant increase in runoff to perhaps several times present values.

In the Rocky Mountains, the average full glacial snowline depression, about 1000 meters (3300 feet), suggests that the mean annual temperature was about 11°F cooler than present. However, when the modern relationship between mountain precipitation and elevation is considered, the inferred change increases to 18° to 27°F (Porter et al., 1983). For the maximum estimated snowline depression of about 1200 meters (3900 feet) in the Yellowstone area, the temperature decrease is 31°F (Pierce, 1983).

In the Wasatch Range, mass-balance calculations suggest a range of climatic conditions for the Little Cottonwood Glacier (McCoy, 1981). If precipitation were the same as present, a temperature decrease of 29°F would be required. However, precipitation may have been higher than present because of evaporation from Lake Bonneville. If a 50 percent increase is assumed, the required temperature decrease is only 22°F.

Alpine permafrost features, presumably formed during the last glaciation, suggest relatively large temperature decreases in the Rocky Mountains. At numerous locations in Colorado, Wyoming, and Utah, the lower limit of these features is about 1000 meters (3300 feet) below the modern limit, consistent with snowline depression (Pewe, 1983). A temperature decrease of at least 18° to 20°F, and possibly as great as 27°F, has been proposed for ice wedge casts in southern Wyoming (Mears, 1981).

Pollen data that span the glacial-interglacial transition are available only for more southerly sites, where the temperature depression was perhaps less than half that proposed for the Rocky Mountains (Barry, 1983). In the Chuska Mountains, the full glacial treeline was about 900 meters (2950 feet) lower than present (Wright et al., 1973), suggesting that summer temperatures decreased 9° to 13°F. Due to an increase in climatic gradients with elevation, the Ponderosa/Juniper boundary was lowered less than 500 meters (1650 feet; Wright et al., 1973). With the temperature/elevation relationship used by Barry (1983), this suggests maximum summer cooling of 5° to 7°F in the valleys. In the San Juan Mountains, Maher (1961) inferred a full glacial treeline depression of about 650 meters (2100 feet) and cooling of about 9°F.

In the Great Basin, most estimates of temperature and precipitation change are based on the hydrologic budgets of pluvial lakes (Smith and Street-Perrott, 1983; Mehringer, 1977); although changes in glacier equilibrium line elevations have recently been considered. Lake Bonneville could have existed under conditions ranging from a temperature decrease of 13°F and a precipitation increase of 90 percent, to a temperature decrease of 29°F and a precipitation increase of 50 percent (McCoy, 1981). However, a temperature increase of 22° to 25°F and a precipitation increase of 25 percent was considered most likely. Lake Lahontan could have existed with a temperature decrease of 18°F, a 10 percent increase in cloudiness, and no change in precipitation (Benson, 1981). Runoff probably increased by about three to five times present values (Smith and Street-Perrott, 1983). For the few glaciers in the Great Basin, the difference between full glacial and modern equilibrium line elevations suggests a decrease in mean annual temperature of 13°F (Dohrenwend, 1984).

At Grand Mesa, about 20 miles southwest of the Estes Gulch site, full glacial depressions of snowline and permafrost zones appear similar to those in other areas of the Rocky Mountains. The lower limit of Pinedale Till is difficult to determine because clearly defined end moraines are not present (Yeend, 1969); however, this limit has been estimated at about 2000 meters (6600 feet) on the north side of the mesa and about 2300 meters (7500 feet) on the south side (Cole and Sexton, 1981; Hail, 1972a,b). Most of the till mapped by Yeend (1969) is probably periglacial mudflow deposits (Sinnock, 1978); however, their source elevation is uncertain. Talus cones which Yeend (1969) considered periglacial descend as low as 2500 meters (8200 feet). In contrast, the modern glaciation limit is about 3300 meters

(10,800 feet), the elevation of the highest part of Grand Mesa; the periglacial limit may also be above this elevation. During the last full glacial period, the periglacial environment did not extend to the floors of the Colorado and Gunnison river valleys (Pewe, 1983).

The full glacial climate near the floors of these valleys, and at the Estes Gulch site, was probably transitional between that of the Rocky Mountains and those of lower areas represented by the Colorado Plateau and the Great Basin. Climatic zones may have been compressed vertically, as indicated by vegetation studies in the southwest (Spaulding et al., 1983); and relatively warm air may have flowed up Grand Valley. Average annual temperatures may have been 9° to 18°F lower than present. Although average annual precipitation may have increased locally during the last glaciation, it was probably not much higher than present amounts in the Rifle area.

The Holocene Climate

Broad changes in post-glacial climate have been documented for the western United States. Following a period of transitional climate, changes in average temperature for periods on the order of hundreds to thousands of years were probably about +4°F (Knox, 1983). However, few of the paleoenvironmental data available have been used to derive quantitative estimates of climate change.

The time following the last glaciation has been divided into three climatic intervals:

- A transitional period from 14,000 or 12,000 to 8000 or 7000 years.
- A slightly warmer period ending around 4000 years.
- A slightly cooler period continuing to the present.

Evidence for the mid-Holocene warm period is abundant in surrounding areas, but is poor in Colorado, perhaps because the sites studied are insensitive to small climatic changes (Baker, 1983).

Short periods during the Holocene of greater effective moisture are documented in parts of the southwestern United States. These studies associate more pluvial conditions with intense, warm-season precipitation, triggering major periods of landscape instability, erosion, and sedimentation (Gile et al., 1981). Observation in the Paradox Basin (Woodward-Clyde Consultants, 1982) indicate that the valley fill was removed and redeposited during multiple cut-and-fill episodes. Episodic fluctuations in Holocene surficial geologic processes in the Colorado Plateau area are indicated by periodic eolian deposition during neoglacial interstadices of the last 6000 years (Curry, 1976) and by incipient soil development on buried fine-grained fluvial deposits.

No data on Holocene climates are available for the Estes Gulch site area, but inferences may be drawn from pollen studies in surrounding areas (Baker, 1983). The closest and possibly most similar site, Alkali Basin (Markgraf and Scott, 1981), is located northwest of Gunnison, Colorado on the opposite site of the West Elk Mountains. At an elevation of 2800 meters (9000 feet), this site was not glaciated. The period from about 10,000 to 4000 years is interpreted to be about 1.5°F cooler and 50 percent moister than the period from about 4000 years to the present. No mid-Holocene warm period is evident, although such a period does occur at the nearest low elevation, unglaciated site on the opposite side of the site area; this site is at Swan Lake, Idaho (Bright, 1986).

The other pollen sites surrounding the site area are mostly in high alpine locations (elevations 2470 to 3905 meters or 8100 to 12,500 feet) and all were glaciated. Sites in the San Juan Mountains include Molas Lake (Maher, 1961), Hurricane Basin (Andrews et al., 1975), and Lake Emma (Carrara et al., 1984); in the La Plata Mountains, Twin Lakes (Peterson and Mehringer, 1976); in the Front Range, Redrock Lake (Maher, 1972); and in the Wasatch Mountains, Snowbird Bog (Madsen and Curry, 1979). In general, these sites display the trend of early Holocene warming, mid-Holocene warmth, and slight late Holocene cooling. However, the timing of the changes and the number and direction of briefer climatic fluctuations varies. The highest post-glacial temperatures probably exceeded present temperatures by about 2°F at Molas Lake (Maher, 1961), at least 0.7°F at Lake Emma (Carrras et al., 1984), and 1.3°F at Hurricane Basin (Andrews et al., 1975). Temperature changes probably differed slightly at lower elevations.

During the last few centuries, tree-ring studies (Fritts, 1971) have shown significant variability in climate during periods ranging from a few years to a few decades and longer. Historic records (Bradley, 1976), although shorter, corroborate these short-term fluctuations. Relative changes in effective moisture for the Colorado Plateau have been interpreted for the last several centuries from tree-ring data (Stockton and Jacoby, 1976). This study included data from several sites in western Colorado. A synthetic hydrograph, developed for the discharge of the San Juan River near Bluff, Utah, integrates local variations in moisture over a large area. An important aspect of this hydrograph is its short-term variability, which may illustrate the potential variability in the Rifle-Estes Gulch area. The strongest periodicities in the hydrograph were roughly 50 and five years, but weaker periodicities of three and two years also occurred.

Historical climatic records for several stations in the San Juan Mountains have been analyzed in detail (Bradley and Barry, 1976). The resulting trends indicate the general magnitude of short-term variations that could be expected in the Estes Gulch area. For the most carefully studied station (Durango from 1900 to 1970), the nine-year weighted-mean temperature varied relatively little, by about 3.3°F. In contrast, the nine-year weighted-mean precipitation varied by a factor of about 1.7, from 32 to 58 centimeters (13.5 to 23 inches), and the annual mean precipitation varied by a factor of more than two. Variations also occurred in the seasonal distribution of temperature and precipitation and in the frequency of rainfall events in particular size classes.

General trends in temperature indicated regional cooling from the late 1860s until about 1930, followed by regional warming. General trends in precipitation were roughly inverse to those in temperature, but were much less consistent. Poor early records suggest that precipitation may have been very low in the 1860s, and thereafter increased to the 1890s. A major low around 1900 was followed by a rapid increase to a major peak about 1908. The following period was characterized by frequent fluctuations, with a major low in 1929 to 1932 and a major peak around 1936 to 1938.

For the next few hundred to 1000 years, average temperature and precipitation will probably fluctuate within the same ranges as during the recent past. However, extreme events exceeding the range of historic variability have probably occurred and may recur within the lifetime of a tailings repository. The stability of slopes and the behavior of streams near a repository can be affected either by extreme events, or by brief shifts in average conditions, especially if the landscape is sensitive to change.

D.3.4 SITE GEOLOGY

The Estes Gulch site is located in Section 14, Township 5 South, Range 93 North, about 0.5 mile west of the Estes Gulch tributary to Government Creek (Figure D.3.8). The site lies within the head of a drainage basin extending northward from Government Road to the slope of the Grand Hogback monocline. The principal landform of the area are the high terraces on either side of Government Creek that slope gently toward this drainage. The site lies on this terrace at the foot of the Grand Hogback. A fan-shaped debris slide forms the oldest pediment surface on the terrace. A horseshoe-shaped flat bottomed basin eroded below this old pediment surface is the setting for the disposal site (see Figure D.3.9, map symbol "ps"). Tributaries of Government Creek have dissected the high terrace (up to 175 feet deep) on either side of the site basin. Estes Gulch lies about 1000 feet to the east and an unnamed canyon lies a similar distance to the west. This west side canyon head is in a deep box-end canyon that almost completely dissects the head of the fan above the old pediment.

Bedrock in the Estes Gulch area consists of variegated claystone, siltstone, and fine-grained sandstone of the Wasatch Formation. The strike of the Wasatch Formation is to the northwest. The fine-grained sedimentary units of the upper Wasatch Formation although dipping very steeply, form the gentle terrace slopes that terminate in a bluff overlooking Government Creek Valley. Cretaceous units of the underlying Williams Fork Formation (Mesaverde Group) sandstones, shales, and coal crop out along the monocline to the north of the site. The more resistant coarser grained sandstone units of the Williams Fork Formation form the prominent spine of the Grand Hogback. The Tertiary Green River Formation oil shales, sandstones, and marlstones crop out along the eastern Book Cliffs about four miles west of the site. The conglomeratic Ohio Creek Formation at the base of the Wasatch Formation and the very thick sandstone, coal, and shale beds of the Williams Fork Formation are the most probable potential uppermost aquifers that underlie the site. The kaolinitic sandstone of the Ohio Creek, which varies in thickness from 50 to 100 feet in the area of the site, appears to be impermeable in outcroppings observed on or near the Estes Gulch disposal site. However, USGS information from a location 60 miles away indicates that the Ohio Creek consists of massive conglomeratic sandstone containing mostly pebbles and chert.

Surficial geologic units within the Estes Gulch area are mainly the result of processes of pediment formation, slope movement, erosion, and alluviation during the Pleistocene and Holocene. Surficial geology of the area is shown on Figure D.3.9. Erosional planation of bedrock surfaces during the Pleistocene produced the pediments capped with pediment alluvium and older deposits. Coarse, matrix-supported landslide and debris flow deposits occur adjacent to steep slopes of the Grand Hogback monocline. Eolian silt and sand deposits commonly overlie pediment surfaces and older alluvial fans. Floodplain alluvium and terrace gravels occur along Government Creek, Rifle Creek, and other tributary streams.

Bedrock at the Estes Gulch site for the proposed stabilized tailings pile consists of claystones, siltstones, and sandstones of the Wasatch Formation. The strata along the bluff facing Government Creek dips from 10 to 20 degrees to the southwest while the portion of the terrace that directly underlies the disposal site dips from 65 to 75 degrees southwesterly. A fault zone, revealed by slant drilled coreholes, has been located at the transition zone of the change in steepness of the dip, 500 to 800 feet downslope of the proposed toe of the disposal site. The evidence suggests that the fault is a rupture along a tight fold of the Grand Hogback monocline and trends along the strike of the upturned limb. The lack of surface evidence for the fault is attributed to the Laramide age of the structure; also the erodability of the soft rocks in which the fault occurs differs little from the durability the disturbed rock in the fault zone. The site is structurally located within the limb of the Grand Hogback monocline. Bedrock is exposed only in deep stream channels cut into the pediment alluvium ridges at the north end of the site; in deeply incised gullies along the south side of the site and in the tributaries of Government Creek. These exposures consist of highly fractured and weathered layers of claystone and sandstone.

Surficial deposits in the site area consist of alluvial fan deposits of several ages, ridges of coarse pediment alluvium, eolian silts and sands, and minor recent debris flows (Figure D.3.10). The ridges within the site area are capped by pediment alluvium consisting of clay, sand, silt, and subrounded to angular cobbles. A cap of slide debris, consisting of angular cobbles and large boulders of sandstone rests on the ridge tops of the pediment alluvium deposits on the west and east sides of the site. This bouldery debris forms a moderately erosion resistant layer 10 to 15 feet thick over the mixed clays, silts, sands, and gravel of the pediment alluvium. The origin of the slide has been cut off from the site area by headward advance of a deep canyon west of the site. This diversion also eliminates the potential for upland flooding to affect the site.

The central flat surface of the Estes Gulch site consists of an younger alluvial surface deposited within an erosional valley between the ridges of pediment alluvium. These fine-grained fan deposits consist primarily of fine-grained eolian silt and sand. Test borings and trenches on the site reveal a varying thickness of clayey eolian deposits mixed with sandy to gravelly fan deposits and alluvium. Thickness of the clayey eolian deposits ranges from about five feet at the northern end of the site to about 35 feet near the south end of the site. Sandy alluvium layers about five feet thick occur near the base of the eolian deposits. Sandstone and siltstone bedrock at the far north end of the site is overlain by a thin layer of sandy alluvium and possibly some minor landslide deposits. Thickness of the eolian and alluvial deposits is greatest within the narrow wash passing through the center of the site. Geologic cross sections through the site, based on borehole logs, are shown on Figures D.3.11 and D.3.12.

Evidence of a possible paleochannel in the lower alluvium is suggested by a deposits of sandstone cobbles and boulders exposed by a parallel gully on the slope below the tailings site. These deposits were not encountered in the considerable numbers of exploration holes within the disposal site, however.

The sand and gravel layers near the base of the silty eolian deposits appear to represent coarse alluvial and colluvial sediments overlying the bedrock of the Wasatch Formation.

The results of core drilling and infiltration packer tests in 1988 within the disposal site and the slant hole core drilling downslope from the site, indicate that the upper 10 to 20 feet of the bedrock is slightly more fractured than the deeper, less weathered bedrock. Fractures appear randomly but are more closely spaced near secondary faults. Many zones in the slant holes encountered no fractures at all. Slant hole No. 722 showed no fractures from 140 to 205 feet near the alignment of the toe ditch. Secondary faults are believed to be dip-slip faults with only minor displacement and show typically one-eighth-inch red clay gauge fillings. Unfilled (or coated fractures) may occur near these faults. Slickensided fractures with curved surfaces occurred only in high plasticity claystone and do not necessarily indicate fault movement. One dip-slip fault with breccia development and clay gauge was observed in slant hole No. 722 at 188.5 to 120 feet. In addition to packer tests, constant-head permeability tests were conducted on existing wells. One well (No. 965) that lies very near the fault zone showed very tight formations similar to other well locations tested. Details on these tests and borehole logs are shown in Section D.7.5.2, Groundwater Flow and Hydraulic Characteristics, and Addendum D2, Borehole Information.

The thickness of individual sedimentary facies ranged from less than one foot to 25 feet, with an average thickness of about 5.5 feet. The majority of units consisted of silty fine sandstone and about 35 percent consisted of claystone. Sandstone types ranged through every gradation from clayey, very fine sandstone to medium grained. Bedding planes that clearly show the dip of the strata are rare. Cementation consisting of calcium carbonate is weak. The bedrock is considered rippable.

The projected fault zone was encountered in slant core hole No. 721 between the slant depth of 132 to 148.5 feet (actual depth 92 to 104 feet) 800 feet downslope from the east end of the toe ditch. The 16.5-foot-wide zone consisted of brecciated fragments and clay gauge. Thin secondary faults occurred within an approximately by 40-foot wide zone on either side of the fault. Units upslope of the fault dip consistently at 65 degrees and those immediately downslope of the fault, as indicated by the core, are about 45 degree dips.

Two alluvial fans of younger ages occur at the north end of the site. A partially dissected fan consisting of coarse sand, gravel, and cobbles extends southward from the mouth of the stream channel incised into the bedrock ridge at the north end of the site. This is overlain by a thin, actively forming alluvial fan consisting of coarse silt and sand and angular to subrounded gravel, cobbles, and boulders of sandstone and siltstone.

Landslide and debris flow deposits occur within the southwest and northeast quarters of Section 14, but do not affect the proposed tailings site area. The massive debris flow north of the tailings site consists of angular cobbles and boulders of sandstone, siltstone, and claystone in fine-grained, clayey silt matrix with a matrix-supported fabric. The exact age of the debris flow deposit is not known, but erosional and soil development features indicate an age no younger than late Pleistocene. The landslide deposits southwest of the site (see Figure D.3.9) consist of a highly eroded and gullied area adjacent to Highway 13 (Government Road). Weathering and erosion of the tilted claystones have resulted in renewed, but minor, slumping of small areas of the older landslide mass which will subsequently be covered by the proposed cell area. A very small, thin debris flow occurs along the locally unprotected and oversteepend southeast facing slope of the pediment alluvium ridge at the west side of the Estes Gulch site. Material in this flow originated in a small, deeply incised gully in the side of the ridge. Fine-grained silt, sand, and gravel have been carried out onto the flat surface of the older alluvial fan and spread out in a broad, thin lobe about 150 feet north of the head of a tributary gully (see Figures D.3.9 and D.3.10). The deposit appears to be a very localized occurrence with continued, small movement of parts of the flow mass during rainstorms. This debris flow has not had a significant impact on the proposed tailings pile site.

The older alluvial fan surface ("oaf" on Figure D.3.10) at the site is an area of active gullying processes. A network of gullies incises a three- to five-foot thickness of eolian silty clay, an underlying buried soil, and sandy to gravelly alluvial and colluvial deposits (SHB, 1985). The gullies through the center of the site have nearly vertical walls and reach depths of up to 15 feet. The eolian deposits are highly erosive and piping along the margins of the gullies is common. The piping is the result of runoff infiltrating desiccation cracks grounded in the clayey soil. Desiccation appears to result from the deep incision of the gullies. The depth and intensity of gullying is greatest at the south end of the site. Actively eroding gullies up to 20 feet wide and 15 feet deep occur in this area, generally between contour levels 6015 and 6060 (see Figure D.3.10). Active gully expansion is occurring both downward and laterally. Well developed piping is present throughout the gully system. Piping holes and cracks occur up to 15 feet from gully embankments and appear to be the main initial form of tributary gully development.

Nickpoints developed on sandstone boulder layers in the main eastside gully occur about 600 feet south of the southern edge of the proposed embankment of the stabilized tailings pile. The nickpoints are incised about eight to 10 feet below the surface of the older alluvial fan. The nickpoints are slowly, but actively, moving headward. The deeply incised gully passing through the center of the site to the valley head has a nickpoint at the point where the proposed southern edge of the tailings pile crosses the gully (about contour level 6010 on Figure D.3.10). These nickpoints are also incised to the thin sandstone boulder layer which overlies bedrock and are actively moving headward at a slow rate. Other secondary nickpoints are present in the main gully system through the center of the site. These also are actively migrating headward as evidenced by recent bank undermining, piping, and recent exposure of tree roots within the gully.

The incised gully at the head of the Estes Gulch site basin cuts through the pediment alluvium capped bedrock ridge. The incision ranges from about four feet deep at the ridge crest to about eight feet deep near the apex of the small alluvial fan at the basin head. The gully drops steeply in a series of steps cut into bedrock and spreads out on the flat alluvial surface into several shallowly incised gullies. The sideslopes of the incised channel through the ridge are bare and are sites of active surface erosion, soil creep, and minor, shallow failures of surficial deposits. Exposed roots of trees growing in parts of the channel attest to continuing erosion of the channel. Material transported in this channel is deposited as a recent alluvial fan at the Estes Gulch site basin head.

Surface soils at the Estes Gulch site are up to 6.5 feet deep, very clayey, and moderately to highly erosive. The soil developed on the older alluvial fan surface is classified as a Potts-Ildefonso complex, with a brown loam surface layer overlying a reddish brown clay loam subsoil (Harman and Murray, 1985). Clay-rich soils within the area may be expansive. Colluvial and slopewash deposits in the southern half of the section may be subject to hydrocompaction (Stover and Soule, 1985). When dry, the soil surface is loose and flaky and easily loosened and eroded by rainsplash and sheetwash. Water does not infiltrate well into the clayey soil and often ponds on the surface. Sandstone gravel and cobble clasts in the soil surface are more numerous in the head of the basin. Near the recent alluvial fans about 20 to 30 percent of the soil surface is covered with angular to subrounded clasts. Grasses and shrubs appear to be the main controls on surface erosion. Areas of less vegetation are more highly eroded.

Gully erosion is an ongoing process in the site area. Areas of thin vegetative cover are especially subject to accelerated erosion. The site appears to be overgrazed, perhaps contributing to the sparse vegetative cover and the high erosion rate. Most gully processes could be controlled by proper surface grading, revegetation, erosion control structures, and protection from grazing.

D.3.5 MINERAL AND OTHER RESOURCES

An abundance of mineral resources occurs within the Rifle area. Known mineral and fossil fuel deposits in the region are natural aggregate, crushed stone, uranium, oil, natural gas, coal, and oil shale. Economically important deposits of mineral resources and natural aggregate have not been recognized beneath the Estes Gulch proposed alternate site.

D.3.6 SEISMOTECTONIC SETTING

D.3.6.1 Regional setting

Seismic hazard studies in much of the southwestern United States are hampered by the lack of a reliable long-term historical record. Movements on major fault systems in the region may have recurrence intervals on the order of tens to hundreds of thousands of years, while the historical record dates back only to the middle or late nineteenth century.

The historical record for Arizona dates back to 1776 (DuBois et al., 1982); for Utah to 1850 (Arabasz et al., 1979); for Colorado to 1870 (Kirkham and Rogers, 1981); and for New Mexico to 1849 (Sanford et al., 1981). Reliable and reasonably complete instrumental records generally date back only to the early 1960s. As a general rule, the historical record is probably reliable for moderate to large earthquakes since about 1900 to 1910, while the instrumental record is probably reliable for earthquakes of magnitude 4.5 or greater since the early 1960s (Von Hake, 1984).

In the absence of a reliable long-term historical record, probabilistic analyses of seismic risk are of limited use. Therefore, seismic risk analyses are largely based on studies of the geologic and seismotectonic setting, Cenozoic geologic history, and geomorphic evidence of late Tertiary and Quaternary fault movements. Fortunately, erosion rates are slow and vegetation is generally sparse in the arid to semiarid climates that prevail in most of the region. Long faults, which are necessary for large earthquakes, will not remain undetected if careful geologic investigations are made (Krinitzsky and Chang, 1975).

The site is located near the northeast edge of the Colorado Plateau physiographic and seismotectonic province. The boundaries of seismotectonic provinces in the site region, as defined for this study, are shown on Figure D.3.13. They are determined on the basis of published studies of Neogene faulting, regional seismicity trends, areas of Cenozoic igneous activity, geophysical data, and the distribution of major physiographic provinces. In Colorado, adjacent to the Colorado Plateau province on the east, lies the Western Mountains physiographic and seismotectonic province. Seismotectonic provinces in Colorado are shown on Figure D.3.14. Also shown on Figure D.3.15 is a plot of historical and instrumentally located earthquake epicenters (for events of magnitude $\geq$4 and intensity (IMM) $\geq$V)) for the Colorado Plateau region. These data were provided by the National Oceanic and Atmospheric Administration (NOAA), National Geophysical Data Center. A listing of the epicentral data used in compilation of this figure is available from the UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.

Beyond the border zones, the Plateau is surrounded on three sides by the extensional, block-faulted regime of the Basin and Range and Rio Grande Rift Provinces. The Colorado Plateau, Basin and Range, Rio Grande Rift, and Sierra Nevada appear to be part of an interrelated system that has experienced major uplift and extension during the last 20 million years (Zoback and Zoback, 1980; Thompson and Zoback, 1979). Within the Basin and Range and Rio Grande Rift bounding the Plateau are found geologic and geomorphic evidence of repeated surface faulting events associated with large earthquakes during Quaternary time. These areas have experienced some of the largest historical earthquakes in the entire United States. These regions are characterized by large volumes of Cenozoic intrusive rock, thinner crust, higher heat flow, and stress fields oriented differently than the modern stress field in the interior of the Plateau (Thompson and Zoback, 1979). The boundary of the Colorado

Plateau and the Basin and Range Province on the west is marked by the Wasatch Frontal fault system in Utah, which forms a major segment of the Intermountain Seismic Belt (Smith and Sbar, 1974). The transition zone in northern and central Arizona is referred to in this study as the Arizona border zone. Some of the largest historical earthquakes of the Colorado Plateau have occurred in the border zone in northern and central Arizona along the edge of the Arizona Basin and Range province. The Rio Grande Rift and the eastern Colorado Plateau border zone in New Mexico and southwestern Colorado and the border zone of the Colorado Plateau and Western Mountain Provinces in western Colorado have also been the locus of elevated seismicity in historical times. An area of persistent seismic activity near Montrose, Colorado may be related to the Ridgway Fault, which terminates the southeast end of the Uncompahgre Uplift (Kirkham and Rogers, 1981; Sullivan et al, 1980).

To the north, the Plateau is bordered by the Wyoming Basin, a series of broad basins and uplifts that are structurally and tectonically similar to the Plateau. This transition zone is not marked by elevated seismicity, except for probable mining-related events in the eastern Utah coal-mining belt (Smith and Sbar, 1974). Seismotectonic characteristics of the Colorado Plateau and adjacent provinces are cited in Table D.3.5.

D.3.6.2 Colorado Plateau seismotectonic province

The modern Colorado Plateau is composed of a stable interior portion bounded on the west, south, and east by more highly active border zones. For this study, the interior and border zones are defined as separate subprovinces, and the boundary is drawn at the 40-km (25-mile) crustal thickness contour. The border zones lie within the physiographic boundary of the Colorado Plateau, but are characterized by elevated seismicity, thinner crust, higher heat flow, common normal faulting, and elevated levels of Tertiary and Quaternary volcanism relative to the interior. Nearly all of the larger historical earthquakes of the Plateau have occurred within the border zones.

The Colorado Plateau is a major continental block which has been uplifted since late Tertiary time at a low rate of between two to three millimeters per year (Gable and Hatton, 1980). The plateau block has experienced little internal distortion in contrast with the more tectonically active regions of the Rio Grande Rift, the Arizona Basin and Range province, and the Intermountain Seismic Zone. Major seismotectonic characteristics of the Colorado Plateau interior province are listed in Table D.3.5. Average thickness of the earth's crust beneath the region is 40 km (25 miles) (Wong et al., 1982). Lithosphere thickness averages 80 km (50 miles). Earthquake focal depths of five to 26 km (three to 16 miles) have been recorded for seismic events within the province interior (Giardina, 1977). Faulting mode is primarily strike-slip and thrust with a north-northeast direction of least principal horizontal stress (Zoback and Zoback, 1980).

Neogene faulting is generally rare within the interior portion of the Colorado Plateau, except for faulting associated with the Uncompahgre Uplift and the collapsed salt anticlines of the Paradox Valley. Earthquakes are rare. The historical seismicity of the interior portion has been classified by Wong (1984) as very low level, having events of small to moderate magnitude with diffusely distributed epicenters. The largest instrumentally recorded earthquakes within the interior portion have fallen in the magnitude range of 4.5 to 5.0.

The largest historical earthquakes recorded within the Colorado Plateau have occurred in the border zones. These include:

- o Events of estimated magnitudes 5.5 to 5.75 (M_L) at Lockett Tanks, Arizona, in 1912, and Fredonia, Arizona, in 1959 (DuBois et al., 1982). These events occurred within the Arizona border zone separating the Colorado Plateau from the Basin and Range Province to the south.

- o The Dulce, New Mexico, earthquake of January 23, 1966, of magnitude (m_b) 5.5 (NOAA Earthquake Data File). This event occurred in the zone of transition between the Colorado Plateau and Rio Grande Rift (Herrmann et al., 1980).

- o The earthquake of October 11, 1960, of magnitude 5.5, located northeast of Ridgway, Colorado, which was strongly felt in the Ridgway-Montrose area. This event may be associated with the Ridgway fault which terminates the southeastern end of the Uncompahgre Uplift, marks the northwestern boundary of the San Juan volcanic field, and may be the boundary between the Colorado Plateau and Western Mountain Provinces (Sullivan and Martin, 1981; Kirkham and Rogers, 1981).

Recurrence intervals have not been established for large earthquakes within the Colorado Plateau. They may be on the order of tens or hundreds of thousands of years.

Kirkham and Rogers (1981) have identified several faults with apparent Quaternary movement associated with the Uncompahgre Uplift and the salt anticline regions of the Colorado Plateau. Along the northeast flank of the Uncompahgre Uplift, an east-west trending fault offsets Quaternary pediment gravels by about four feet and underlying Mancos Shale by about 10 feet. Other faults along the northeastern flank of the uplift appear to be no younger than Laramide age. Faults expressing Quaternary movement also occur along the southwestern flank of the Uncompahgre Uplift. The Ute Creek graben bounding faults appear to have been active during the late Pliocene and Pleistocene, and may be active today. Other faults have indications of Quaternary movement, most important of which is the Ridgway fault bounding the southern end of the uplift. The Ridgway fault offsets Quaternary gravels and is associated with historical earthquakes. A fault bounded graben trending northwest in the Piceance Basin crosses Piceance Creek and Ryan Creek and exhibits surface features indicative of Quaternary movement. Movement within the past 100 years is suspected on a fault in this graben (McGuire et al., 1982). Faults associated with the collapse of salt anticlines are common in the Paradox Basin. The faults are the result of salt flowage and are unlikely to generate earthquakes larger than magnitude 4 or 5 (Kirkham and Rogers, 1981).

The area of western Colorado that includes the site does not display some of the significant characteristics of the typical Colorado Plateau border zones, such as thinner crust and higher heat flow. Physiographically, this transition is also marked by increasing elevation within the uplifted areas adjacent to the Rocky Mountains, in contrast to the marked elevation decreases characteristic of the transitions to the Basin and Range and Rio Grande Rift. The transition is marked, however, by an increase in the level of seismicity relative to the Colorado Plateau interior. This seismicity is broadly centered over the Colorado Plateau/Western Mountain Province transition zone (Kirkham and Rogers, 1981). Geologic and geomorphic evidence has been interpreted as showing that certain structures in this region, notably the Uncompahgre Uplift, experienced considerable late Tertiary uplift that may be continuing today.

Analysis of the historical and instrumental seismic record for this region indicates that activity may be associated with a series of parallel, northwest-trending structural features. These features are as follows (Figure D.3.16):

- An apparent feature extending from the Dulce, New Mexico, area along the south flank of the San Juan Mountains, through the approximate boundary of the Paradox Basin and the Uncompahgre Uplift. This feature may mark a hinge line separating the Uncompahgre Uplift from the Paradox Basin.

- An apparent feature lying about 100 km (62 miles) north of lineament 1, which passes through the central portion of the San Juan Mountains, through the seismicity in the Ridgway-Montrose, Colorado, area (possibly associated with the east-west-trending Ridgway fault) and along the northeast side of the Uncompahgre Uplift. This feature may mark a hinge line separating the Uncompahgre Uplift from the Piceance Basin.

- A third apparent feature, lying about 62 miles (100 km) north of lineament 2. This lineament does not appear to coincide with any major physical features. It runs roughly along the southwest side of the Elk Mountains Uplift, through the area of Grand and Battlement Mesas, and fades away in the interior of the Piceance Basin. Several northwest-trending normal faults and folds in the Piceance Basin (Tweto, 1979) may coincide with this feature.

A recent study of felt reports of the earthquake of November 7, 1882, (generally assumed to have occurred in the Denver area) by McGuire et al. (1982), has suggested that it may have occurred within the Piceance Basin. McGuire et al. (1982) also identified a possible causative structure, showing apparent evidence of Quaternary activity, within the Basin. Rough estimated isoseismals based on felt reports indicate possible association with a northwest-trending structure that approximately coincides with lineament 3.

Apparent seismicity associated with the northwest end of this feature near the Colorado/Utah border occurs within the Rangeley oil and gas field and may be induced by fluid withdrawal.

- o A fourth apparent lineament, which may merge with lineament 3 in the interior of the Piceance Basin. This feature appears to run along the northeast flank of the Elk Mountains Uplift, and may coincide with the Grand Hogback monocline and the southwest side of the White Mountains Uplift (Tweto, 1979).

These features cut across the roughly north-south-trending boundary between the Colorado Plateau and the Western Mountain Province of Kirkham and Rogers (1981) (Southern Rocky Mountains of Hunt, 1967). This indicates that the seismicity of this region may coincide with deep-seated, northwest-trending, active structural features that cut across the province border.

The northeast-trending Colorado Lineament (Warner, 1980; Brill and Nuttli, 1983) is not apparent as a controlling seismic feature in the study region on the basis of seismicity trends. Warner (1980) concluded that the Colorado Lineament represents a system of wrench-faults of Late Precambrian age. He estimated that movement on this system may have virtually ceased about 1700 million years ago. However, Brill and Nuttli (1983) believe the Colorado Lineament to be one of the source zones for the larger historical earthquakes of the west-central United States. Hite (1975) described features within the Paradox Basin, which he determined to be evidence of extensive movements on northeast-trending faults as late as Eocene time. The presence of major northeast-trending basement faults concealed at depth beneath younger sediments in the site region cannot be ruled out entirely. However, the predominant structural and tectonic grain of surface geologic features is northwest-trending. The apparent correspondence of northwest-trending structural features and seismicity trends seems to indicate that seismicity in the site region is not directly associated with the northeast-trending Colorado Lineament.

D.3.6.3 Intermountain seismic zone

Seismicity throughout the Intermountain Seismic Zone is characterized by earthquake focal depths less than 15 km (nine miles) (Smith and Sbar, 1974). Most major faults trend north to northeast. The general direction of least principal horizontal stress is east-northeast (see Table D.3.5). Fault movement is mainly normal slip. The current stress regime of northeast-southwest extension appears to control historic surface faulting.

The entire zone has experienced more than 15 earthquakes of magnitude 6.0 or greater since the mid-1800s (Wong et al., 1982). The largest recorded event was the 1959 Hebgen Lake, Montana, earthquake of magnitude 7.1. Seismicity near Salt Lake City is anomalously low. In southern Utah, historic earthquake intensities have ranged from III to VI (NOAA, 1985). Earthquake epicenters generally have poor correlation with late Cenozoic faults (Wong et al., 1982). This may be caused by listric faulting and the occurrence of earthquakes on curved fault surfaces at depth. Offset of Quaternary deposits along some fault zones is evident. The maximum recorded earthquake in southern Utah was a magnitude 6.5 event near Richfield in 1901 (see Table D.3.5). Historical earthquake epicenter distributions for the Intermountain Seismic Belt are shown on Figure D.3.17.

The Intermountain Seismic Belt includes the Wasatch Frontal Fault System and other major potentially active faults of northern and central Utah. This zone is highly seismic and capable of large earthquakes up to local magnitude (M_L) 7.5. Historical earthquake data for the Wasatch Front suggest expected return periods of 22 to 25 years for $M_L > 6.0$, 111 to 115 years for $M_L > 7.0$, and 232 to 263 years for $M_L > 7.5$ (Arabasz et al., 1979).

D.3.6.4 Arizona Basin and Range province

The Arizona Basin and Range province lies south and west of the Colorado Plateau rim (see Figure D.3.13). It is characterized by block-faulted mountain ranges and intervening alluvial valleys. Formation of the landscape has been the result of large-scale faulting, folding, and volcanic activity associated with the Laramide and Basin and Range orogenics (Giardina, 1977). The region is generally subsiding, relative to the Colorado Plateau, at a rate of about 0.018 to 0.08 millimeters per year (0.00007 to 0.003 inch/year) over the past 12 million years (Gable and Hatton, 1983). The Sonoran Desert region of the province in southwestern Arizona has been tectonically stable since the Quaternary. The region along the western and southern edge of the Colorado Plateau has experienced high-angle faulting continuing in places into the late Pleistocene and perhaps into early Holocene (Morrison et al., 1981). Tectonic deformation began about 17 to 10 million years ago in Arizona. Deformation along the edge of the Colorado Plateau ceased about six to four million years ago (Morrison et al., 1981). Initial development of a compression stress field later changed to regional extension oriented east-west to west-northwest. Current horizontal distension is estimated at 0.12 to 0.59 inch/ year (0.3 to 1.5 cm/year) (Gable and Hatton, 1983). Crustal thickness is estimated at 30 km (19 miles) and lithospheric thickness is about 60 km (37 miles).

Earthquake focal mechanisms from historical events indicate depths of 10 to 15 km (six to nine miles) (Eberhart-Phillips et al., 1981). Least principal horizontal stress directions are west-northwest to east-west (Zoback and Zoback, 1980). The dominant structural style is high-angle normal faulting which has produced horsts and grabens with a wide range of displacements. Most faults are oriented northwest to north to northeast.

Most earthquake activity has occurred in a broad arc around the edge of the Colorado Plateau. In Arizona, major earthquakes have occurred north of the Grand Canyon, near Flagstaff, and in the Chino Valley region south of Williams. The maximum recorded earthquake occurred near Fredonia, Arizona, with a magnitude of 5.75. Historical earthquake intensities for the Arizona Basin and Range province range from II to VII (Dubois et al., 1981). The only definite association of earthquake epicenters and major tectonic structures is along the central Arizona-Utah border.

Neotectonic faulting has occurred in a broad northwest-trending zone across central Arizona and along major active structures, extending south from the edge of the Intermountain Seismic Zone in Utah. Although the province has only moderate seismicity with no large historical events, it is believed capable of large magnitude earthquakes (Menges and Pearthree, 1982; Pearthree et al., 1983). Ages of neotectonic displacement range from late Pliocene to possibly Holocene. Recurrence intervals of neotectonic fault displacement along the major active systems along the Arizona-Utah border are estimated on the order of hundreds to thousands of years (Gable and Hatton, 1980).

D.3.6.5 Rio Grande Rift

The Rio Grande Rift section of the border zone lies in western New Mexico along the eastern edge of the Colorado Plateau (see Figure D.3.13). It extends from Chihuahua, Mexico, through west Texas, New Mexico, and most of central Colorado, almost to the Wyoming border. The present rift originated in the Miocene in response to regional extension and uplift that reactivated the Rocky Mountains (Wong et al., 1982). Regional uplift within the last 10 million years has been about 1.2 to 1.5 millimeters per year (0.47 to 0.59 inch/year) (Gable and Hatton, 1980). The southern Rocky Mountain region of Colorado and New Mexico was strongly uplifted between seven and four million years ago, but the rate has since decreased. The rift is characterized by broad, north-south trending basins in which mafic flows and volcanic ash beds are intercalated with alluvial fill. Rifting appears to be continuing, as evidenced by fault scarps cutting Pleistocene deposits, high heat flow, ongoing elevation changes, and activemagmatism (Wong et al., 1982). Crustal thickness averages 40 km (25 miles) and lithosphere thickness is estimated at 60 km (37 miles) (see Table D.3.5).

Earthquake focal depths, calculated from historical events, range from 20 to 44 km (12 to 27 miles) (Wong et al., 1982). Most faults within the rift zone have north-south orientations and normal slip movement. The direction of least principal horizontal stress is west-northwest (Zoback and Zoback, 1980). In the northern Rio Grande Rift, north-south epicentral trends appear to be related to areas of uplift and arching (Wong et al., 1982).

A high percentage of all the potentially active faults in Colorado and New Mexico lie within this province. The rift has been subdivided into northern and southern subprovinces in Colorado by Kirkham and Rogers (1981) on the basis of young faulting. Well-defined evidence of repeated late Quaternary movements is abundant on several faults in the southern subprovince, whereas such evidence is obscure in the northern subprovince. Several major faults are present in the northern subprovince, some of which were active as early as the Precambrian. Of the major faults in this region, only the Frontal fault on the east flank of the Gore Range has possible early Quaternary activity (Kirkham and Rogers, 1981).

D.3.6.6 Western Mountains province

The mountainous areas to the west of the Rio Grande Rift province form the Western Mountains province of Colorado (see Figure D.3.14). Included in this province are the San Juan Mountains, Elk and West Elk Mountains, west flank of the Sawatch Range, White River Uplift, and Gunnison Uplift. The Sawatch and White River uplifts lack pre-Laramide expression, but their borders may be controlled, in part, by older basement faults (Tweto, 1980c). Neogene faults are scarce in this province. Most faults expressing Neogene movement are associated with evaporite flowage or caldera collapse (Kirkham and Rogers, 1981). Despite the apparent absence of major Neogene faults, numerous earthquakes have been recorded within the province. The largest historical earthquake felt in the province was a magnitude 5.5 event near Montrose (Kirkham and Rogers, 1981). No major tectonic faults have been proven to have had Quaternary activity. Crustal thickness of the Southern Rocky Mountains region averages 45 to 50 km thick (see Table D.3.5). Earthquake focal depths have not been calculated from seismic events. Most faults have normal slip movement.

D.3.7 GEOLOGIC HAZARD ANALYSIS

D.3.7.1 Geomorphic hazards

The Estes Gulch site is located in the head of a drainage basin extending northward from Government Creek. The site lies on the dissected alluvial fan surface sloping southward from the Grand Hogback monocline. The fan surface is cut on the east and west sides of the site by tributaries of Government Creek. A gully cut up to 15 feet deep in silty surficial deposits extends northward through the center of the site. Clayey, silty, and sandy eolian, alluvial, and colluvial deposits overlie bedrock and increase in thickness downslope from about five feet to about 35 feet. The silty eolian deposits are highly erosive and gullying is an active process. The claystones, siltstones, and sandstones of the Wasatch Formation bedrock are intensely fractured and weathered to depths of at least 100 feet below their upper contact surfaces.

Major issues related to the geomorphic hazards at the Estes Gulch site are (1) gully erosion and arroyo encroachment; (2) wind erosion; (3) surface-water runoff diversion; and (4) possible slope failure on steep slopes. Hazards from seismic activity are discussed in other sections of this Appendix. Site geology and surface conditions affecting gully erosion and surface-water runoff are discussed in detail in the Site Geology Section (D.3.4) of this report.

Surficial erosion by deeply incised gullies and the headward extension of these systems into the area of the proposed tailings pile represent the major geomorphic hazards at the site. Extensive gully systems extend in three main channels in the west, center, and east sides of the site (see Figure D.3.10). These channels are developed on the clayey and silty surficial eolian deposits and the sandy, gravelly alluvium underlying them. In several places along the south side of the site, gullies have incised down to a hard sandstone cobble layer, of less than one-foot thickness, overlying the clay-stone and sandstone bedrock, a depth of eight to 10 feet. Nickpoints within the main gullies are actively migrating headward. Extensive piping occurs up to 10 feet to the sides of developing gully systems and indicates points where gullies are expanding both headward and laterally. Although no precise rate of gully development has been determined, it is evident that this is an active process. The flat, sloping surface of the older alluvial fan is undergoing net degradation, except for slow eolian silt input and the deposition of a small alluvial fan at the basin head. Net erosion and gully development can be expected to continue in the future.

The proposed stabilized tailings pile is expected to fill the basin head between the ridges to the west and east. A properly engineered pile in this position would eliminate surface-water flow over the current basin head, thus preventing future gully development in this area. All runoff in the narrow channel cut into the bedrock ridge at the basin head would have to be diverted away from the current channel and away from a tailings pile.

Runoff on the ridges to the west and east must also be diverted away from the pile. The west and south sides of the proposed pile require a resistant armor cover tied into bedrock to prevent gully erosion headward into the pile. The alluvial, colluvial, and eolian deposits overlying bedrock appear to be highly erosive. The underlying sandstone cobble layer and the claystone and sandstone bedrock are moderately resistant to erosion, especially in an unweathered state.

Slope failure presently is a small-scale but persistent process at the Estes Gulch site. Bare soil areas are subject to shallow surface slips of fine-grained material. Minor, shallow debris flows have occurred at the mouths of small, steep gradient channels in the ridge along the west side of the site. Emplacement of a stabilized tailings pile in the basin will eliminate the source of these surface failures.

No precise data on wind speed, duration, or direction are available for the Estes Gulch site. No eolian dunes are currently present, nor do any occur in the local stratigraphy. A properly armored and vegetated tailings pile surface would eliminate any hazard of wind erosion.

Subsidence caused by mine collapse, fluid withdrawal, or solutioning of underlying bedrock is not a hazard at the site. No evaporite deposits have been recognized in the local stratigraphy. No mines occur beneath the tailings. The closest mining activity is an inactive coal mine about two miles south east of the site.

Climatic changes would probably be of a lesser magnitude than those which occurred at the end of the Pleistocene, about 10,000 years ago. Predicted changes in the amount of precipitation, seasonality of precipitation, or temperature are not expected to produce site changes which would affect the stability of the final tailings pile design within the next 1000 years.

D.3.7.2 Impact of natural resource development

Economic resources in the site region consist of oil and natural gas, oil shale, uranium, and sand and gravel. Economically important deposits of mineral resources and natural aggregates have not been recognized beneath the Estes Gulch site.

Uranium-vanadium deposits occur in the Navajo (?) and Entrada sandstones in the Rifle Creek area (Fischer, 1960). The closest developed deposit is about two miles east of the Estes Gulch site. No known uranium deposits occur close enough to the site to affect future mining activity and site stability.

No economic coal deposits have been recognized beneath or adjacent to the site. The closest developed coal deposit is an inactive mine about two miles southeast of the site.

Oil shale, petroleum, and natural gas deposits are known to occur in the region in the Wasatch Formation, Mesaverde Group, Dakota/Burro Canyon Formation, Morrison Formation, and Entrada Sandstone. Although economically important deposits may occur in these formations, no deposits have been recognized at the site. Therefore, no hazard to site stability is anticipated. Sand and gravel exploitation possibilities are low. The quality and quantity of alluvial sand and gravel, talus deposits, and eolian sand are low. No potential hazard is expected at the site due to future aggregate resource development. No geothermal sources occur at the Estes Gulch site.

D.3.7.3 Volcanic hazards

Volcanic eruptions or flows do not present a hazard to the Estes Gulch site. No volcanic deposits have been recognized at the surface of the site or in strata beneath the site to depths of 300 feet. Minor outcrops of Tertiary air-fall ash and basalt occur about six miles north of the site (Tweto et al., 1978). Miocene and Pliocene basalts occur on Battlement Mesa, about 15 miles south of the site. The closest Quaternary and Holocene volcanic rocks occur near Dotsero, about 38 miles east of the site. Future volcanic activity in the region cannot be discounted, but the timing and occurrence cannot be predicted. No volcanic flow activity is expected to affect the site within the 1000-year design life.

D.3.7.4 Analysis of seismic risk

Technical approach

The objectives of the seismic hazard analysis performed for this study are as follows:

- o Selection of the design earthquake and estimation of the on-site peak horizontal acceleration for use in subsequent engineering analysis.
- o Recognition of any potential for on-site fault rupture.
- o Recognition of any potential for earthquake-induced landsliding or subsidence due to tectonic causes.

The technical analysis performed for this study involved a critical review of all the information developed during the investigation and a step-by-step approach to estimating seismic risk.

The first step was the determination of the magnitude of the FE in the seismotectonic province within which the site is located. This earthquake was then assumed to occur at a radial distance of 15 km (nine miles) from the site, and the resulting on-site acceleration was calculated using the acceleration/attenuation relationship of Campbell (1981). As discussed in the Technical Approach Document (TAD) (DOE, 1989), other acceleration/attenuation relationships were evaluated. Campbell's (1981) relationship has the best application for the Colorado Plateau seismotectonic region.

Following the above analysis, the maximum on-site acceleration resulting from maximum magnitude earthquakes occurring in each of the remote seismotectonic provinces within the region of interest was determined. A detailed analysis of individual faults within remote provinces was not performed, unless they lie within a radius of 65 km (40 miles) of the site. A conservative approach was taken wherein the closest distance of the remote province from the site was first measured. The measurement was made using published maps and literature to delineate province boundaries. The ME values for the remote provinces were estimated based on published studies and personal communications from researchers active in the area. The ME earthquake was then assumed to occur at the closest approach of each remote province to the site, and the resulting on-site acceleration was calculated.

After completion of the first two steps in the analysis, the on-site accelerations resulting from the FE within the province containing the site and from the MEs at the closest approaches of each of the remote provinces were compared. The largest value was taken as the critical acceleration during the subsequent capable fault analysis.

Following a thorough review of the literature on statistical relationships among earthquake magnitude and fault rupture parameters such as fault length and surface area, the equation for plate interiors developed by Bonilla et al. (1984) was selected for use at Colorado Plateau sites. This relationship is $M_s = 6.02 + 0.729 \log L$; where M_s = earthquake magnitude (surface wave); L = fault rupture, length at the ground surface in kilometers. For UMTRA Project studies, the equation from Bonilla, et al. (1984) is applied to faults of tectonic origin which have produced tectonic effects visible at the ground surface or in cross sectional exposures.

The relationship of Bonilla et al. (1984) can be shown to be statistically meaningful because most events in the data base occur in a thickness of brittle crust of between 15 and 20 kilometers. This makes surface rupture length (intersection of the rupture plane with the earth's surface) roughly proportional to earthquake size. These relationships are particularly applicable to cases where no historical events have occurred to provide data on fault geometry at depth, i.e., paleoseismic rupture length parameters can be used. Assuming the rupture length is the only measurable variable to define magnitude (besides fault mechanism) this relationship has the best application. These relationships are not valid in areas where brittle rupture occurs to extended depths (e.g., subduction zones or cratonic areas) nor for faults which do not rupture the thickness of the brittle crust (e.g., Gulf Coast growth faults, landslide failures and solution collapse, or fluid withdrawal collapse features). This second category of faults may loosely be considered as nontectonic in origin.

Based on the review of published and unpublished geologic data and the air-photo analysis, a compilation of all mapped faults and air-photo lineaments within a radial distance of 65 km (40 miles) of the site was prepared. The fault length/ magnitude relationships of Bonilla et al., (1984) were used to determine the ME that each structure would produce if it were determined to be a capable fault. An on-site acceleration resulting from each fault was then calculated. These values were then compared to the critical acceleration determined during the previous analysis. Any features potentially capable of producing a larger on-site acceleration than the critical value were subjected to a detailed field investigation to determine if they are capable faults.

The capable fault investigation consisted of the analysis of the seismic record for evidence of micro- or macroseismicity associated with the fault, close inspection of the mapped fault trace on aerial photography, detailed ground reconnaissance for evidence of late Quaternary or Holocene movements, and careful investigation of the indicated fault during the LSA aerial reconnaissance.

If any evidence was found to indicate that the fault (or faults) is capable, the largest calculated on-site acceleration would then be recommended as the design acceleration value. The fault would be designated as the controlling fault and the ME on that fault would be specified as the design earthquake.

Previous studies

Several probabilistic earthquake maps, which plot contours of maximum horizontal accelerations, velocities, and intensities for various return periods have been prepared for the contiguous United States. Examples of such studies are those by Liu and DeCapua (1975), Algermissen and Perkins (1976), The Applied Technology Council (1978), and Algermissen et al. (1982). These studies were utilized to estimate the maximum value of each parameter for the site area. The resulting values are listed in Table D.3.6.

Liu and DeCapua (1975) developed 100-year contour maps of intensity and acceleration for the Rocky Mountain states. On their 100-year contour map of maximum predicted intensity, the site area lies in a region characterized by Modified Mercalli Intensity IV and V, which lies to the east of the Intermountain Seismic Belt. Considering this, it would be reasonable to assume that a Modified Mercalli Intensity IV to V event would be experienced in the site area once every 100 years. Based on their 100-year contour map of peak accelerations for the Rocky Mountain states, an acceleration of 0.02g to 0.03g is predicted.

Contours of horizontal acceleration having a 90 percent probability of not being exceeded in 50 years were presented for the contiguous United States by Algermissen and Perkins (1976). On their map, the site area lies near the margin of a zone of maximum predicted horizontal acceleration ranging from 0.03g to 0.04g. This zone roughly corresponds to a Rio Grande Rift/ Colorado Plateau transition zone and includes much of the Western Mountain province and the east central Colorado Plateau Province.

The preliminary study of Algermissen and Perkins (1976) was updated by Algermissen et al. (1982), who presented probabilistic estimates of maximum acceleration and velocity in rock for periods of 10, 50, and 250 years. In comparison with the 1976 study, the 1982 study resulted in only minor modification of their estimates of peak accelerations for the Rifle-Estes Gulch area.

A study performed by the Applied Technology Council (1978) presented a map showing effective peak accelerations for the contiguous United States. The geographic contours of seismic source zones and horizontal accelerations in the site area are the same as those presented by Algermissen and Perkins (1976) and Algermissen et al. (1982).

The accelerations calculated in these previous studies are uniformly lower than the maximum values derived from this study. The previous studies are probabilistic analyses based on the rather brief historical record. The conservative approach taken in this study assumes the potential occurrence of the most extreme possible events. During this site-specific study, a great deal of attention is paid to the details of the regional and local geologic structure. The maximum capabilities of all faults in the study area are taken into account. In addition, the design life of 1000 years is the basis of the present analysis, as compared to the time periods of 10, 50, 100, and 250 years assumed in the previous studies. Extrapolation of the results of the previous studies to the 1000-year design life, although tenuous at best, would result in values more consistent with the conclusions of this study.

Review of seismic data for the Colorado Plateau

Epicentral compilation

An epicentral compilation for use in derivation of seismic parameters for the Colorado Plateau was obtained for this study from the NOAA earthquake data file. The complete listing is available from DOE UMTRA Project Office, Albuquerque, New Mexico. The compilation is up-to-date through 1985.

In order to facilitate the computer search and to restrict the search area as closely as possible to the Colorado Plateau, two search areas were specified, a circle of radius 199 miles (320 km) and center at latitude

36.0°N, longitude 110.0°W, and a circle of radius 200 km centered on Rifle, Colorado. The choice of search areas resulted in some overlap beyond the borders of the Colorado Plateau, especially in central Arizona.These data were considered to be representative of seismicity of the border zones, and were included in the analysis.

Table D.3.7 was derived from this list. It represents all instrumentally-located earthquakes within the Colorado Plateau (interior and border zones) of magnitude ≥4.0 since January 1, 1960. The list contains 70 events. Of these, a total of 15 occurred either in the eastern Utah coal mining belt or in the oil and gas fields near Rangely, Colorado. These are considered to be artificially-induced events caused by mining or oil and gas withdrawal (Smith and Sbar, 1974). They were not included in the subsequent analysis. Of the remaining 55 events, only two occurred within the stable interior portion of the Plateau as defined for this study. These include magnitude (m_b) events of 4.0 in the Paradox Basin on February 3, 1970, and 4.4 near Grand Junction, Colorado, on January 30, 1975. The data indicate that only four percent of the seismicity of the Colorado Plateau occurs in the stable interior. Those events that do occur appear to be associated with tectonically unique structures such as the Uncompahgre Uplift and Paradox Basin.

The remaining 53 events, representing 96 percent of the data, occurred in the border zones. Twenty-three events occurred in the Rio Grande Rift border zone, and of these, 18 were associated with the swarm of events near Dulce, New Mexico, from January 1966 to January 1967.

Eighteen of the events are associated with the border zone of the Colorado Plateau and the Intermountain Seismic Belt in Utah and northern Arizona. Most of these events occurred along the Wasatch frontal fault system. Seven events occurred in the border zone between the Colorado Plateau and the Western Mountain Province. These include the event of October 11, 1960, of magnitude 5.5 near Montrose, Colorado.

The remaining five events occurred in the Arizona Border Zone, and include several events of magnitude (m_b) 5.5 to 5.75 in the Flagstaff area.

Graphical determination of ME

The data were plotted on Figure 3.18 to determine the ME value for the Colorado Plateau. Obviously, due to the scarcity of data for the Colorado Plateau Interior, the data are representative of the border zones. The data show that there is no basis for any determination of the ME value for the interior from the instrumental seismic record. The historical record is also extremely limited and is probably even less reliable. The scarcity of recorded earthquakes of magnitude 5.0 and greater also limits the reliability of the ME determination for the border zones. The true ME value may lay anywhere within the range from 6.2 to 6.8. The average value of this range, magnitude 6.5, is a reasonably conservative value. This value is recommended as the ME value for the Colorado Plateau interior and border zones together. This value is also the value adopted by Kirkham and Rogers (1981) as the ME for the Colorado Plateau.

The data do not permit any estimate of the recurrence interval for the ME event within the interior province. It may be on the order of tens to hundreds of thousands of years. For the border zones a reasonable estimate can be made on the basis of the historical record. Assuming the record for moderate to large earthquakes to be complete since about 1900, the data base covers a period of 85 years. If it is assumed, conservatively, that one magnitude 6.5 earthquake occurs every 85 years within the approximately 425,000 km2 area of the Colorado Plateau (interior and border zones), the probability of occurrence of a magnitude 6.5 event within any 15-km (nine-mile) radius within the region is 0.06×10^{-4}. The recurrence interval of an ME earthquake within any 15-km radius area is thus 166,700 years. This value represents an absolute minimum recurrence interval for the border zones.

A graphical determination of the recurrence interval of the ME within the entire Colorado Plateau interior and border zone is represented in Figure D.3.19. The results indicate a recurrence probability of 0.0019 ME events per year, or a recurrence interval of 526 years.

Determination of FE Magnitude

The definition of Floating Earthquake adopted for use in UMTRA Project seismic hazard evaluations is "an earthquake within a specific seismotectonic province which is not associated with a known tectonic structure." It is important to distinguish between ME and FE. The ME magnitude should be larger than the FE magnitude, because large earthquakes are generally associated with ground breakage on known tectonic structures. The FE magnitude should never be greater than the ME.

It is generally accepted that floating earthquakes are events of low to moderate magnitude. For example, Slemmons et al. (1982) state "The maximum magnitude for this type of earthquake in the eastern and central United States is about M_s = 5.75 to 6."

Krinitzsky and Chang (1975) state that "uncertainties in the association of earthquakes with faults affect only small events, magnitudes 4 or 5. Long faults, which are necessary for large earthquakes, would not remain undetected if careful geologic investigations were made." They further state that "the formation of new faults capable of causing destructive earthquakes is not a possibility that should be considered in design."

The maximum magnitude of the floating earthquake should therefore be equal to the threshold magnitude at which ground breakage will occur.

It is generally assumed that all earthquakes of magnitude greater than about 6.0 to 6.2 do produce fault scarps at the ground surface in the western United States. Wallace (1982) indicates that earthquakes of magnitude greater than about 6.0 are generally associated with ground breakage in the Basin and Range Province. The threshold magnitude is not precisely known for the Colorado Plateau, because there are no recorded seismic events associated with ground breakage. The largest recorded earthquakes in the Colorado Plateau have all fallen in the approximate magnitude range of 5.5 to 5.8. It is conceivable that this range may represent the ME value for the prevailing stress field. Thompson and Zoback (1979) state that the lack of major faulting and/or seismicity within the Plateau interior indicates low differential (shear) stresses. This range is considerably lower than the ME value of 6.5 used for some UMTRA Project studies in the Colorado Plateau. The larger value is adopted in part because of the limitations of the historical data base. The magnitude range 5.5 to 5.8 may be a reasonable value for the FE magnitude, but a more conservative value is advisable considering the lack of a long-term data base. Since all earthquakes of magnitude 6.5 should be associated with ground breakage (i.e., be associated with a known tectonic structure) and the largest historical events fall in the range 5.5 to 5.8, the FE magnitude must fall somewhere within the range 5.8 to 6.5.

In accordance with the seismic design procedures previously agreed upon by the NRC and the DOE (DOE, 1989), the more conservative value of $M_L = 6.2$ is recommended for the maximum magnitude of the FE in the Colorado Plateau. This event is assumed to occur at a radial distance of 15 km (nine miles) from the site. Using the constrained acceleration/attenuation relationship of Campbell (1981), this results in an on-site Peak Horizontal Acceleration (PHA) (mean plus one standard deviation, or 84th percentile) of 0.21g.

The recurrence interval for the Colorado Plateau for this event cannot be reliably estimated, due to the lack of data, especially for the Colorado Plateau interior. It may be on the order of tens or hundreds of thousands of years. A graphical estimate of recurrence values (Figure D.3.18) shows an occurrence rate of 0.004 events of this magnitude per year, or one event of magnitude 6.2 every 250 years within the Colorado Plateau. This may be an extremely conservative estimate, considering the largest actual historical events and the limited data base. If it is assumed that one earthquake of magnitude 6.2 occurs randomly every 250 years within the entire Plateau (an area of approximately 425,000 km^2), then the apparent probability of occurrence is 1×10^{-8} events per square km per year. Using this base value, the probability of an event occurring within a specified time period and within any specified radial distance of the site can be simply derived. The probability of occurrence of the FE within the 15-km (nine-mile) radius of any site during the 1000-year design life is 2.25×10^{-3}, or less than one percent.

Effect of MEs on other regional seismotectonic features

Remote seismotectonic provinces considered to be significant to the seismic hazard evaluation of the Estes Gulch site include the following:

- o The Intermountain Seismic Belt.
- o The Rio Grande Rift.
- o The Wyoming Basin.
- o The Western Mountain Province of Kirkham and Rogers (1981).

Intermountain Seismic Belt

The Intermountain Seismic Belt (Smith and Sbar, 1974) is a zone of pronounced earthquake activity extending north from Arizona through Utah, eastern Idaho and western Wyoming, and terminating in northwestern Montana. It is coincident with the boundary between the Basin and Range Province and the Colorado Plateau-Middle Rocky Mountains in central Utah, approximately 300 km (186 miles) to the west of the Estes Gulch site. The largest historical event of the Intermountain Region was the 1959 earthquake of magnitude 7.1 at Hebgen Lake, Montana. More than 15 events with magnitudes greater than six have been reported since the mid-1800's.

The Intermountain Seismic Belt includes the Wasatch frontal fault system and other major potentially active faults of northern and central Utah, which lie at distances of 350 km (217 miles) or more to the west of the site region.

Though the seismic activity associated with the Intermountain Seismic Belt is irregularly distributed over a broad area, there is no evidence that seismicity associated with it has occurred within the interior of the Colorado Plateau. It therefore appears that the closest approach of potential earthquakes associated with the Intermountain Seismic Belt to the site is about 300 km (186 miles). A magnitude 7.5 earthquake occurring at the closest approach of the Intermountain Seismic Belt would produce accelerations of approximately 0.03g at the site (Table D.3.8).

Rio Grande Rift

The Rio Grande Rift is a north-south-trending extensional graben feature of great length and tectonic significance. It extends from Chihuahua, Mexico, through west Texas, New Mexico, and most of central Colorado, almost to the Wyoming state line. The rift was initiated in Neogene time and has experienced continued activity through the Quaternary. It is characterized by fault scarps in young alluvium, abrupt mountain fronts that exhibit faceted spurs, deep, narrow linear valleys, Neogene basin-fill sedimentary rocks, and a bimodal suite of mafic and silicic igneous rocks.

A high percentage of all the potentially capable faults in Colorado and New Mexico lie within this province. The rift has been subdivided into northern and southern subprovinces in Colorado by Kirkham and Rogers (1981), on the basis of young faulting. Well defined evidence of repeated late Quaternary movement is abundant on several faults in the southern subprovince, whereas such evidence is obscure in the northern subprovince.

The closest approach of capable or potentially capable faults associated with the Rio Grande Rift to the site area is about 325 km (202 miles). The estimated magnitude of an ME associated with the Rio Grande Rift in Colorado (Kirkham and Rogers, 1981) is 6.5 to 7.5. An event of magnitude 7.5 occurring at a distance of 325 km (202 miles) from the site area would result in acceleration of approximately 0.01g as detailed in Table D.3.8.

Wyoming Basin

The Wyoming Basin consists of a series of broad structural and topographic basins that merge with and resemble the adjoining part of the Colorado Plateau (Hunt, 1967). These basins are partially filled with Tertiary deposits and are separated by low anticlinal uplifts of older rocks.

The earthquake history of the Wyoming Basin is apparently similar to the widely distributed, low to moderate magnitude pattern of the stable interior portion of the Colorado Plateau. Witkind (1975) identified numerous suspected active faults in the Wyoming Basin along the Colorado/Wyoming border between 107° and 108° west longitude, which may represent a continuation of structures associated with the Rio Grande Rift in Colorado. However, these faults are not known to have been associated with seismic activity.

Coffman et al. (1982) list 38 earthquakes of moderate intensity within the entire state of Wyoming. Most of these have occurred within the Intermountain Seismic Belt in the western part of the state, especially in the Yellowstone Park region.

The ME for the Wyoming Basin may be about equal to that of the Colorado Plateau, i.e., in the range of 5.7 to 6.0 or possibly ranging as high as 6.5. The closest approach of the physiographic boundary of the Wyoming Basin to the site area is about 200 km (124 miles). The occurrence of magnitude 5.7 or 6.5 events at the closest approach would be expected to produce maximum on-site accelerations of only about 0.009g at the site (Table D.3.8).

Western Mountain Province

The seismotectonic setting and major structural features of the Western Mountain Province are discussed above (see Section D.3.6).

Earthquake epicentral maps of the Colorado Plateau region show a heightened level of seismic activity possibly coinciding with the border zone along the contact with the Western Mountain Province, which is located roughly within about 30-km (19 miles) of the site. The ME magnitude for the Colorado Plateau, according to Kirkham and Rogers (1981), is 5.5 to 6.5, and for the Western Mountain Province is 6.5. Therefore, the ME associated with the border zone of the two provinces is assumed herein to have a magnitude of 6.5.

The maximum horizontal acceleration in rock expected at the site area, from a possible ME event having a magnitude of 6.5, occurring within 30 km (19 miles) of the site area, is 0.13g, as detailed in Table D.3.8.

Comparison of FE and remote source earthquakes

The estimated on-site accelerations from remote source earthquakes (Table D.3.8) are uniformly lower than the value of 0.21g calculated for the FE at a radial distance of 15 km. Therefore, site design parameters are not influenced by remote source earthquakes.

Recommended seismic design parameters

All mapped faults and lineaments within a 40-mile radius of the site were analyzed for seismic characteristics. The estimated ME and estimated on-site acceleration were calculated for each fault. The results of this analysis is presented in Table D.3.9.

Several mapped faults could produce larger accelerations at the site than the FE at a radius of 15 km (nine miles) if they are definitely tectonically capable. Field analysis of the potential design faults indicates that none of these faults are capable of tectonically induced movement. None of the faults with an estimated on-site acceleration in excess of 0.21g offset rock units younger than Tertiary age. The majority of these faults have offsets in units of Cretaceous and Pennsylvanian age.

Faults identified by Kirkham and Rogers (1981) as off-setting Quaternary sediments were examined in the field. Except for the Ridgway fault system, all displacement appears to be the result of collapse features in Quaternary volcanic flows. The fault in the Ridgway system may be active. Quaternary gravel deposits are offset on part of this fault, and the system is associated with historical earthquakes. The Ridgway system does not produce an on-site acceleration in excess of the design value of

0.21g. The graben fault of probable Quaternary age in the Piceance Basin does not yield a calculated on-site acceleration in excess of 0.21g.

On the basis of the seismotectonic analysis of faults within a 65-km (40-mile) radius of the Estes Gulch site, it is recommended that the floating earthquake (FE) be adapted as the design fault. This fault is assumed to occur at a radial distance of 15 km (nine miles) from the site. A design earthquake of magnitude (M_L) 6.2 occurring at this distance would produce a free-field, nonamplified, peak horizontal ground acceleration at the site of 0.21g.

Potential for on-site fault rupture

As discussed above, there are no indications of any capable faults in the immediate site area. The newly discovered fault that passes within a zone 500 to 800 feet from the toe of the proposed disposal cell is associated with the Laramide aged White River uplift. The closest published mapped faults, which are also Laramide structures, lie about about three miles from the site. These features were carefully examined during the site investigations and showed no indication of Quaternary movement.

Bedrock in the site area is partially overlain by Quaternary pediment alluvium and alluvial fan deposits. Field inspection of older fault traces overlain by Quaternary deposits within five miles of the Estes Gulch site revealed no offset or fault scarps. Geologic and geomorphic evidence indicates no evident potential for on-site fault rupture during the 1000-year design life.

Potential liquefaction hazard

A review of published earthquake reports by Youd and Hoose (1977), indicates that shallow, saturated, Holocene fluvial, deltic and eolian deposits and poorly compacted artificial sand fills have the highest susceptibility to liquefaction and subsequent ground failure. Holocene alluvial fan, alluvial plain, beach, terrace and playa deposits were found to be less susceptible. Pleistocene sand deposits are generally even less susceptible, and glacial till, clay rich and pre-Pleistocene deposits are usually immune to liquefaction. The degree of sorting, the degree of compaction during sedimentation or construction, and the grain-size distribution are major factors controlling liquefaction potential. The greater the sorting and the looser the packing, the greater the liquefaction potential. Most episodes of liquefaction have developed at relatively shallow depths (probably less than six feet) and in areas where the water table (free or perched) was located within a few meters of the ground surface.

The potential for liquefaction also depends on the degree of seismic shaking. The opportunity for ground failure in a given area is a function of the seismicity of the area and the rate of occurrence of earthquake ground motions of sufficient intensity to produce ground failure in susceptible materials. The maximum distance from a seismic source to potentially damaging ground failures as a function of earthquake magnitude was determined by Youd and Perkins (1978). Liquefaction is not likely to be produced by earthquakes of magnitudes less than about 5 or at a distance greater than 75 to 150 km (47 to 62 miles) from the hypocenter.

The on-site exploratory drilling performed by DOE representatives at the Estes Gulch site does not indicate the presence of any natural materials susceptible to liquefaction underlying the site. The lack of shallow ground water below the proposed site precludes the possibility of widespread saturated subsurface materials. Subsurface materials consist of clayey, sandy silt, and closely packed sand, gravel, and cobbles. These materials would not be considered as susceptible to liquefaction, especially in the absence of saturated conditions.

Reservoir-induced seismicity

Published studies of reservoir-induced seismicity include reports by Carder (1970; 1945), The National Academy of Sciences (1972), Judd (1974), Milne (1976), Gupta and Rastogi (1976), Stuart-Alexander and Mark (1976), Packer et al. (1979), and Meade (1982). A review of the previous literature by Meade (1982) indicates that the phenomenon occurs only where faults are in association with very deep reservoirs or reservoirs with very large storage capacity. Less than one percent of the world's reservoirs have been associated with macroearthquakes ($M_L \geq 3.0$) (Stuart-Alexander and Mark, 1976). The closest reservoir to the Estes Gulch site is Rifle Gap Reservoir. Figure D.3.3 shows that there is a Laramide age fault in the area behind the Grand Hogback where the reservoir is located. It lies about two miles from the site and has a normal surface area of about 0.5 square mile. The maximum depth is relatively shallow. The small size and shallow depth indicate that there would be no reservoir-induced seismicity associated with this impoundment, even at its maximum areal extent and depth.

There are no large reservoirs in the vicinity of the Estes Gulch site at the present time. The limited storage capacity and drainage area of other impoundments in the site area preclude the likelihood of their triggering seismic events. There is, therefore, no probability of reservoir-induced seismicity in the site area at the present time. Construction of future large reservoirs on the Colorado River or Government Creek cannot be ruled out. However, construction of dams would result in inundation of considerable areas of valuable agricultural and residential land, and does not appear to be likely during the 1000-year proposed design life.

Duration of strong earthquake ground motion

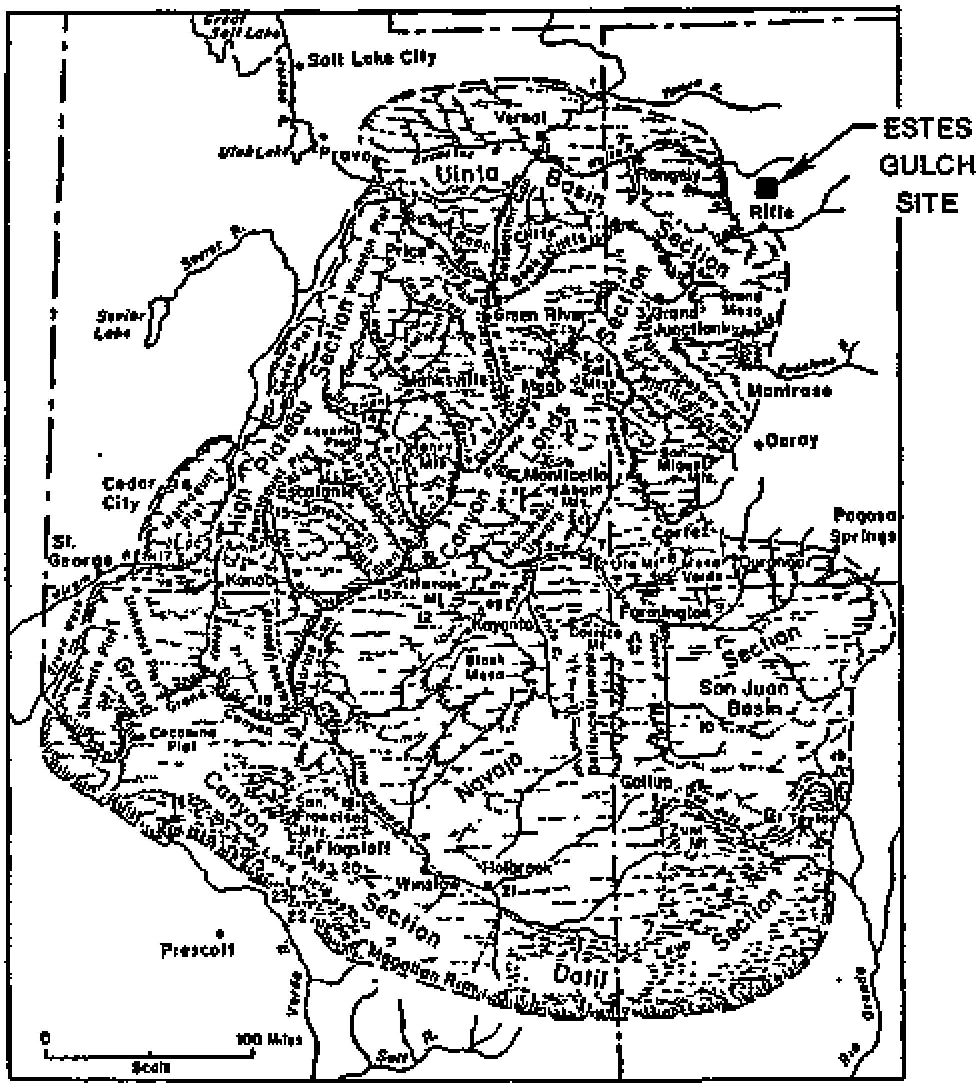
For UMTRA Project studies, duration is defined as the bracketed time interval in which the acceleration is greater than 0.05g at the site. The definition and method of estimating the duration for soil and rock follow the procedure of Krinitzsky and Chang (1977).

The proposed tailings pile at the Estes Gulch site will rest mainly on a bedrock layer of claystone and sandstone, once the overlying alluvial material has been removed. Duration values for bedrock faults within a five-mile radius of the site and for the FE are determined using the method for a rock site. Durations of strong earthquake ground motion for these two faults are given in Table D.3.10.

D.3.7.5 Fault compilation

A compilation of all mapped faults and earthquake epicenters within 65 km (40 miles) of the site is shown on Plate D.3.1. In addition, all suspected faults and lineaments derived from aerial photographic interpretation were compiled. All faults and lineaments were observed at least once during the low-sun-angle aerial reconnaissance. Most features within 20 km of the site were field checked during the ground reconnaissance phase of the study. Other features of regional significance outside this 20-km (12-mile) radius were also field checked. There were no capable faults within the 65-km radius of the Estes Gulch site that could produce on-site acceleration in excess of the design acceleration of 0.21g. Faults close to the site which were determined to have acceleration values over 0.21g (Table D.3.9) have no offset in rock units younger than Tertiary in age. These faults, therefore, are not considered capable, as defined for UMTRA Project studies.

Only one fault within the 65-km radius area of the site appears to be a capable structure. The graben system trending northwest in the Piceance Basin (Number 10 on Plate D.3.1) has been reported as the source area for a large earthquake in 1882 (McGuire et al., 1982). Field inspection of this graben revealed strong geomorphic features suggestive of late Quaternary, and possibly Holocene, movement on the south fault. Based on estimated maximum magnitude/distance relationships (Campbell, 1981) movement along the entire 11-mile length of this fault would result in an estimated on-site ground acceleration of 0.14g, well below the design value.



National Parks and Monuments

1. Dinosaur Nat. Mon.
2. Black Canyon of the Gunnison Nat. Mon.
3. Colorado Nat. Mon.
4. Arches Nat. Mon.
5. Canyonlands Nat. Park
6. Natural Bridges Nat. Mon.
7. Hovenweep Nat. Mon.
8. Mesaverde Nat. Park
9. Aztec Ruins Nat. Mon.
10. Chaco Canyon Nat. Mon.
11. Canyon de Chelly Nat. Mon.
12. Navajo Nat. Mon. (Betatakin and Kiet Seel)
13. Rainbow Bridge Nat. Mon.
14. Capitol Reef Nat. Mon.
15. Bryce Canyon Nat. Park
16. Cedar Breaks Nat. Mon.
17. Zion Nat. Park
18. Grand Canyon Nat. Park
19. Wupatki and Sunset Crater Nat. Mons.
20. Walnut Canyon Nat. Mon.
21. Petrified Forest and Painted Desert Nat. Mon.
22. Montezuma Castle Nat. Mon.
23. Tuzigoot Nat. Mon.

Escarpments at South End of High Plateaus

pc Pink Cliffs
wc White Cliffs
vc Vermilion Cliffs

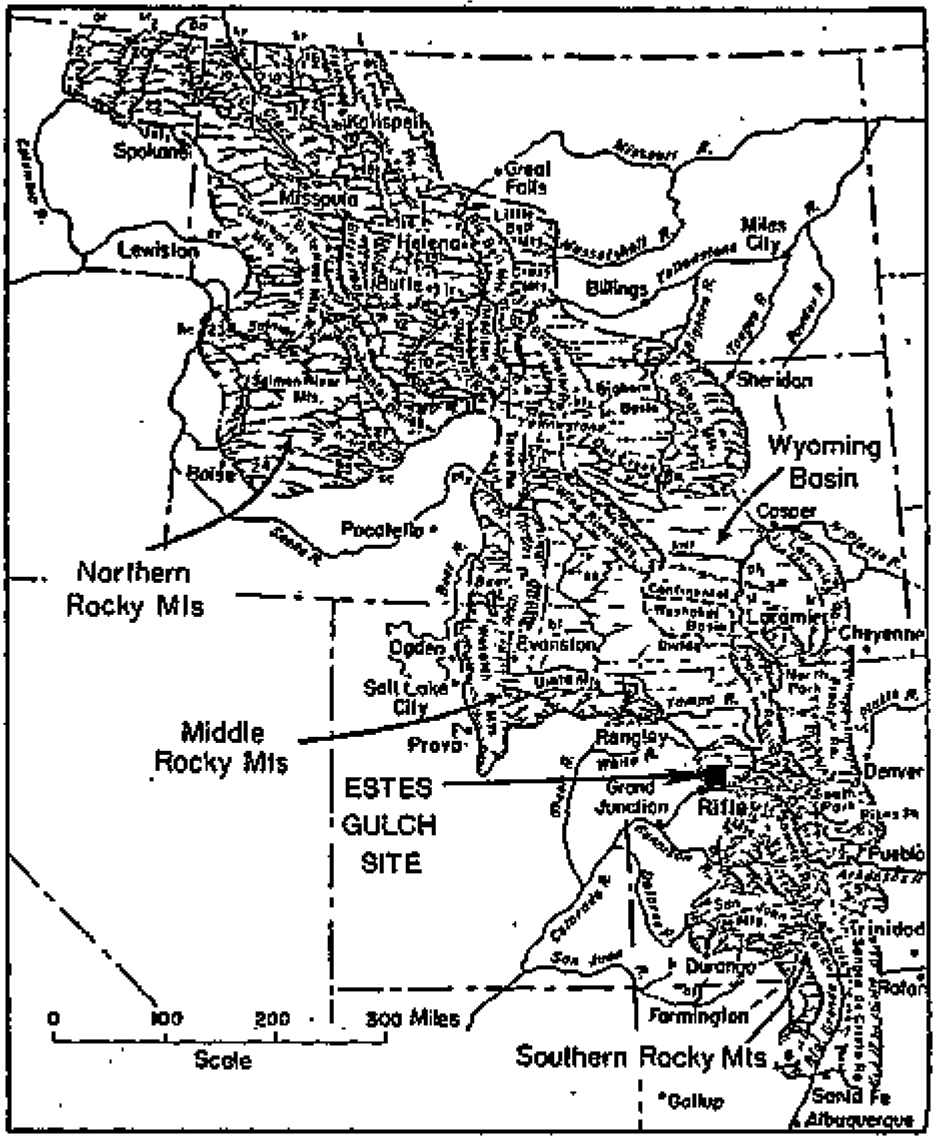
Other Prominent Features

wf Waterpocket Fold
er Elk Ridge
cr Comb Ridge
mv Monument Valley
ag Agathla Peak
sr Shiprock
cb Cabezon Peak

REF: HUNT, 1967.

(a) Colorado Plateau

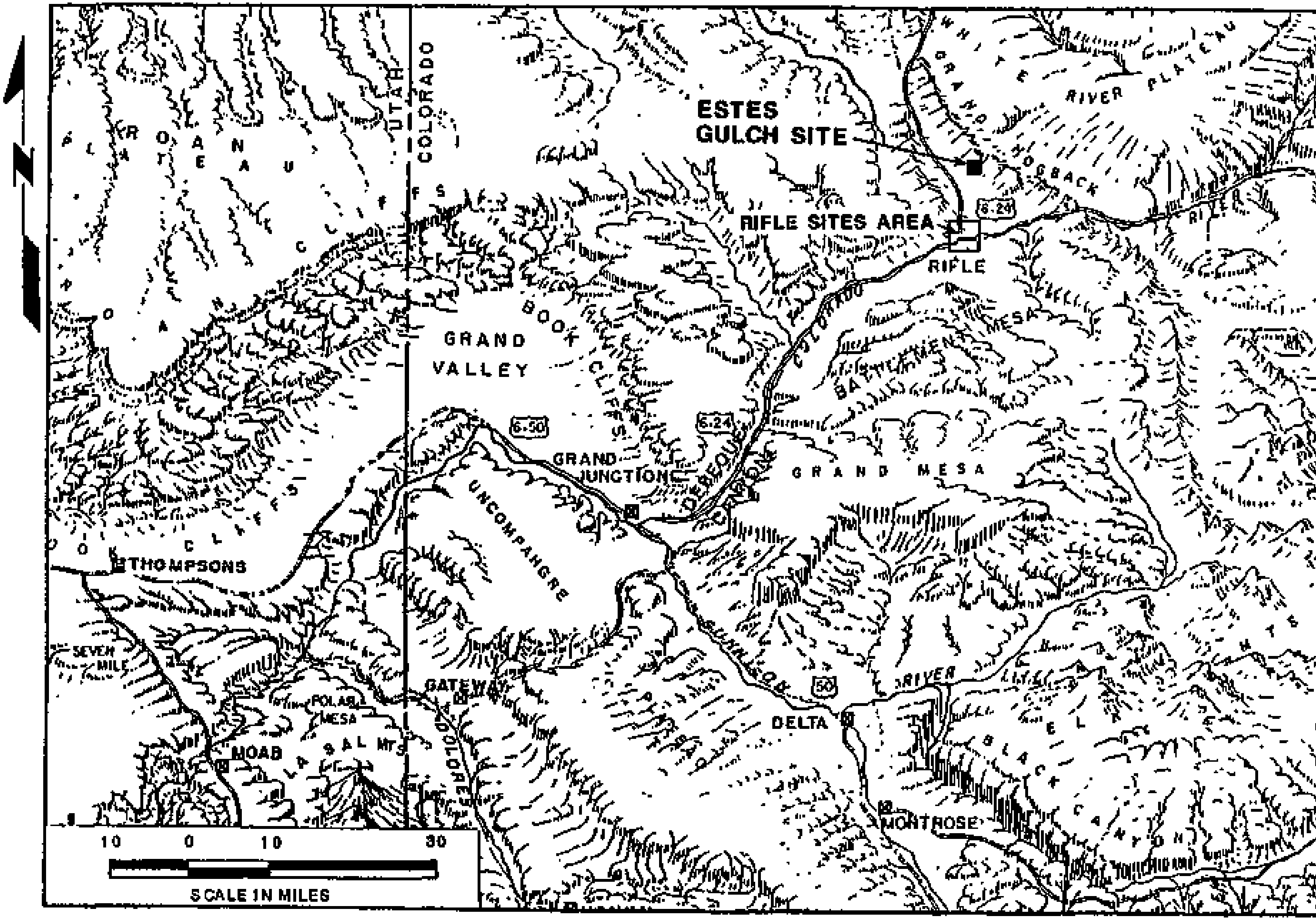
FIGURE D.3.1
PHYSIOGRAPHIC MAPS



REF: HUNT, 1967.

(b) Rocky Mountains and Wyoming Basin

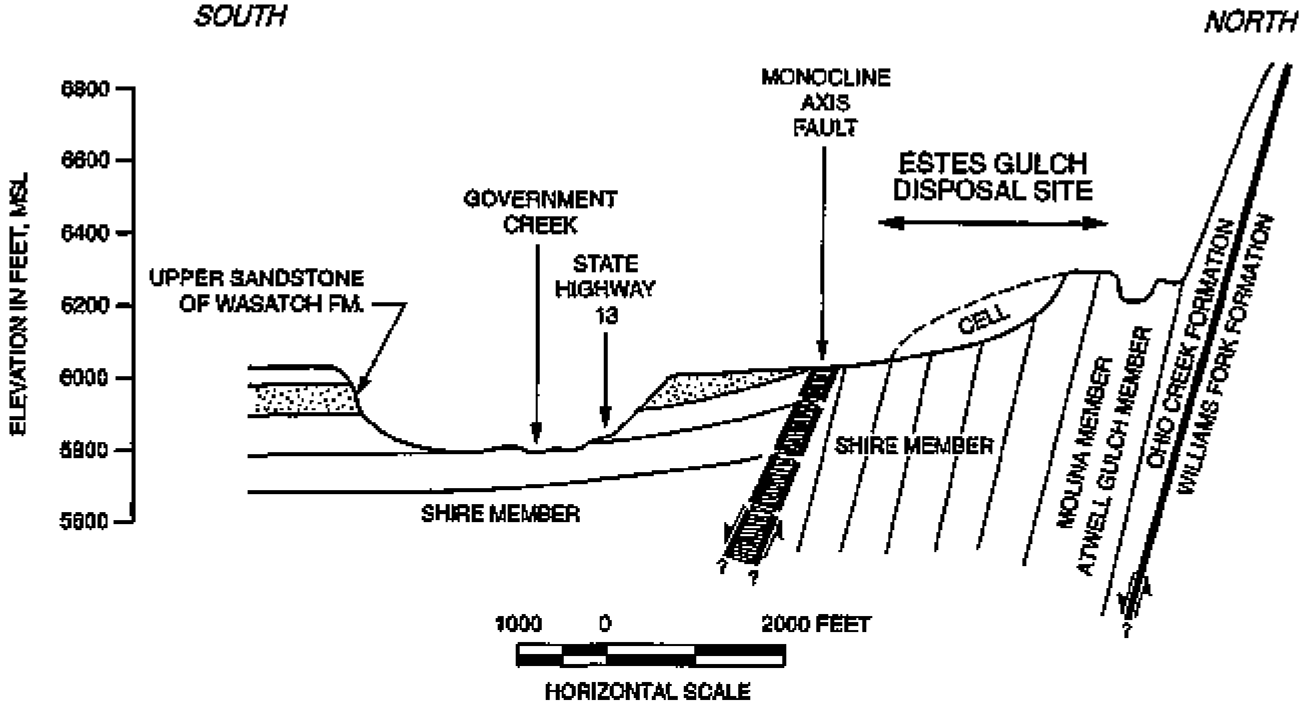
FIGURE D.3.1 (CONCLUDED)
PHYSIOGRAPHIC MAPS

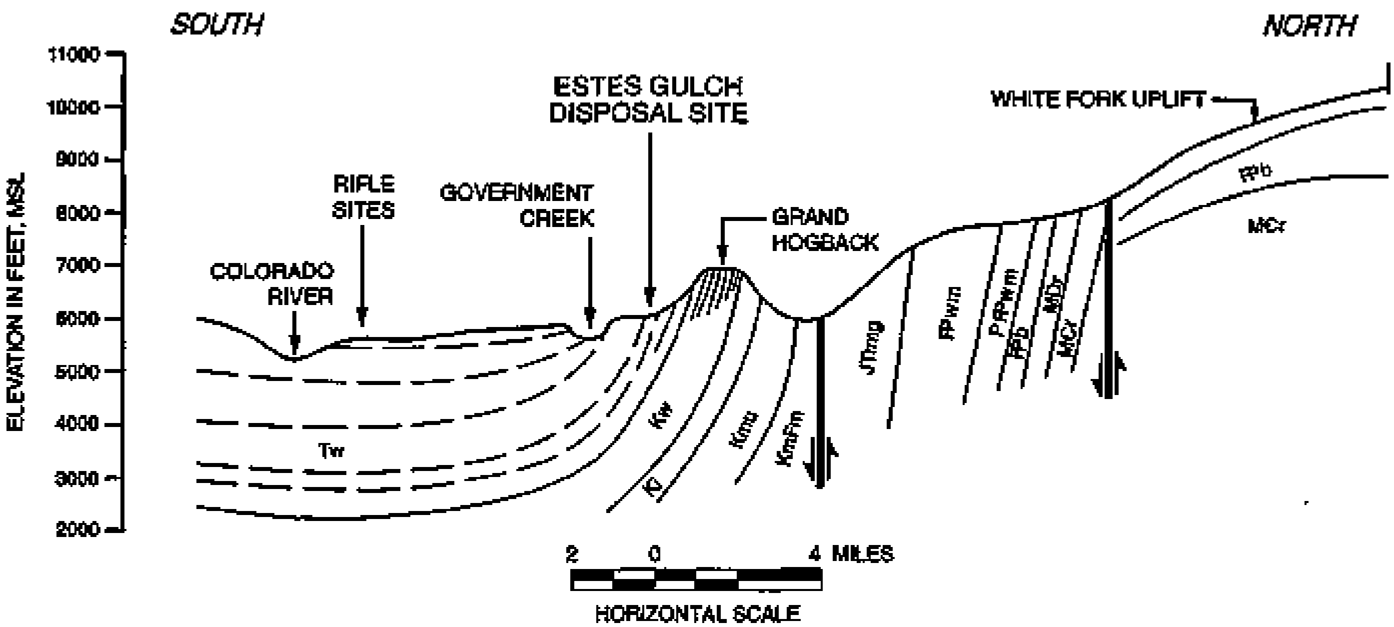


REF: AFTER COLORADO GEOLOGICAL SURVEY, 1982.

FIGURE D.3.2

PHYSIOGRAPHIC FEATURES OF THE GRAND JUNCTION-RIFLE AREA



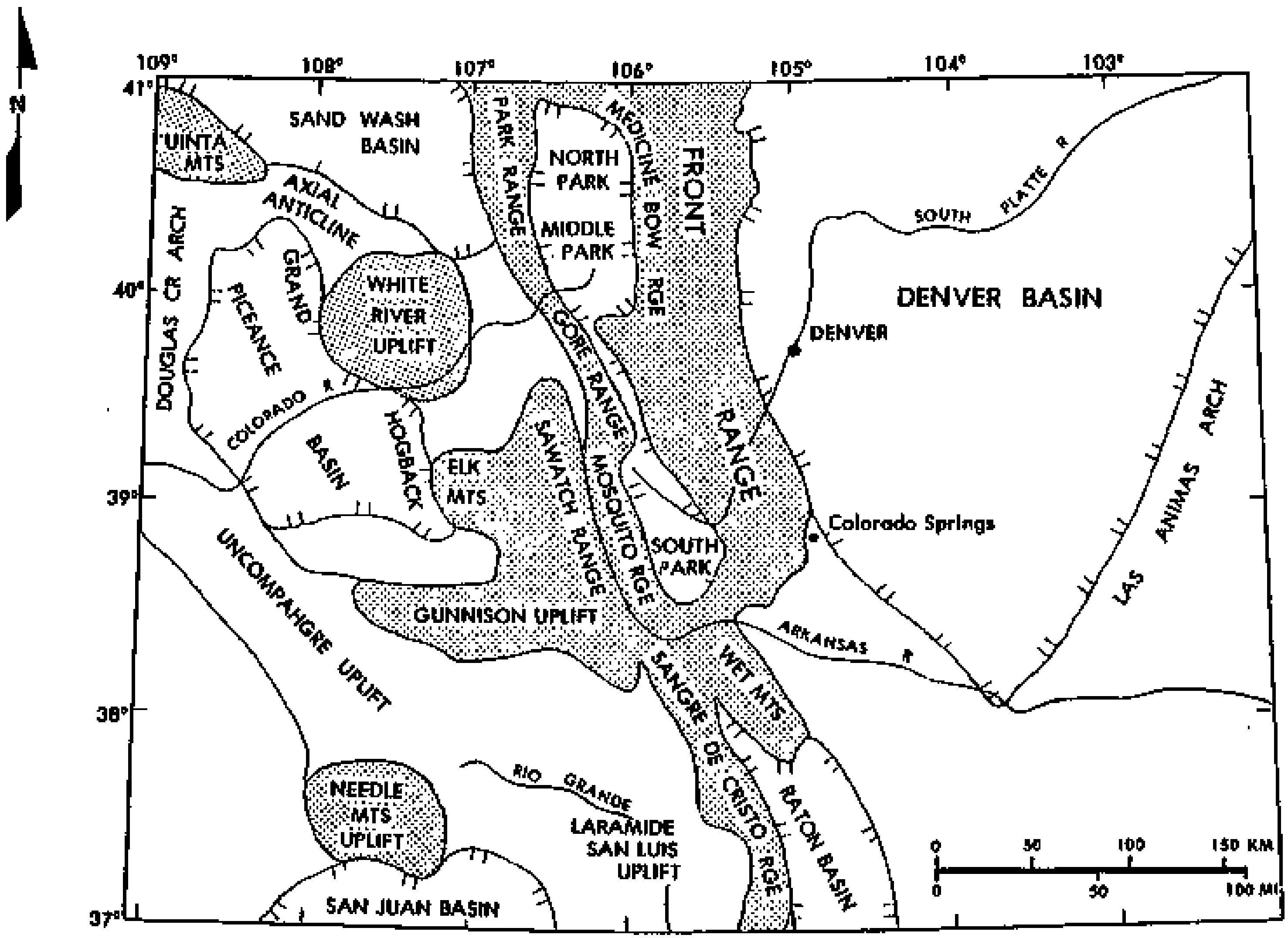


LEGEND

Tw	WASATCH FORMATION	PPwm	WEBER SANDSTONE AND MAROON FORMATION
Kw	WILLIAMS FORK FORMATION, MESAVERDE GROUP	PPm	MINTURN FORMATION
Ki	ILES FORMATION, MESAVERDE GROUP	PPb	BELDEN FORMATION
Kmu	UPPER UNIT OF MANCOS SHALE	MDr	MISSISSIPPIAN AND DEVONIAN ROCKS
KmFm	FRONTIER SANDSTONE AND MOWRY SHALE MEMBER OF MANCOS SHALE	MCr	MISSISSIPPIAN AND CAMBRIAN ROCKS
JTmrg	MORRISON, ENTRADA, AND GLEN CANYON FORMATIONS		FAULT/FRACTURE ZONE

D.3.3
GEOLOGIC CROSS SECTIONS, ESTES GULCH, COLORADO, SITE

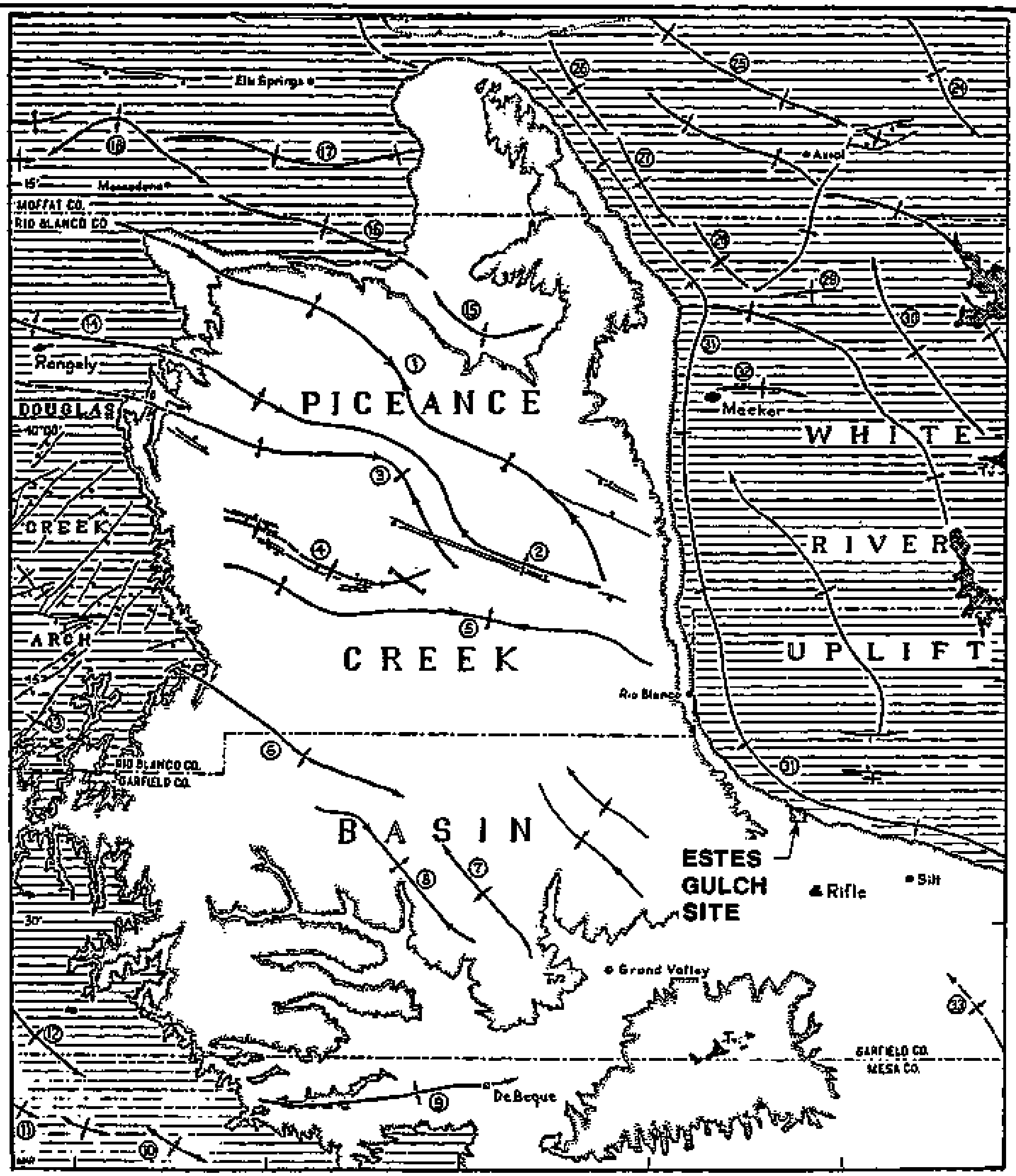
MAC: SITE/RFL/RAP95/GEO X-SEC



TOPOGRAPHICALLY PROMINENT UPLIFTS SHADED; BURIED, SUBSIDED OR TOPOGRAPHICALLY INCONSPICUOUS UPLIFTS AS LABELED.

REF: TWETO, 1980b.

FIGURE D.3.4
LARAMIDE UPLIFTS AND BASINS IN COLORADO



REF: MURRAY AND HAUN, 1974.

NOTE: ENCIRCLED NUMBERS ARE REFERENCED IN TABLE D.3.9.

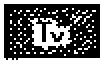
5 0 5 10

SCALE IN MILES

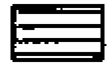
FIGURE D.3.5
TECTONIC MAP OF PICEANCE CREEK BASIN AND THE RIFLE, COLORADO AREA

EXPLANATION

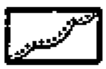
OUTCROP SYMBOLS



MIOCENE (?) AND PLIOCENE
VOLCANIC ROCKS



MESOZOIC AND PALEOZOIC ROCKS
(LOCALLY INCLUDES TERTIARY BROWNS PARK FORMATION)



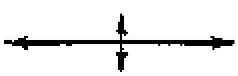
BASE OF EOCENE GREEN RIVER FORMATION

PRECAMBRIAN ROCKS

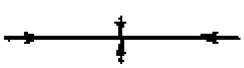
BASE OF EOCENE AND PALEOCENE
WASATCH FORMATION

STRUCTURE SYMBOLS

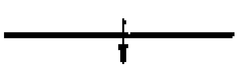
FOLDS



ANTICLINE
SHOWING DIRECTION OF PLUNGE

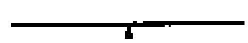


SYNCLINE
SHOWING DIRECTION OF PLUNGE



MONOCLINE

FAULTS



NORMAL FAULT
BAR AND BALL ON DOWNTHROWN SIDE

REVERSE FAULT
DOTTED WHERE CONCEALED OR INFERRED

FIGURE D.3.5 (CONCLUDED)
TECTONIC MAP OF PICEANCE CREEK BASIN AND THE RIFLE, COLORADO AREA

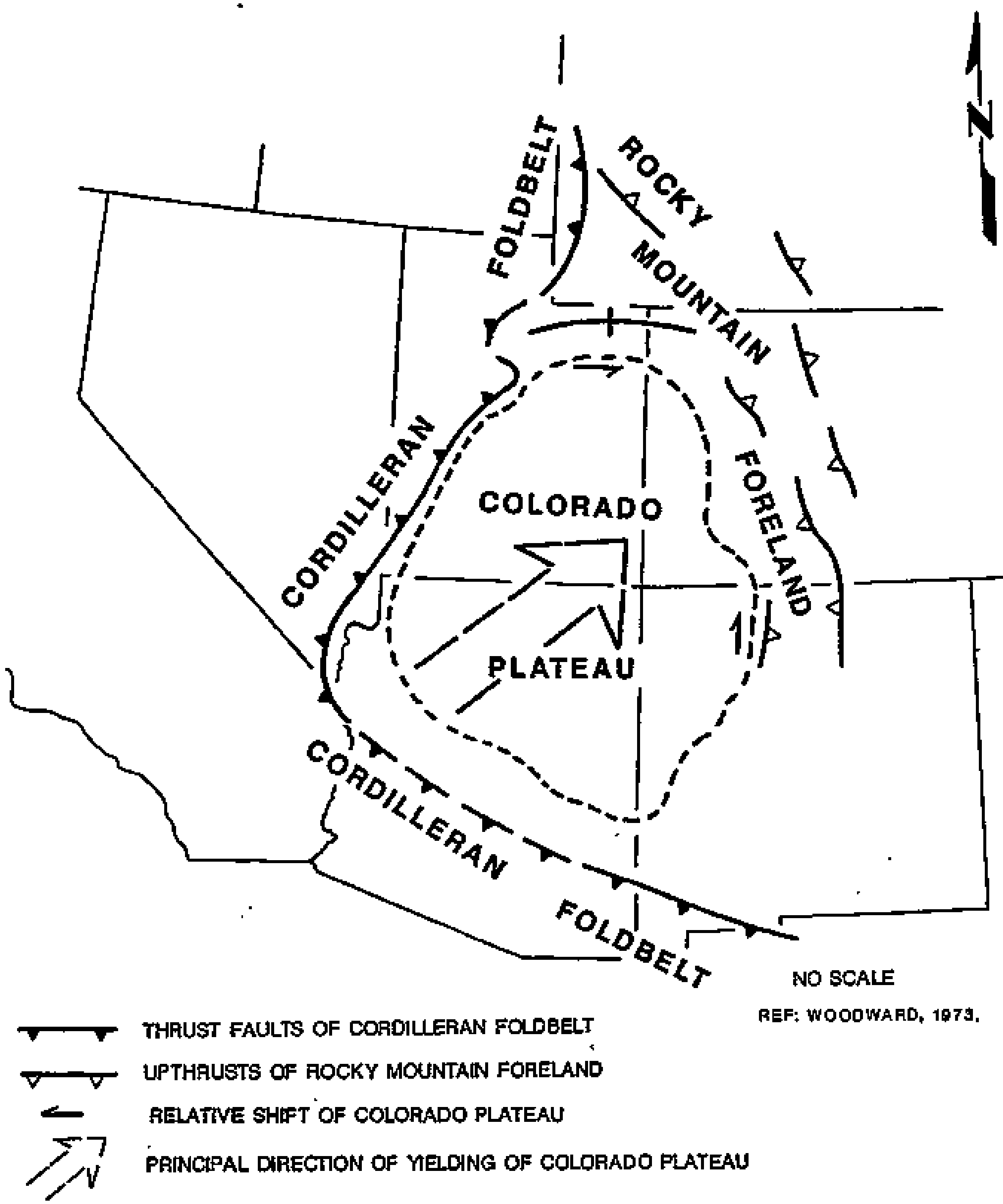
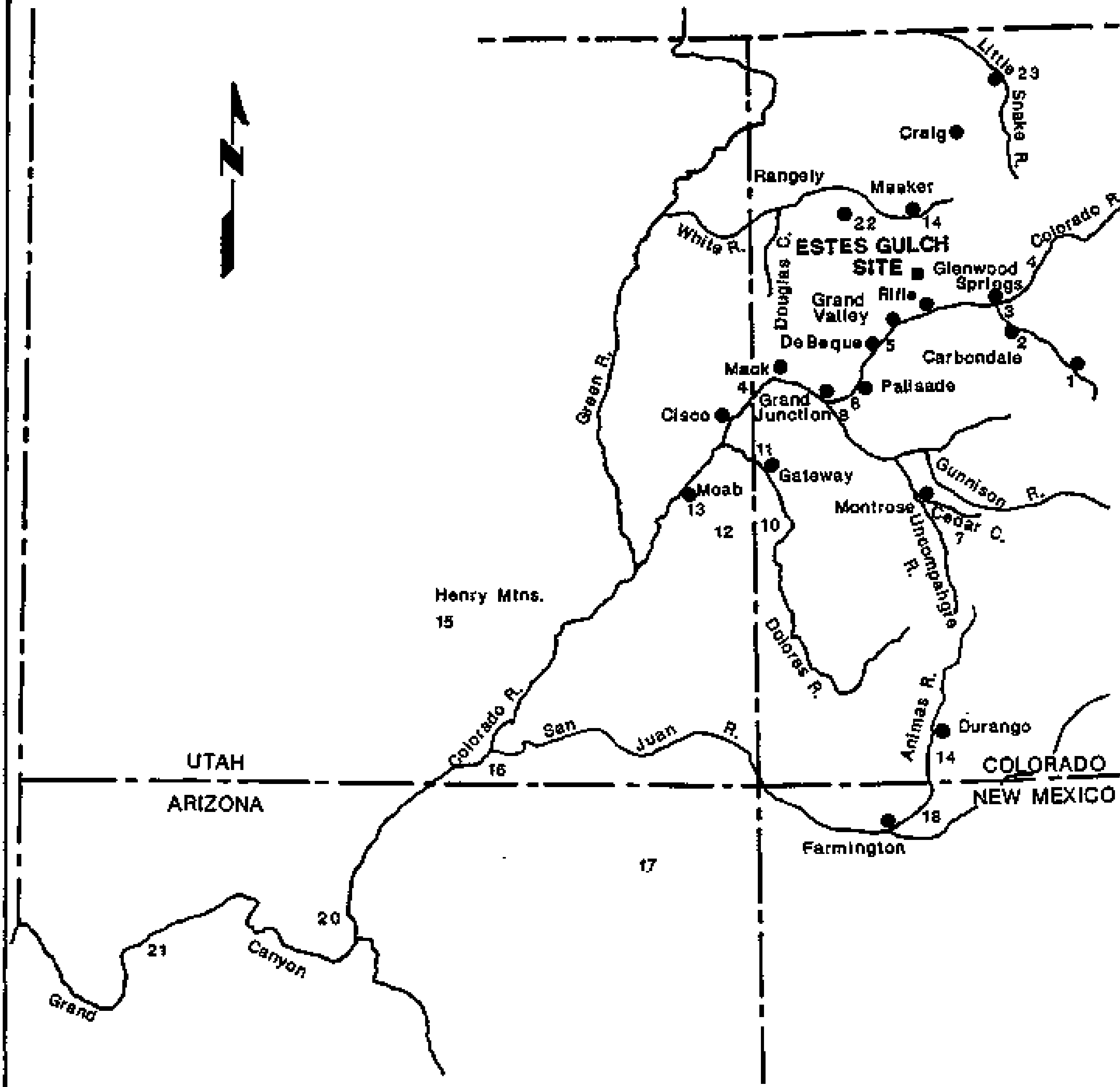


FIGURE D.3.6

GENERALIZED TECTONIC MAP SHOWING CORDILLERAN FOLDBELT, COLORADO PLATEAU & ROCKY MOUNTAIN FORELAND



NOTE: NUMBERS ARE REFERENCED IN TABLE D.3.2.

FIGURE D.3.7
LOCATION OF THE ESTES GULCH SITE AND SITES WHERE EROSION RATES HAVE BEEN ESTIMATED

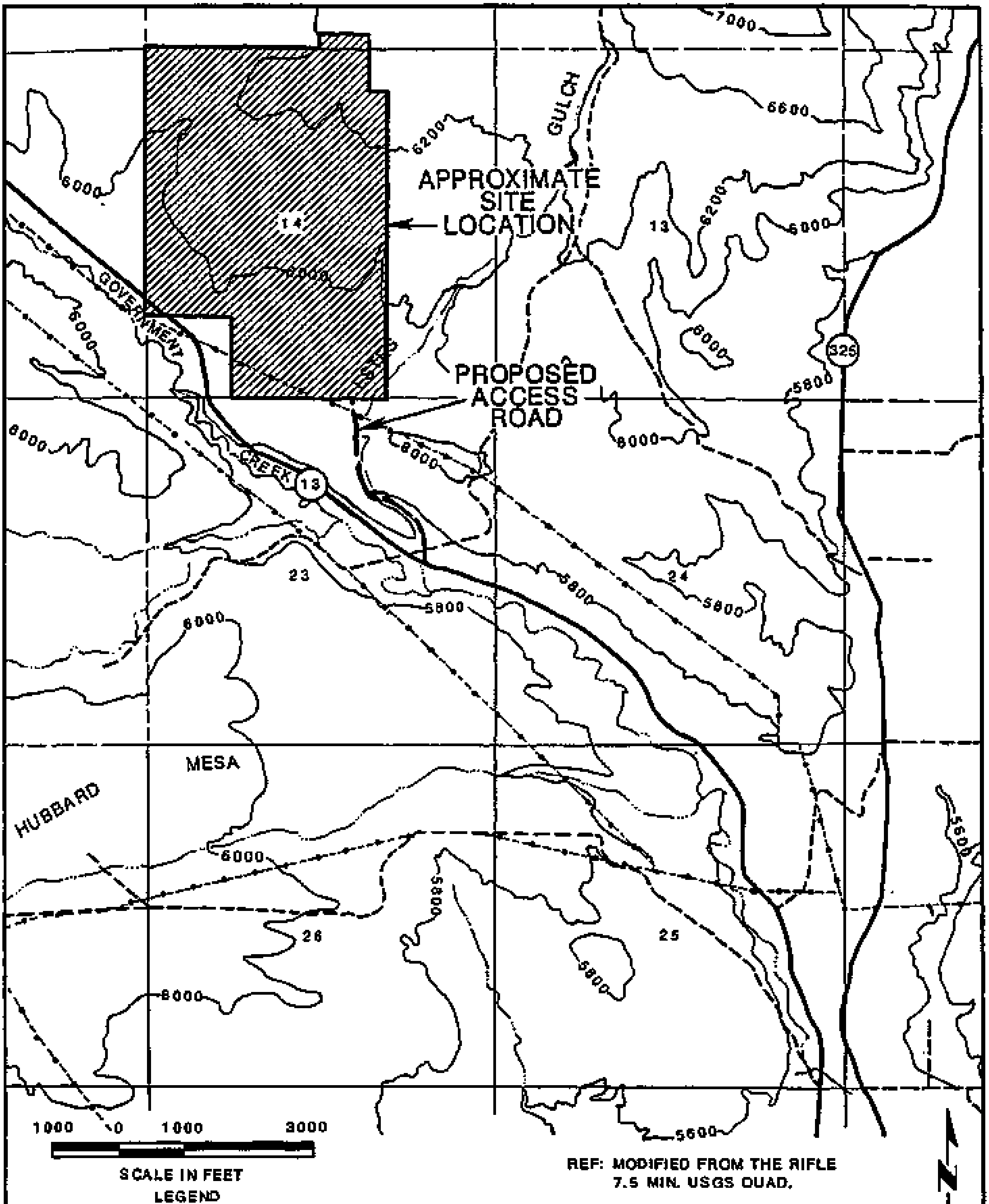


FIGURE D.3.8
TOPOGRAPHIC LOCATION MAP OF THE ESTES GULCH SITE AREA

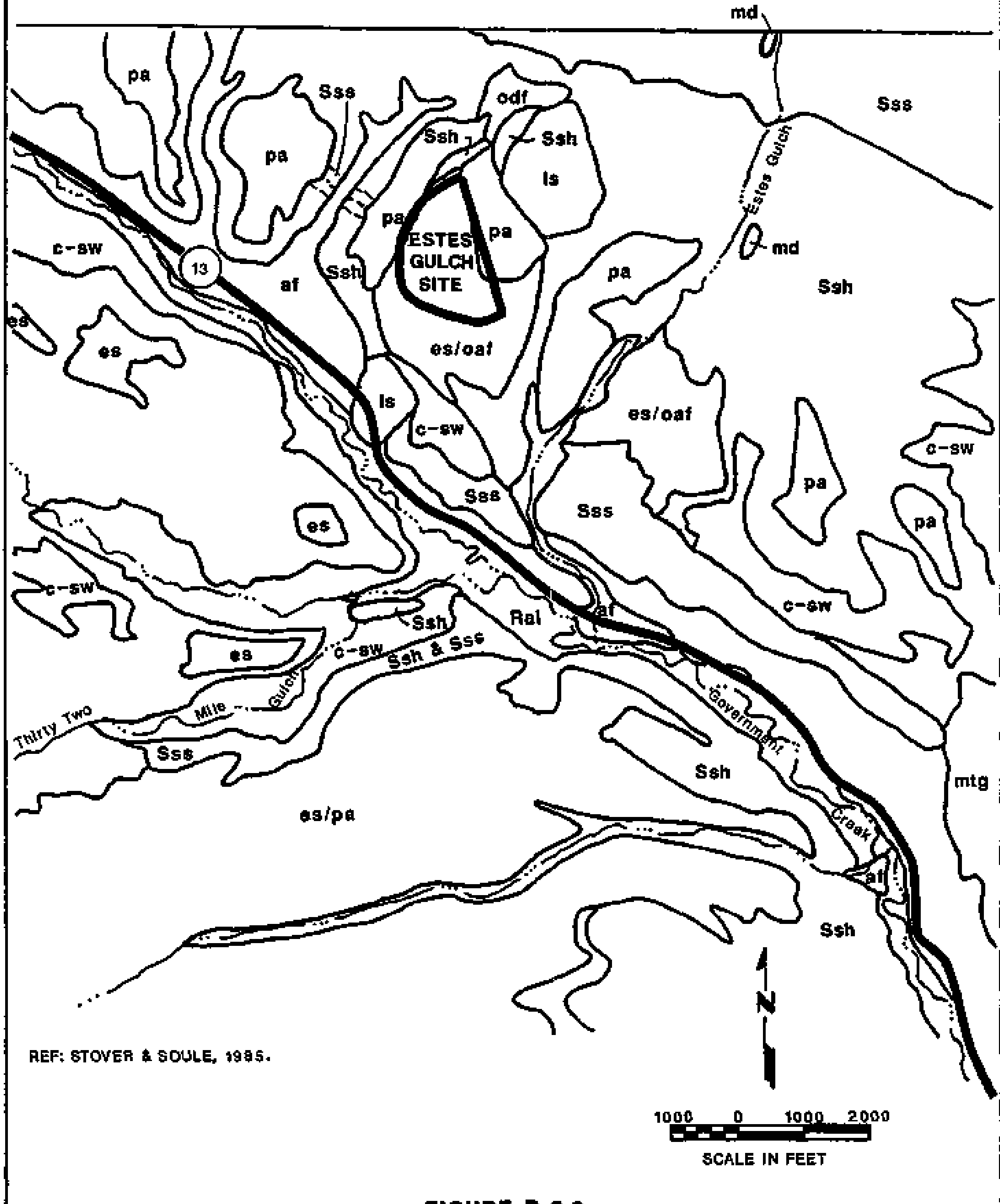


FIGURE D.3.9
SURFICIAL GEOLOGY OF
THE RIFLE-ESTES GULCH AREA

Explanation of Map Units for Figure D.3.9,
Surficial Geologic Map of Estes Gulch Area

Ral	Recent floodplain alluvium. Gravels composed of clay, silt, sand, and cobble-to-boulder size clasts in modern, active stream floodplains.
Mtg	Middle terrace gravel. Older terrace gravel deposits approximately 350 feet above the modern Colorado River.
Raf	Recent alluvial fan deposits. Materials accumulating on modern alluvial fans and composed of clay, sand, silt, subangular gravels, and boulders.
af	Alluvial fan deposits. Dissected fans; less active than recent alluvial fan deposits.
oaf	Old alluvial fan gravels. Deposits of older alluvium that are remnants of ancient alluvial fans.
pa	Pediment alluvium and slide debris. Deposits consisting of clay, sand, silt, and subrounded to angular cobbles and fragments of underlyng bedrock. Ranges from five to 25 feet thick and is veneered with thin deposits of eolian sand and silt mixed with fine-grained sheetwash deposits. May grade laterally into thicker alluvial fan gravels.
ls	Landslide or slump deposits. Slope failure deposits, including some areas of soil creep or earth flowage.
odf	Ancient debris flow deposit. Eroded and weathered gravelly deposits isolated at least 400 feet above the modern Colorado River Valley floor.
c-sw	Colluvium and slopewash deposits. Pebble to cobble size rock fragments in a sandy or clayey matrix deposited after downslope transport and sheetwash deposition of material from adjacent sideslopes.
es	Wind deposited sand and silt. Reddish-brown loess occurring as stable dunes and thin surface veneers. Mapped where greater than three feet thick, but thinner deposits occur in other areas.
MD	Mine dump. Deposits of waste rock debris from mining operations.
Sss	Bedded sedimentary rocks, sandstones predominate.
SSh	Bedded sedimentary rocks, shales predominate.

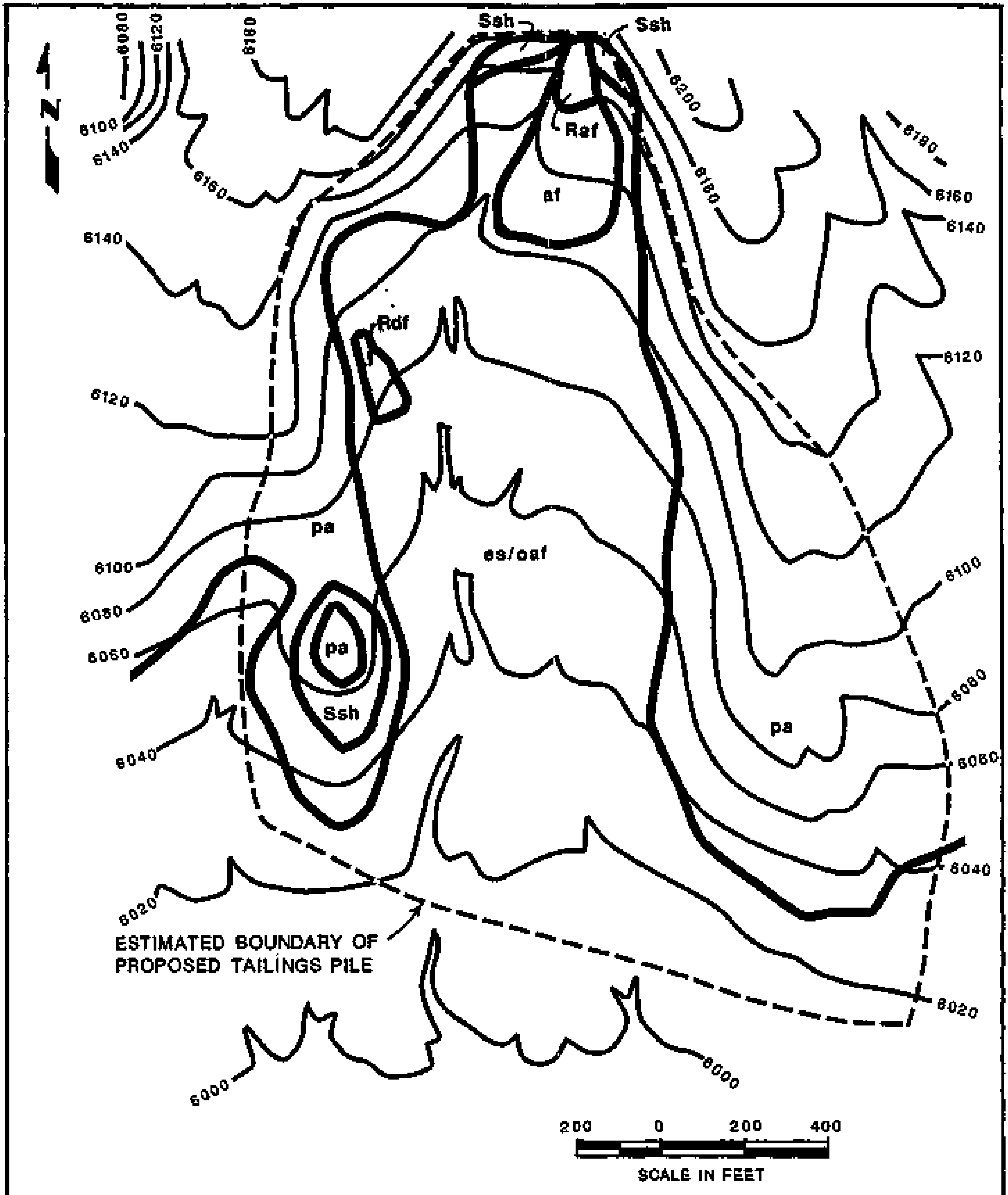


FIGURE D.3.10
SURFICIAL GEOLOGIC MAP OF THE ESTES GULCH SITE

EXPLANATION FOR MAP UNITS ON FIGURE D.3.10,
SURFICIAL GEOLOGIC MAP OF ESTES GULCH SITE

Raf Recent alluvial fan deposit. Materials accumulating on modern alluvial fans and composed of clay, silt, sand, subangular gravel, and boulders.

af Alluvial fan deposits. Dissected alluvial fans. Older and less active than recent alluvial fan deposits.

oaf Old alluvial fan deposits. Deposits of older alluvium that are remnants of ancient alluvial fans. Composed of clay, silt, sand, gravel, and boulders, with intermixed eolian deposits.

es Wind deposited silt and sand. Reddish-brown deposits occurring as thin surface veneers.

pa Pediment alluvium. Deposits consisting of clay, silt, sand, and subrounded to angular cobbles and fragments of underlying bedrock. Often capped by lag gravel deposits and eolian sand and silt. May grade laterally into alluvial fan gravels.

Rdf Recent debris flow deposits. Thin, localized accumulations of clay, silt, sand, and fine-grained gravel extending from steep, narrow gullies onto flat alluvial surfaces.

Ssh Wasatch Formation bedded sedimentary rocks; claystone with minor siltstone and sandstone.

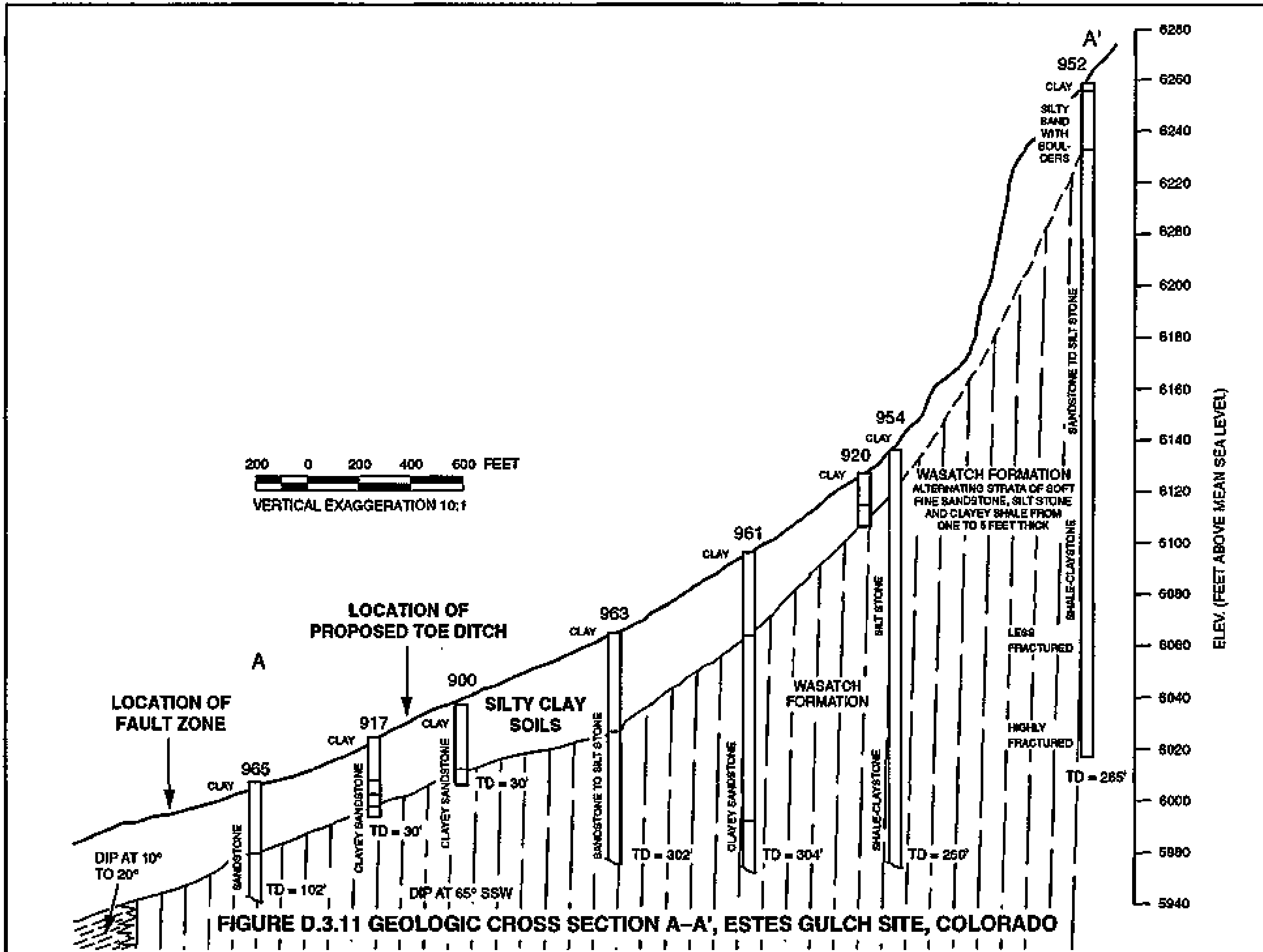


FIGURE D.3.11 GEOLOGIC CROSS SECTION A–A', ESTES GULCH SITE, COLORADO

MAC: SITE/RFURAP/ESTES/CSECA-A'

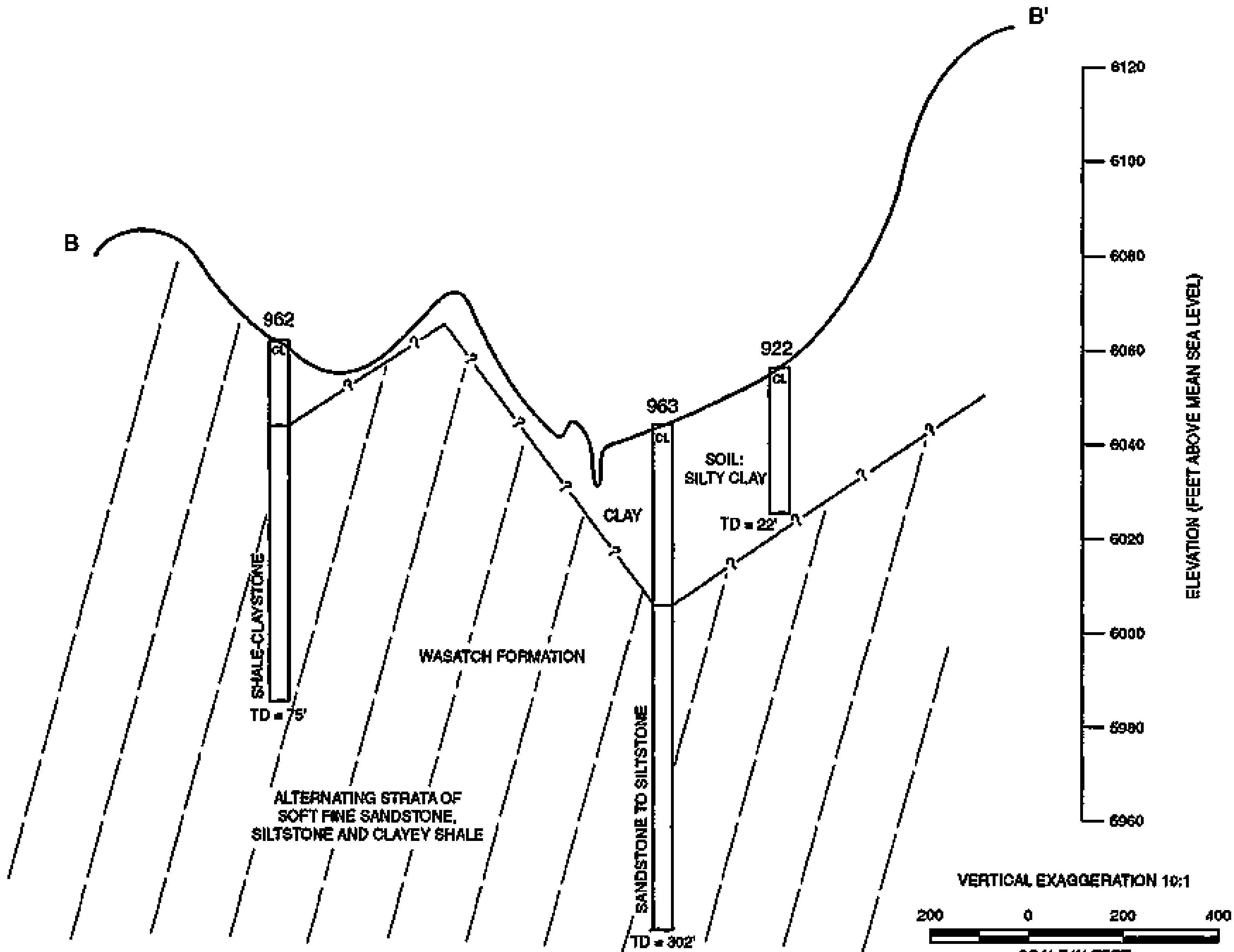
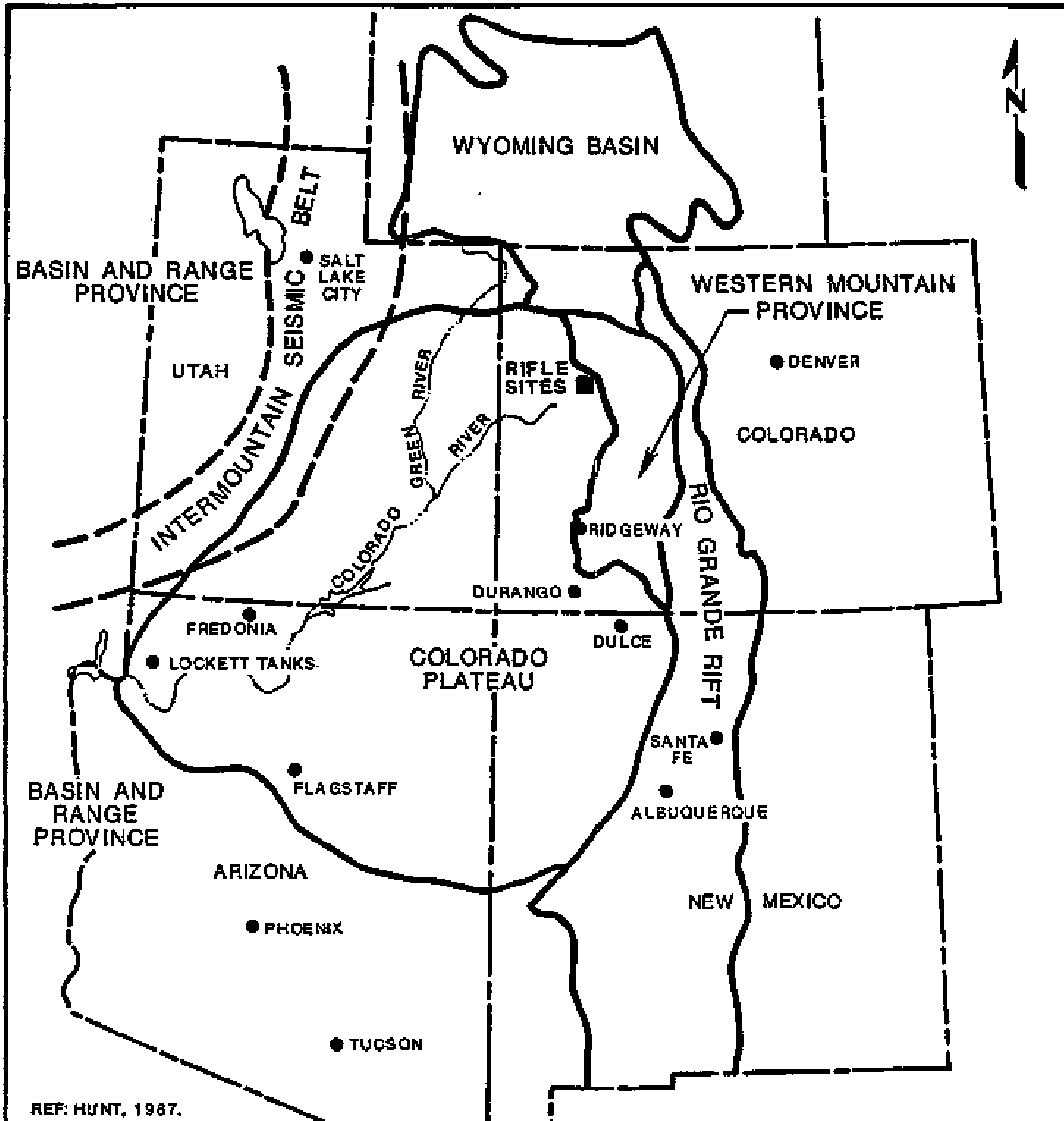


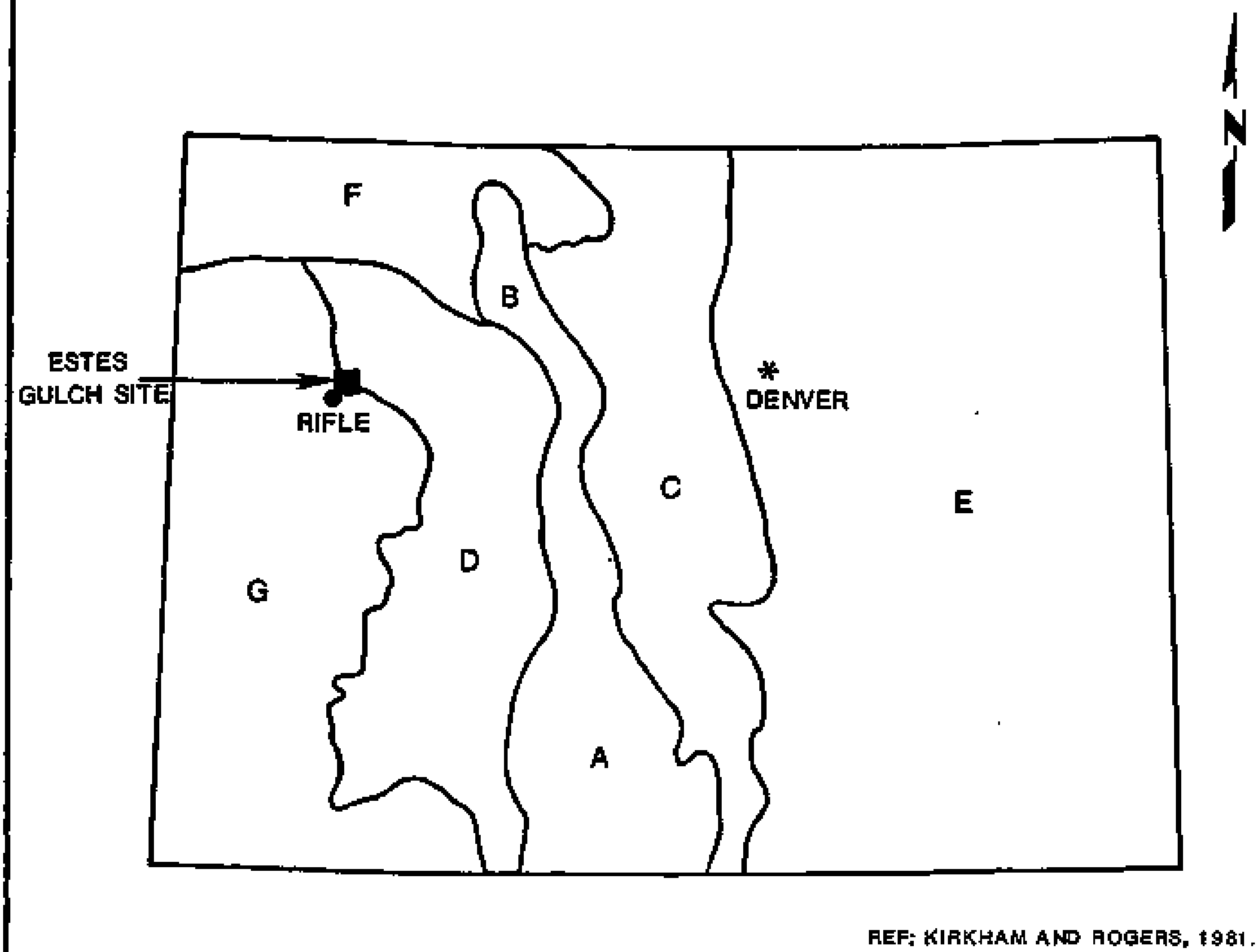
FIGURE D.3.12
GEOLOGIC CROSS SECTION B-B', ESTES GULCH SITE, COLORADO

MAC: SITE/RFL/RAP95/ESTESCSECB-B'



REF: HUNT, 1967.
KELLY AND CLINTON, 1960.
KIRKHAM AND ROGERS, 1981.
NEW MEXICO GEOLOGICAL SOCIETY, 1982.
MENGES AND PEARTHREE, 1982.
PEARTHREE ET AL., 1983.
SMITH AND SBAR, 1974.

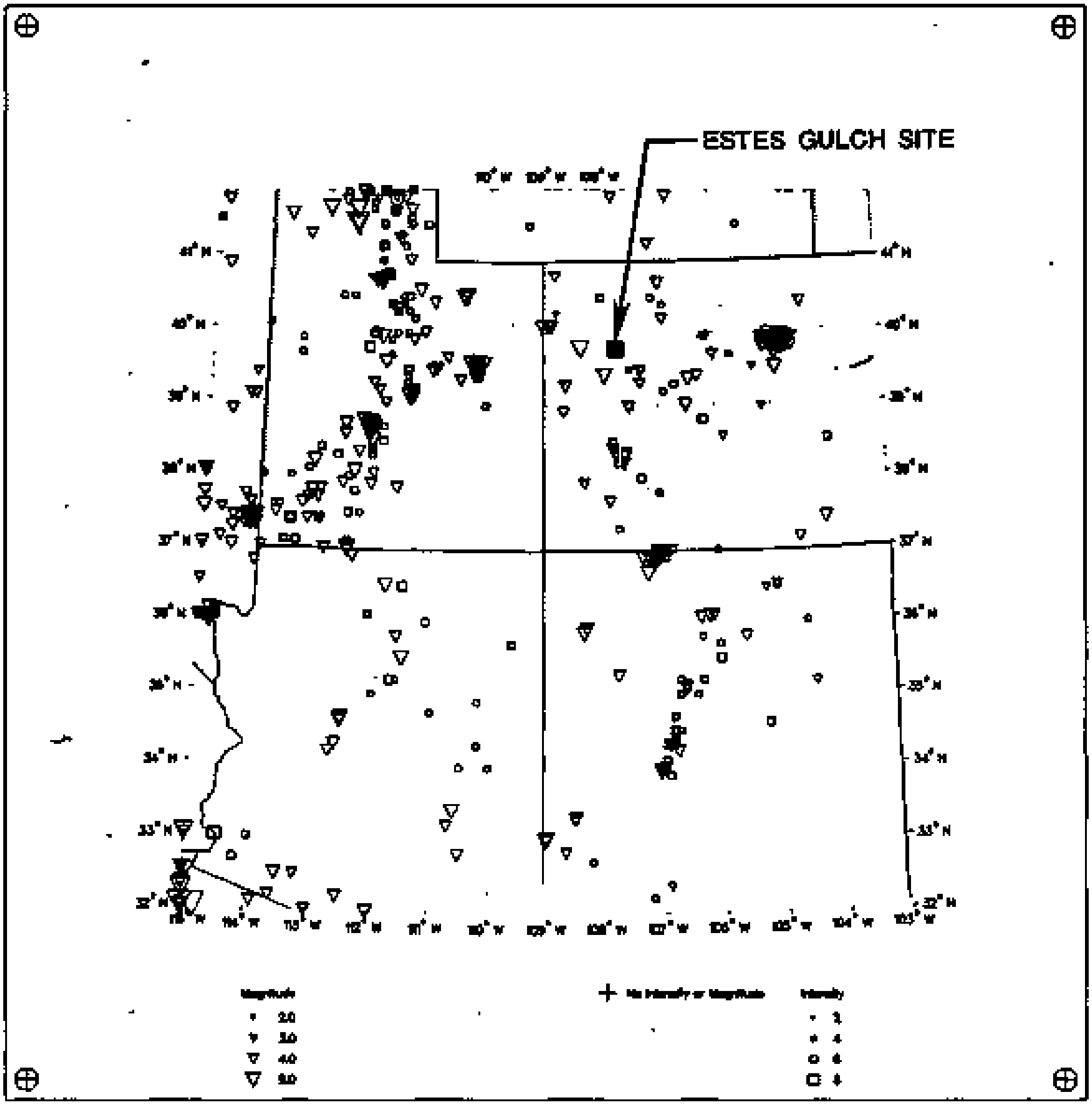
FIGURE D.3.13
REGIONAL SEISMOTECTONIC SETTING



LEGEND

A - SOUTHERN RIO GRANDE RIFT SUBPROVINCE
B - NORTHERN RIO GRANDE RIFT SUBPROVINCE
C - EASTERN MOUNTAIN PROVINCE
D - WESTERN MOUNTAIN PROVINCE
E - PLAINS PROVINCE
F - UINTA-ELKHEAD PROVINCE
G - COLORADO PLATEAU PROVINCE

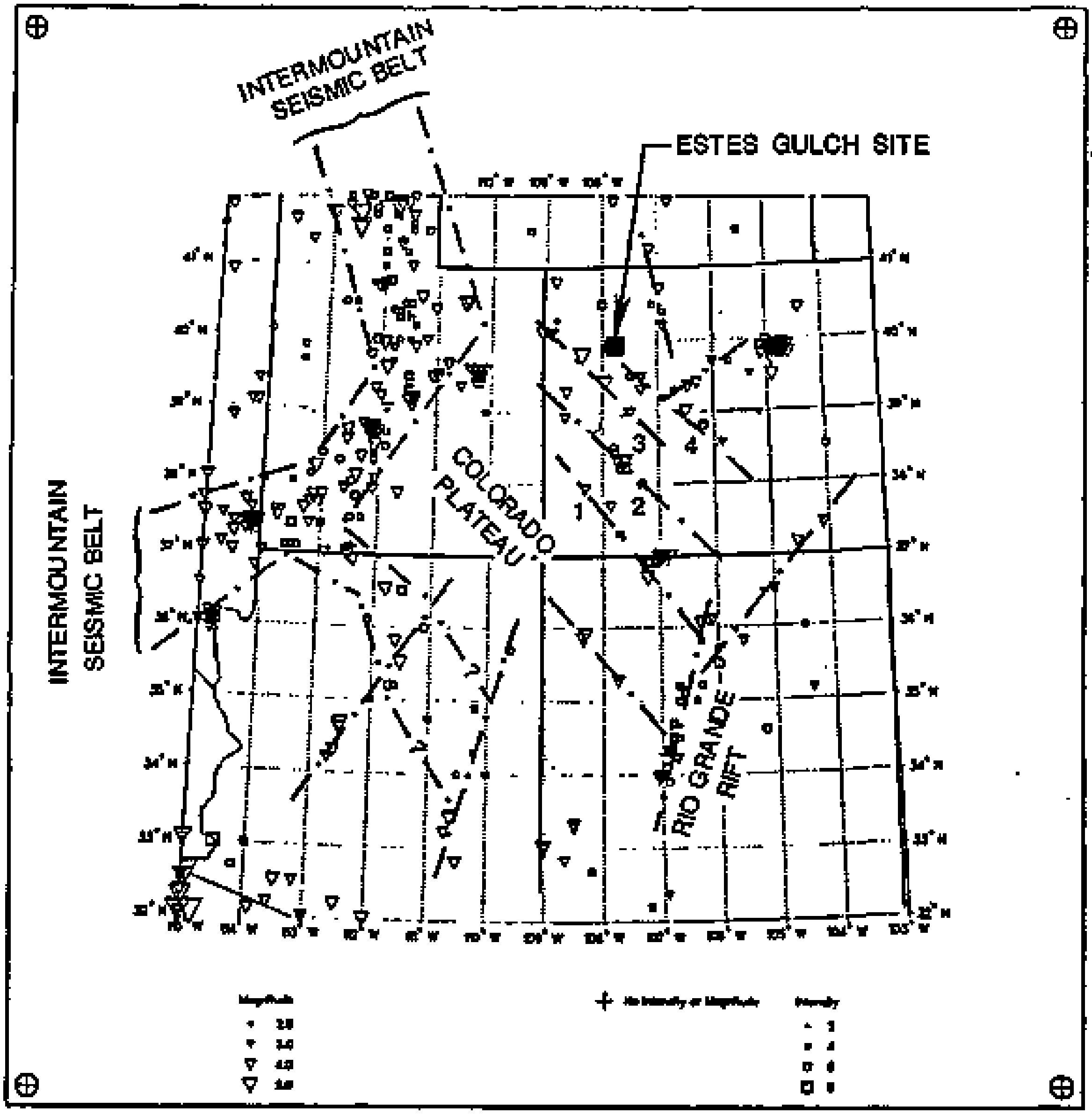
FIGURE D.3.14
SEISMOTECTONIC PROVINCES IN COLORADO



REF: NOAA/NGDC 1985 DATA FILE.

EPICENTRAL COMPILATION LIMITED TO EVENTS OF MAGNITUDE ≥4 AND/OR INTENSITY (MMI)≥V.

FIGURE D.3.15
MAP OF HISTORICAL AND INSTRUMENTALLY DETECTED EARTHQUAKE EPICENTERS OF THE SOUTHWESTERN UNITED STATES

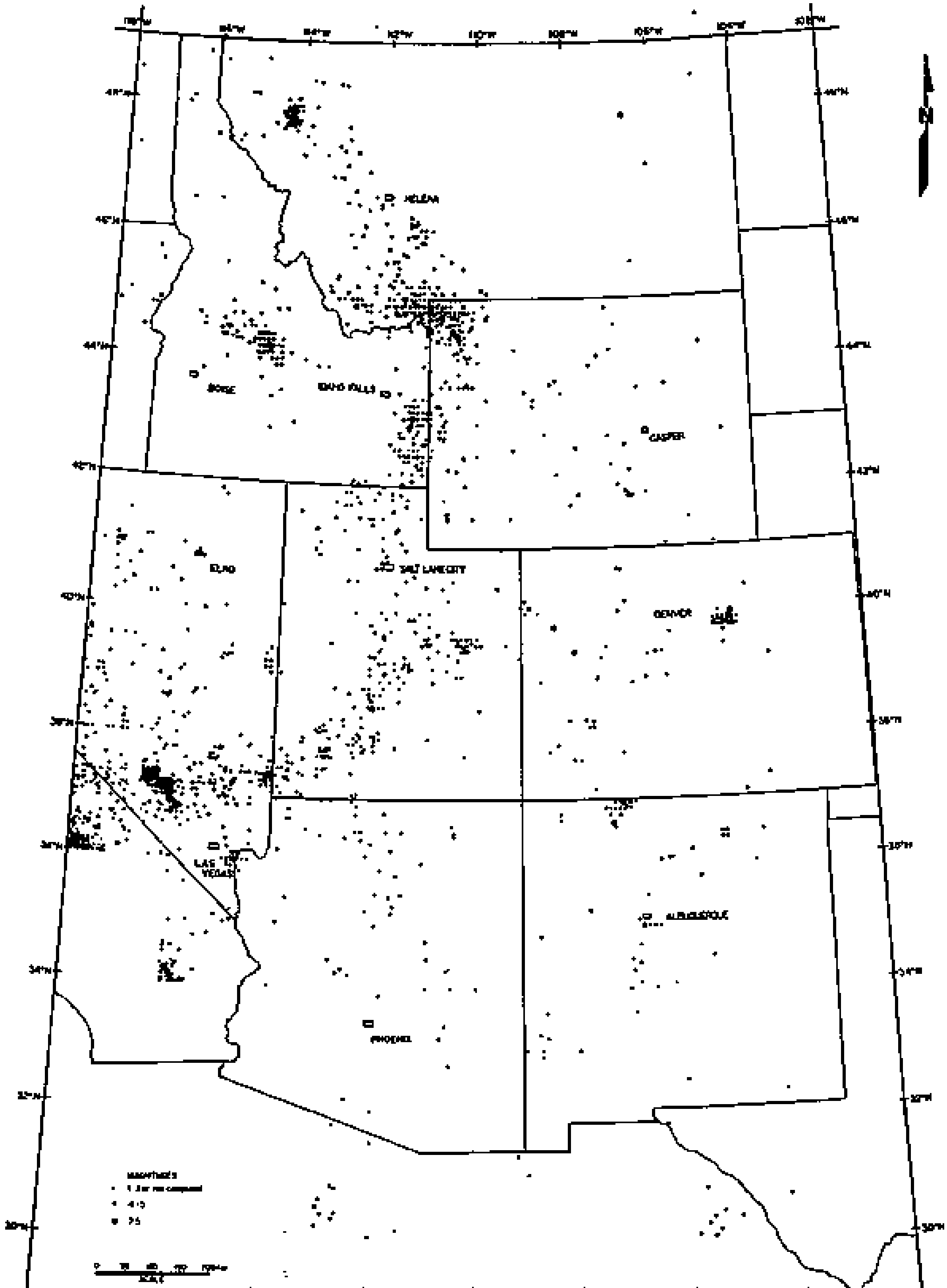


SOURCE: NOAA/NGDC 1985 EARTHQUAKE DATA FILE, LIMITED TO EARTHQUAKES OF I(MM) ≥ V AND/OR MAGNITUDE ≥ 3.0.

LINEAMENTS 1-4 DISCUSSED IN TEXT.

FIGURE D.3.16

COMPILATION OF HISTORICAL AND INSTRUMENTALLY DETECTED EARTHQUAKES OF COLORADO PLATEAU REGION, SHOWING APPARENT SEISMICITY TRENDS AND LOCATION OF ESTES GULCH SITE



COMPILED BY R.B. SMITH

FROM ARABASZ et al. 1979

FIGURE D.3.17
HISTORIC EARTHQUAKE EPICENTER MAP OF THE INTERMOUNTAIN SEISMIC BELT (~1850 – 1974)

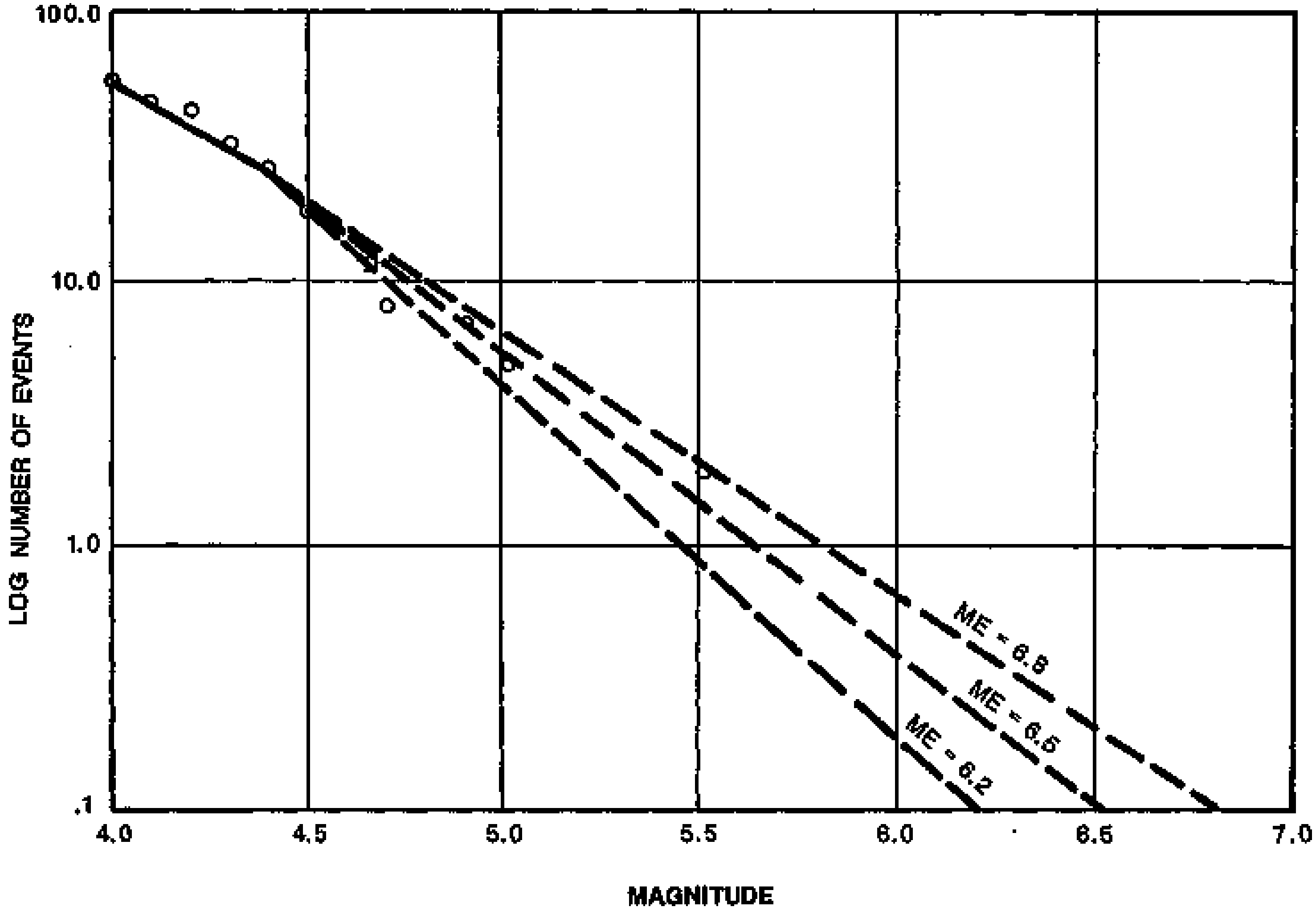


FIGURE D.3.18
GRAPHICAL DETERMINATION OF ME MAGNITUDE, COLORADO PLATEAU INTERIOR AND BORDER ZONES

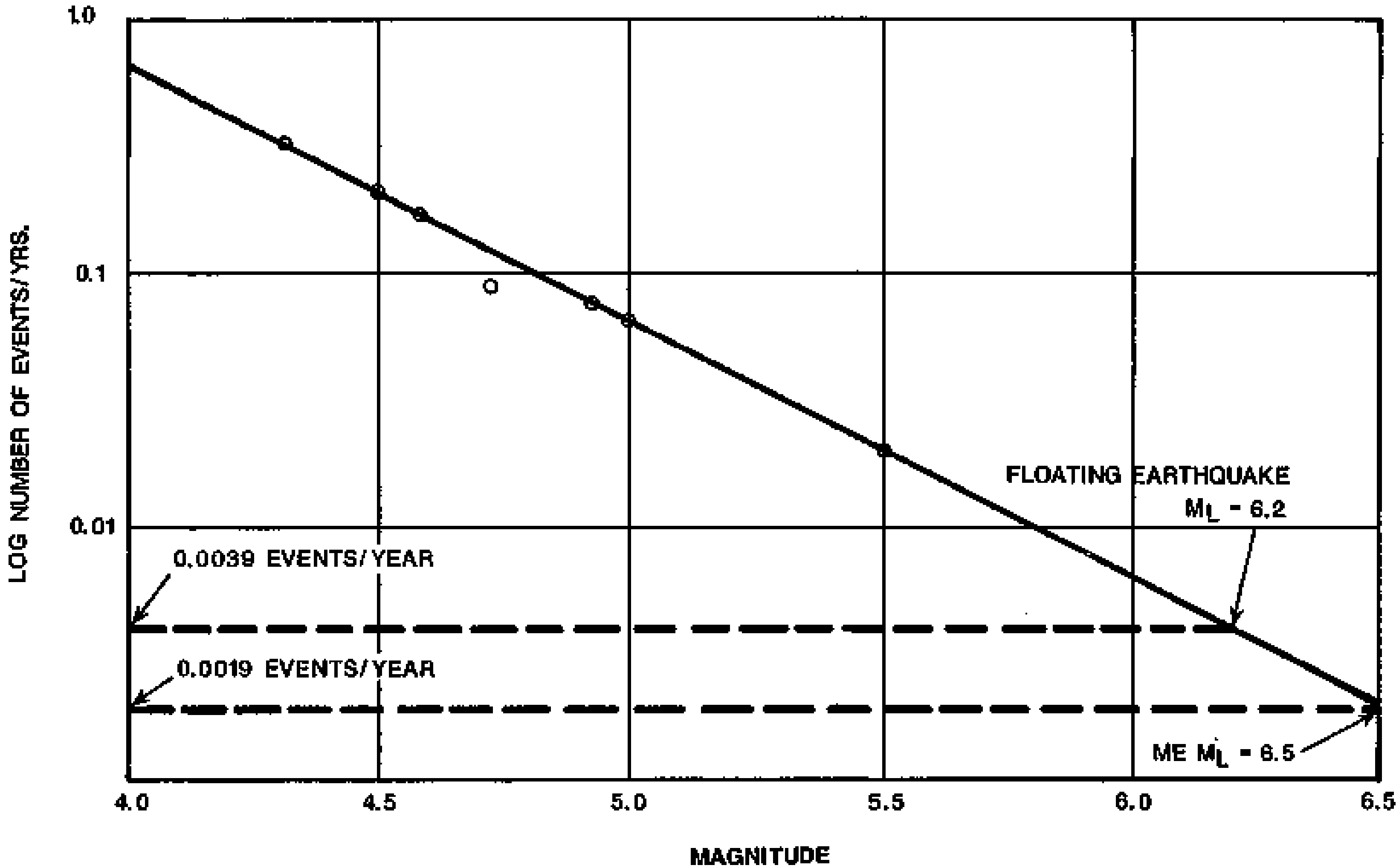


FIGURE D.3.19
GRAPHICAL DETERMINATION OF RECURRENCE INTERVALS FOR FLOATING EARTHQUAKE AND MAXIMUM EARTHQUAKE, COLORADO PLATEAU INTERIOR AND BORDER ZONE

Table D.3.1 Generalized stratigraphic section of the Grand Junction-Rifle area

Geologic age	Stratigraphic unit	Rock description	Approximate thickness in feet
Late Tertiary	Unnamed Basalt	Numerous dark gray, black, and dark red-brown basalt lava flows on Grand and Battlement Mesas. Form cliffs.	800
		unconformity	
Early Tertiary	Uinta Formation	Tan, gray, and buff siltstone, sandstone, and marlstone.	800-1000
	Green River Formation	Tan to gray calcareous siltstone with dark brownish gray kerogen- rich beds (oil shale). Forms steep slopes and cliffs.	1000-3000
Estes Gulch Site	Wasatch Formation and Ohio Creek Conglomerate	Variegated sandstone, siltstone, shale, mudstone, conglomerate. Forms benches and slopes.	300-5000
		unconformity	
Late Cretaceous	Mesaverde Group	Buff colored sandstones and siltstones with coal beds. Forms cliffs.	1000-5000
	Mancos Shale	Gray and black shale with thin beds of sandstone and limestone. Forms slopes and valley floors.	3000-6000
	Dakota Sandstone	Sandstone, coaly shale, conglomerate. Forms benches and slopes.	100-225
		unconformity	
Early Cretaceous	Burro Canyon Formation	Green siltstone, shale, sand- stone, conglomerate. Forms benches and slopes.	10-225
	Summerville Formation	Red and green colored siltstone, mudstone, and thin sandstones. Forms slopes.	40-60
Middle Jurassic	Entrada Sandstone	White and salmon-red quartz sandstone. Slick Rock member forms cliffs.	75-300

Table D.3.1 Generalized stratigraphic section of the Grand Junction-Rifle area (Concluded)

Geologic age	Stratigraphic unit	Rock description	Approximate thickness in feet
		unconformity	
Late Triassic	Kayenta Formation	Red and purple siltstone, shale, sandstone, and conglomerate. Forms bench between cliffs.	0-200
Late Triassic	Wingate Sandstone	Buff and light red sandstone, cross-bedded. Forms steep cliffs.	300-400
	Chinle Formation	Red siltstone, shale, limestone, and conglomerate. Forms steep slopes at foot of cliffs.	80-120
		unconformity	
Precambrian Proterozoic Y and X	Unnamed	Gneiss, schist, granite, and pegmatite dikes. Forms floors of canyons in Uncompahgre Plateau.	unknown

Ref. CGS, 1982.

Table D.3.2 Long-term average incision rates in the northeastern Colorado Plateau and adjacent areas

Site on Figure D.3.7	Location	Basis for calculation	Estimated incision (ft)	Time interval (10^6 yrs)	Calculated incision rate (ft/10^3 yrs)
Gunnison River basin above Grand Junction, CO:					
7	Cedar Creek near Montrose, CO	Lava Creek B ash at several sites above channel (Izett and Wilcox, 1982)	215-<420	0-0.62	0.35-<0.68
8	Gunnison River near Grand Mesa, CO	Channel cutting since extrusion of basalt of Grand Mesa; incision time from Larson et al. (1975)	5200-5300	0-10	0.52-0.53
Colorado River basin above Grand Junction, CO:					
2	Roaring Fork River near Carbondale, CO	Lava Creek B ash above channel (Piety, 1981; Izett and Wilcox, 1982)	320	0-0.62	0.52
1	Roaring Fork River near Aspen, CO	Basalt flow above river (Larson et al., 1975)	980	0-1.5	0.66
	Roaring Fork River, Aspen to Glenwood Springs, CO	Relative heights above channel of 1.5 m.y. basalt near Aspen (site 1) and 8 m.y. basalt near Glenwood Springs (site 3) (Larson et al., 1975)	minimal	1.5-8	<0.1?
3	Colorado and Roaring Fork Rivers near Glenwood Springs, CO	Two basalt flows above channel (Larson et al., 1975)	980 1970 2950-2980	0-8 8-10 0-10	0.13 0.98 0.30-0.32
4	Colorado River near east end of Glenwood Canyon, CO	Lava Creek B ash above channel (Izett and Wilcox, 1982)	300	0-0.62	0.48

Table D.3.2 Long-term average incision rates in the northeastern Colorado Plateau and adjacent areas (Continued)

Site on Figure D.3.7	Location	Basis for calculation	Estimated incision (ft)	Time interval (10^6 yrs)	Calculated incision rate (ft/10^3 yrs)
6	Colorado River at Palisade, CO	Ancestral Colorado River (?) gravel overlying basalt of Grand Mesa (Yeend, 1969); incision timing from Larson et al. (1975)	5280	0-10	0.53
Other parts of Colorado River basin:					
14	White River near Meeker, CO	Lava Creek B ash above channel (Whitney et al., 1983); age from Izett and Wilcox (1982)	300	0-0.62	0.48
11	Dolores River near Gateway, CO	Late Pliocene - early Pleistocene gravels above channel (Hunt, 1969)	200	0-1.5 to 0-3.0 (estimated)	0.07-0.13
12	Pack Creek near Moab, UT	Alluvium with reversed magnetic polarity above channel (Woodward-Clyde Consultants, 1982); reversal age from Johnson (1982)	850	0->0.79	<1.08
13	Mill Creek near Moab, UT	Alluvium with reversed magnetic polarity above channel (Woodward-Clyde Consultants, 1982); reversal age from Johnson (1982)	550	0->0.79	<0.70
10	Paradox Valley, CO	Bishop ash above Paradox Creek (Cater, 1970)	280	0-0.7	0.40
16	Colorado River at San Juan River, UT	Channel downcutting estimated from series of erosion surfaces, oldest overlain by dated basalt (Stokes, 1973; Damon et al., 1974)	4000	0->9.4	<0.43

Table D.3.2 Long-term average incision rates in the northeastern Colorado Plateau and adjacent areas (Concluded)

Site on Figure D.3.7	Location	Basis for calculation	Estimated incision (ft)	Time interval (10^6 yrs)	Calculated incision rate (ft/10^3 yrs)
19	Animas River near Durango, CO	Lava Creek B ash above channel (Gillam et al., 1984); age from Izett and Wilcox (1982)	520	0-0.62	0.84
18	Animas River near Farmington, Co	Lava Creek B ash above channel (Gillam, unpublished); age from Izett and Wilcox (1982)	300	0-0.62	0.48
21	Colorado River at Lava Falls, Grand Canyon, AZ	Dated basalt flow above channel (McKee and McKee, 1972)	50	1-1.2	0.04
22	Piceance Basin	Tree-ring dating of exposed tree roots (Carrara and Carroll, 1979)	0.58 0.16 0.11 0.07	0-0.001 0.001-0.002 0.002-0.003 0.003-0.004	5.8 1.6 1.1 0.7
23	Craig, CO	Pearlett O ash above channel of Little Snake River (Madole, 1976)	400	600,000	0.67

Table D.3.3 Long-term average rates of scarp retreat on the Colorado Plateau

Site on location[a]	Location	Basis for calculation	Estimated Retreat (ft)	Time Interval (10^6yrs)	Calculated unilateral retreat rate[a] (ft/10^3yrs)
8	Gunnison River near Grand Mesa, CO	Unilateral valley widening from present Gunnison River to Grand Mesa, if river cut into formerly extensive basalt plain; incision timing from Larson et al. (1975)	>51,000 (>12 miles)	0-10	>5.1
5	Colorado River between Grand Valley and DeBeque, CO	Bilateral separation of basalt remnants on Battlement Mesa and Mt. Callahan, if they were formerly continuous (Yeend, 1969); incision timing from Larson et al. (1975)	44,900 (8.5 miles)	0-10	2.2
9	Northwestern Book Cliffs, CO and UT	Unilateral valley widening since Colorado River established in late Pliocene or earliest Pleistocene (Hunt, 1969)	148,000 (28 miles)	0-2 (estimated)	74
15	Circle Cliffs, UT	Bilateral valley widening since Colorado River established in mid to late Tertiary (Hunt, 1969)	42,200 (8 miles)	0-10 to 0-20 (estimated)	1.1-2.1
16	Colorado River at Green River, UT	Bilateral widening of inner canyon since late Pliocene (Hunt, 1969)	5,300 (1 mile)	0-3 (estimated)	0.9
20-21	Colorado River at Grand Canyon, AZ	Bilateral widening since canyon cutting began in late Miocene (Hunt, 1969)	26,400-79,200 (5-15 miles)	0-10 to 0-5 (estimated)	1.3-7.9

Table D.3.3 Long-term average rates of scarp retreat on the Colorado Plateau (Concluded)

Site on location[a]	Location	Basis for calculation	Estimated Retreat (ft)	Time Interval (10^6 yrs)	Calculated unilateral retreat rate[a] (ft/10^3 yrs)
20	Eastern Grand Canyon, AZ	Ages of fossil packrat middens in cliffs (Cole and Mayer, 1982); possibly a minimum rate (Haman, 1983)	n.d.	0.12-0.24	>0.6-2.4
17	Black Mesa from Kayenta to Chinle, AZ	Dimensions of valleys cut into mesa top and beheaded by scarp retreat (Schmidt, 1980)	n.d.	late Quaternary	9

[a]Valley widths were halved to obtain an average unilateral retreat rate.

Table D.3.4 Denudation rates for large parts of the Colorado River basin[a]

Location	Sediment load included[b]	Denudation rate (ft/10^3 yrs)		
		Period	Measured	Estimated long-term[c]
Entire Basin				
Dole and Stabler (1909)	S, D, B	1 year[d]	0.19	
Gould (1960)	S, D, B, and Holocene deposits at mouth	not stated	0.47 (rock) -0.79 (soil)	
Above Grand Canyon, AZ				
Hunt (1969)	S	1925-1939	0.54	
Judson and Ritter (1964); Ritter (1967)	S, D, B	1925-1957	0.54	
Brown (1945)	S	1925-1941	0.63	0.83
Corbel (1959)	S, D, B	not stated	0.75	
Above Cisco, UT				
Brown (1945)	S	1929-1941	0.32	0.56

[a]Based on modern sediment yield and reservoir sedimentation data.
[b]S = suspended; D = dissolved; B = bed.
[c]Estimated long-term rates include allowances for climatic trends, sampling and computation methods, and historic land use.
[d]Period too short to be representative.

Table D.3.5 Seismotectonic characteristics of the Colorado Plateau and adjacent provinces

Province	Crustal thickness[a,b] (miles)	Lithosphere thickness[a,c] (miles)	Earthquake focal depth (miles)	Direction of least principal horizontal stress[d,c]	Primary mode of faulting[d,b]	Maximum recorded earthquake	Maximum earthquake	Floating earthquake
Colorado Plateau Interior (Northern Arizona)	25	50	3-16[e]	NNE	Strike slip and thrust	M = 5.5[f]	M = 6.5	M = 6.2
Basin and Range (Central and North Central Arizona)	19	37	6-9[g]	WNW to E-W	normal	M = 5.75[f]	M = 6.5	M = 6.2
Intermountain Seismic Belt (Southern Utah)	15	19	9[h]	ENE	normal	M = 6.5[i]	M = 7.5	M = 6.2
Rio Grande Rift (Northwestern New Mexico)	25	37	25-27[j]	WNW	normal	M = 6.3[k]	M = 6.5	M = 6.2
Southern Rocky Mountains	28-31	62	--	E-W	normal	M = 5.5[c]	M = 6.5[c]	M = 6.2

[a]Thompson and Zoback, 1979.
[b]Smith, 1978.
[c]Keller et al., 1979.
[d]Zoback and Zoback, 1980.
[e]Giardina, 1977.
[f]Dubois et al., 1981.
[g]Eberhart-Phillips et al., 1981.
[h]Smith and Sbar, 1974.
[i]Arabasz et al., 1979.
[j]Wong et al., 1982.
[k]Kirkham and Rogers, 1981.

Table D.3.6 Probabilistic estimates of maximum acceleration, velocity, and intensity in the site area

Source	Return period or probability	Maximum acceleration (g)	Maximum velocity (cm/s)	Maximum modified Mercalli intensity
Liu & DeCapua (1975)	100 years	0.02 to 0.03	--	IV-V
Algermissen & Perkins (1976)	90% probability of not being exceeded in 50 years	0.03 to 0.04	--	--
Applied Technology Council (1978)	--	0.04 to 0.05	--	--
Algermissen et al. (1982)	90% probability of not being exceeded in 10 years	<0.04	<2	--
Algermissen et al. (1982)	90% probability of not being exceeded in 50 years	0.04 to 0.05	2	--
Algermissen et al. (1982)	90% probability of not being exceeded in 250 years	0.10 to 0.12	4-6	--

Table D.3.7 Earthquakes of M $\geq$4.0 since 1960 in the Colorado Plateau
(source NOAA earthquake data file. Search run on November 1, 1985)

Date YR	MO	DA	Time HR	MIN	SEC	Location LAT(N)	LONG(W)		Depth km	Magnitude M_b	M_s	other	local	Intensity
1960	10	11	00	05	30.5	38.3	107.6	Montrose, CO (Colorado Plateau/ UMP Border Zone)				5.5		VI
1963	06	19	08	30	47.5	37.9	112.6	SW Utah (IMSB Border Zone)	33	4.2				
1963	07	07	19	20	42.4	39.5	111.9	Wasatch Zone, Utah (IMSB Border Zone)		4.9				VI
1963	07	09	20	25	27.5	40.0	111.2	Wasatch Zone, Utah (IMSB Border Zone)	33	4.1				
1963	07	10	10	32	50.6	39.9	111.4	Wasatch Zone, Utah (IMSB Border Zone)	33	4.2				V
1963	09	02	17	40	15.4	39.6	110.1	EUT coal mining belt (mining-induced?)	33	4.1				
1963	09	11	11	59	41.0	33.2	110.7	Globe, AZ (AZ Border Zone)	33	4.2				
1964	06	06	12	46	59.9	39.4	110.2	EUT coal mining belt (mining-induced)	30	4.2				
1965	01	10	20	08	14.4	37.4	113.1	SW Utah (IMSB Border Zone)	33	4.0				IV
1965	03	21	22	56	39.7	39.5	110.3	EUT coal mining belt (mining-induced)		4.0				IV
1965	03	26	00	51	26.5	39.5	110.3	EUT coal mining belt (mining-induced)		4.3				V
1966	01	23	01	56	38.0	37.0	107.0	Dulce, NM (RGR Border Zone)	16	5.5				VII
1966	01	23	06	14	15.6	36.9	107.2	Dulce, NM (RGR Border Zone)	5	4.2				V
1966	01	23	07	44	35.7	36.9	107.3	Dulce, NM (RGR Border Zone)	5	4.6				
1966	01	25	10	30	03.0	36.8	107.1	Dulce, [illegible] GR Border Zone)	5	4.0				

Table D.3.7 Earthquakes of M ≥4.0 since 1900 in the Colorado Plateau (Continued)
(source NOAA earthquake data file. Search run on November 1, 1985)

Date YR	MO	DA	Time HR	MIN	SEC	Location LAT(N)	LONG(W)		Depth km	Magnitude m_b	M_s	other	local	Intensity
1966	01	23	11	04	07.1	36.9	107.2	Dulce, NM (RGR Border Zone)	5	4.3				V
1966	01	23	23	40	00.1	36.9	107.0	Dulce, NM (RGR Border Zone)	5	4.6				V
1966	01	23	19	43	19.7	36.9	107.1	Dulce, NM (RGR Border Zone)	5	4.5				V
1966	04	23	20	20	54.5	39.2	111.4	Wasatch Zone, Utah (IMSB Border Zone)	33	4.4				
1966	04	30	18	29	13.0	39.6	110.4	EUT coal mining belt (mining-induced?)	3	4.0				V
1966	05	04	05	40	37.3	36.8	107.1	Dulce, NM (RGR Border Zone)	5	4.1				
1966	05	08	17	23	37.8	36.9	106.9	Dulce, NM (RGR Border Zone)	5	4.5				V
1966	05	08	17	50	35.6	37.0	106.8	Dulce, NM (RGR Border Zone)	5	4.2				V
1966	05	09	02	08	53.3	36.9	106.9	Dulce, NM (RGR Border Zone)	5	4.2				V
1966	05	09	02	57	23.6	37.0	106.9	Dulce, NM (RGR Border Zone)	5	4.4				V
1966	05	19	00	26	42.2	36.9	107.0	Dulce, NM (RGR Border Zone)	5	4.6				
1966	05	20	13	40	40.8	37.9	112.1	SW Utah (IMSB Border Zone)	10	4.3				
1966	06	02	21	59	11.5	36.9	107.0	Dulce, NM (RGR Border Zone)	5	5.0				VI
1966	06	21	05	24	30.2	36.9	107.1	Dulce, NM (RGR Border Zone)	5	4.2				
1966	06	04	10	29	39.3	37.0	107.0	Dulce, NM (RGR Border Zone)	5	4.1				V
1966	07	06	05	47	08.3	40.2	108.9	Rangley, CO (oil & gas withdrawal?)	5	4.5				V
1966	09	04	09	52	34.5	38.3	107.6	SW CO (Colorado Plateau/ UMP Border Zone)	33	4.2				

Table D.3.7 Earthquakes of M ≥4.0 since 1960 in the Colorado Plateau (Continued)
(source NOAA earthquake data file. Search run on November 1, 1985)

Date YR	MO	DA	Time HR	MIN	SEC	Location LAT(N)	LONG(W)		Depth km	Magnitude m_b	M_s	other	local	Intensity
1966	10	03	14	03	50.0	35.6	111.6	Coconino Co., AZ (AZ Border Zone)	33	4.4				V
1966	12	16	02	00	44.0	37.0	107.0	Dulce, NM (RGR Border Zone)	33	4.2				
1967	01	06	15	41	15.3	36.9	107.0	Dulce, NM (RGR Border Zone)	33	4.3				V
1967	01	12	03	52	06.2	39.0	107.5	SW CO (Colorado Plateau/ UWP Border Zone)	33	4.4				V
1967	01	16	09	22	45.9	37.7	107.9	Silverton, CO (UWP Border Zone)	33	4.1				V
1967	02	15	03	20	03.4	40.1	109.1	Rangley, CO (oil & gas withdrawal(?)	5	4.5				V
1967	04	04	22	53	39.5	38.3	107.7	SW CO (Colorado Plateau/ UWP Border Zone)	33	4.5				V
1967	10	25	02	41	34.4	39.4	110.3	EUT coal mining belt (mining-induced?)		4.0				V
1967	10	25	05	53	08.4	39.4	110.3	EUT coal mining belt (mining-induced?)		4.0				V
1968	01	16	09	42	54.2	39.2	112.0	Wasatch Zone, Utah (IMSB Border Zone)	33	4.0				V
1968	08	06	06	25	36.4	39.1	111.4	Wasatch Zone, Utah (IMSB Border Zone)	15	4.0				V
1968	08	29	09	31	40.1	39.5	110.2	EUT coal mining belt (mining-induced?)		4.2				V
1968	09	24	02	10	51.8	38.0	112.1	SW Utah (IMSB Border Zone)	33	4.0				V
1968	11	17	14	33	37.5	39.5	110.9	EUT coal mining belt (mining-induced?)	6	4.6				V

Table 9.3.7 Earthquakes of M ≥4.0 since 1960 in the Colorado Plateau (Continued)
(source NOAA earthquake data file. Search run on November 1, 1985)

Date YR	MO	DA	Time HR	MIN	SEC	Location LAT(N)	LONG(W)		Depth km	Magnitude m_b	M_s	other	local	Intensity
1969	03	13	07	03	14.0	39.4	110.2	EUT coal mining belt (mining-induced?)	2	4.1				V
1969	05	23	05	26	53.6	39.0	111.0	Wasatch Zone, Utah (IMSB Border Zone)	31	4.0				V
1969	12	25	12	49	10.1	33.4	110.6	San Carlos, AZ (AZ Border Zone)	15	4.4			5.1	
1970	02	03*	05	59	35.6	37.9	108.3	Paradox Basin, CO (Colorado Plateau Interior)	33	4.0				V
1970	04	14	10	40	34.2	39.7	110.8	EUT coal mining belt (mining-induced?)	13	4.2				
1970	04	10	10	42	11.9	37.0	111.6	SW Utah (IMSB Border Zone)	10	4.4				
1970	04	21	08	53	52.4	40.1	108.9	Rangley, CO (oil & gas withdrawal)	4	4.3			3.9	V
1970	04	21	15	05	47.5	40.1	108.9	Rangley, CO (oil & gas withdrawal)	4	4.6				V
1970	05	23	22	55	22.4	38.0	112.3	SW Utah (IMSB Border Zone)	3	4.6			4.9	
1970	10	25	07	46	42.1	39.2	111.4	Wasatch Zone, Utah (IMSB Border Zone)	5	4.3				V
1970	11	28	07	40	11.6	35.0	106.7	Albuquerque, NM (RGR Border Zone)	9	4.5				V
1971	01	04	07	39	06.7	35.0	106.7	Albuquerque, NM (RGR Border Zone)	9	4.7				
1971	01	07	20	39	52.1	39.4	107.3	Colorado Plateau/UMP Border Zone	33	4.3			3.8	
1973	07	16	06	36	42.8	39.1	111.5	Wasatch Zone, Utah (IMSB Border Zone)	10	4.2				

Table D.3.7 Earthquakes of M ≥4.0 since 1900 in the Colorado Plateau (Concluded)
(source NOAA earthquake data file. Search run on November 1, 1985)

Date YR	MO	DA	Time HR	MIN	SEC	LAT(N)	LONG(W)	Location	Depth km	Magnitude m_b	M_s	other	local	Intensity
1973	12	24	02	20	14.9	35.3	107.7	Mt. Taylor Region, NM (RGR Border Zone)	10	4.4				V
1975	01	30[a]	16	48	40.3	39.2	108.6	Grand Junction, CO (Colorado Plateau Interior-Uncompahgre Uplift)	5	4.4			3.7	
1975	10	06	15	50	46.9	39.0	111.4	Wasatch Zone, Utah (IMSB Border Zone)	0.005	4.2			3.2	II
1976	01	05	06	23	32.9	35.8	108.3	Crown Point, NM (RGR Border Zone)	25	5.0			4.4	VI
1976	02	04	00	04	58.1	34.6	112.5	Chino Valley, AZ (AZ Border Zone)	12	4.9		5.1	5.2	VI
1976	02	09	03	07	22.0	34.6	112.5	Chino Valley, AZ (AZ Border Zone)	10	4.6			3.3	
1977	03	05	03	00	54.7	35.9	108.2	Crown Point, NM (RGR Border Zone)	22	4.6			4.2	VI
1977	09	24	11	16	48.4	39.3	107.3	Colorado Plateau/SRM Border Zone	0.005	4.0			3.0	
1980	05	24	10	03	36.3	39.9	111.9	Wasatch Zone, Utah (IMSB Border Zone)	0.005	5.0			4.2	V
1981	05	14	05	11	04.1	39.4	111.0	Wasatch Zone, Utah (IMSB Border Zone)	1	4.0		4.0	3.3	V

[a] Colorado Plateau Interior

Ref. NOAA, 1985.

Table D.3.8 Estimated maximum peak horizontal ground acceleration at site area from MEs on regional seismotectonic features[a]

Source area	Maximum earthquake magnitude	Approximate distance from site area	Maximum free field, non-amplified peak horizontal ground acceleration[b] expected at site area (fraction of unit gravity)
Intermountain Seismic Belt	7.0-7.5	186 miles	0.02
Rio Grande Rift	6.5-7.5	202 miles	0.01
Wyoming Basin	5.7-6.5	124 miles	0.009
Colorado Plateau/ Western Mountain Province Transition Zone	6.5	19 miles	0.13

[a]See text for explanation of values assumed.
[b]Calculated from acceleration/attenuation relationship of Campbell (1981).

Table D.3.9 Summary of analysis of mapped faults and lineaments within a 40-mile (65-km) radius of the Estes Gulch site, Colorado

	Fault/ lineament	Source	Length	Distance from site	Estimated ME[a]	Estimated on-site acceleration[b]	Comments
1.	Unnamed	Tweto, 1976	5 mi	32 mi	6.7	0.08g	Not potential design fault
2.	Unnamed	Tweto, 1976	7 mi	47 mi	6.8	0.05g	Not potential design fault
3.	Unnamed	Tweto, 1976	5 mi	61 mi	6.7	0.03g	Not potential design fault
4.	Unnamed	Tweto, 1976	3 mi	35 mi	6.5	0.06g	Not potential design fault
5.	Unnamed	Tweto, 1976	5.6 mi	36 mi	6.7	0.07g	Not potential design fault.
6.	Unnamed	Kirkham & Rogers, 1981	12 mi	52 mi	7.0	0.06g	Not potential design fault. Youngest offset is in late Tertiary igneous rocks.
7.	Unnamed	Cashion, 1973	8 mi	36 mi	6.8	0.08g	Not potential design fault
8.	Unnamed	Cashion, 1973	5.6 mi	33 mi	6.7	0.08g	Not potential design fault
9.	Unnamed	Cashion, 1973	3 mi	30 mi	6.5	0.08g	Not potential design fault
10.	Piceance Basin	McGuire et al., 1982	11 mi	24 mi	6.9	0.14g	Not potential design fault. Probable Quaternary offset.

Table D.3.9 Summary of analysis of mapped faults and lineaments within a 40-mile (65-km) radius of the Estes Gulch site, Colorado (Continued)

Fault/ Lineament	Source	Length	Distance from site	Estimated ME[a]	Estimated on-site acceleration[b]	Comments
11. Unnamed	Cashion, 1979 Wackman (unpublished)	9.3 mi	21 mi	6.9	0.16g	Not potential design fault. Probable Quaternary offset.
12. Unnamed	Tweto et al., 1978	1.8 mi	24 km	6.4	0.09g	Not potential design fault. Probable Quaternary offset.
13. Unnamed	Tweto et al., 1978	3.1 mi	23 mi	6.5	0.11g	Not potential design fault. Probable Quaternary offset.
14. Unnamed	Tweto et al., 1978	6.8 mi	17 mi	6.8	0.18g	Not potential design fault. Probable Quaternary offset.
15. Unnamed	Tweto et al., 1978	6.2 mi	24 mi	6.7	0.12g	Not potential design fault. Probable Quaternary offset.
16. Unnamed	Kirkham & Rogers, 1981	6.2 mi	47 mi	6.7	0.05g	Collapse feature in early Quaternary volcanics. Not potential design fault.
17. Unnamed	Tweto et al., 1978	12.4 mi	9 mi	7.0	0.35g	Not potential design fault. Youngest offset unit is Cretaceous.

Table D.3.9 Summary of analysis of mapped faults and lineaments within a 40-mile (65-km) radius of the Estes Gulch site, Colorado (Continued)

Fault/ Lineament	Source	Length	Distance from site	Estimated ME[a]	Estimated on-site acceleration[b]	Comments
18. Unnamed	Tweto et al., 1978	9.3 mi	6 mi	6.9	0.41g	Not potential design fault. Youngest offset unit is Pennsylvanian.
19. Unnamed	Tweto et al., 1978	4 mi	9 mi	6.6	0.28g	Not potential design fault. Youngest offset unit is Pennsylvanian.
20. Unnamed	Tweto et al., 1978	9 mi	9 mi	6.9	0.31g	Not potential design fault. Youngest offset unit is Pennsylvanian.
21. Unnamed	Tweto et al., 1978	25 mi	10 mi	7.2	0.35g	Not potential design fault. Youngest offset unit is Pennsylvanian.
22. Unnamed	Tweto et al., 1978	13 mi	41 mi	7.0	0.06g	Not potential design fault.
23. Unnamed	Kirkham & Rogers, 1981	3 mi	42 mi	6.5	0.05g	Not potential design fault. Collapse feature in Quaternary volcanics.

Table D.3.9 Summary of analysis of mapped faults and lineaments within a 40-mile (65-km) radius of the Estes Gulch site, Colorado (Continued)

Fault/ lineament	Source	Length	Distance from site	Estimated ME[a]	Estimated on-site acceleration[b]	Comments
24. Unnamed	Tweto et al., 1978	2.5 mi	2.5 mi	6.4	0.53g	Not potential design fault. Youngest offset unit is Tertiary.
25. Unnamed	Tweto et al., 1978	17 mi	2.5 mi	7.0	0.60g	Not potential design fault. Youngest offset unit is Cretaceous.
26. Unnamed	Kirkham & Rogers, 1981	4.3 mi	24 mi	6.6	0.11g	Not potential design fault. Collapse feature in Quaternary volcanics.
27. Unnamed	Kirkham & Rogers, 1981	3 mi	30 mi	6.5	0.07g	Not potential design fault. Collapse feature in Quaternary volcanics.
28. Unnamed	Kirkham & Rogers, 1981	3 mi	41 mi	6.5	0.05g	Not potential design fault. Collapse feature in Quaternary volcanics.
29. Unnamed	Tweto et al., 1978	29 mi	41 mi	7.2	0.10g	Not potential design fault.
30. Unnamed	Tweto et al., 1978	3.7 mi	45 mi	6.6	0.05g	Not potential design fault.

Table D.3.9 Summary of analysis of mapped faults and lineaments within a 40-mile (65-km) radius of the Estes Gulch site, Colorado (Concluded)

Fault/ lineament	Source	Length	Distance from site	Estimated MS[a]	Estimated on-site acceleration[b]	Comments
31. Unnamed	Tweto et al., 1978	5 mi	43 mi	6.7	0.05g	Not potential design fault.
32. Unnamed	Tweto et al., 1978	2.5 mi	32 mi	6.5	0.07g	Not potential design fault.
33. Unnamed	Tweto et al., 1978	1.9 mi	28 mi	6.4	0.07g	Not potential design fault.
34. Unnamed	Tweto et al., 1978	3.1 mi	34 mi	6.5	0.06g	Not potential design fault.
35. Unnamed	Tweto et al., 1978	1.9 mi	39 mi	6.3	0.05g	Not potential design fault.
36. Unnamed	Tweto et al., 1978	28 mi	40 mi	7.2	0.10g	Not potential design fault.
37. Unnamed	Tweto et al., 1978	6.2 mi	40 mi	6.7	0.06g	Not potential design fault.
38. Unnamed	Tweto et al., 1978	17 mi	46 mi	7.0	0.07g	Not potential design fault.
39. Unnamed	Cashion, 1973	6.2 mi	30 mi	6.7	0.09g	Not potential design fault.
40. Redlands fault	Kirkham & Rogers, 1981	10 mi	59 mi	6.9	0.04g	Not potential design fault. Probable offset in Quaternary deposits.

[a]Using fault length/magnitude relationship of Bonilla et al. (1984).
[b]Using acceleration/attenuation relationship of Campbell (1981).

Table D.3.10 Duration of strong earthquake ground motion at the Estes Gulch site

Fault	Distance to site	Estimated ME	Duration (accel. >0.05g)
24	2.5 miles	6.4	15 second
25	2.5 miles	7.0	19 second
FE	9 miles	6.2	10 second

Fault numbers refer to faults on Table D.3.9. Method used in determination of estimated duration follows procedure of Krinitzsky and Chang (1977) for rock sites. None of these faults are tectonically capable structures. The floating earthquake is the design earthquake for the Estes Gulch site.

D.4 TAILINGS GEOTECHNICAL DATA

D.4.1 DESIGN PARAMETERS OF IN SITU TAILINGS AND OTHER CONTAMINATED MATERIALS

Design parameters of the in situ tailings and other contaminated material are presented in MKE Final Design, Volume II, Calculations, Calculation Number 06-525-05-02, Geotechnical Characteristics, Sheet 4a. In situ parameters pertinent to the design of a relocated pile include moisture content, material type, and dry density. Also important is the distribution of material types within the tailings piles. Details regarding material properties of the in situ tailings and other contaminated materials, including windblown and mixed foundation soils of the tailings piles and mill areas, are presented in Section D.4.3.

D.4.2 DESIGN PARAMETERS OF REMOLDED TAILINGS AND OTHER CONTAMINATED MATERIALS

Also presented in the MKE Final Design are the design parameters of the remolded tailings and other contaminated materials. Remolded material properties are required as input parameters for groundwater, pile stability, settlement, and pile relocation analyses. Since the tailings and other contaminated materials will be relocated, mixing of material types within these two major classifications will occur. The design parameters considered representative of the tailings are those for a sand-slime mixture. Based on borehole and laboratory test data, a mixture consisting of no greater than 45 percent slimes and no less than 55 percent sand should result from the material handling during construction.

D.4.3 MATERIAL PROPERTIES OF IN SITU TAILINGS AND OTHER CONTAMINATED MATERIALS

Materials removed from the processing sites and disposed of at the Estes Gulch site include tailings, the contaminated foundation soils below the tailings, windblown contaminated materials around the pile, and contaminated foundation material of the ore storage area and the mill facilities. At the Old Rifle site, these materials have been mixed to some extent during previous stabilization, so material properties as discussed as tailings in the following subsections are considered representative of the site. At the New Rifle site, the material zones still can be easily distinguished. Types vary by location as a result of the depositional process.

<u>In situ tailings properties</u>

The only in situ material properties required when designing a relocated pile are the distribution of material types within the pile (gradation, Atterberg limits, specific gravity), the densities of the various materials, the moisture content of the materials to be handled, and the quantity of materials. Figures D.4.1 through D.4.9 are cross sections of the tailings piles prepared by Colorado State University (CSU) (1985).

The sections represent the gross stratigraphy of each pile and take into account the known depositional history of each impoundment. Individual boring logs showing detailed stratigraphic columns at each boring location are presented in Addendum D.1 following this appendix. The locations of each boring as well as each cross section are presented in Figures D.4.10 and D.4.11.

For this project tailings are categorized by the percentage of silt- and clay-sized material. Three broad categories are represented: sand tailings (<30 percent passing No. 200 sieve), sand-slime mixtures (between 30 and 70 percent passing, No. 200 sieve), and slime tailings (>70 percent passing No. 200 sieve). In stratigraphic classification, the sand-slime mixture classification is used to denote material mixtures of uniform consistency within the appropriate gradation range and to denote as either a single large or small layer, interbedding of sand and slime stringers, seams, or lenses.

Gradation tests, specific gravity tests, and Atterberg limits tests were conducted on selected samples. These test data were used to aid in classifying the material distribution within each pile according to the previously discussed classification system. The results of these tests are summarized in Tables D.4.2 and D.4.3. Gradation curves for the tailings are shown on Figures D.4.12 through D.4.26.

Moisture content and dry density were determined for samples from various locations in the piles. The results of these data are shown on Tables D.4.2 and D.4.3. The distribution of moisture content within particular tailings profiles is shown on Figures D.4.27 through D.4.43. Free water tables, as reported by CSU (1985), are shown on the pile cross sections, Figures D.4.1 through D.4.9.

<u>Specific gravity, in situ moisture content, and in situ dry-density tests</u>

Specific gravity tests, performed according to American Society for Testing and Materials (ASTM) D854, were used to correlate other tailings data and to aid in the soil classification. Of 11 samples from the Old Rifle tailings pile, the specific gravity ranged from 2.66 to 2.92 and averaged 2.71. There is no apparent correlation between slimes content and specific gravity. Thirty-eight samples of New Rifle tailings were tested. The specific gravities ranged from 2.68 to 3.06 with no distinction by material type. The average specific gravity was 2.77. Values of specific gravity are presented in Tables D.4.2 and D.4.3.

In situ moisture content and dry densities were determined in order to aid the designer in determining the amount of moisture conditioning required when handling the tailings and to determine the volume shrinkage which will occur during placement and compaction. Moisture and density data are presented on Tables D.4.2 and D.4.3.

The range of moisture contents within the sand tailings at Old Rifle is 3.3 to 23.6 percent; the average is 9.4 percent. The range of moisture contents for the sand-slime tailings of the Old Rifle pile is 9.1 to 21.7 percent with an average of 15.4

percent. Moisture contents of the slimes sampled range from 6.1 to 71.8 percent and average 47.6 percent.

The moisture contents of the New Rifle tailings pile range from 2.6 to 32.2 percent for sand tailings, 0.1 to 30.2 percent for sand-slime tailings, and 40.1 to 48.5 percent for slime tailings and average 13.5, 15.6, and 45.0 percent for the respective material types. The statistical variation in moisture content is described in TAC calculation RFL-03-91-02-01-00.

The in situ dry densities of the Old Rifle pile samples range from 82 to 85 pounds per cubic foot (pcf) and average 83 pcf for the dominant sand-slime material. For the slime samples, dry densities range from 51 to 90 pcf and average 68 pcf. In situ dry densities of Old Rifle sand tailings range from 81 to 94 pcf and average 89 pcf. In situ dry densities at the New Rifle pile range from 74 to 92 pcf for sand tailings, 76 to 110 pcf for sand-slime mixtures, and 65 to 91 for the slime tailings. Average values of 86, 92, and 81 pcf for sand, sand-slime, and slime tailings were obtained.

These results support the conclusion that there is little difference in tailings between Old and New Rifle and that the sand and sand-slime materials are relatively well drained while the slimes have water contents approaching saturation. Many of the slimes samples have liquidity indices near 1.0. This indicates that they may be sensitive, causing some difficulty in excavation and handling.

Other contaminated materials

Volume VI, Final Design Calculations, provides information on subpile contaminated materials and excavation quantities (see calculations numbered 06-547-01-00 through 06-547-04-00). The CSU and MSDR logs provide stratigraphic information on the piles subbases. Boring logs by BFEC included in Addendum D.1 show the stratigraphy of the remaining contaminated areas. In general it can be assumed that these materials are near saturation under the piles due to the proximity of the groundwater table. Toward the mill areas dryer soils are anticipated due to the rise of the topography. The exception is a drainage from the highway at Old Rifle near the northeast corner of the site, which appears wet most of the year.

D.4.4 MATERIAL PROPERTIES OF REMOLDED TAILINGS

Classification

In order to classify the tailings according to the classification system in Section D.4.3.1, Atterberg limits, gradation, and hydrometer tests were performed on numerous samples from the tailings piles. Gradation tests were performed according to ASTM C136. Atterberg limits were performed using the ASTM D4318 test method. The results of the gradation and hydrometer test data are presented in Figures D.4.12 through D.4.26. The results of the Atterberg limits tests are given in Tables D.4.2 and D.4.3.

Based on the data obtained from the limited number of tests, the fines portion (No. 200 sieve) consists entirely of silt ranging from nonplastic to high plasticity. None of the samples exhibits the characteristics of a clay type soil even though samples contain up to 10 percent passing the two-micron particle size. This is considered reasonable for a finely crushed rock tailings material.

Moisture-density relationships

Moisture-density relationships (compaction) tests were performed according to ASTM D698. This method is also known as the standard Proctor. The results of the standard Proctor tests are shown in Figures D.4.44 through D.4.50, and summarized on Table D.4.4. The standard Proctor tests were performed to evaluate the density of the tailings as placed at Estes Gulch and to prepare remolded tailings samples for other laboratory tests. Fourteen compaction tests were performed: two on slime tailings, four on sand tailings, and eight on sand-slime mixtures. Only the sand-slime mixtures are presented here. No difference is apparent between Old and New Rifle tailings.

Since the tailings will be mixed during excavation, handling, and compaction, the materials as placed at Estes Gulch will be similar to the sand-slime mixtures. The range of maximum dry density and optimum moisture content is 91 to 110 pcf and 15.5 to 24.4 percent, respectively.

Strength tests

Triaxial and direct shear tests were performed according to Army Corps of Engineers Testing Manual EM 1110-2-1906 with the exception that multi-phased triaxial tests were performed. The results of strength tests are shown on Figures D.4.51 through 5.4.61. The "B" parameter of all triaxial tests exceeded 0.95. Saturation and consolidation data for CSU triaxial tests are not available. Tests were performed on remolded and undisturbed samples of sands, sand-slime, and slime tailings at various moisture contents and dry densities. While none of the tests duplicate the exact field conditions which will be present when the tailings are compacted at Estes Gulch, the following conclusions can be made:

- o The tailings exhibit high drained strengths (in excess of 34 degrees) regardless of initial dry density or sample gradation. The only exception is a single direct shear test, which exhibited an angle of internal friction of 30 degrees and a cohesion of 480 pcf and thus appears not to represent drained conditions. Vick (1983) supports the conclusion that gradation does not affect the strength of tailings. However, density should have an effect on shear strength.

- o The test data indicate that the material strength exceeds that of typical tailings materials (copper tailings are similar to uranium mill tailings), which range from 30 to 37 degrees (Vick, 1983).

A single unconsolidated undrained triaxial test was performed on a slime sample with an initial dry density of 69 pcf and an initial moisture content of 53.1 percent. This test result yields an angle of internal friction of 28 degrees if cohesion is taken as zero psf. Since the material is a silt, the friction angle agrees closely with the total stress envelope of consolidated undrained tests, and the density of this sample is well below that at which tailings will be placed. Actual strengths used in the design are given in the MKE calculations. See in particular Calculation No. 06-525-05-03.

Consolidation tests

Consolidation of the compacted tailings is considered to be nearly instantaneous upon loading because of the low percentage of placement moisture content. Therefore, only secondary settlement is considered important. Values of secondary coefficients of consolidation can be estimated from literature (Holtz & Kovacs, 1981) and laboratory test data. See MKE Calculation No. 06-525-05-03 for values used in design.

Hydraulic conductivity tests

Figure D.4.62 shows saturated hydraulic conductivity as a function of slimes content for Old and New Rifle data. Table D.4.5 gives further information on the test results. Tests were run according to Army Corps of Engineers methods (EM 1110-2-1506). The saturated hydraulic conductivity of Rifle tailings ranges from 9.0 x 10^{-3} cm/s for sand tailings to 7.2 x 10^{-7} cm/s for sand/slime tailings. These values agree closely to the range given by Vick (1983) for copper tailings. This is 1 x 10^{-3} to 5 x 10^{-4} cm/s for peripherally discharged beach sand containing up to 30 percent fines and 1 x 10^{-5} to 5 x 10^{-7} cm/s for low plasticity slimes. Although density affects the hydraulic conductivity of the tailings, its affect is not as great as that of the percent slimes. For design purposes, the saturated hydraulic conductivity of sand-slime tailings can be taken to be between 10^{-3} cm/s and 10^{-5} cm/s.

Unsaturated hydraulic conductivity testing (ASTM D3152 and ASTM D2325) was performed for tailings sand, sand-slime, and slime samples. Additionally, tests were performed on potential radon barrier silty clays obtained from test pits on the disposal site. Results of this testing are provided in Calculation No. 06-579-01-00, Appendix III. Tests on actual radon barrier soil stockpiled on the site were performed and are included in MK reports of August 1994 and February 1995.

D.4.5 MATERIAL PROPERTIES OF OTHER CONTAMINATED MATERIALS

Volume VI, Final Design Calculations, provides information on subpile contaminated materials and excavation quantities (see calculations numbered 06-547-01-00 through 06-547-04-00).

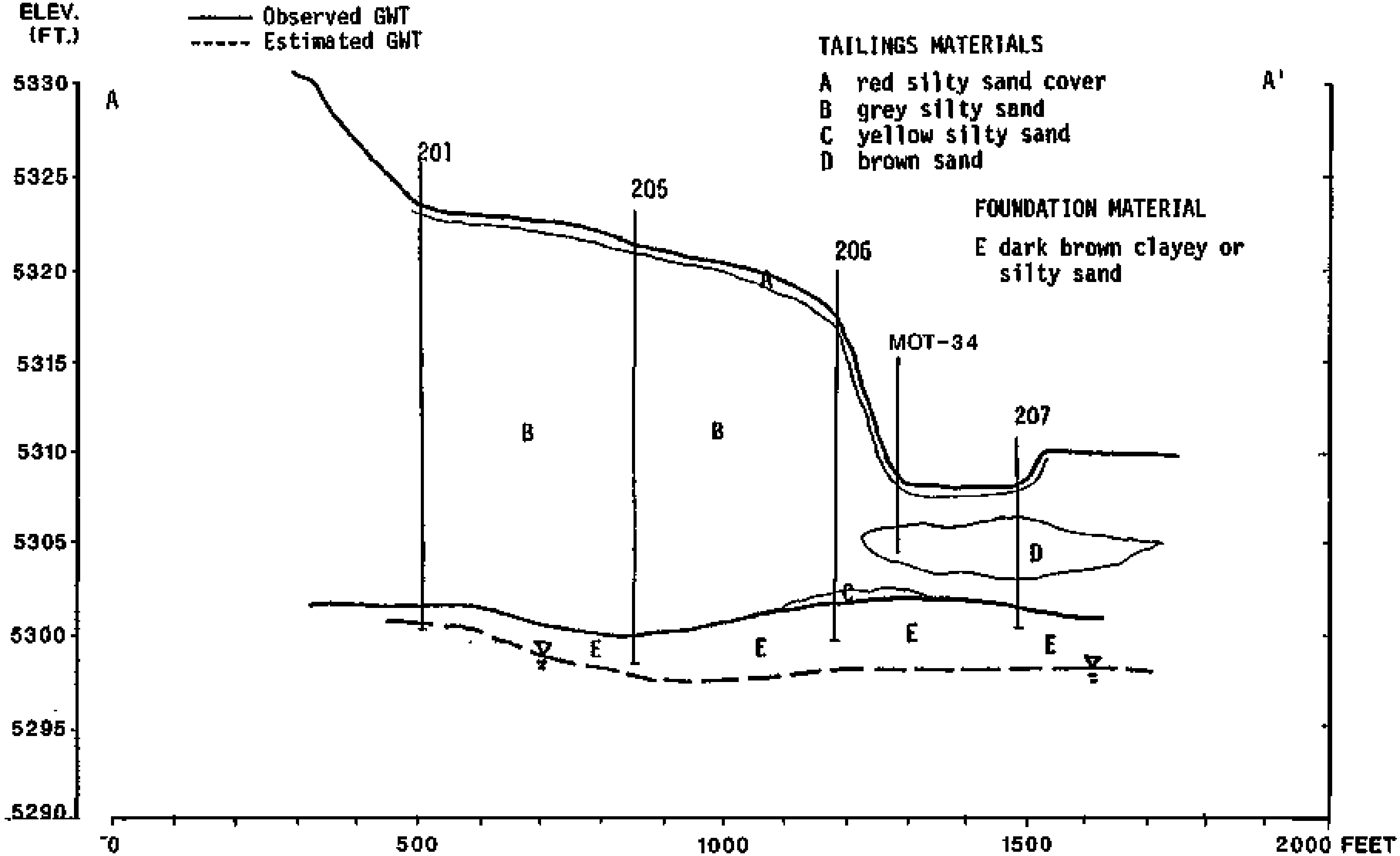


FIGURE D.4.1 CROSS SECTIONAL PROFILE A–A', OLD RIFLE

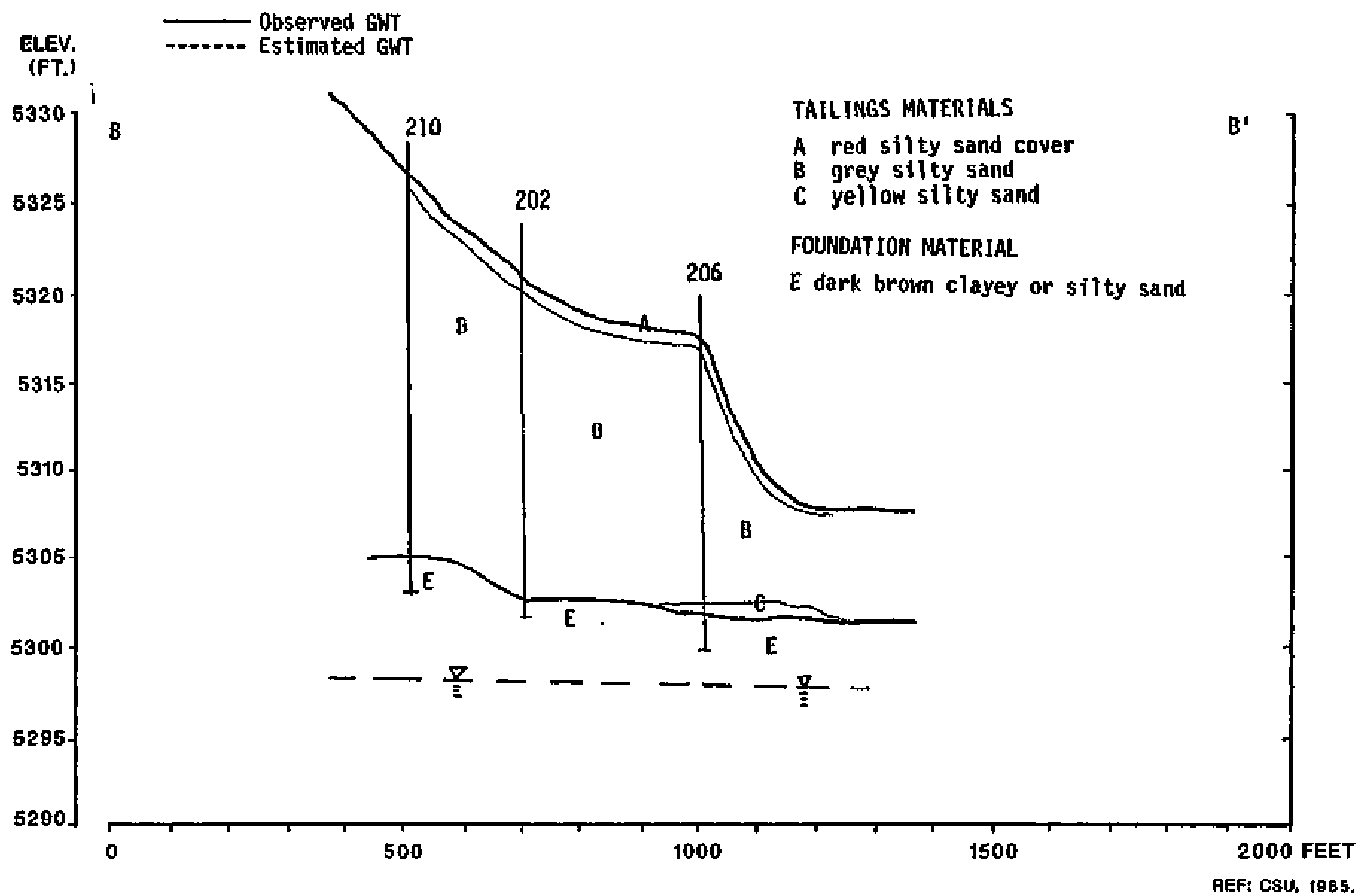


FIGURE D.4.2 CROSS SECTIONAL PROFILE B–B', OLD RIFLE

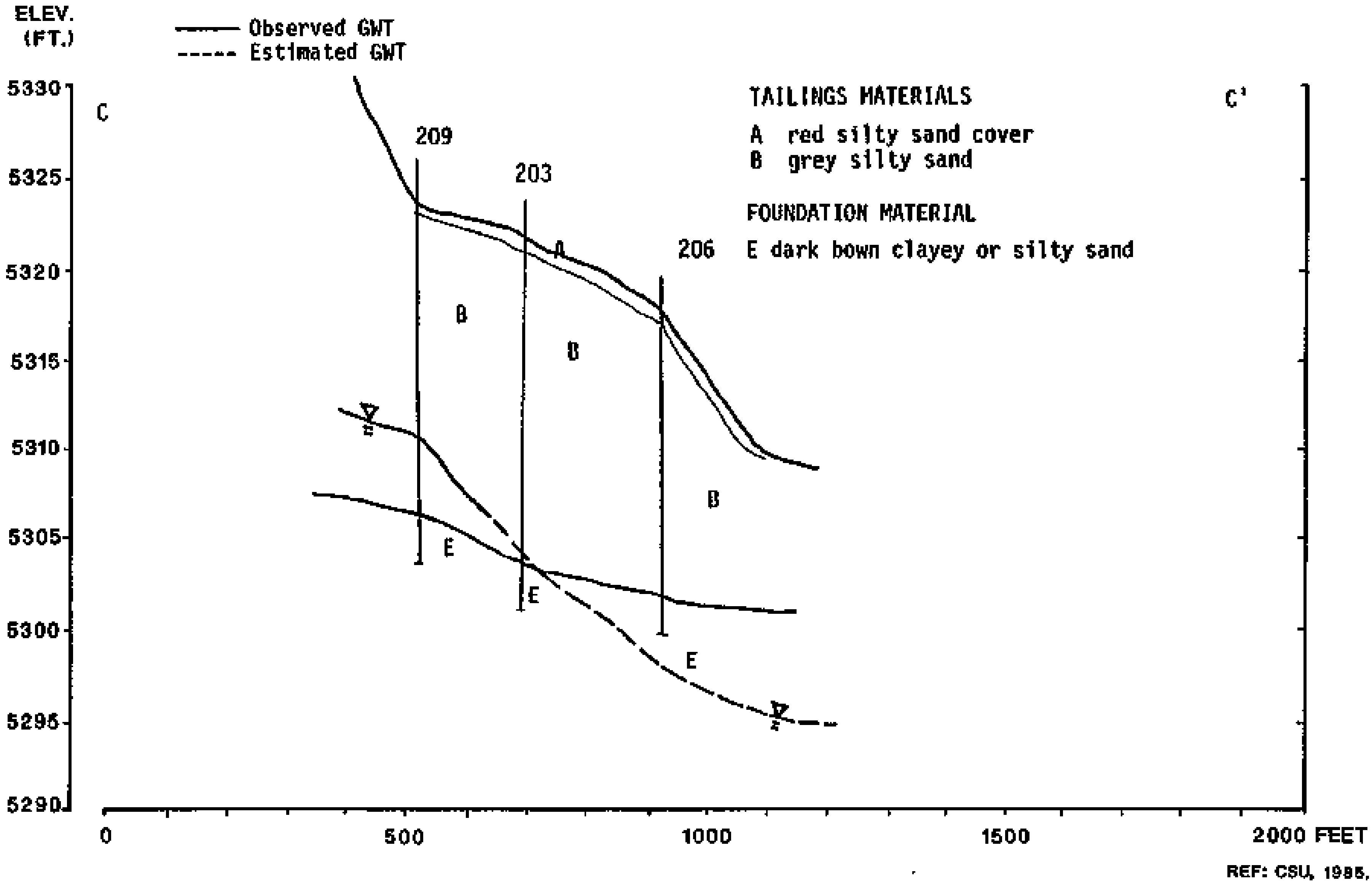


FIGURE D.4.3 CROSS SECTIONAL PROFILE C-C', OLD RIFLE

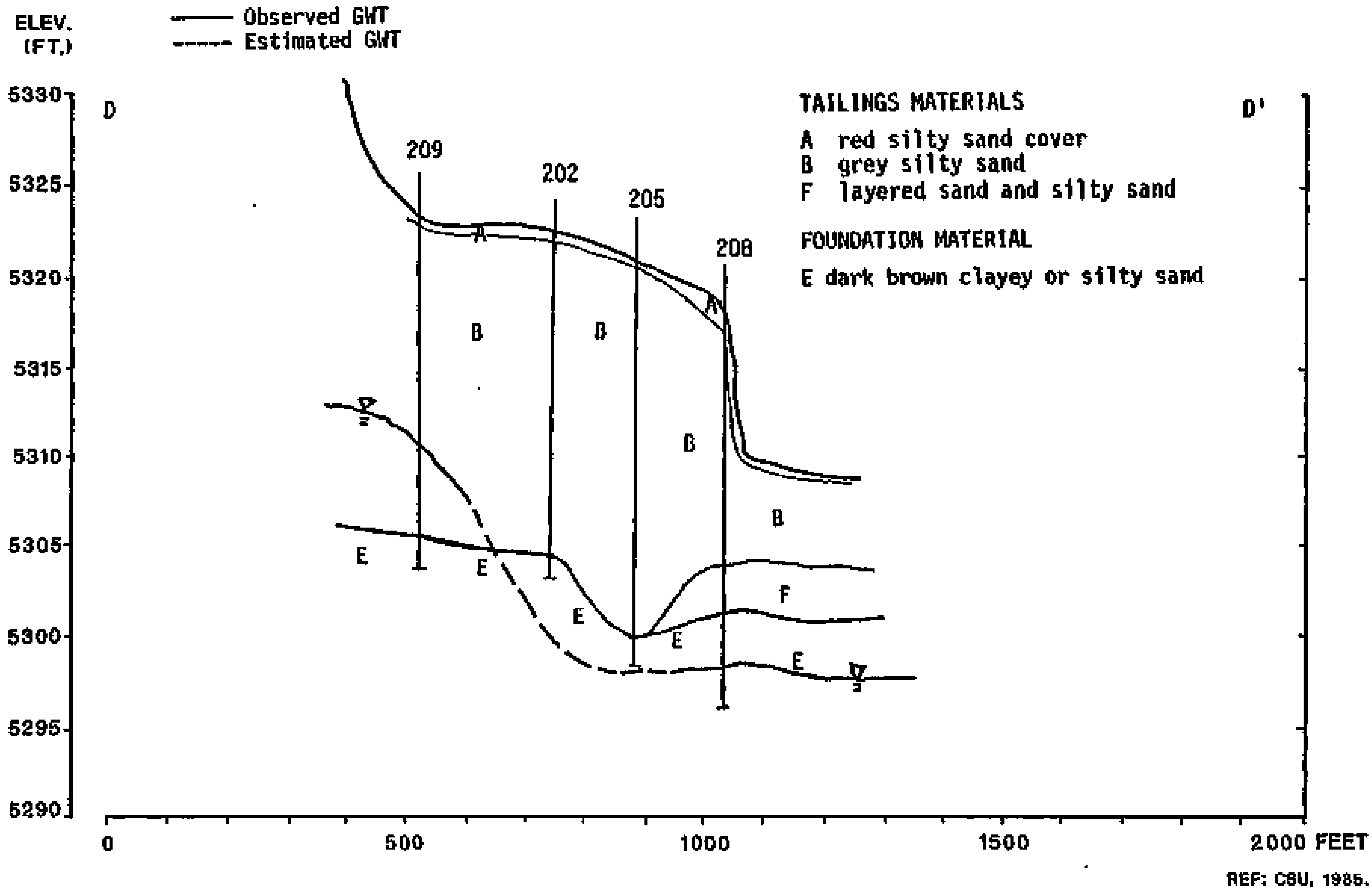


FIGURE D.4.4 CROSS SECTIONAL PROFILE D-D', OLD RIFLE

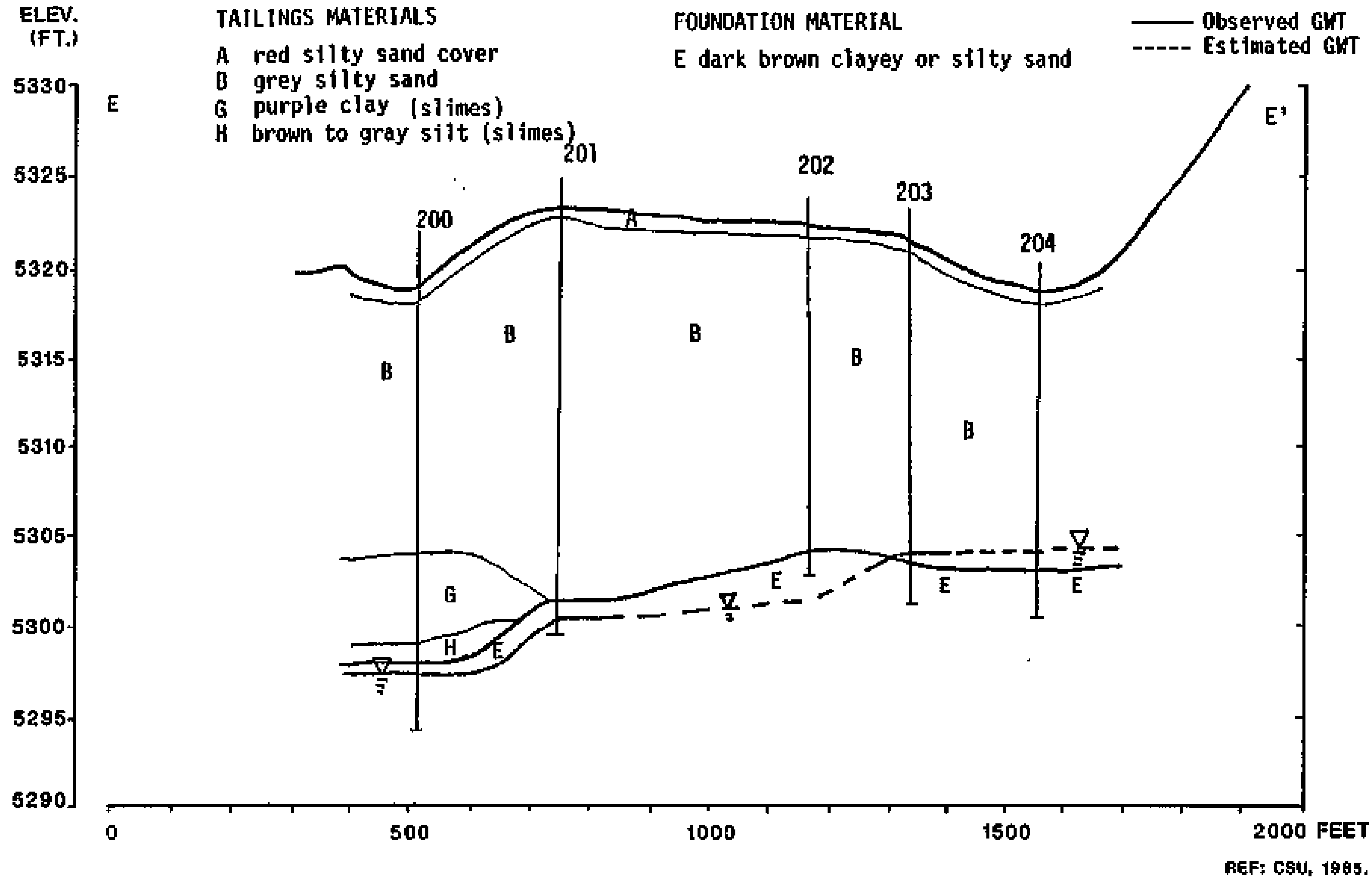


FIGURE D.4.5 CROSS SECTIONAL PROFILE E-E', OLD RIFLE

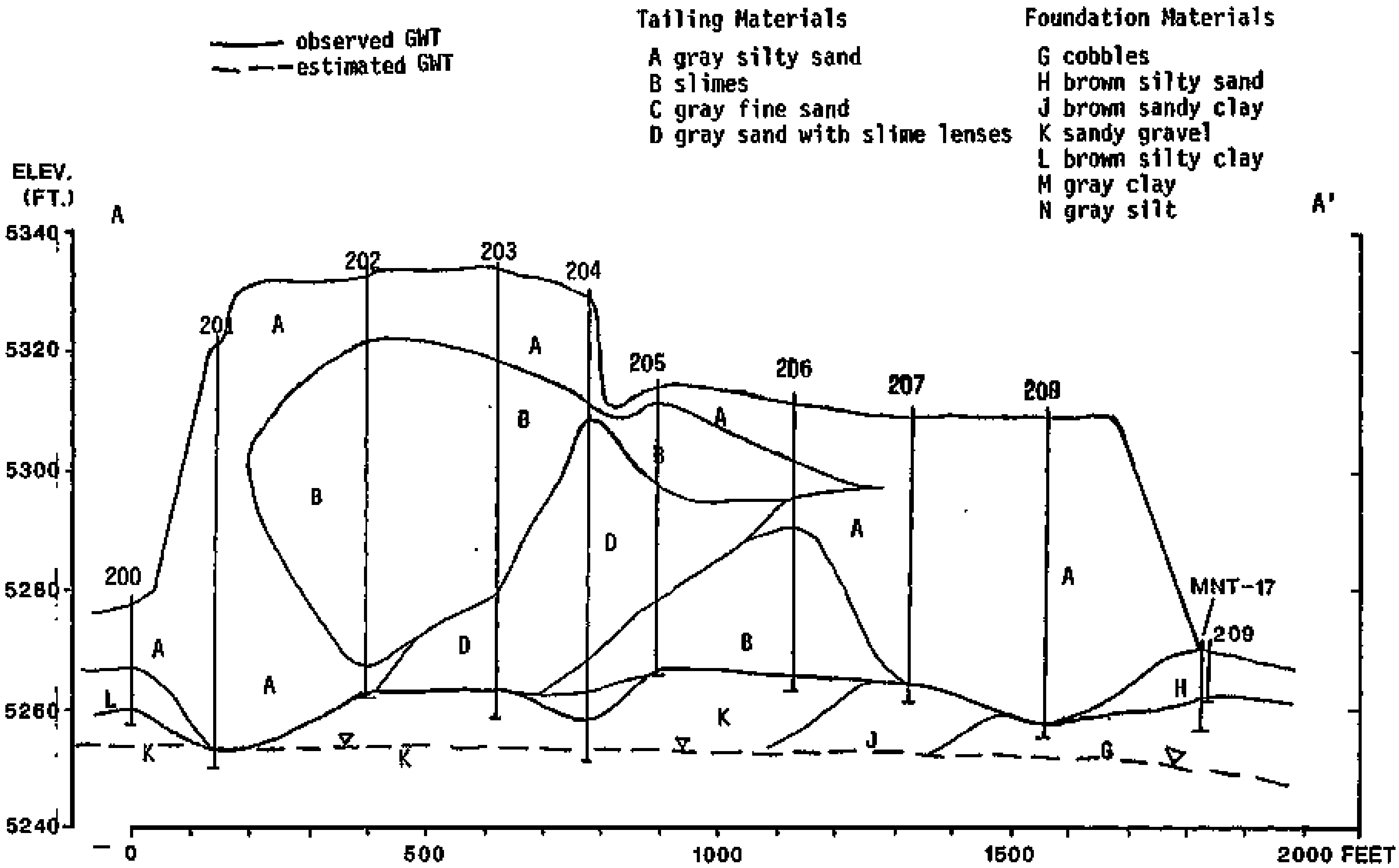


FIGURE D.4.6 CROSS SECTIONAL PROFILE A-A', NEW RIFLE

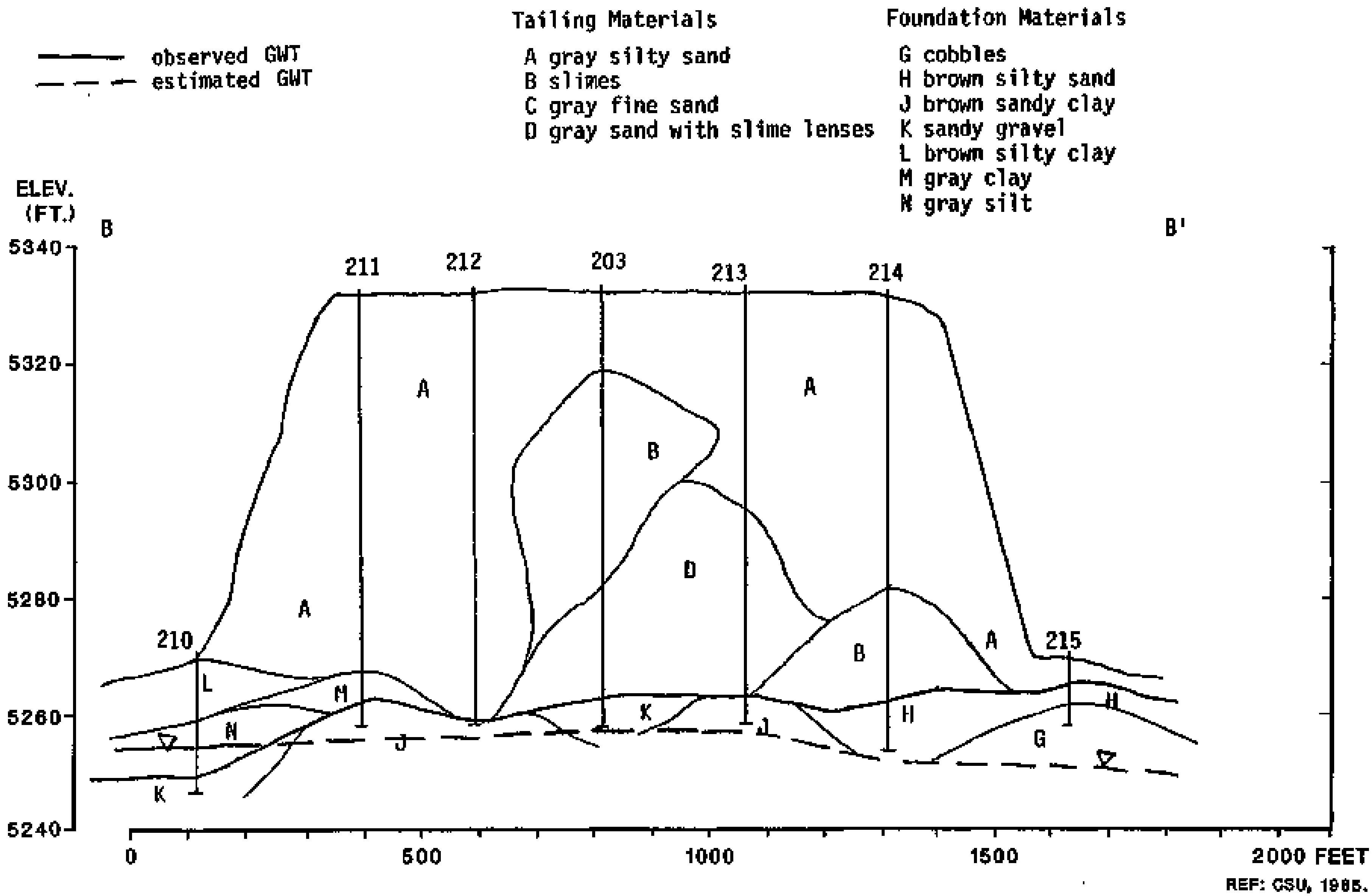


FIGURE D.4.7 CROSS SECTIONAL PROFILE B-B', NEW RIFLE

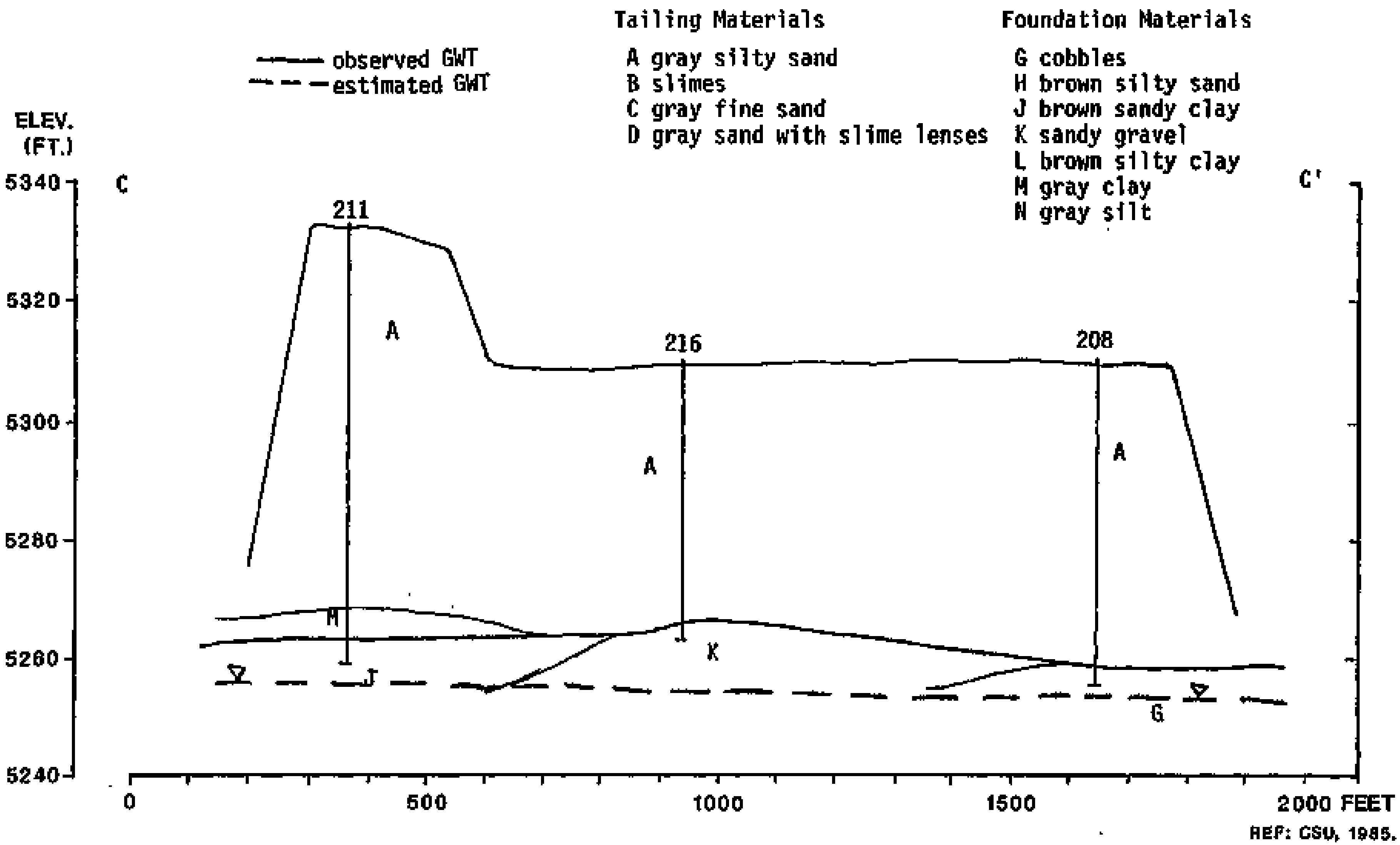


FIGURE D.4.8 CROSS SECTIONAL PROFILE C-C', NEW RIFLE

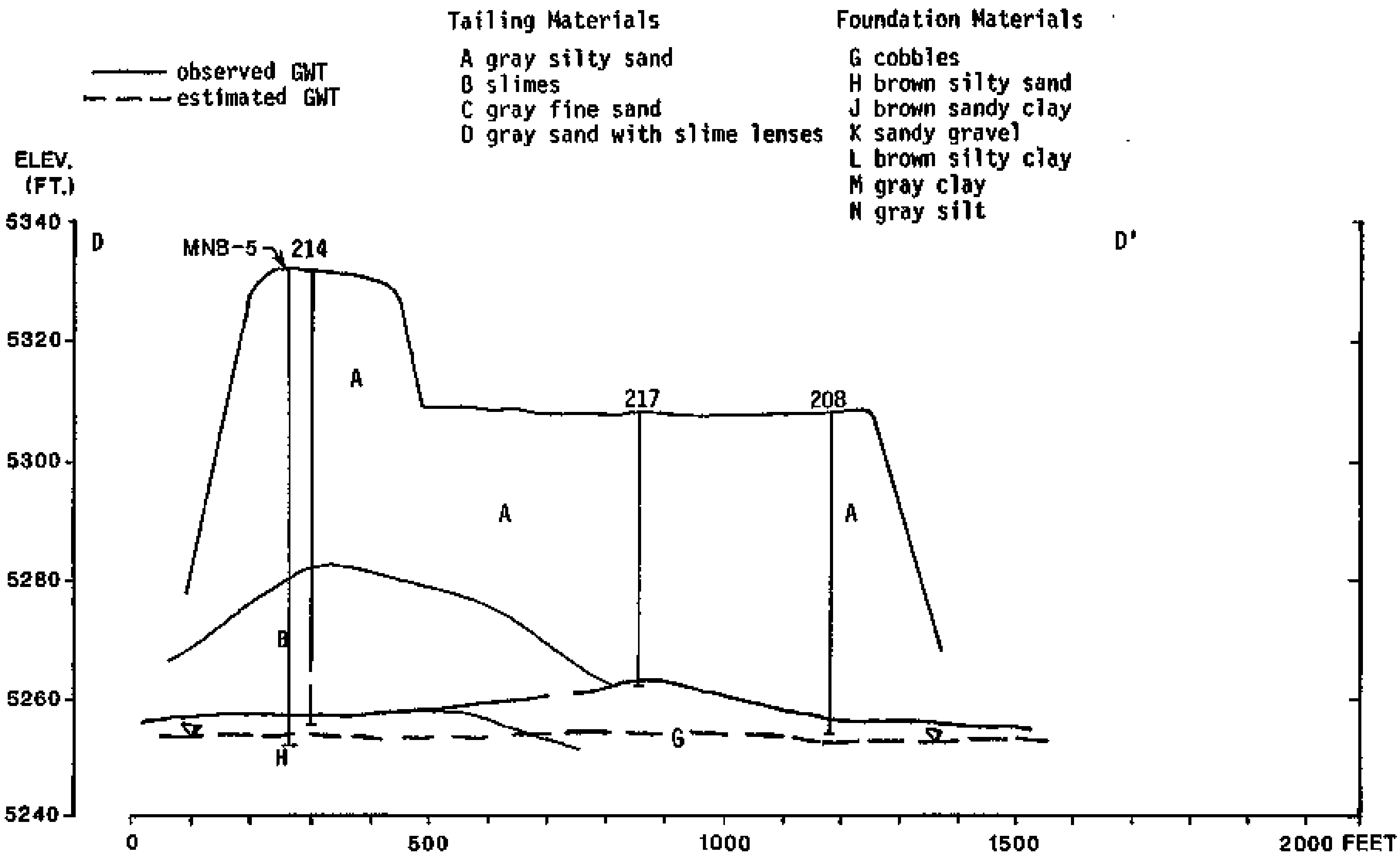


FIGURE D.4.9 CROSS SECTIONAL PROFILE D-D', NEW RIFLE

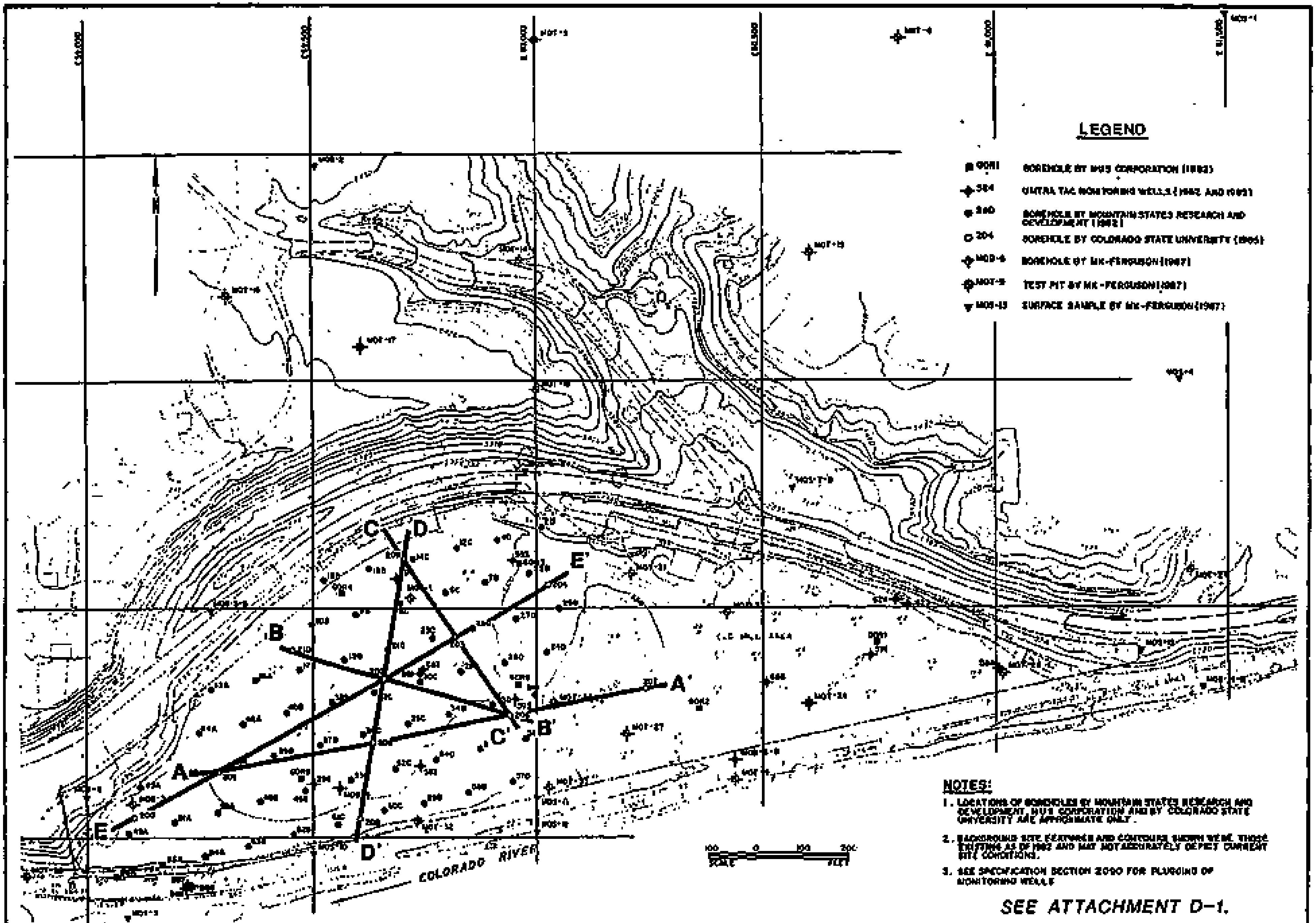
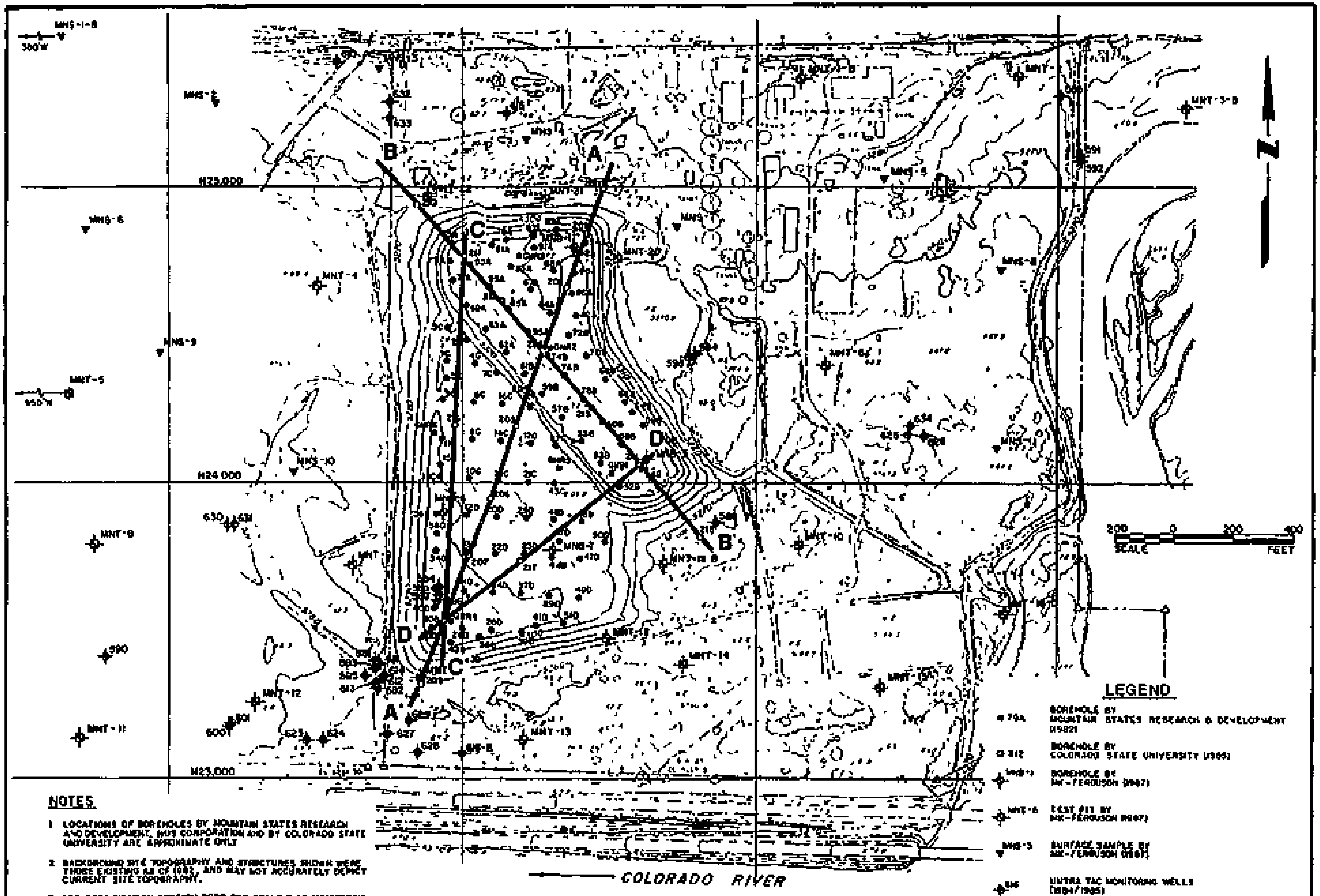


FIGURE D.4.10
LOCATIONS OF BORINGS ON THE OLD RIFLE TAILINGS PILE



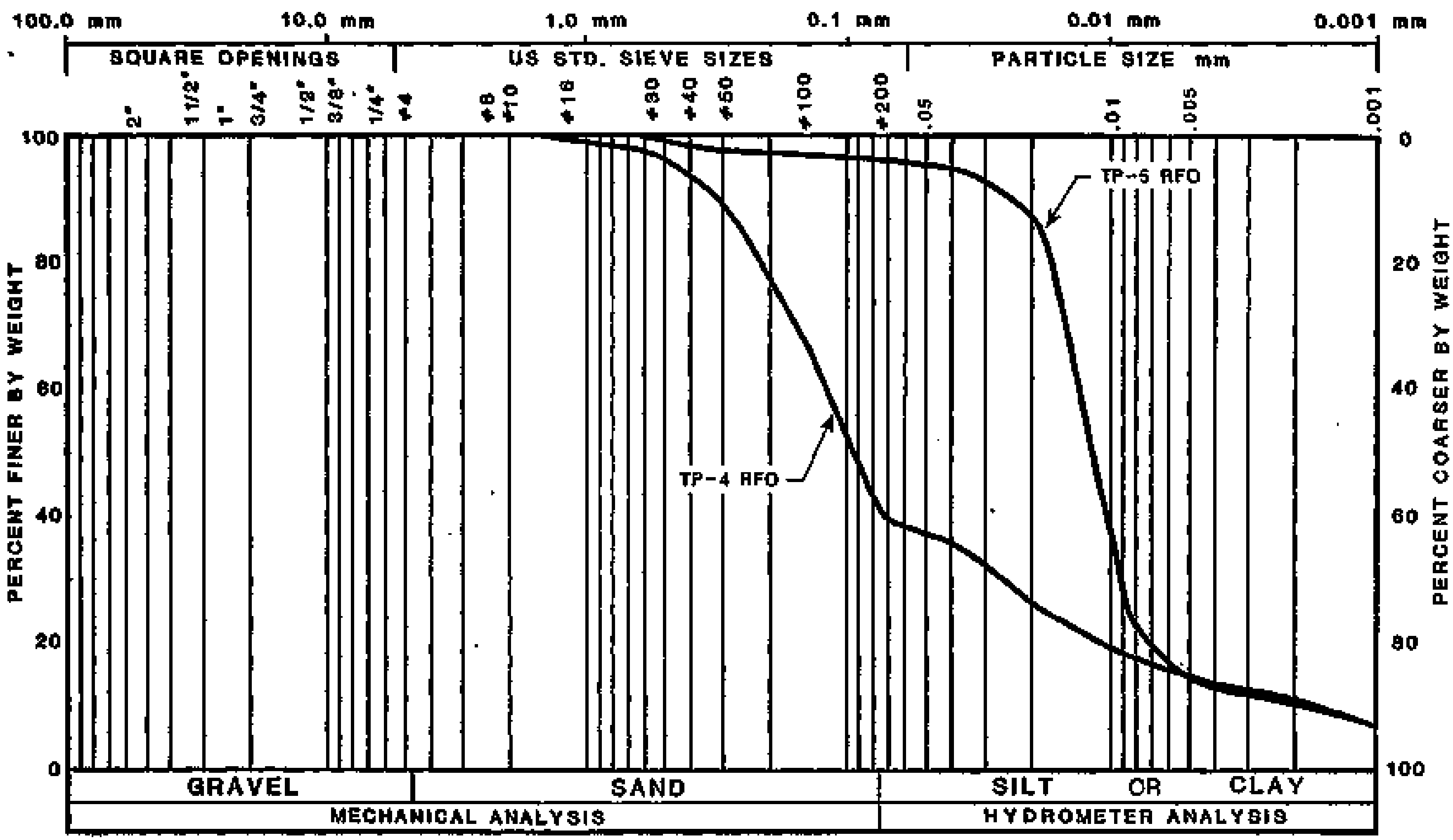
NOTES

1. LOCATIONS OF BOREHOLES BY MOUNTAIN STATES RESEARCH AND DEVELOPMENT, NUS CORPORATION AND BY COLORADO STATE UNIVERSITY ARE APPROXIMATE ONLY
2. BACKGROUND SITE TOPOGRAPHY AND STRUCTURES SHOWN WERE THOSE EXISTING AS OF 1983, AND MAY NOT ACCURATELY DEPICT CURRENT SITE TOPOGRAPHY.
3. SEE SPECIFICATION SECTION 2050 FOR SEALING OF MONITORING WELLS

SEE ATTACHMENT D-2.

FIGURE D.4.11

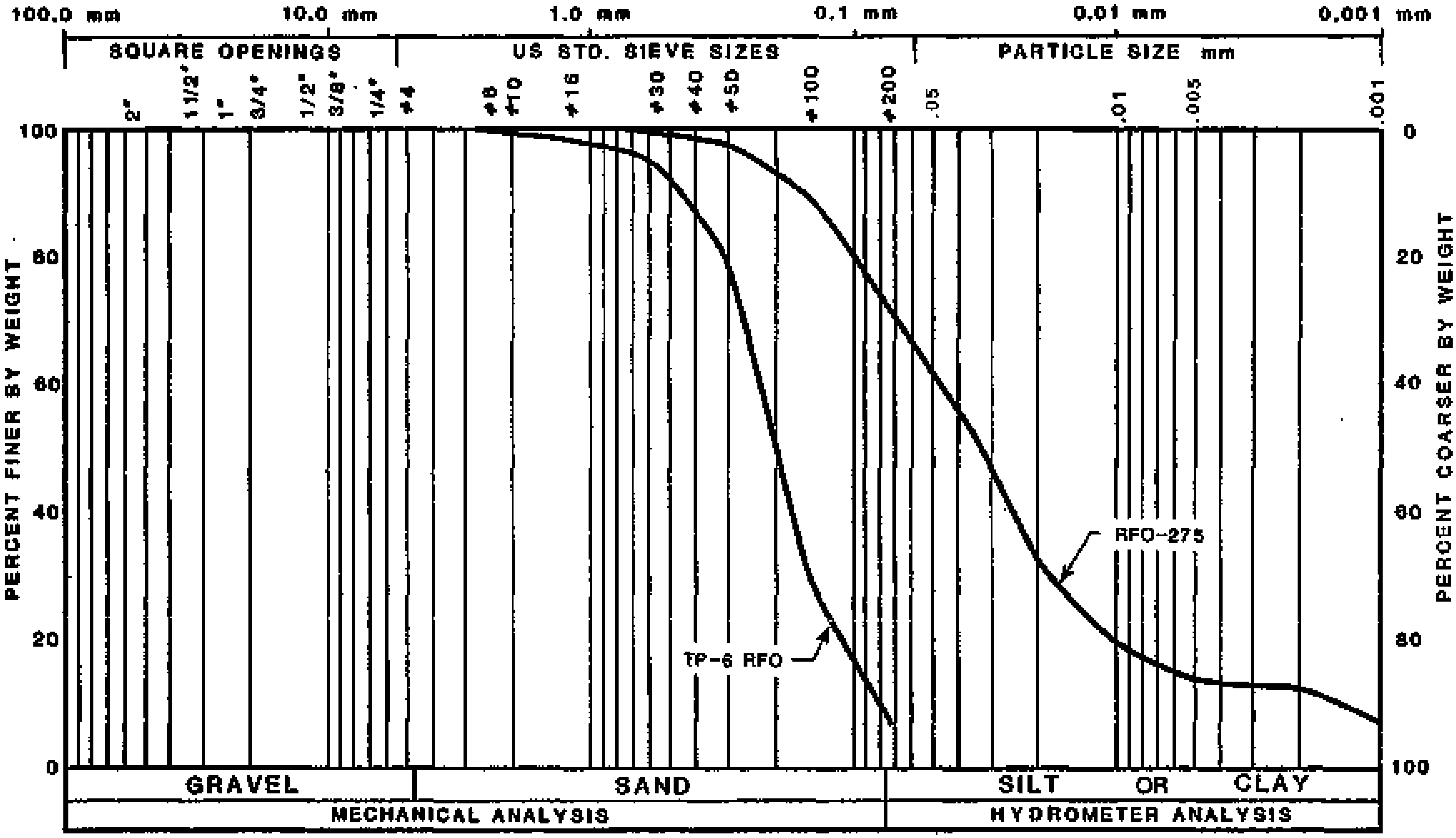
LOCATIONS OF BORINGS ON THE NEW RIFLE TAILINGS PILE



LEGEND		
SAMPLE RFL-01	DEPTH INTERVAL (FT.)	UNIFIED SOIL CLASSIFICATION
TP-4 RFO	12'	SAND-SLIME (SM)
TP-5 RFO	6'	SLIME (ML)

FIGURE D.4.12

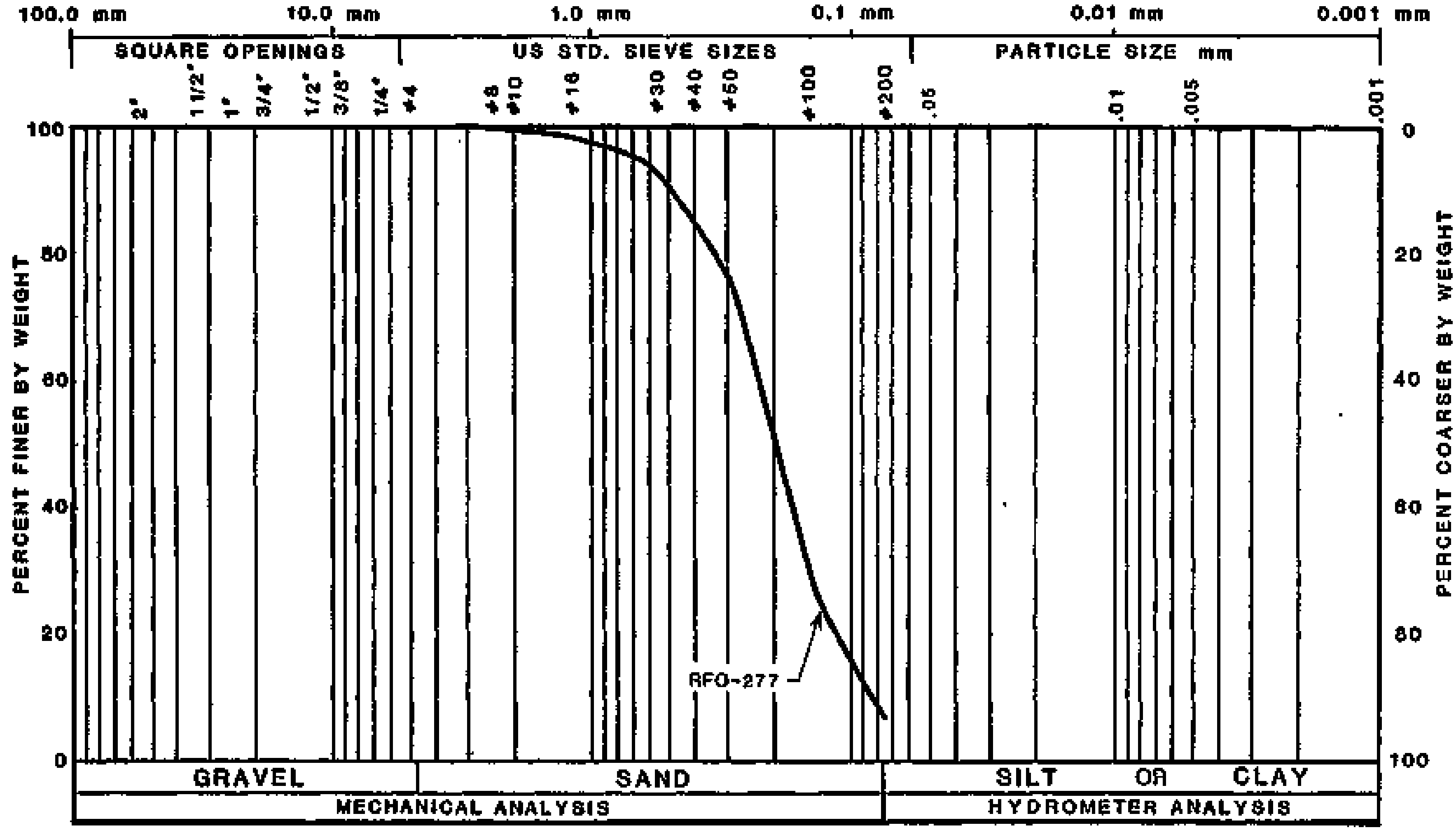
GRADATION CURVES - OLD RIFLE



LEGEND		
SAMPLE RFL-01	DEPTH INTERVAL (FT.)	UNIFIED SOIL CLASSIFICATION
TP-6 RFO	7'	SAND TAILINGS (SP)
RFO-275	9.5' - 12.0'	SLIME (ML)

FIGURE D.4.13
GRADATION CURVES - OLD RIFLE

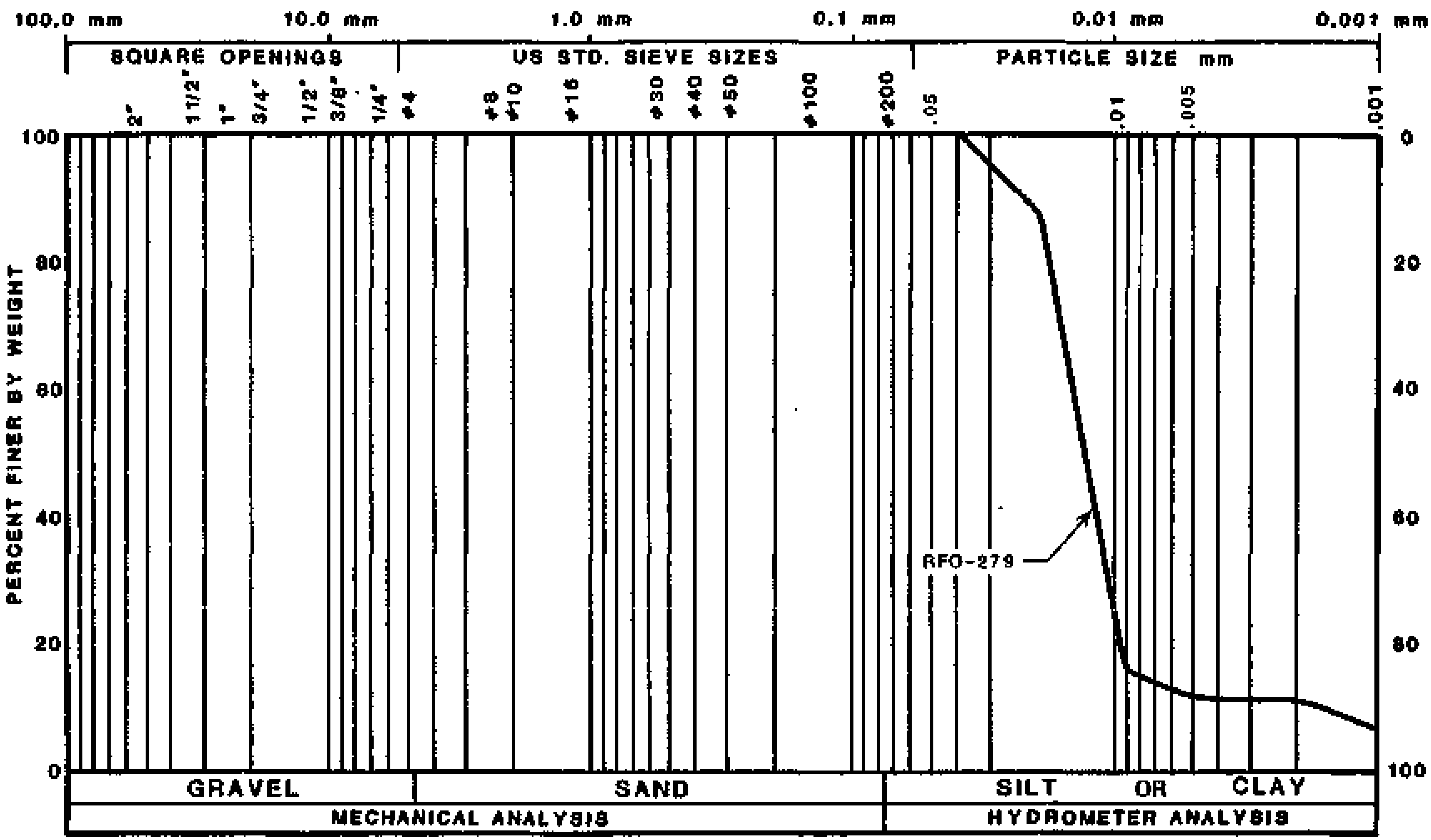
D-153



LEGEND		
SAMPLE RFL-01	DEPTH INTERVAL (FT.)	UNIFIED SOIL CLASSIFICATION
RFO-277	9.5' - 12.0'	SAND TAILINGS (SP)

FIGURE D.4.14

GRADATION CURVE - OLD RIFLE



LEGEND		
SAMPLE RFL-01	DEPTH INTERVAL (FT.)	UNIFIED SOIL CLASSIFICATION
RFO-279	6.0' – 6.5'	SLIME (MH)

FIGURE D.4.15

GRADATION CURVE – OLD RIFLE

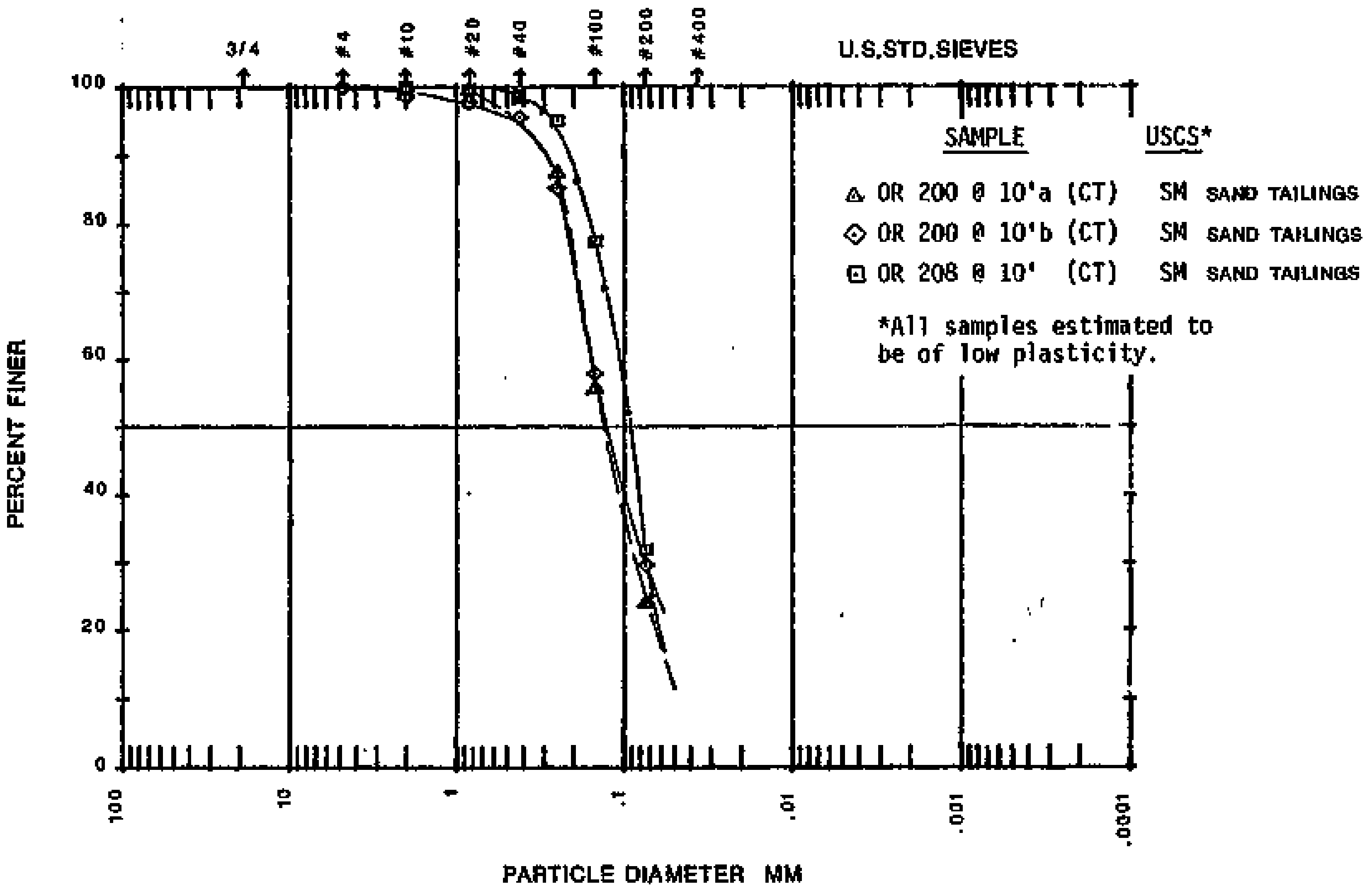


FIGURE D.4.16
GRADATION CURVES – OLD RIFLE

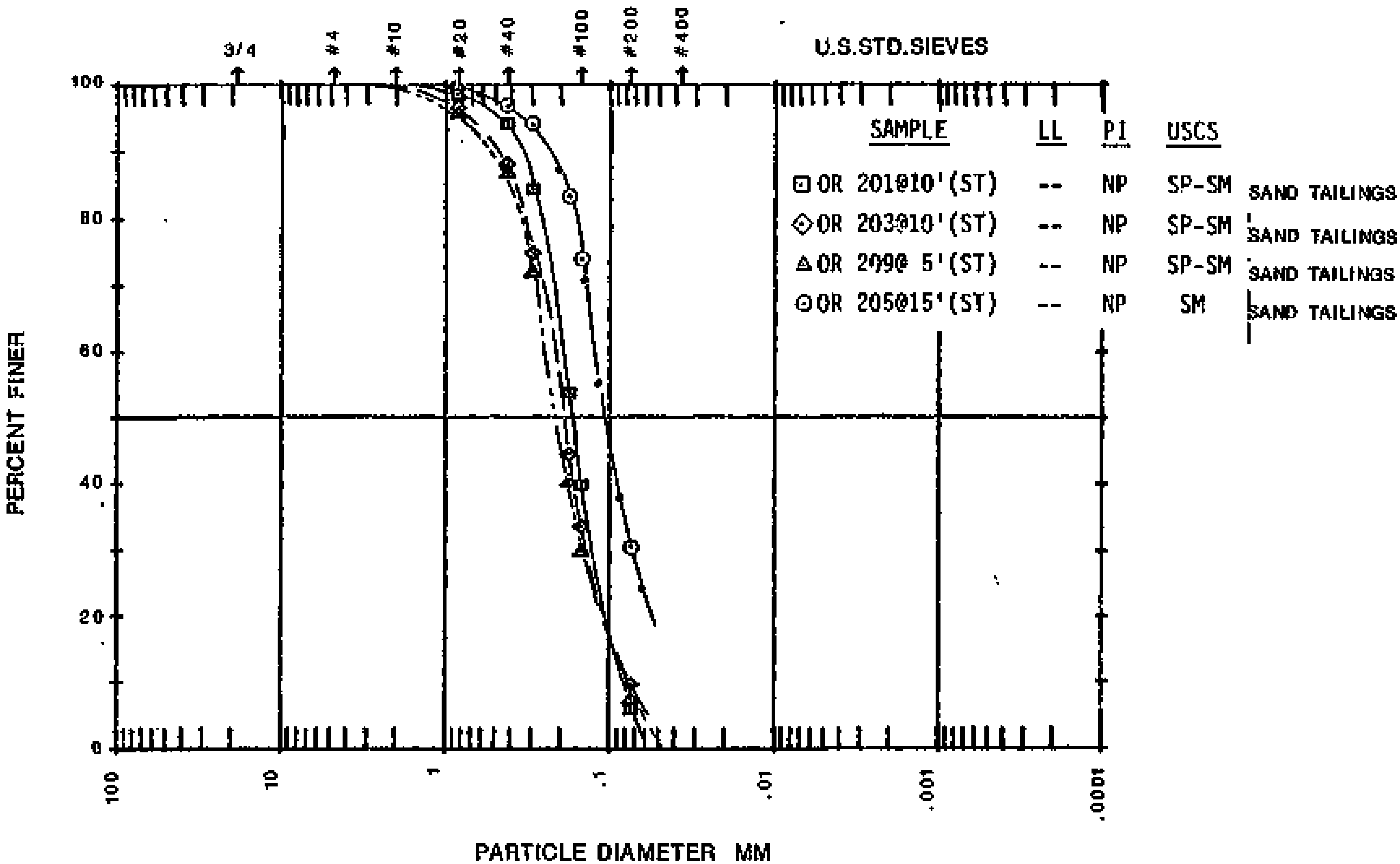


FIGURE D.4.17
GRADATION CURVES - OLD RIFLE

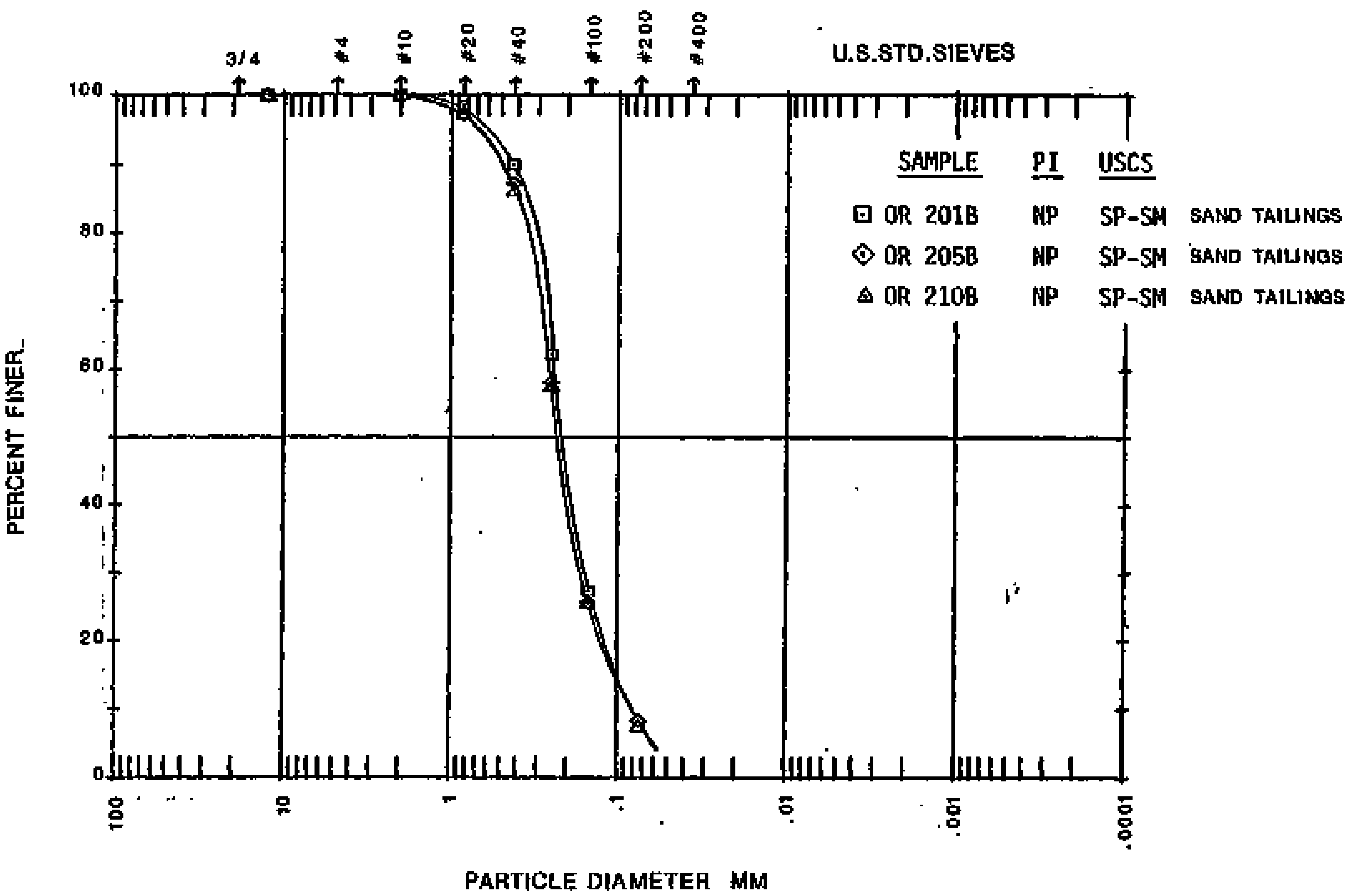
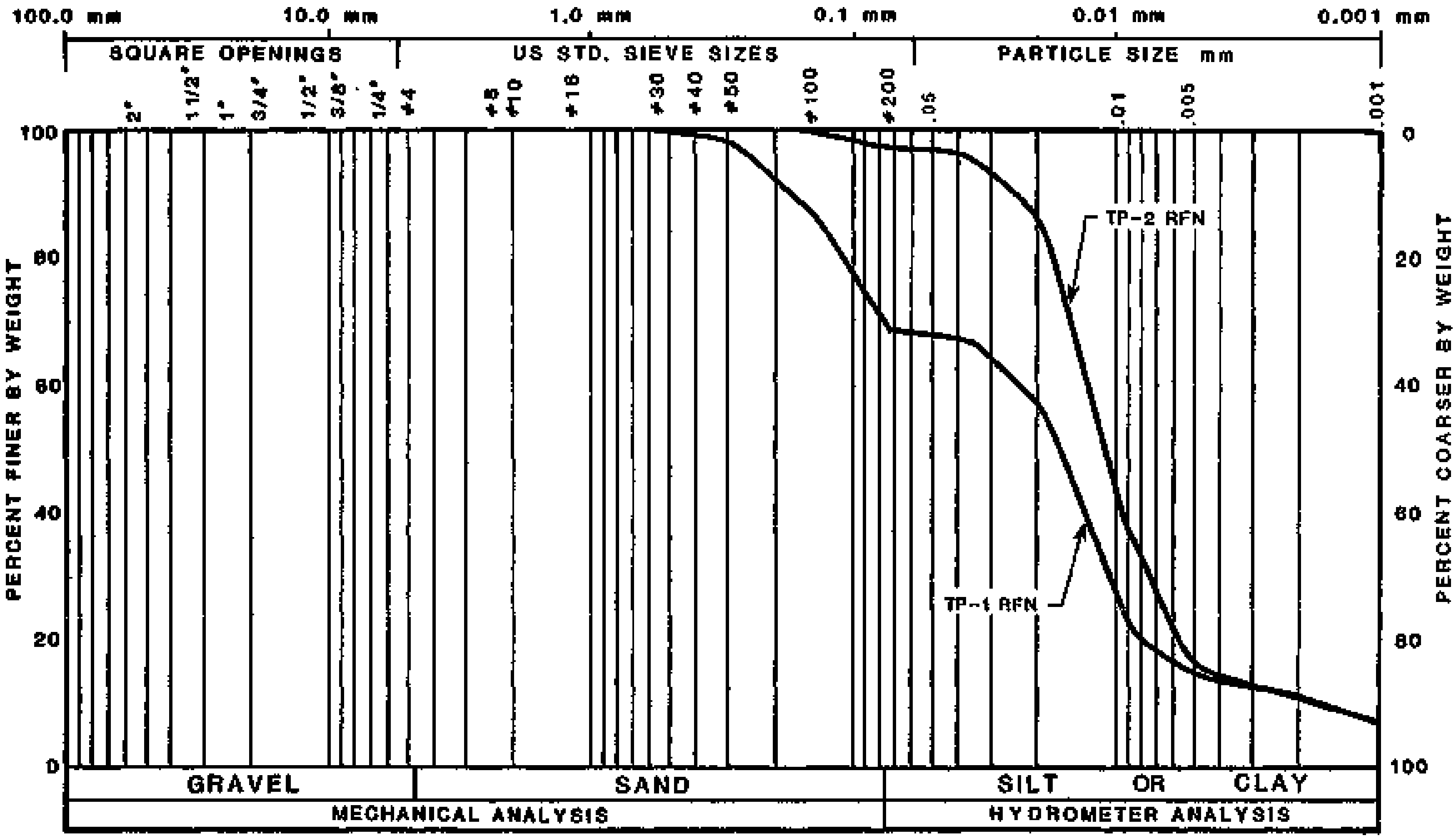
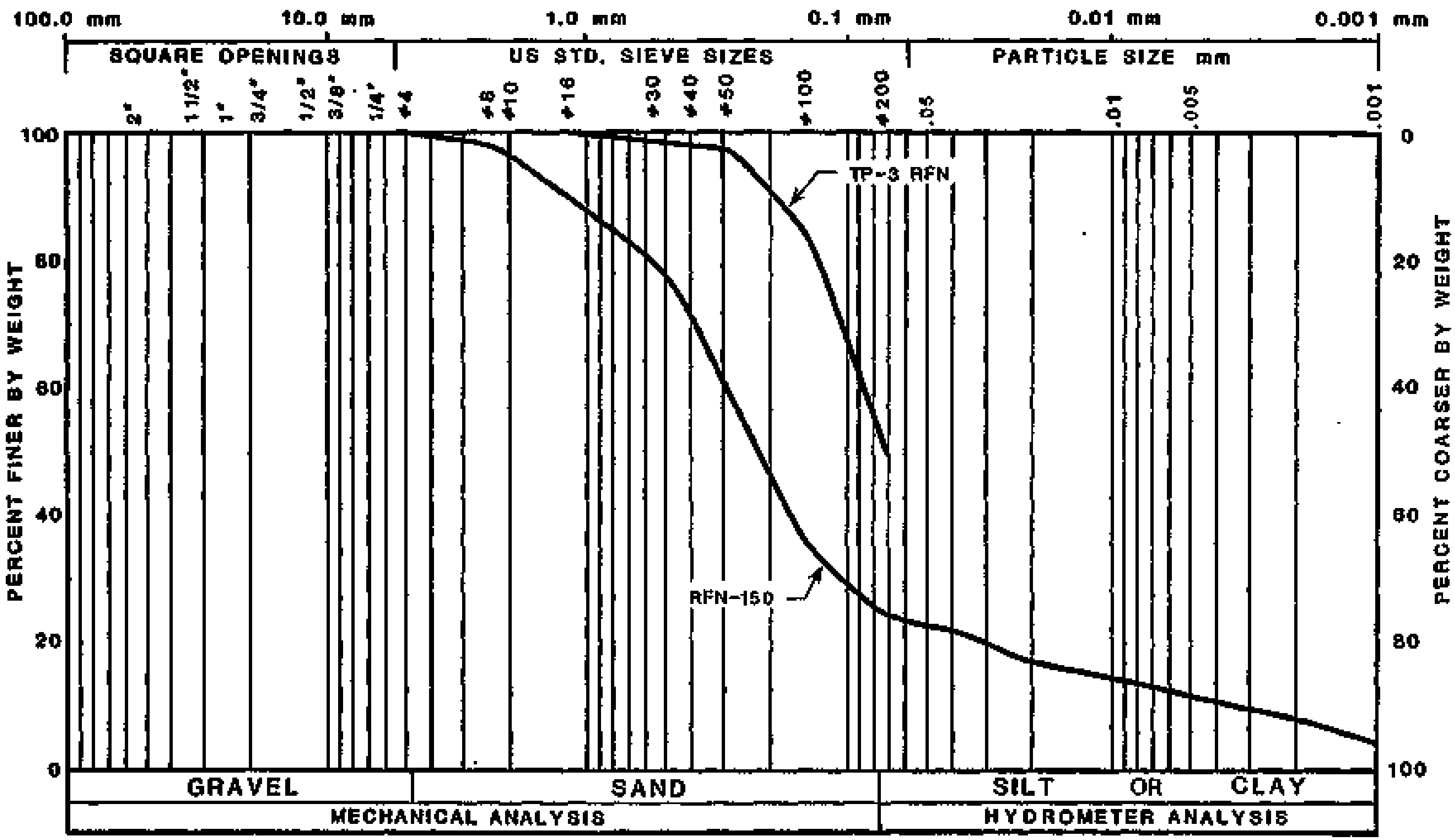


FIGURE D.4.18
GRADATION CURVES - OLD RIFLE



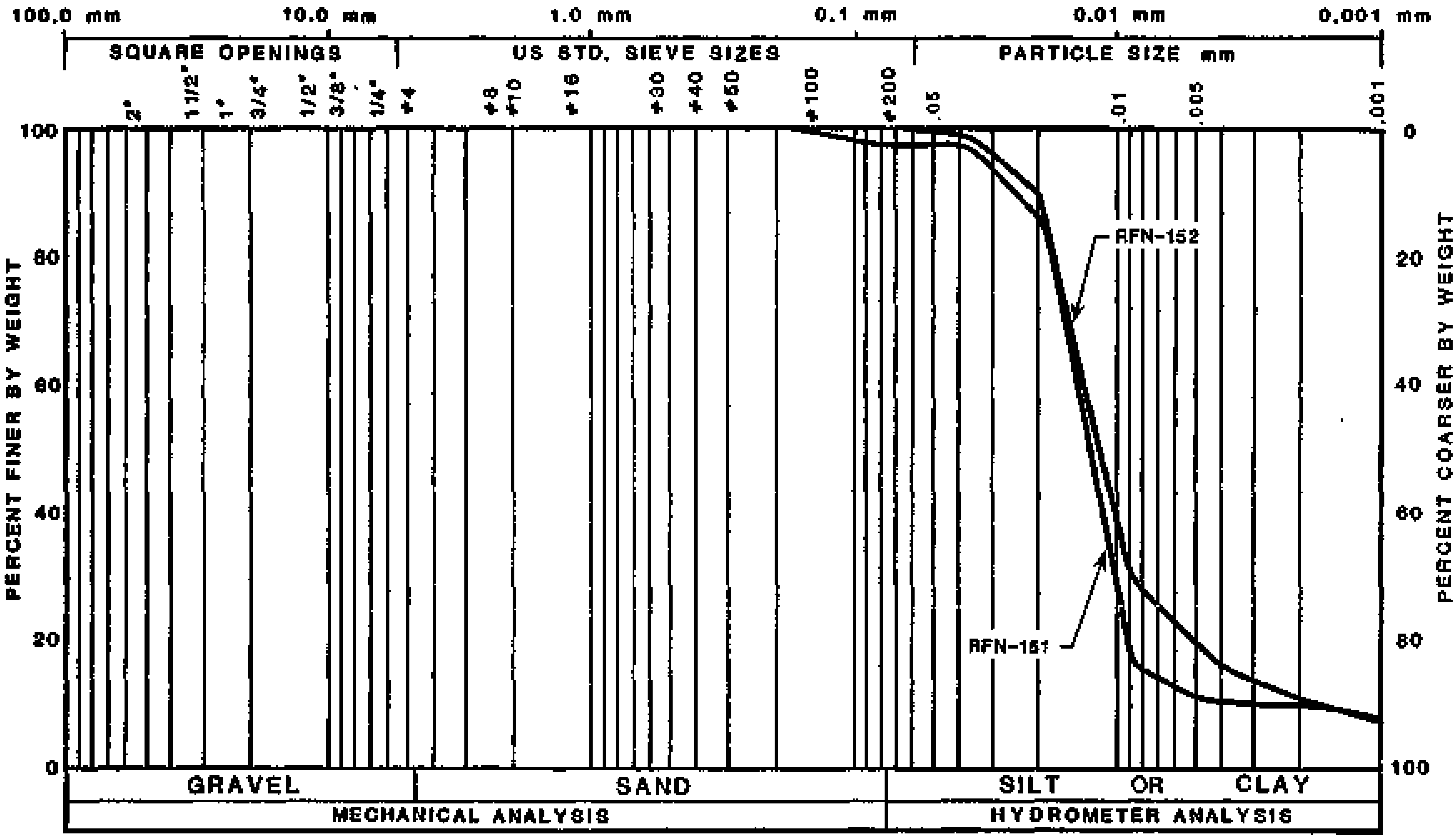
LEGEND		
SAMPLE RFL-01	DEPTH INTERVAL (FT.)	UNIFIED SOIL CLASSIFICATION
TP-1 RFN	6'	SAND-SLIME (ML)
TP-2 RFN	8'	SLIME (ML)

FIGURE D.4.19
GRADATION CURVES – NEW RIFLE



LEGEND		
SAMPLE RFL-01	DEPTH INTERVAL (FT.)	UNIFIED SOIL CLASSIFICATION
RFN-150	59.5' - 62.0'	SAND TAILINGS (SM)
TP-3 RFN	3'	SAND-SLIME (SM-ML)

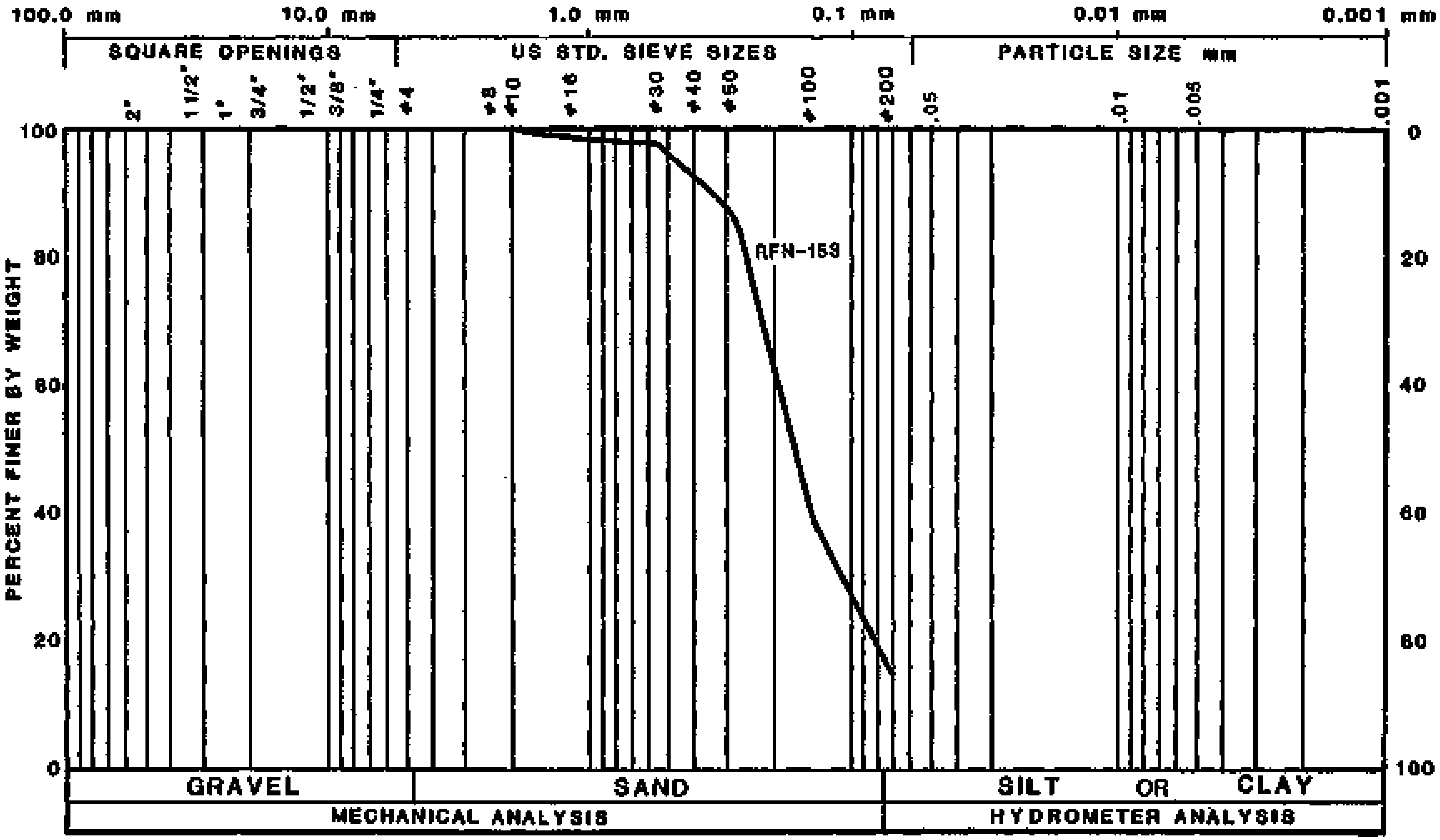
FIGURE D.4.20
GRADATION CURVES - NEW RIFLE



LEGEND		
SAMPLE	DEPTH INTERVAL (FT.)	UNIFIED SOIL CLASSIFICATION
RFN-151	50.0' - 52.3'	SLIME (MH)
RFN-152	8.0' - 10.3'	SLIME (MH)

FIGURE D.4.21

GRADATION CURVES - NEW RIFLE



LEGEND		
SAMPLE RFL-01	DEPTH INTERVAL (FT.)	UNIFIED SOIL CLASSIFICATION
RFN-153	22.5' - 22.0'	SAND TAILINGS (SP-SM)

FIGURE D.4.22

GRADATION CURVES - NEW RIFLE

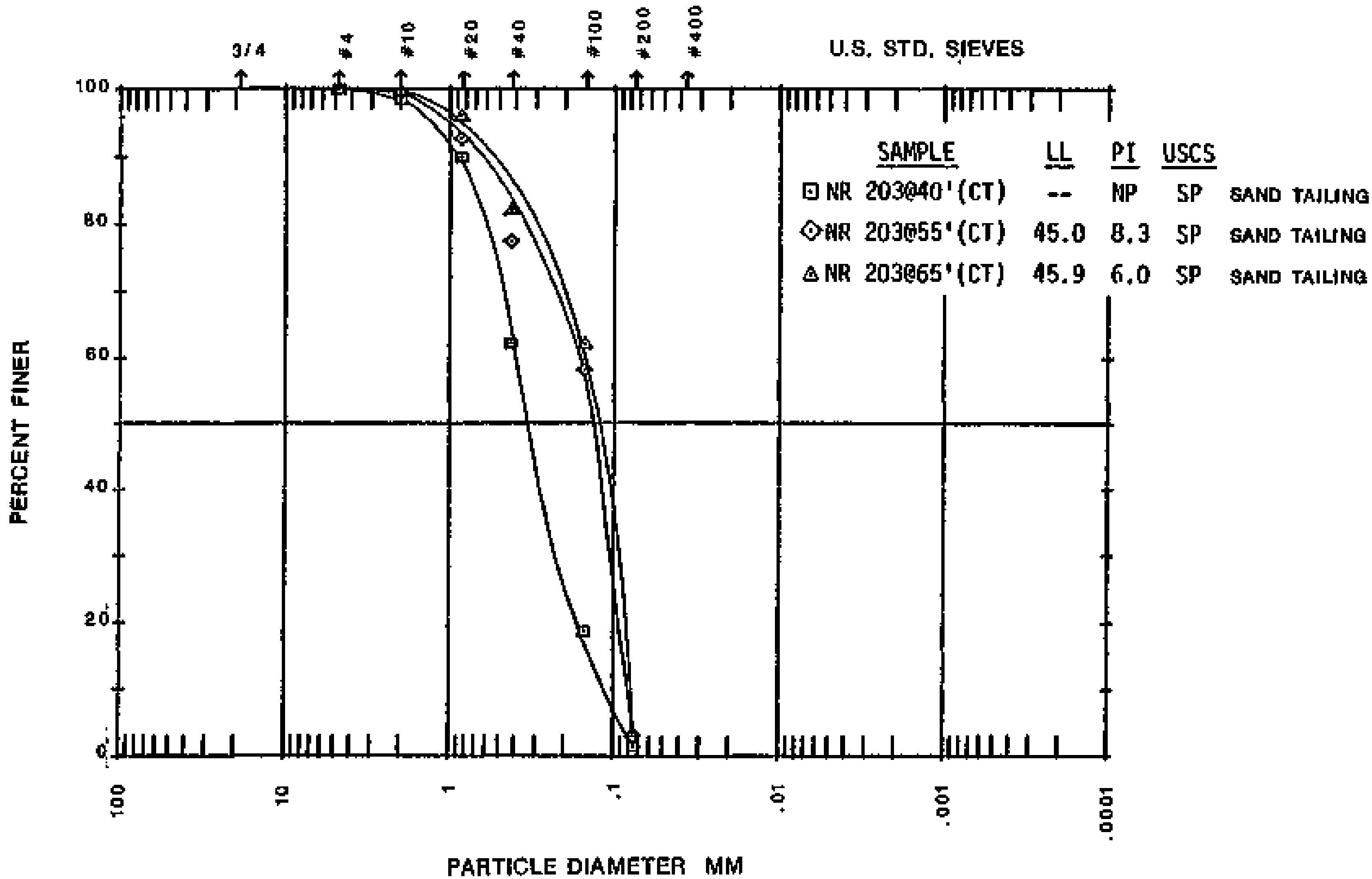


FIGURE D.4.23
GRADATION CURVES - NEW RIFLE

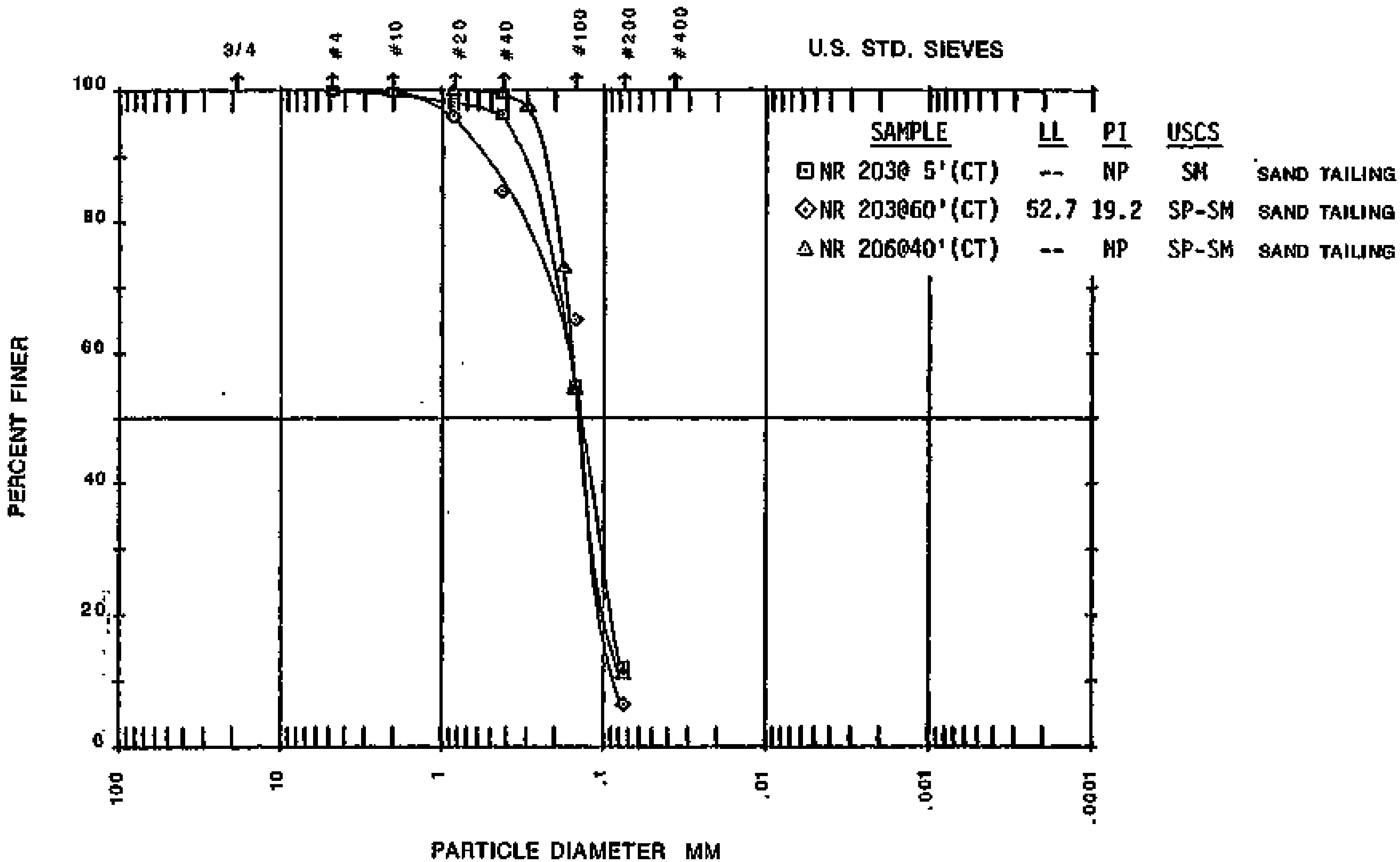


FIGURE D.4.24
GRADATION CURVES - NEW RIFLE

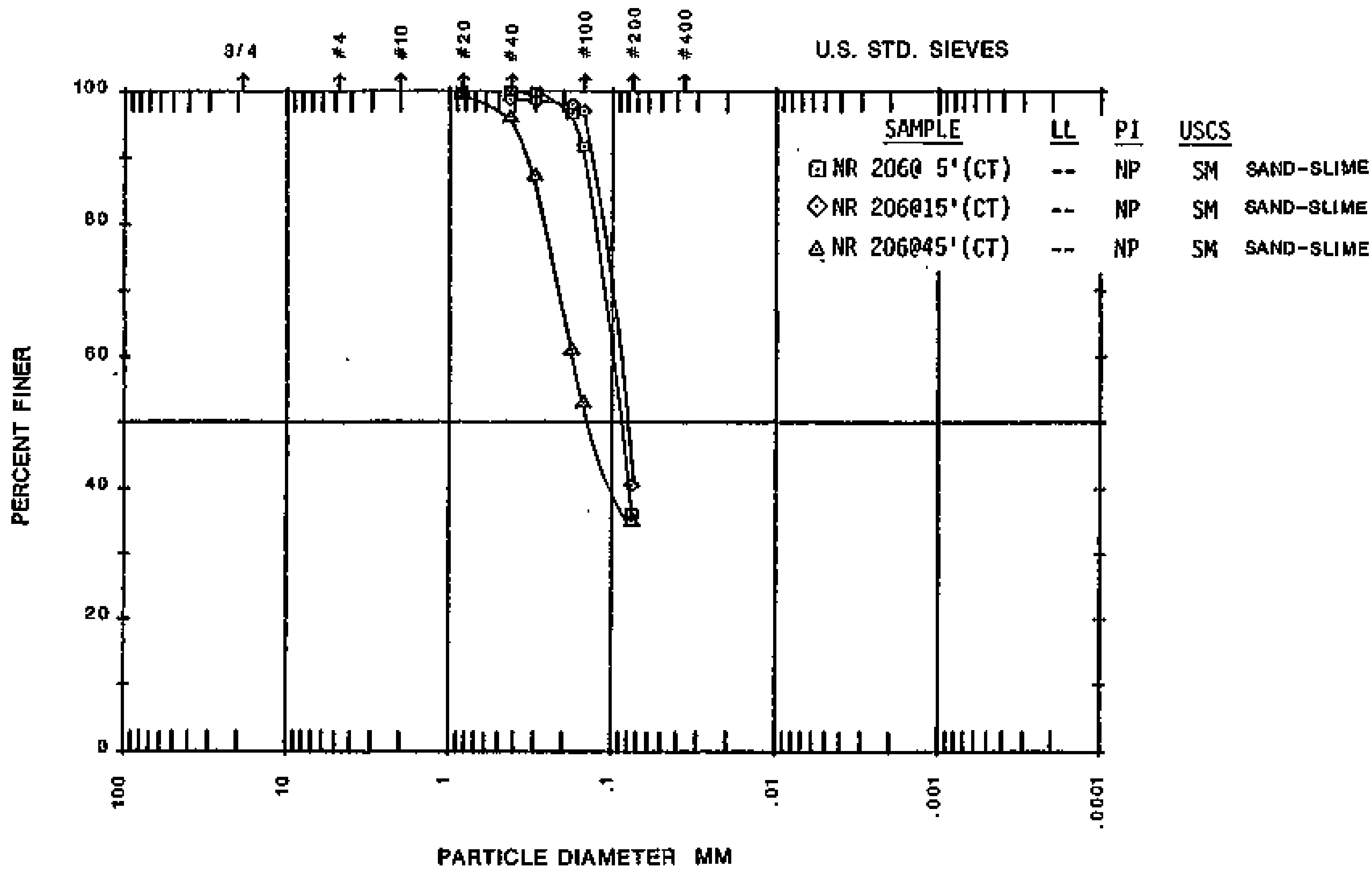


FIGURE D.4.25
GRADATION CURVES - NEW RIFLE

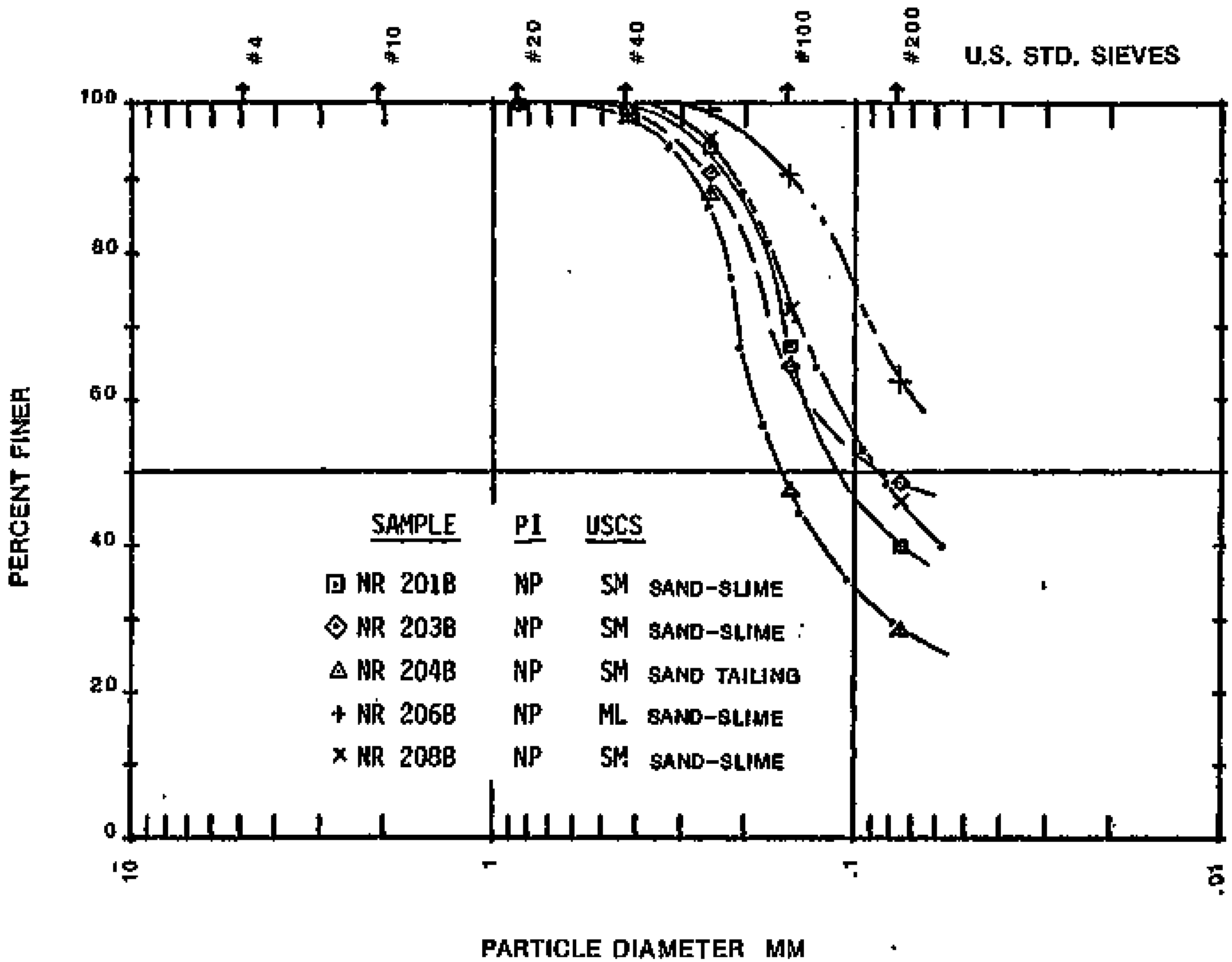
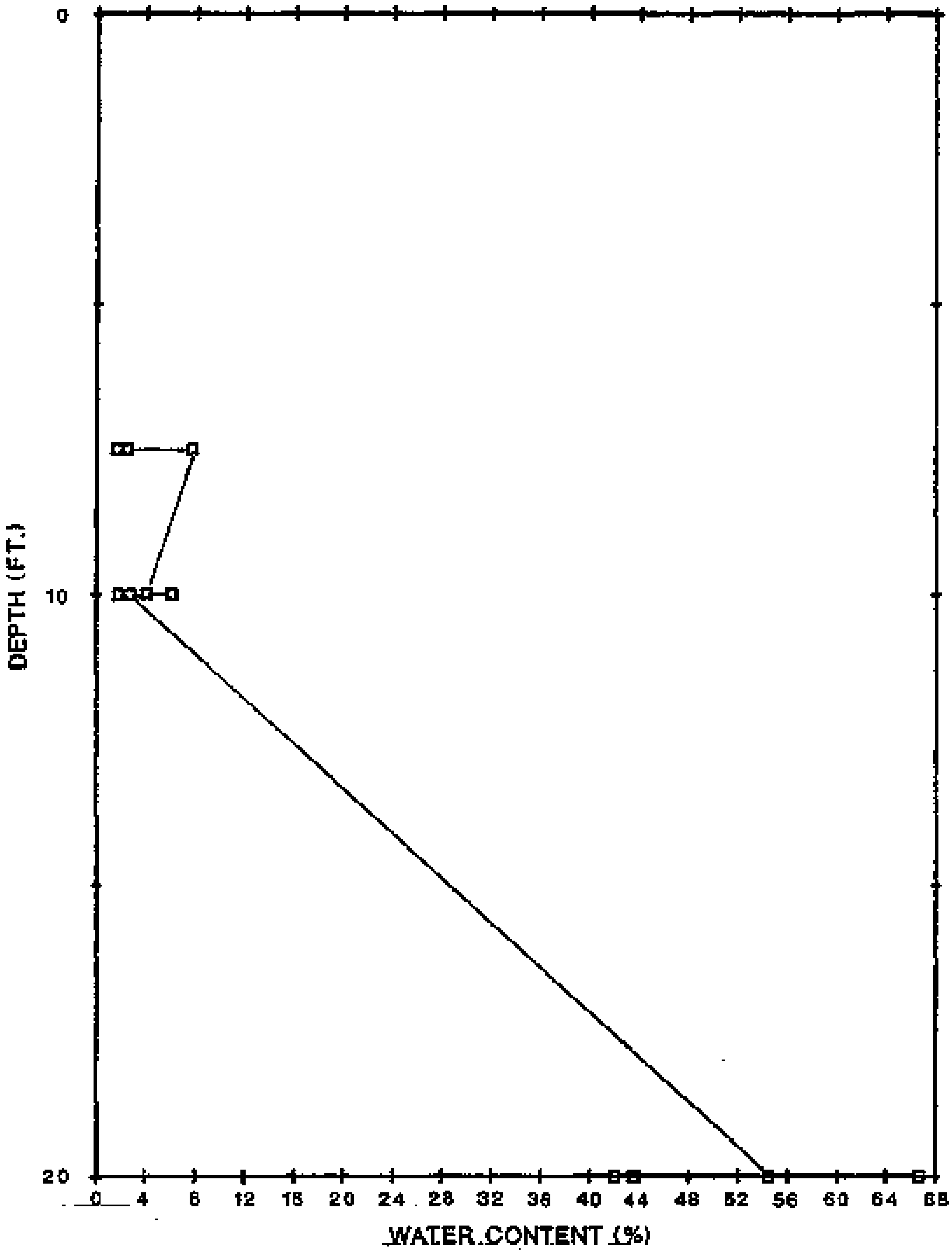
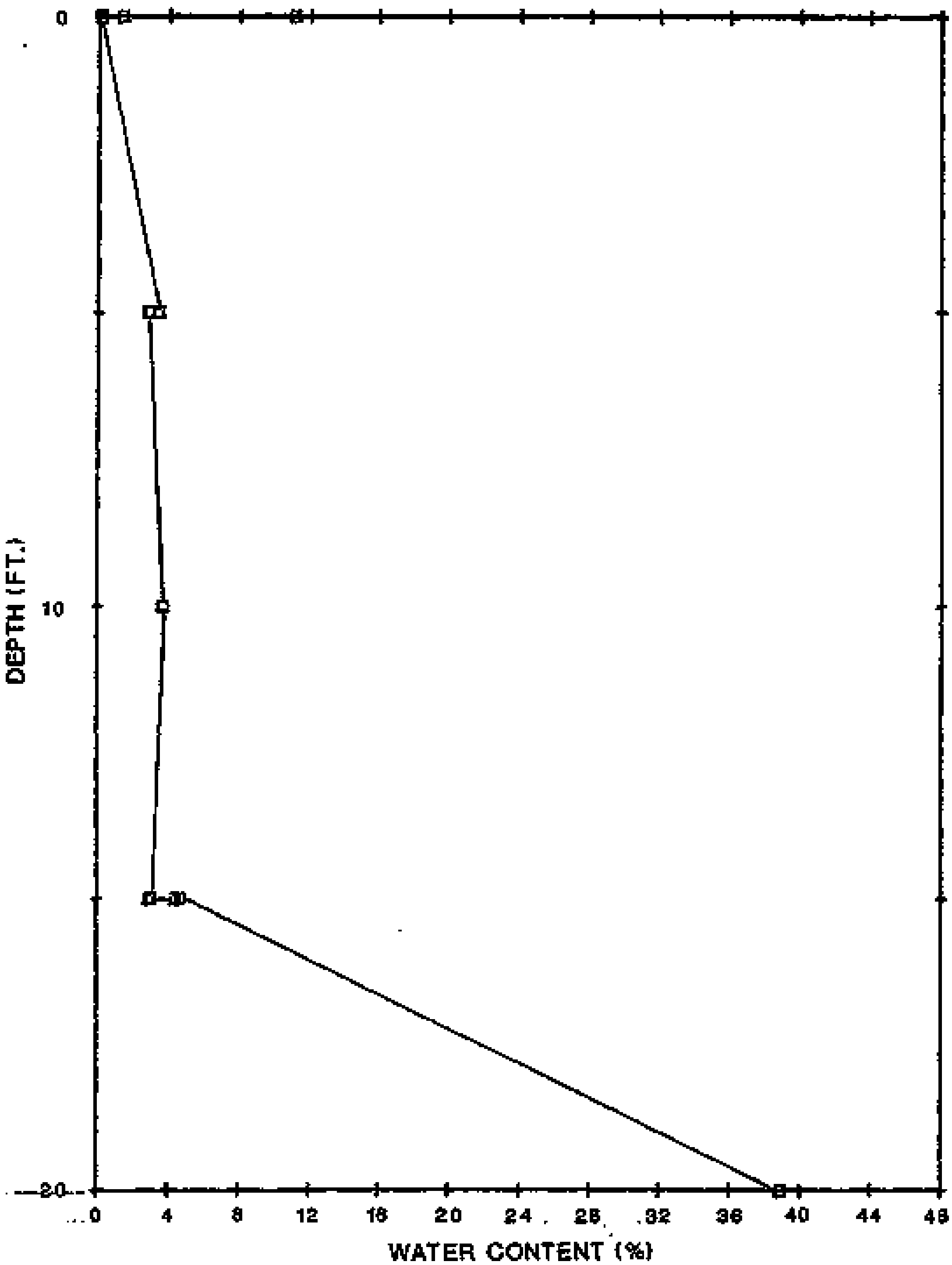


FIGURE D.4.26
GRADATION CURVES - NEW RIFLE



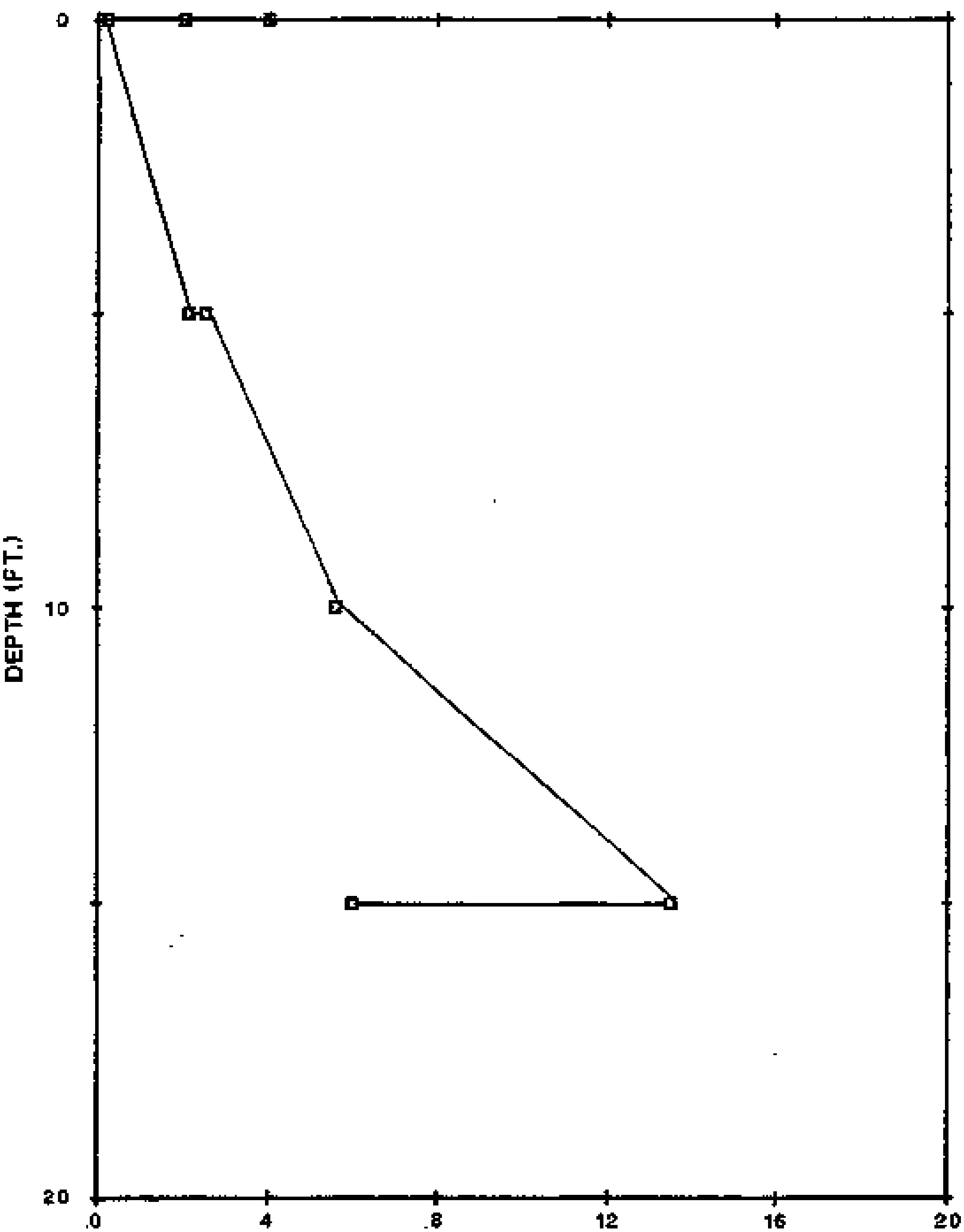
REFERENCE: CSU, 1985.

FIGURE D.4.27
WATER CONTENT WITH DEPTH FOR BORING OR 200
OLD RIFLE



REFERENCE: CSU, 1985.

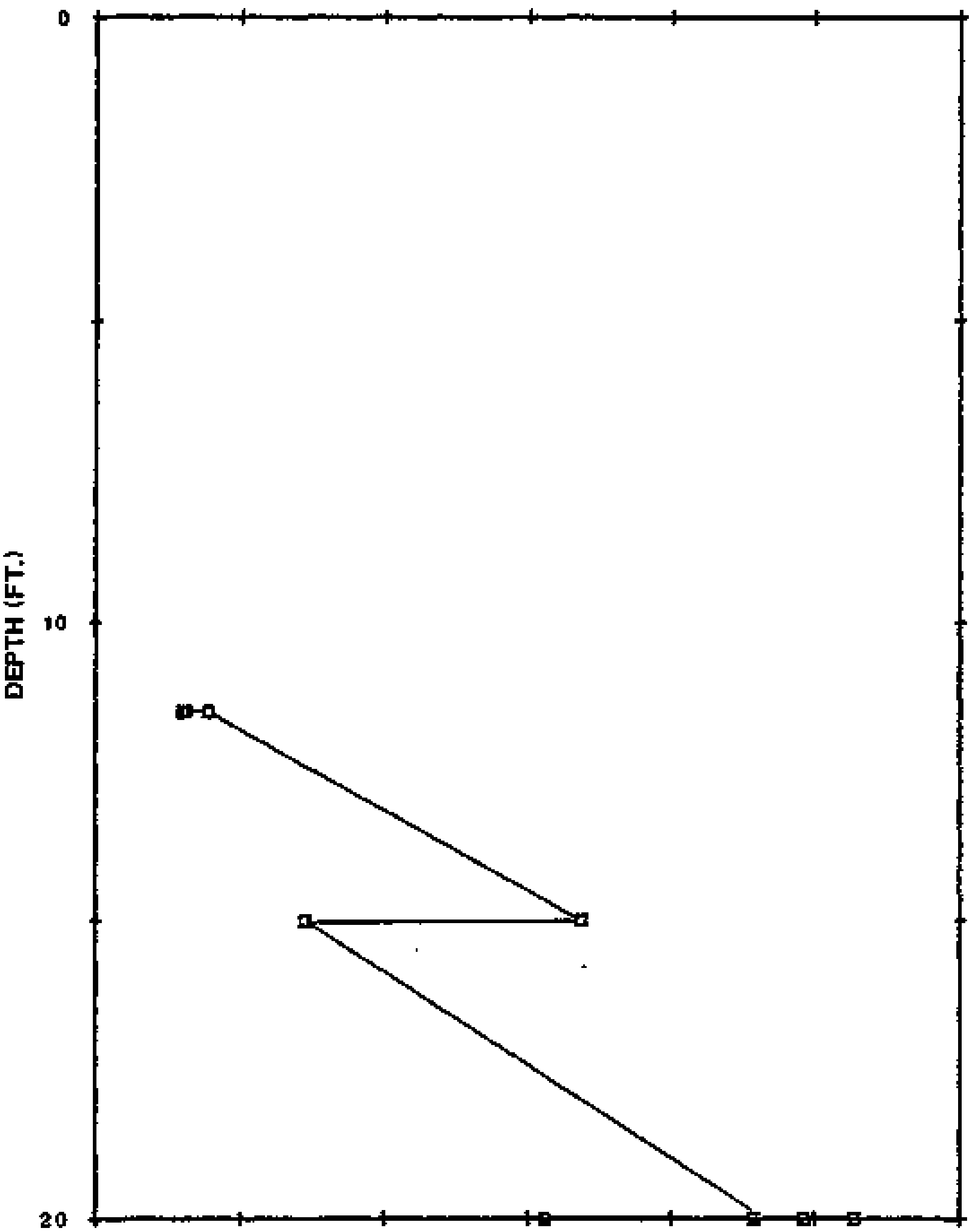
FIGURE D.4.28
WATER CONTENT WITH DEPTH FOR BORING OR 201
OLD RIFLE



REFERENCE: CSU, 1985.

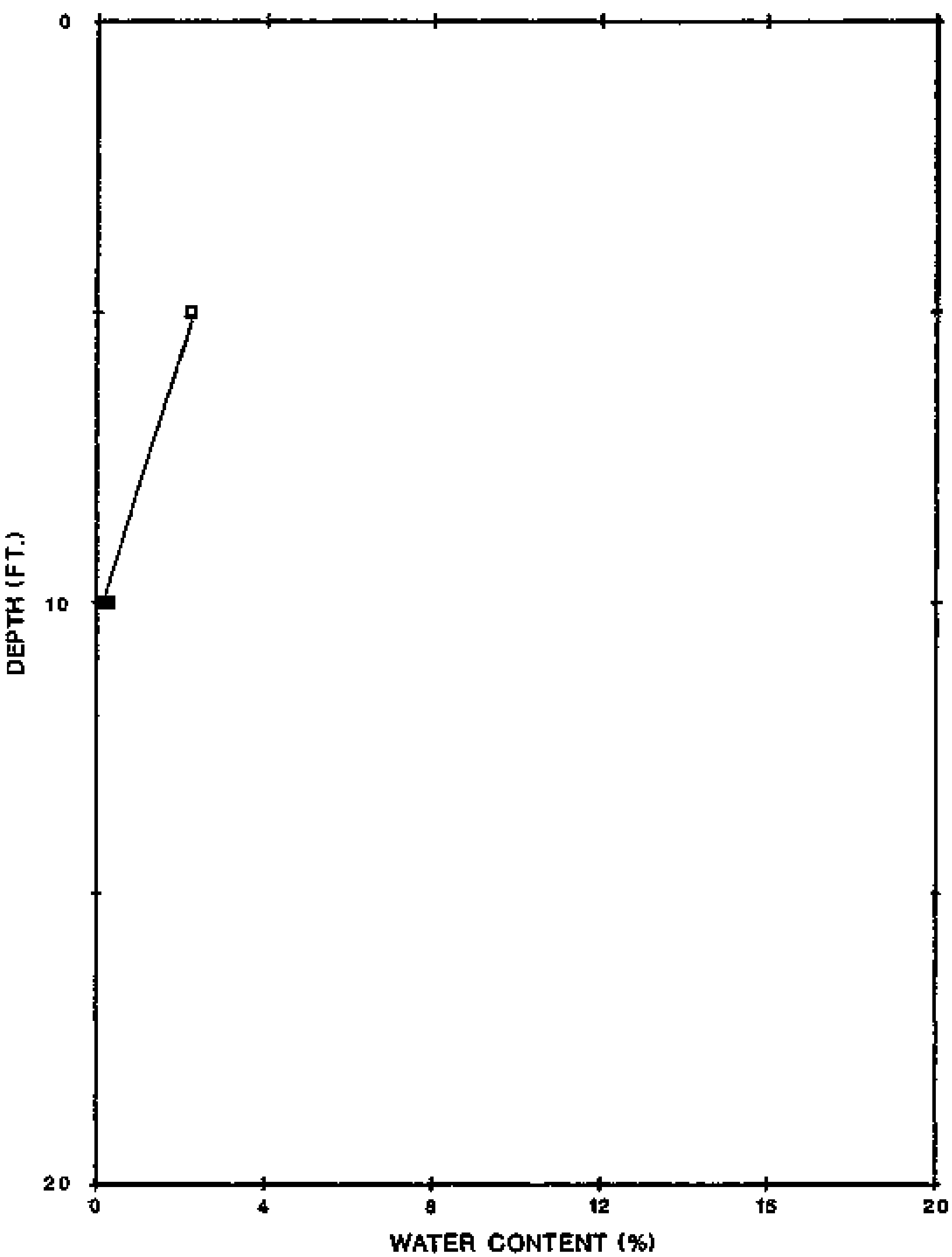
FIGURE D.4.29

WATER CONTENT WITH DEPTH FOR BORING OR 203
OLD RIFLE



REFERENCE: CSU, 1965.

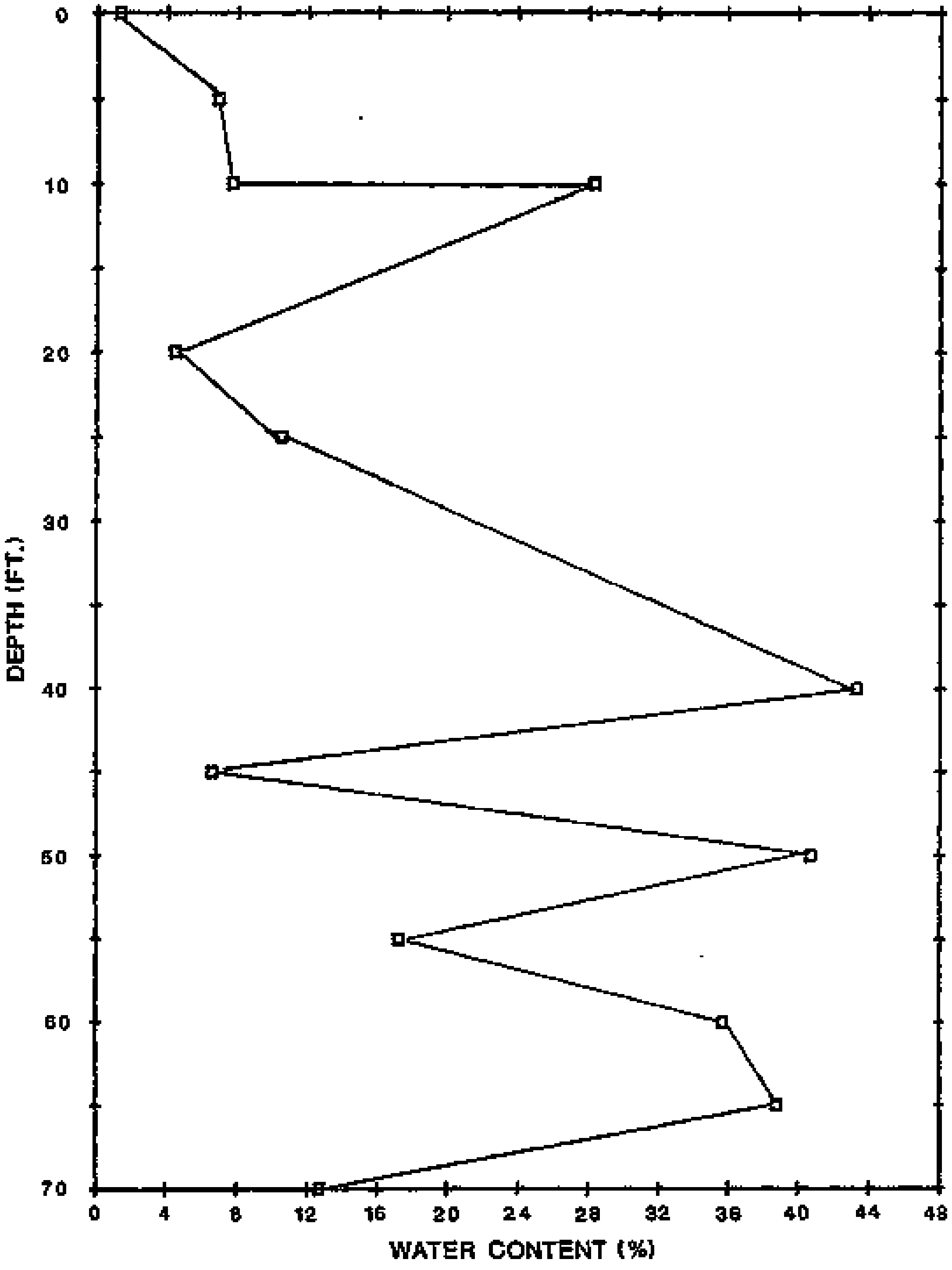
FIGURE D.4.30
WATER CONTENT WITH DEPTH FOR BORING OR 205
OLD RIFLE



REFERENCE: CSU, 1985.

FIGURE D.4.31

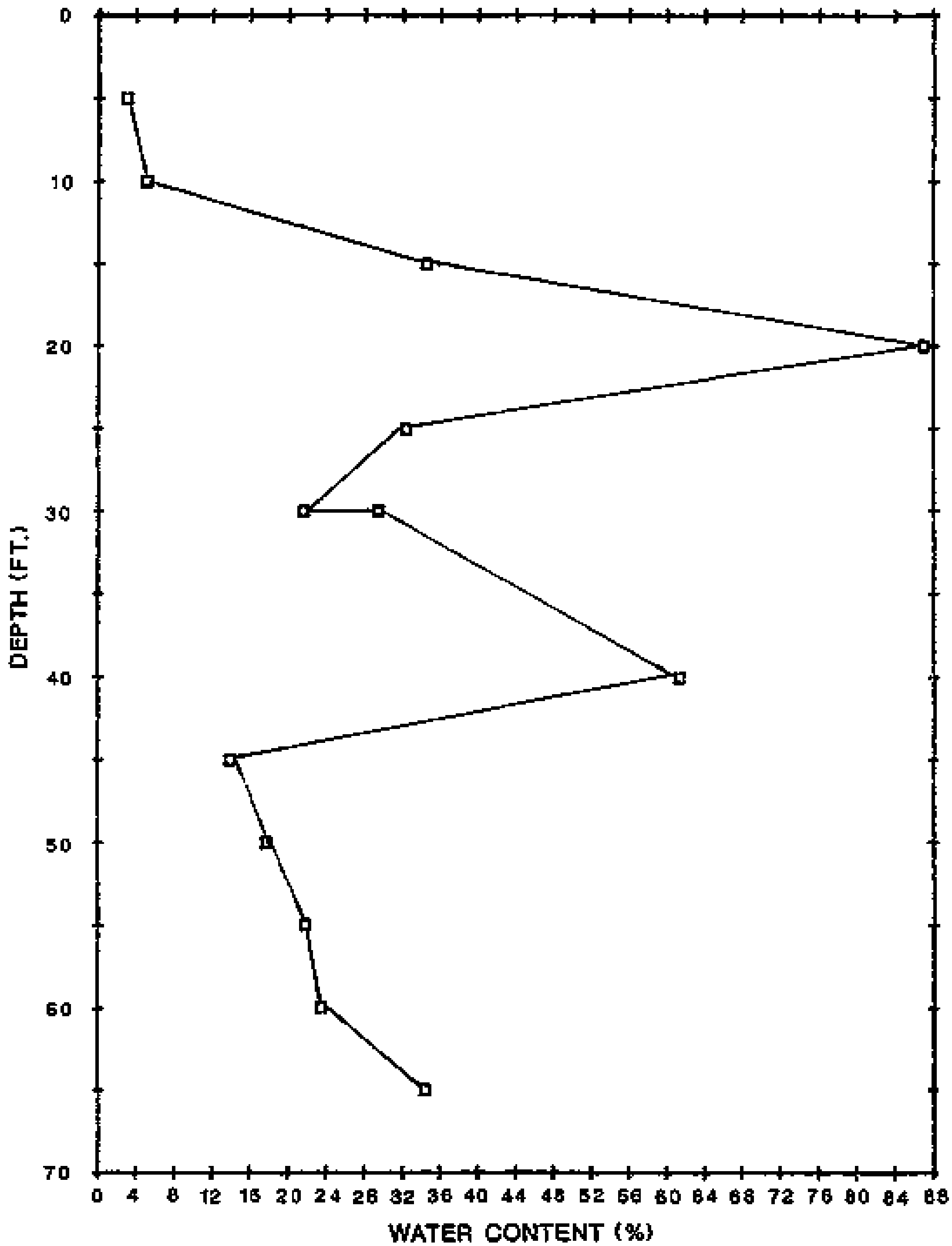
WATER CONTENT WITH DEPTH FOR BORING OR 206 OLD RIFLE



REFERENCE: CSU, 1985.

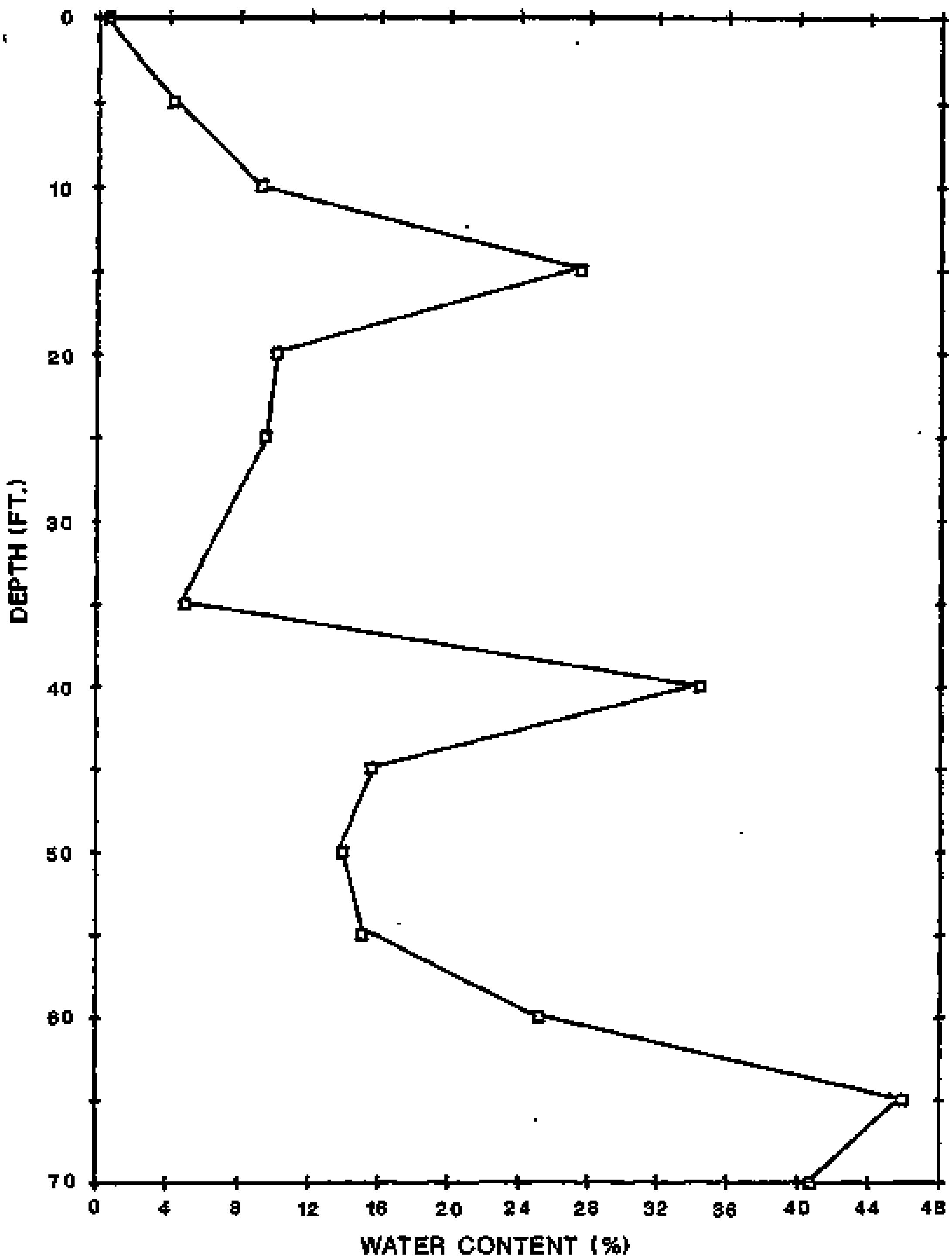
FIGURE D.4.32

WATER CONTENT WITH DEPTH FOR BORING NR 201 NEW RIFLE



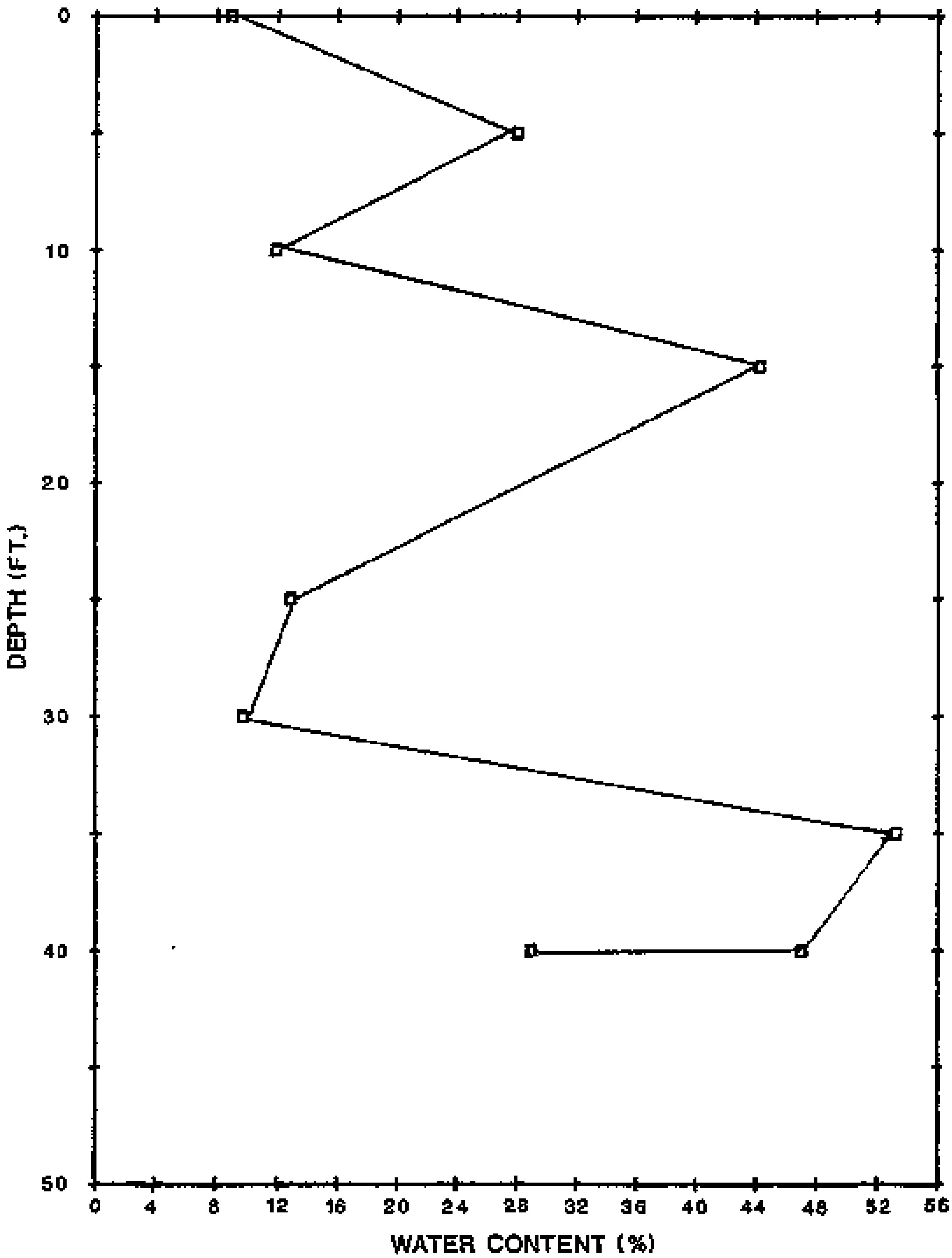
REFERENCE: CSU, 1985.

FIGURE D.4.33
WATER CONTENT WITH DEPTH FOR BORING NR 202
NEW RIFLE



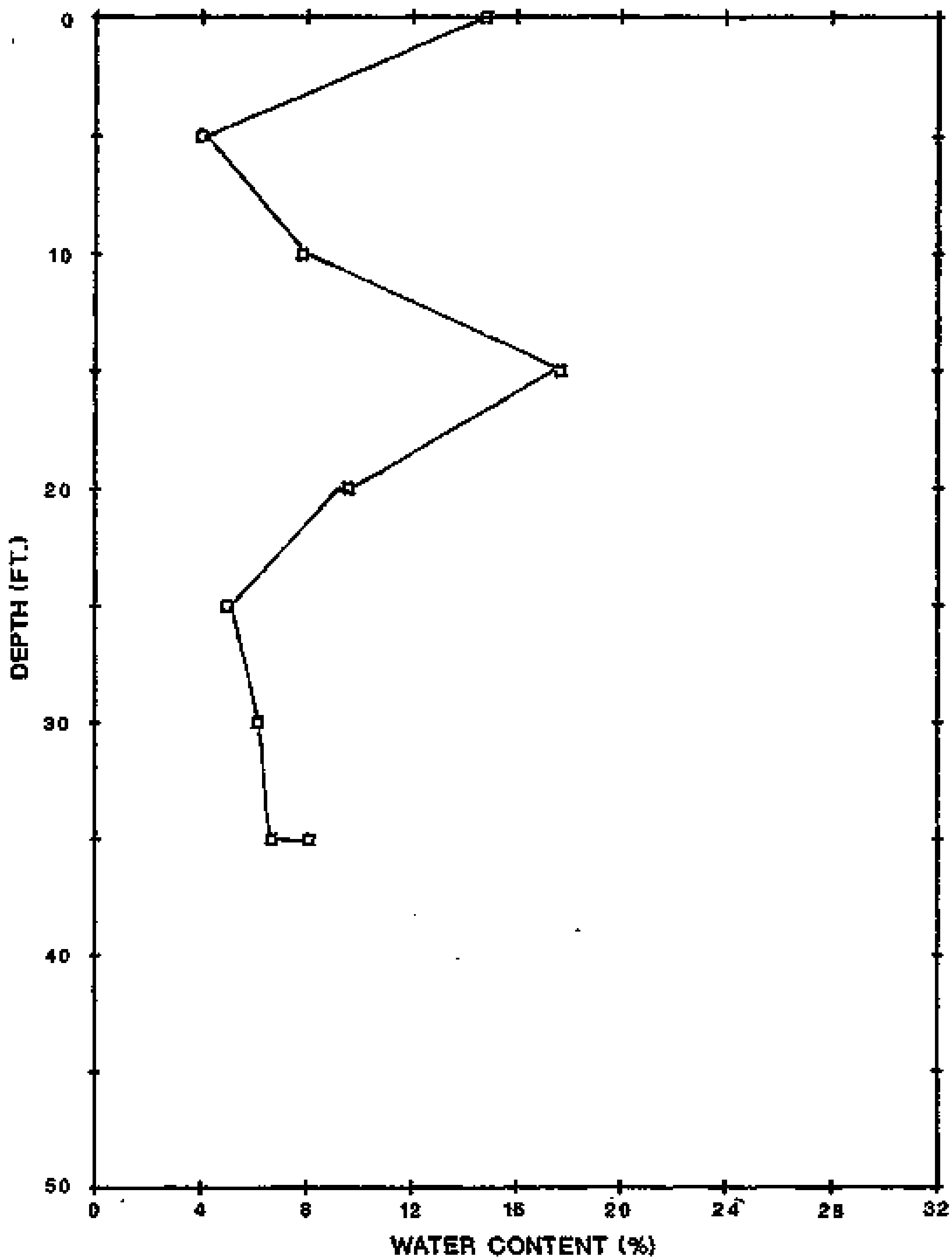
REFERENCE: CSU, 1985.

FIGURE D.4.34
WATER CONTENT WITH DEPTH FOR BORING NR 204
NEW RIFLE



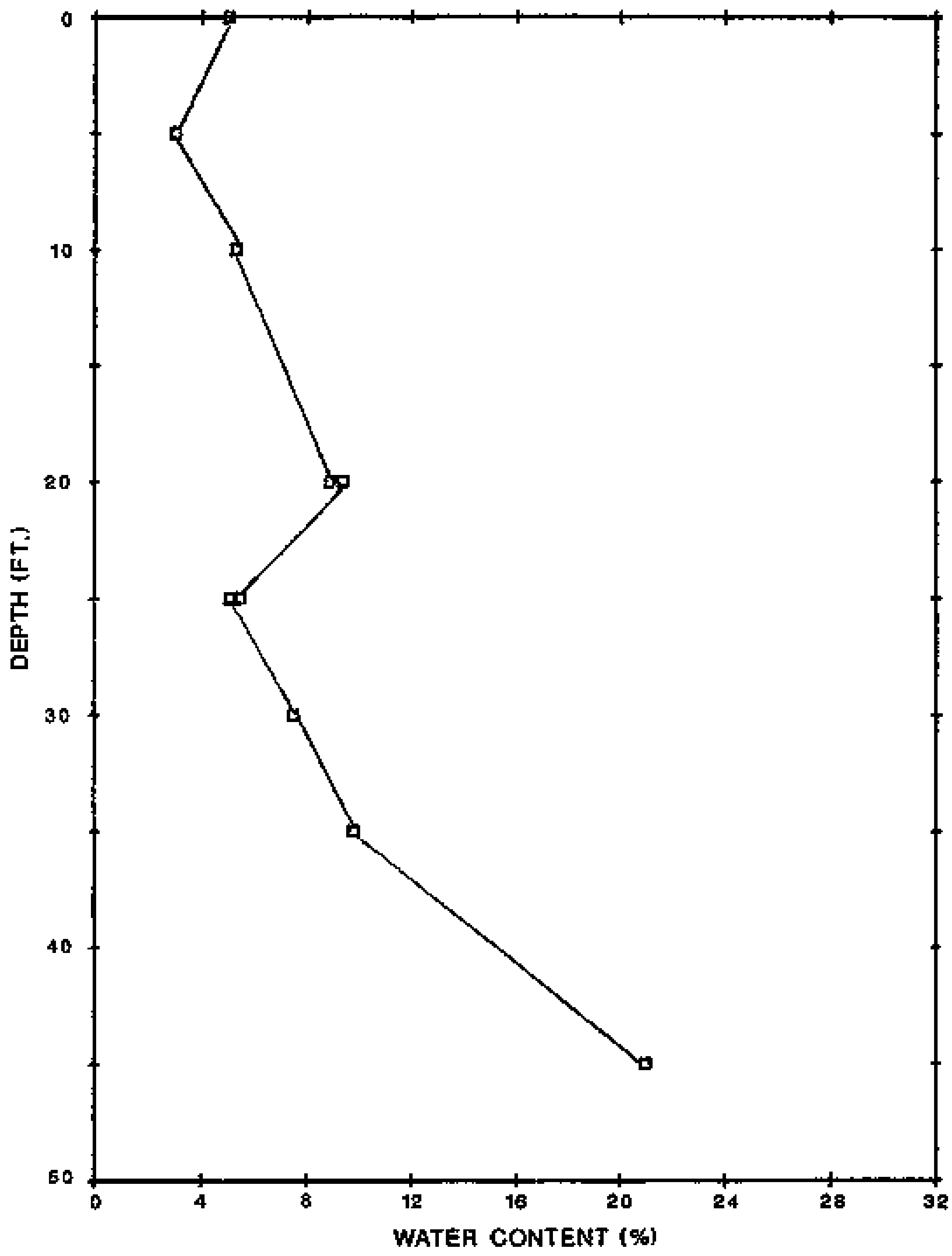
REFERENCE: CSU, 1985.

FIGURE D.4.35
WATER CONTENT WITH DEPTH FOR BORING NR 203
NEW RIFLE



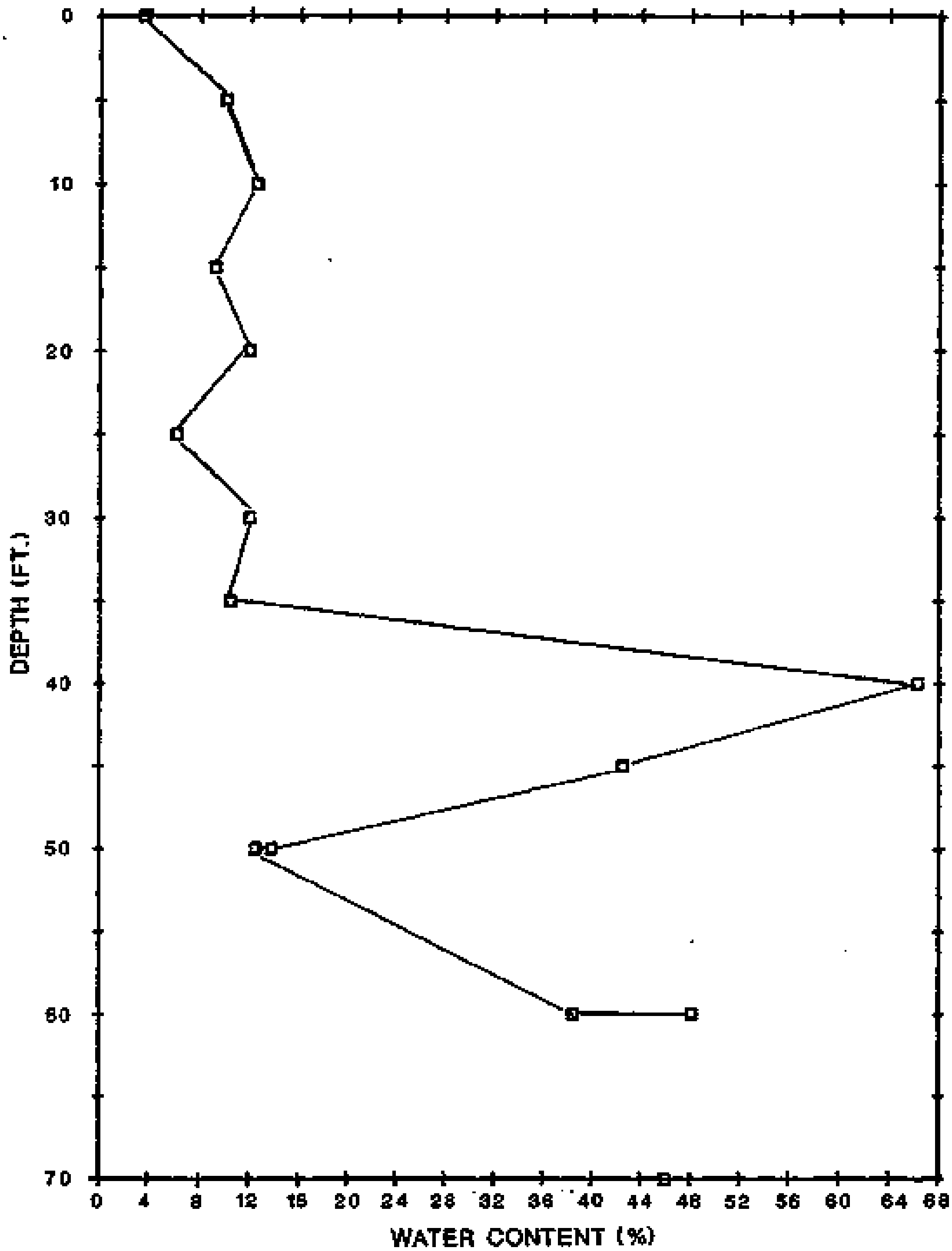
REFERENCE: CSU, 1985.

FIGURE D.4.36
WATER CONTENT WITH DEPTH FOR BORING NR 207
NEW RIFLE



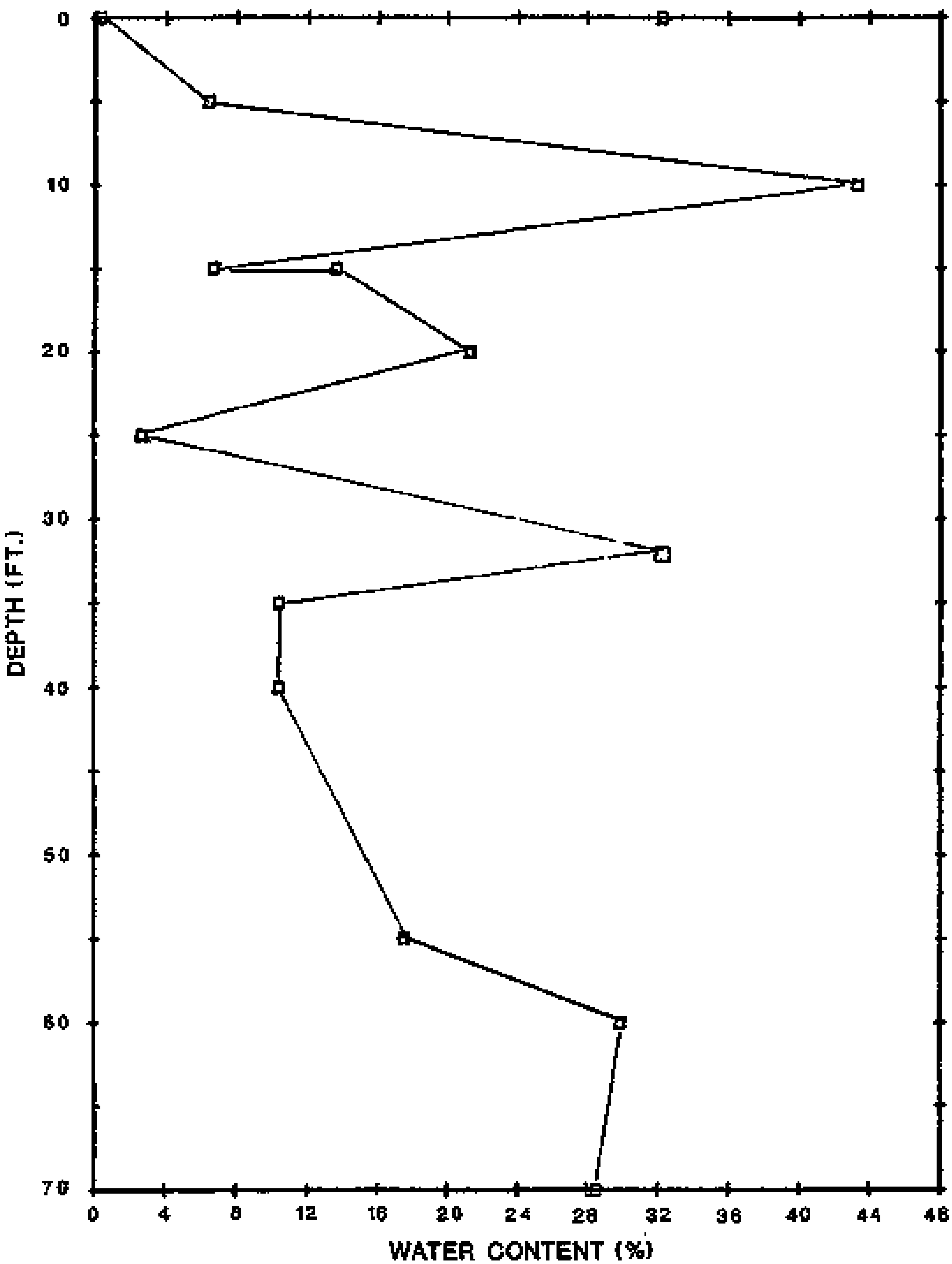
REFERENCE: CSU, 1985.

FIGURE D.4.37
WATER CONTENT WITH DEPTH FOR BORING NR 208
NEW RIFLE



REFERENCE: CSU, 1985.

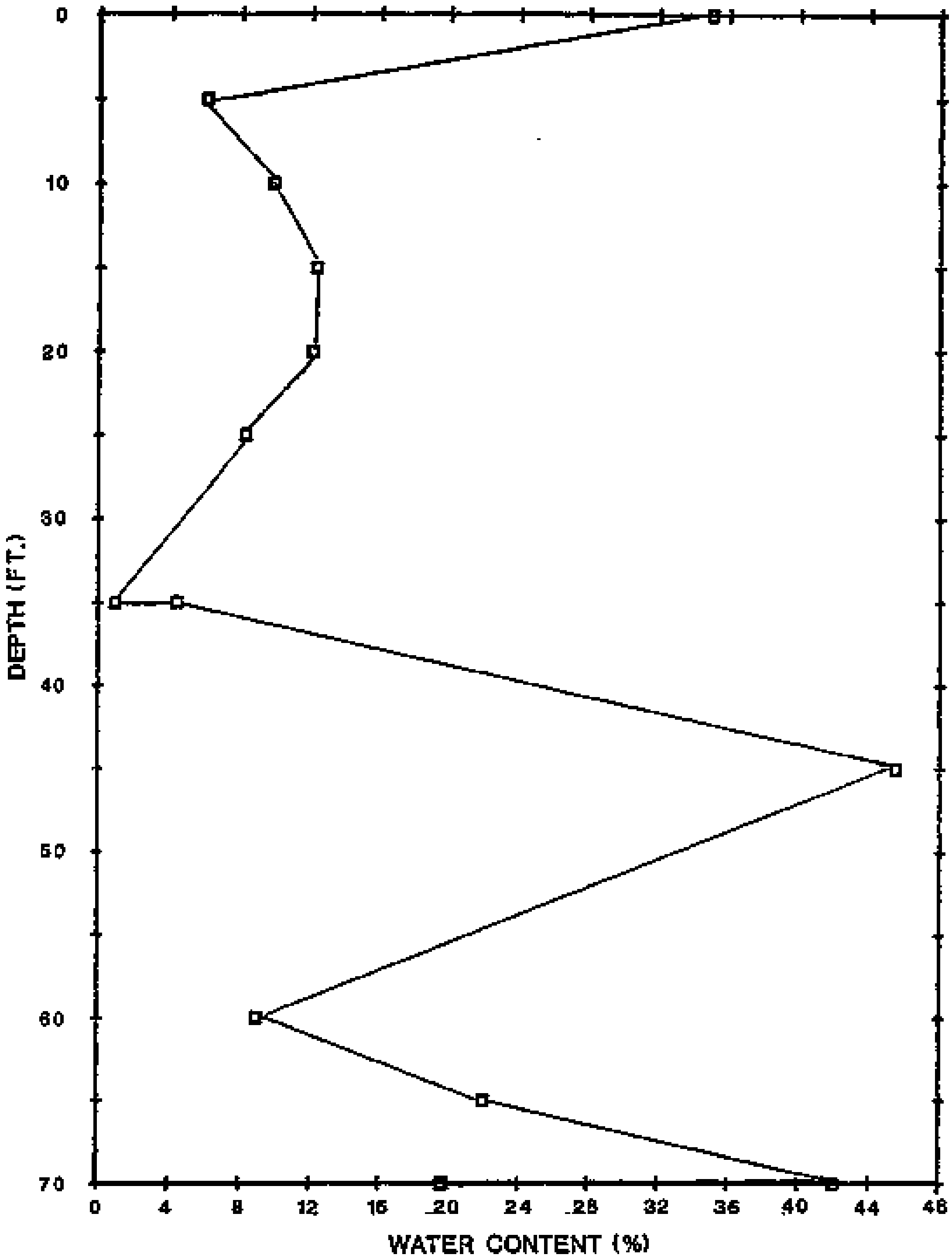
FIGURE D.4.38
WATER CONTENT WITH DEPTH FOR BORING NR 211
NEW RIFLE



REFERENCE: CSU, 1985.

FIGURE D.4.39

WATER CONTENT WITH DEPTH FOR BORING NR 212
NEW RIFLE

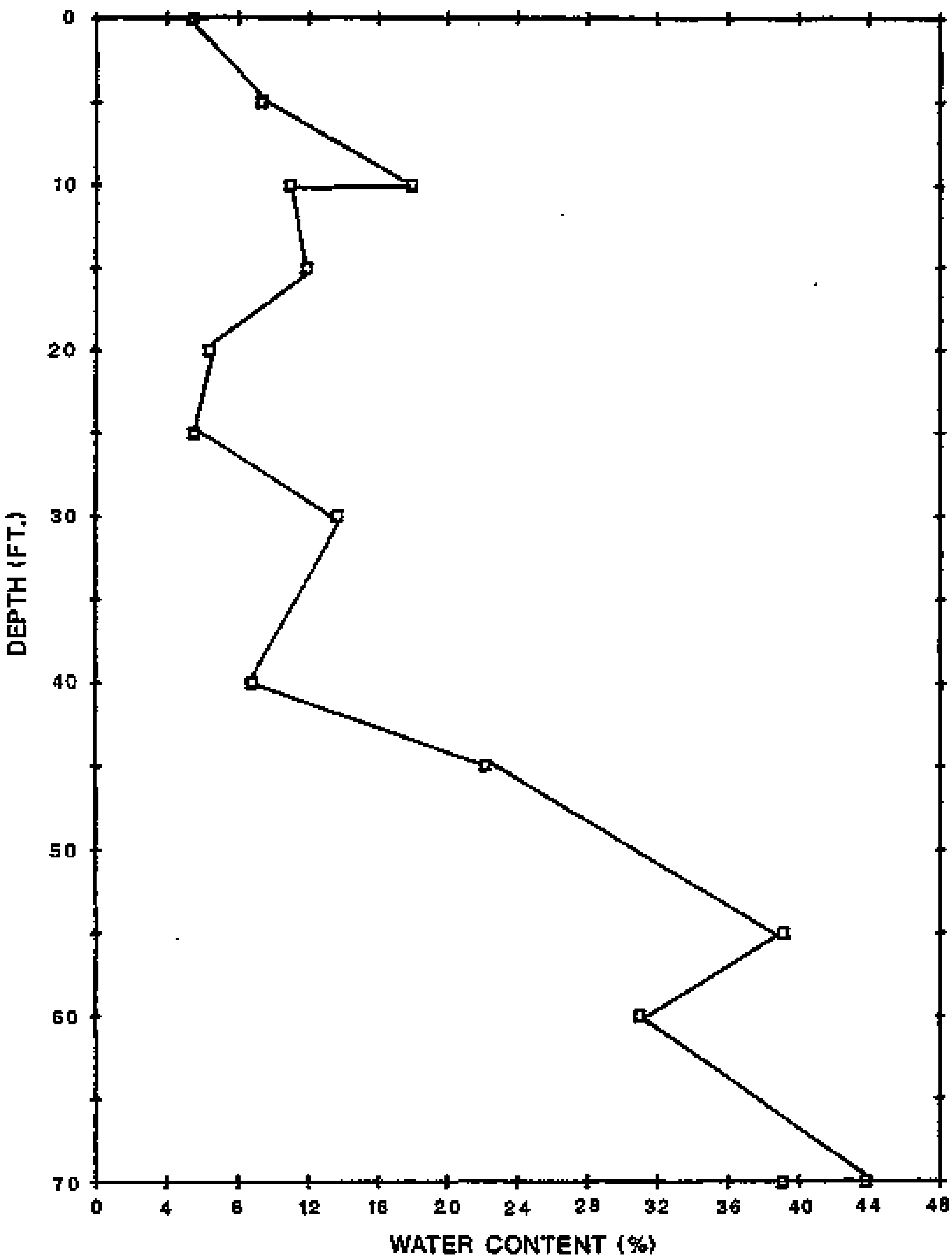


REFERENCE: CSU, 1985.

FIGURE D.4.40

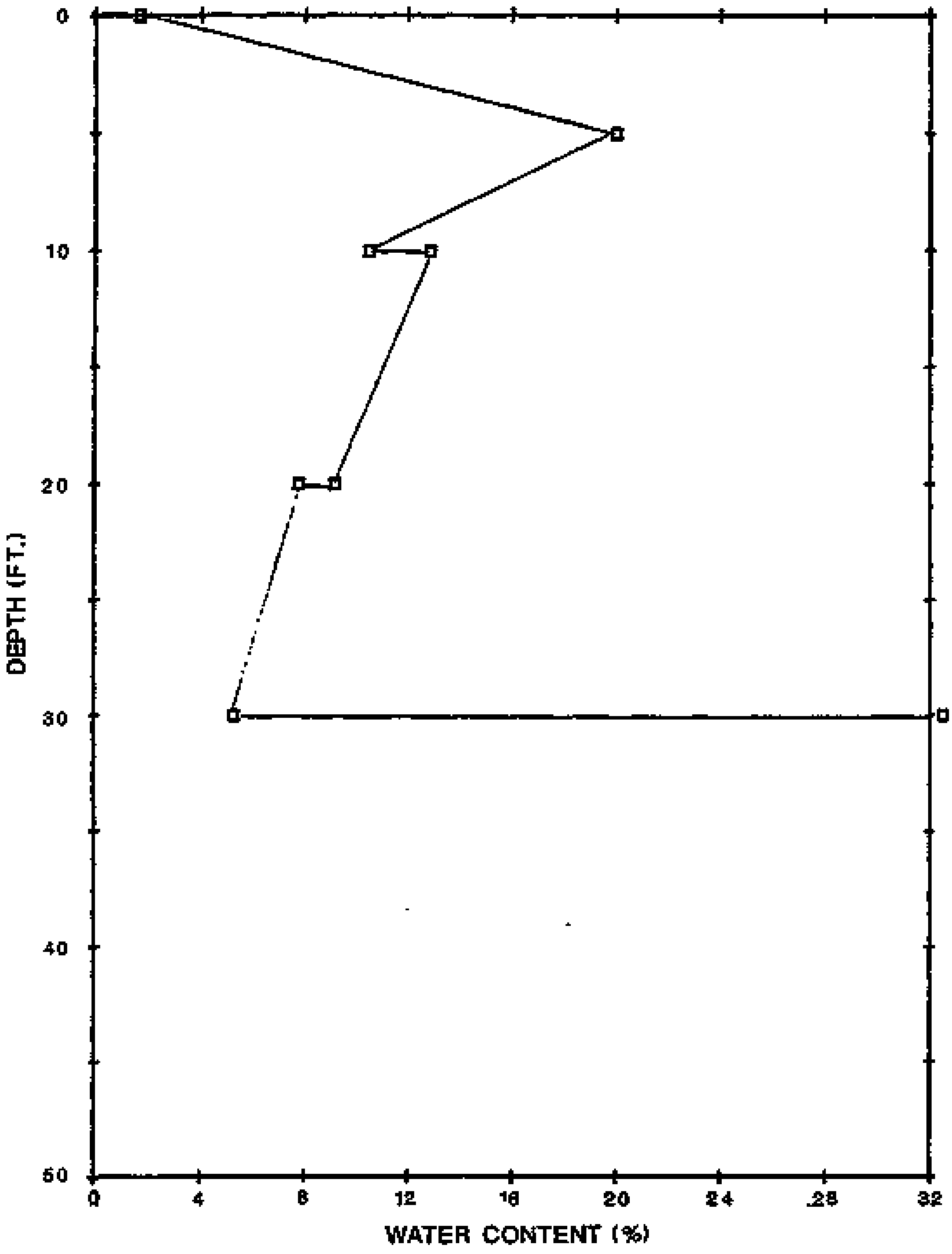
WATER CONTENT WITH DEPTH FOR BORING NR 213

NEW RIFLE



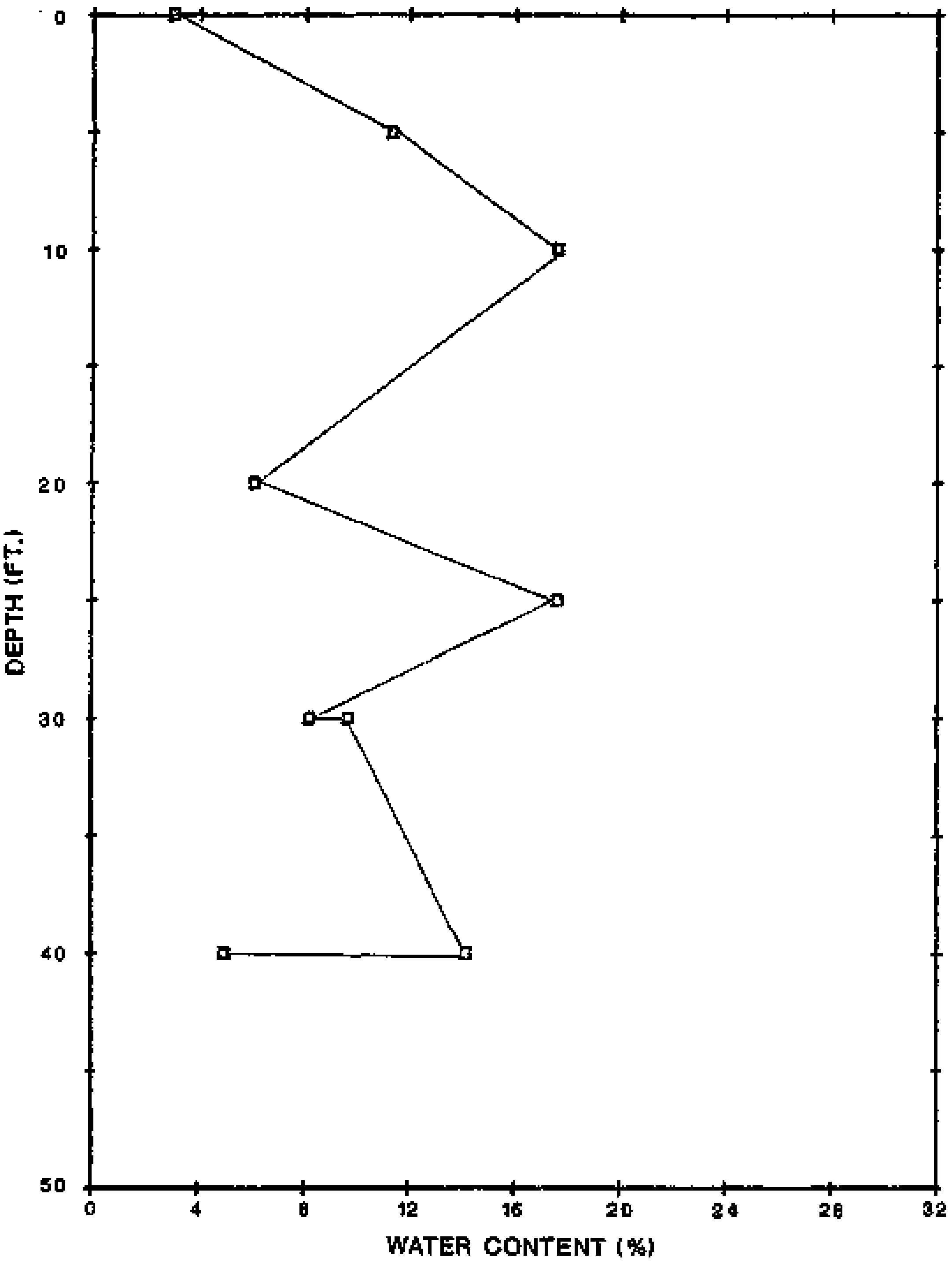
REFERENCE: CSU, 1985.

FIGURE D.4.41
WATER CONTENT WITH DEPTH FOR BORING NR 214
NEW RIFLE



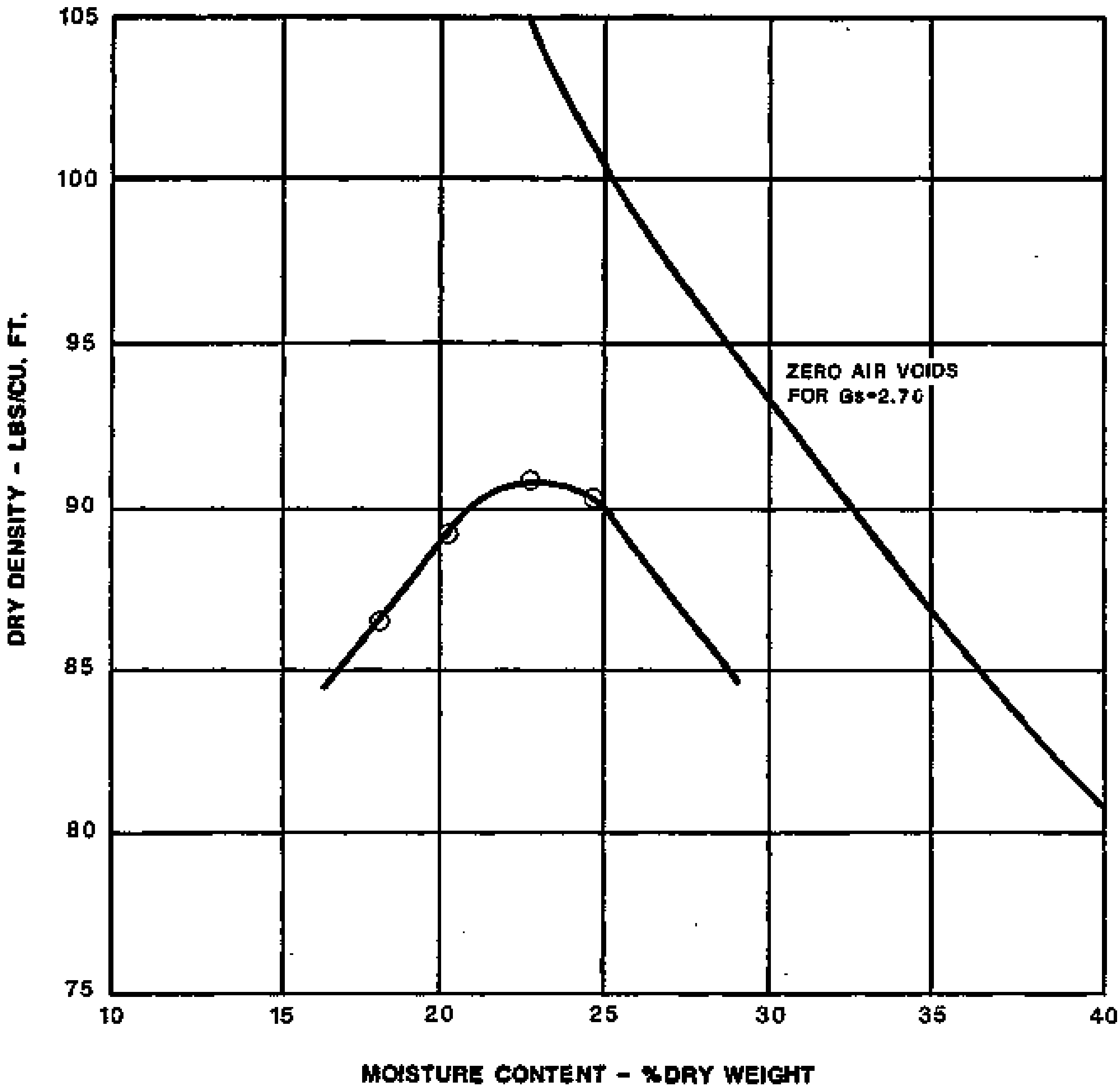
REFERENCE: CSU, 1985.

FIGURE D.4.42
WATER CONTENT WITH DEPTH FOR BORING NR 216
NEW RIFLE



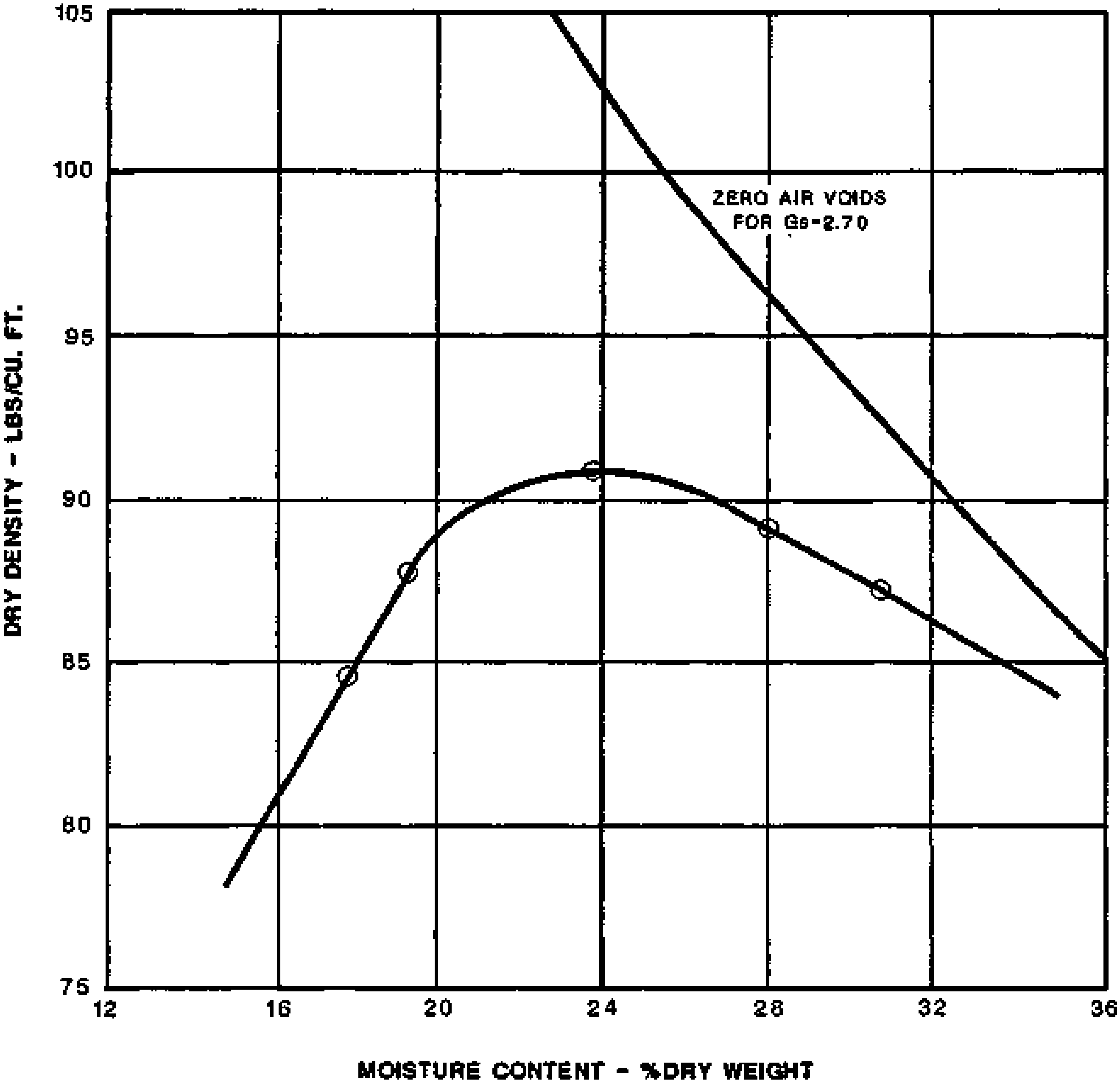
REFERENCE: CSU, 1985.

FIGURE D.4.43
WATER CONTENT WITH DEPTH FOR BORING NR 217
NEW RIFLE



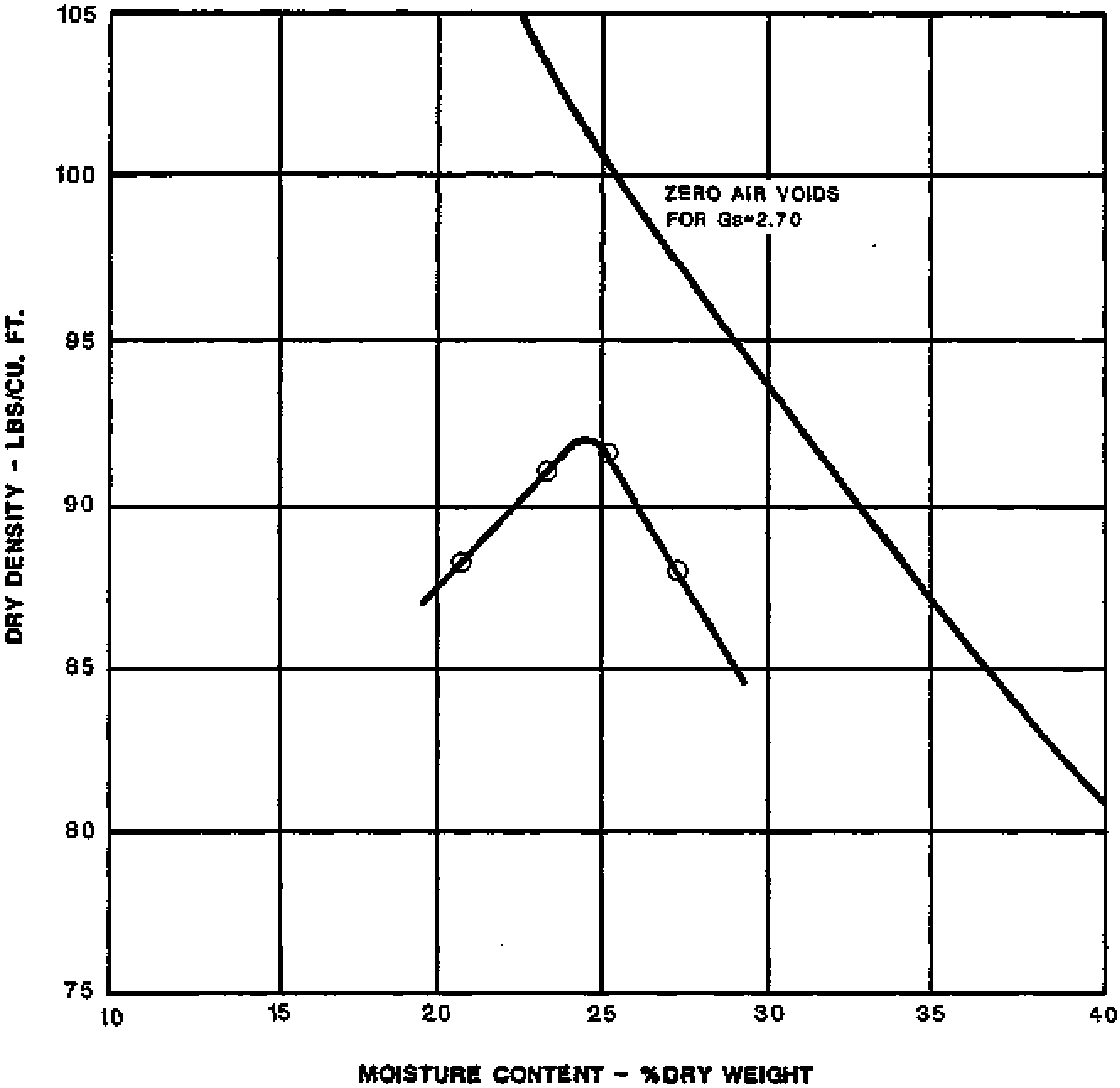
LEGEND			
SAMPLE	DEPTH INTERVAL (FT.)	OPTIMUM MOISTURE CONTENT (%)	MAXIMUM DRY DENSITY LBS/CU. FT.
TP-4 RFO	12.0	22.7	91.0

FIGURE D.4.44
SUMMARY OF MOISTURE-DENSITY RELATIONSHIP TESTS
OLD RIFLE



LEGEND			
SAMPLE	DEPTH INTERVAL (FT.)	OPTIMUM MOISTURE CONTENT (%)	MAXIMUM DRY DENSITY LBS/CU. FT.
TP-1 RFN	6.0	24.4	91.0

FIGURE D.4.45
SUMMARY OF MOISTURE-DENSITY RELATIONSHIP TESTS
NEW RIFLE



LEGEND			
SAMPLE	DEPTH INTERVAL (FT.)	OPTIMUM MOISTURE CONTENT (%)	MAXIMUM DRY DENSITY LBS/CU. FT.
TP-3 RFN	3.0	24.4	92.0

FIGURE D.4.46
SUMMARY OF MOISTURE-DENSITY RELATIONSHIP TESTS
NEW RIFLE

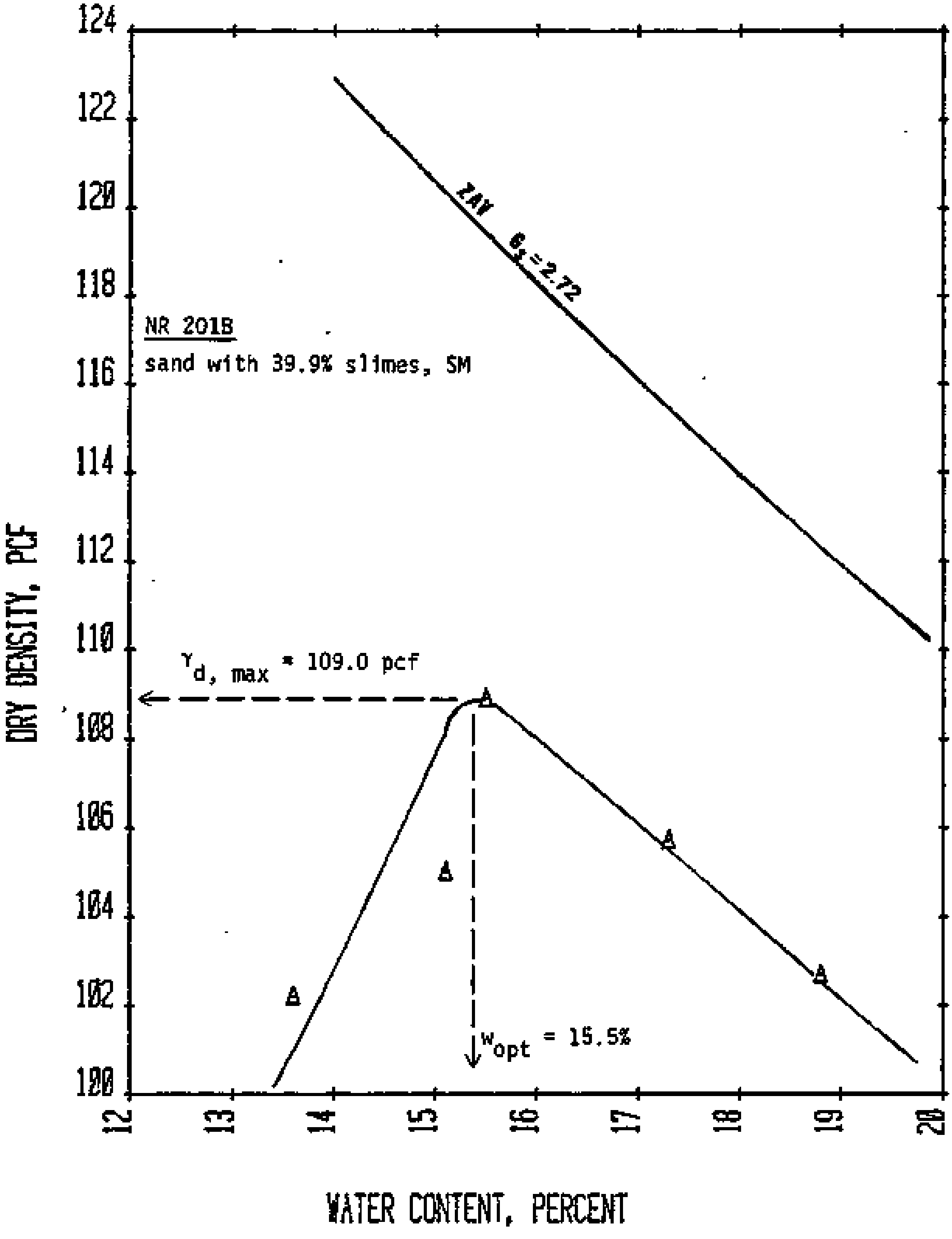


FIGURE D.4.47

STANDARD PROCTOR COMPACTION CURVE: NR 201B, SAND/SLIME MIXTURE, NEW RIFLE

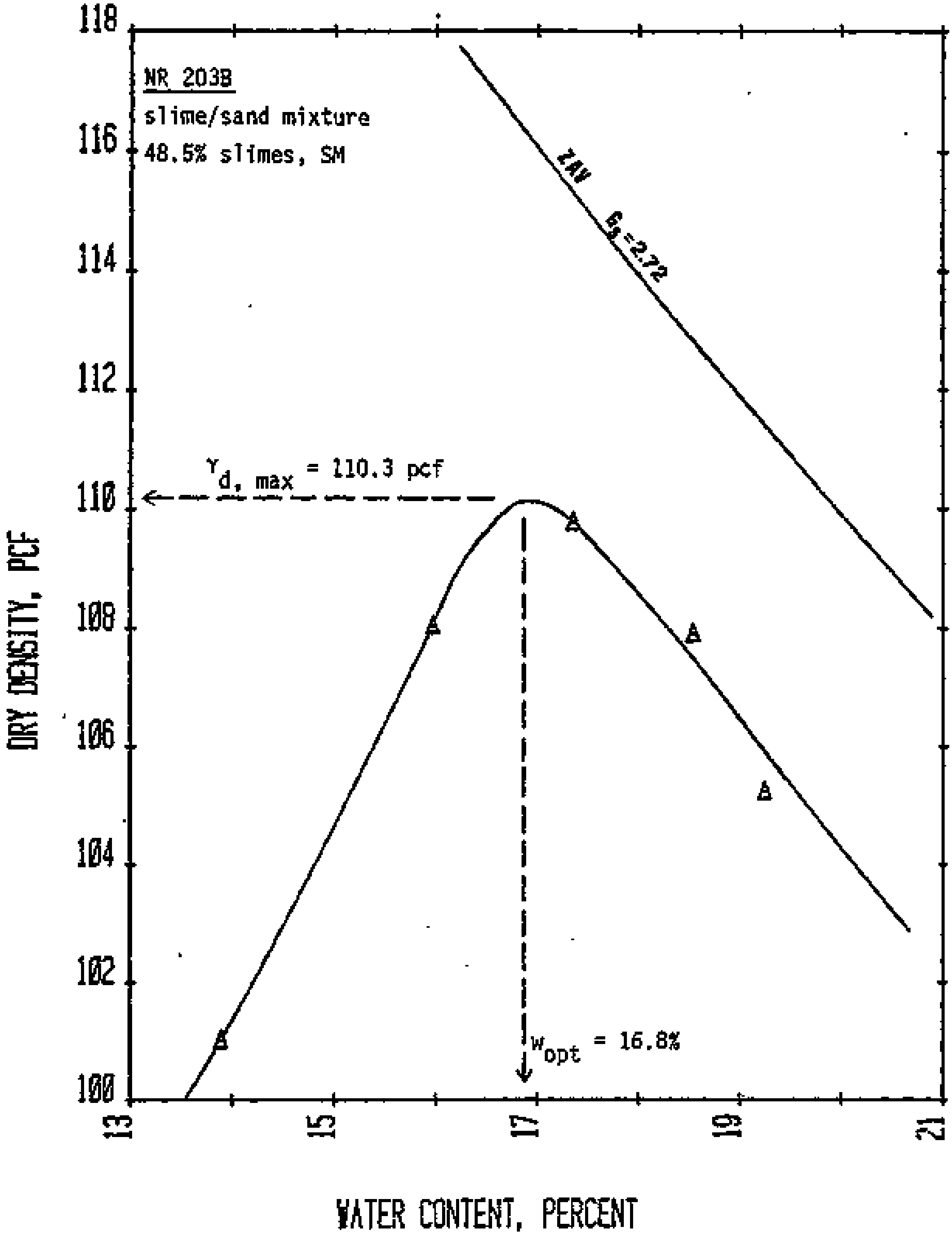


FIGURE D.4.48
STANDARD PROCTOR COMPACTION CURVE: NR 203B, SLIME/SAND MIXTURE, NEW RIFLE

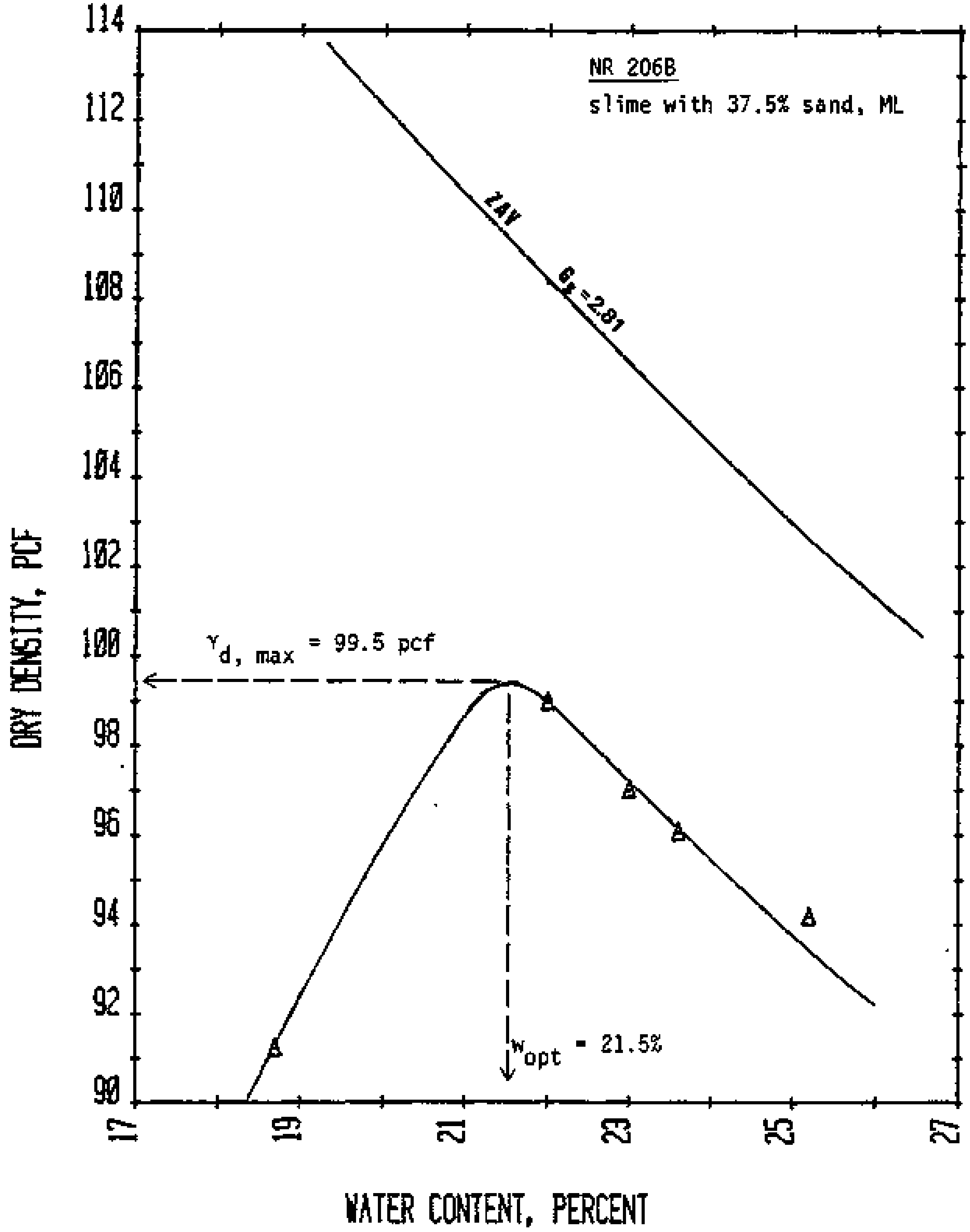


FIGURE D.4.49
STANDARD PROCTOR COMPACTION CURVE: NR 206B, SAND/SLIME MIXTURE, NEW RIFLE

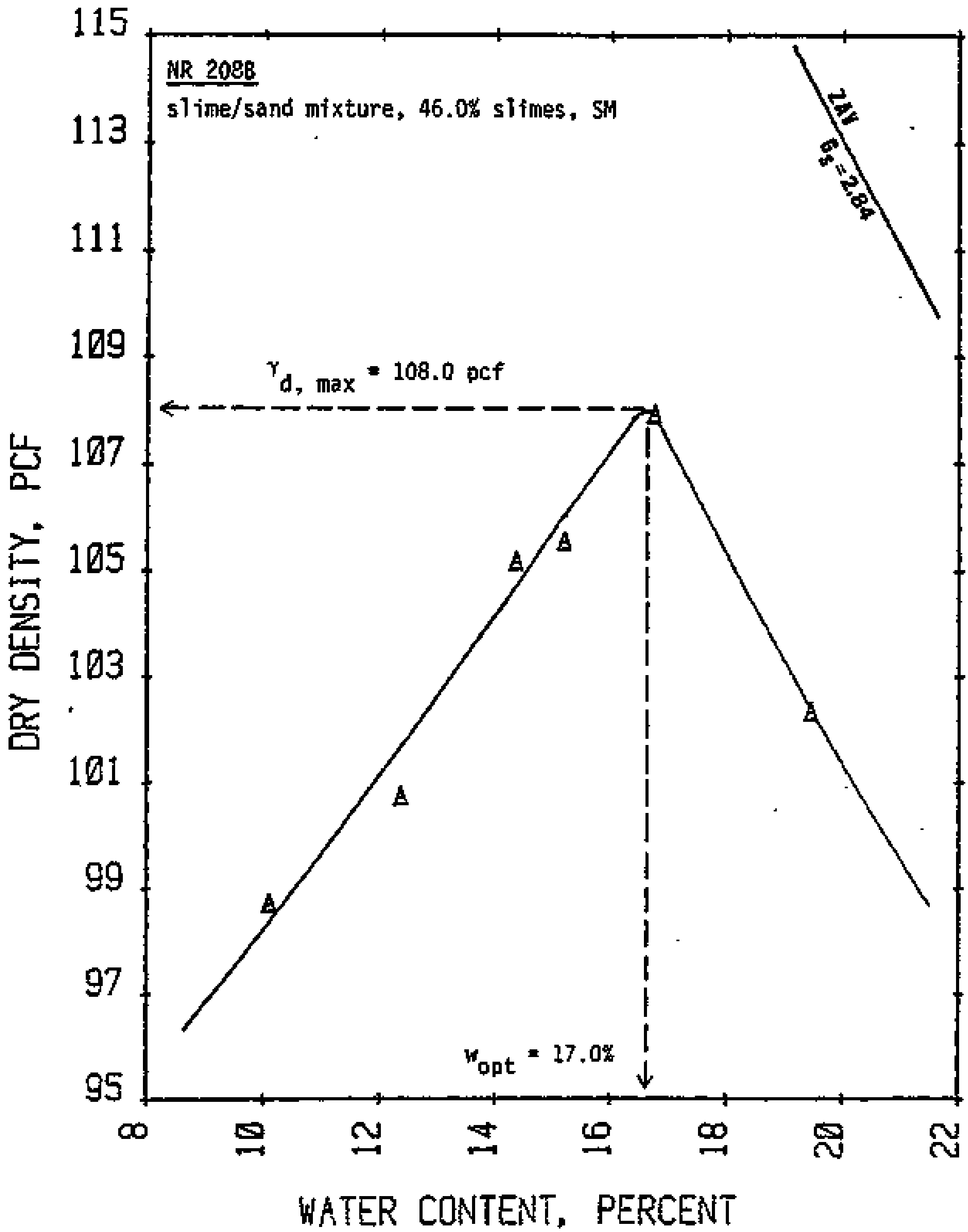


FIGURE D.4.50
STANDARD PROCTOR COMPACTION CURVE: NR 208B, SLIME/SAND MIXTURE, NEW RIFLE

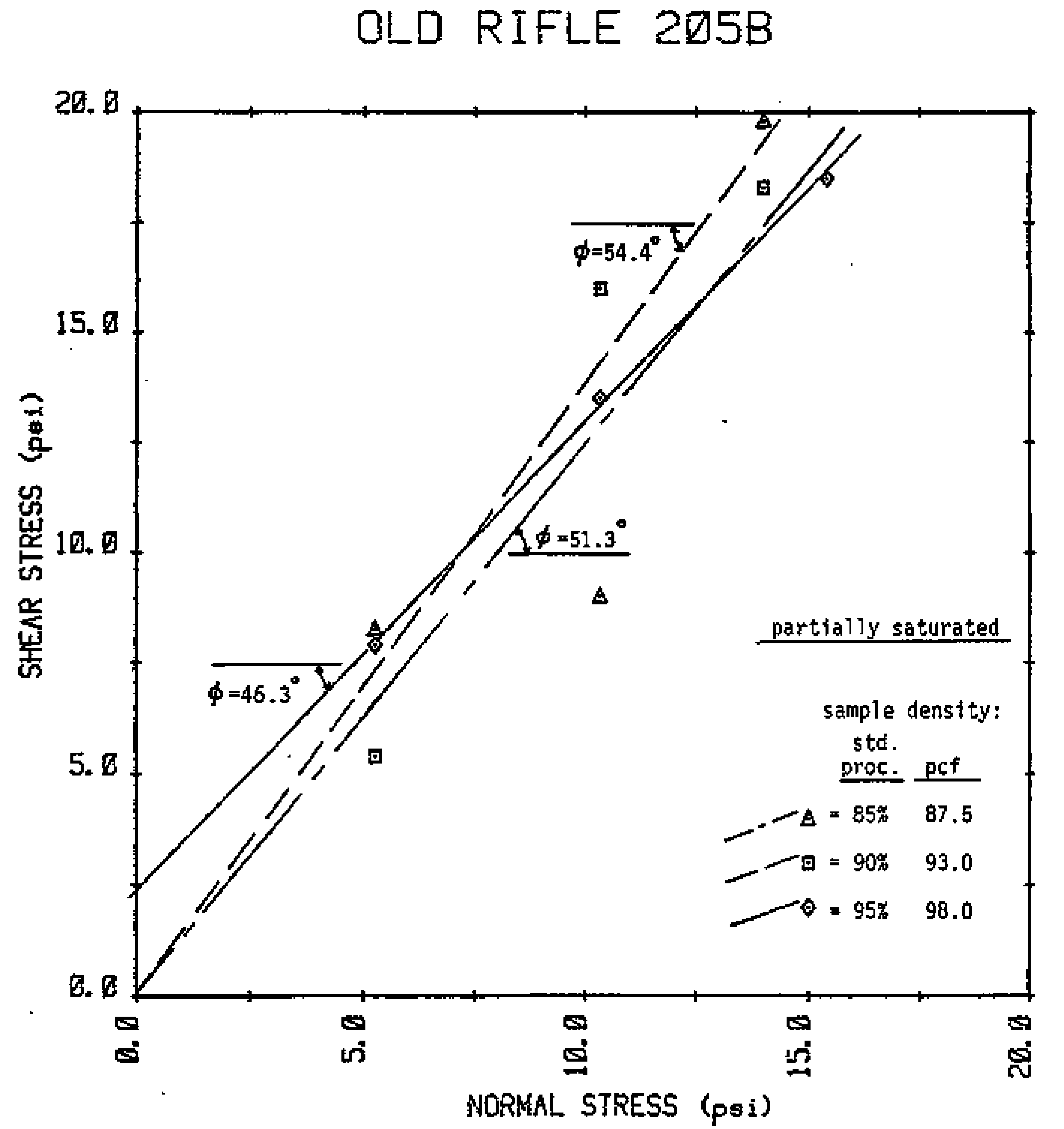


FIGURE D.4.51

DIRECT SHEAR MOHR FAILURE ENVELOPES: PARTIALLY SATURATED SAND TAILINGS, OLD RIFLE

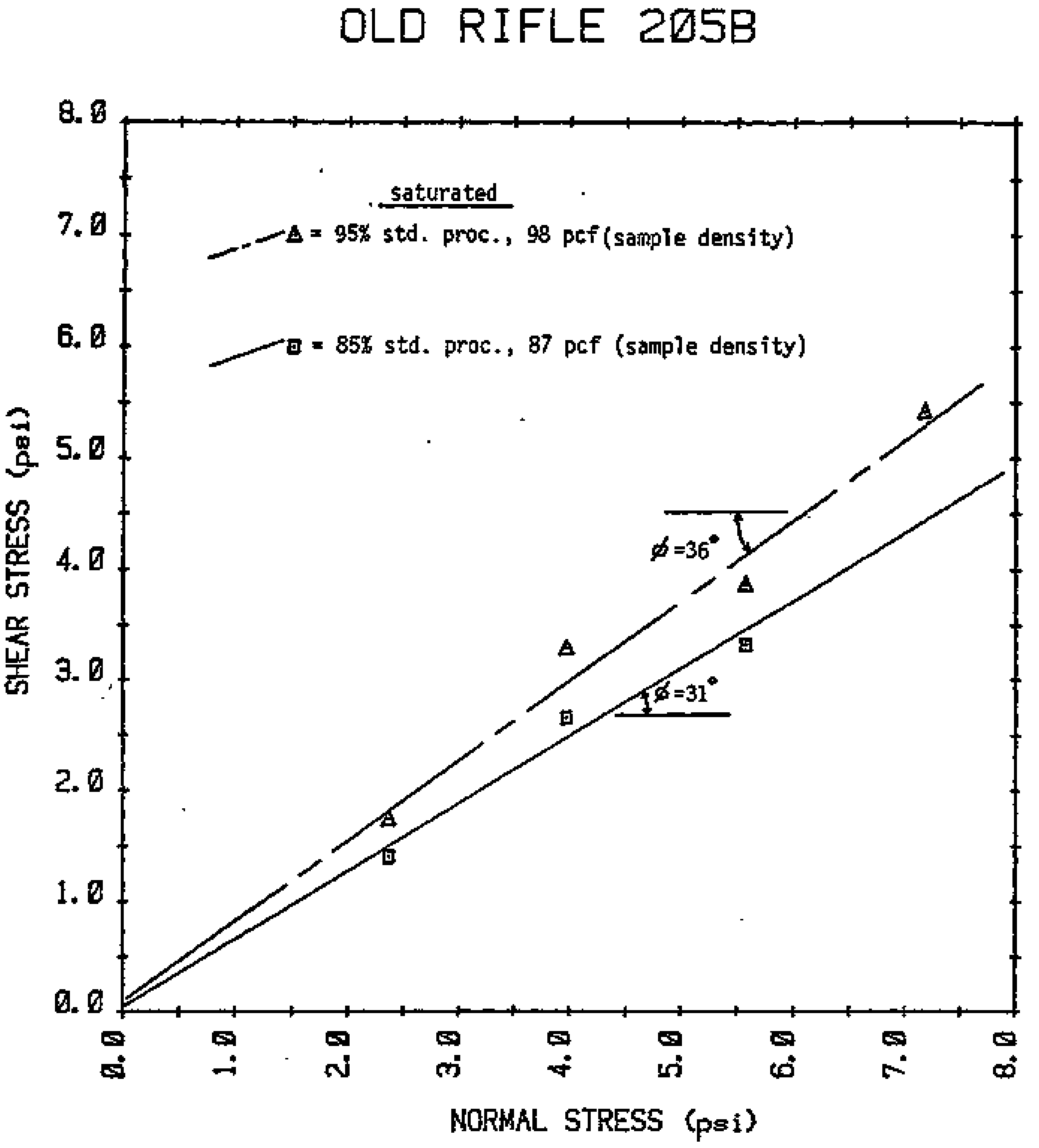


FIGURE D.4.52
DIRECT SHEAR MOHR FAILURE ENVELOPES: SATURATED SAND TAILINGS, OLD RIFLE

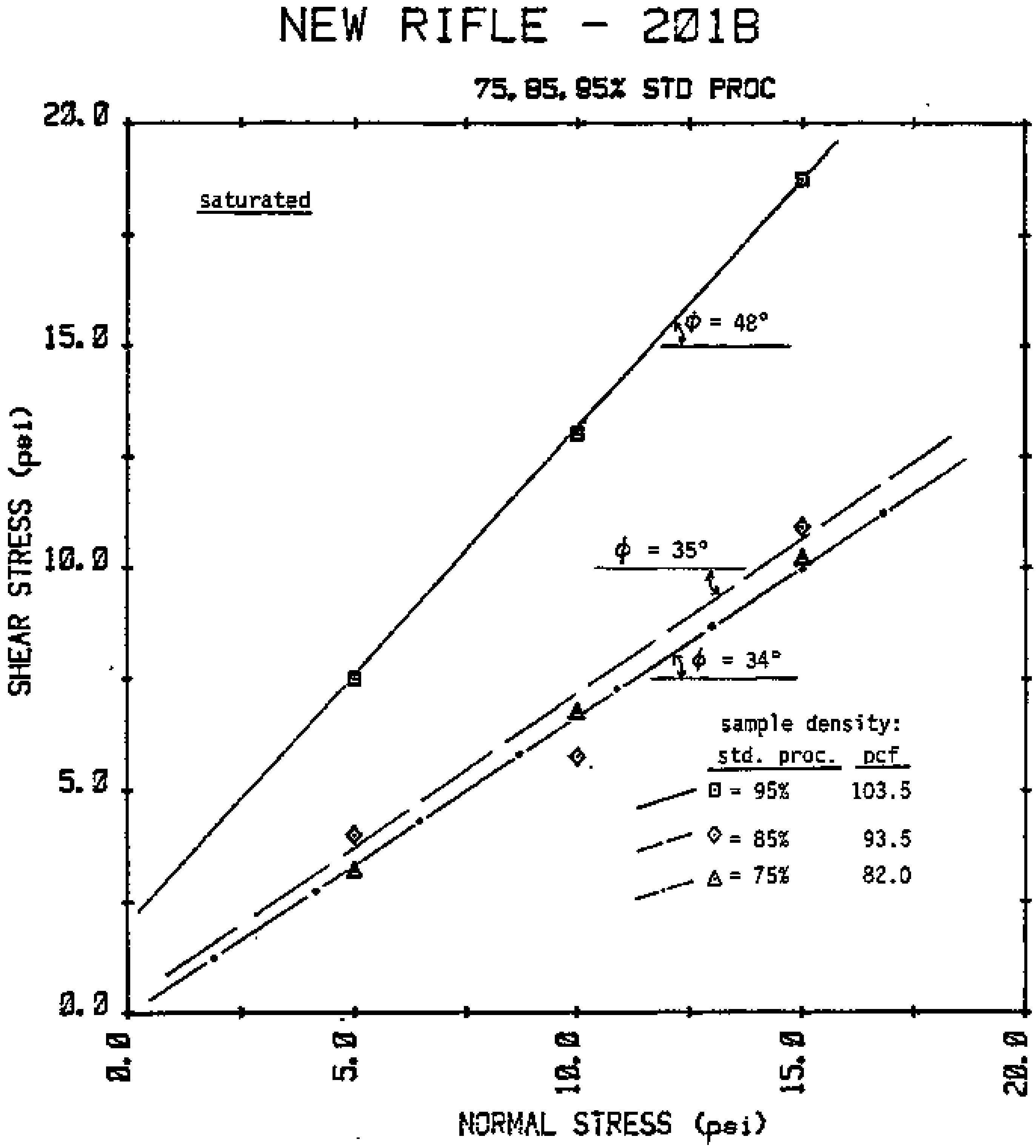


FIGURE D.4.53
DIRECT SHEAR MOHR FAILURE ENVELOPES:
SATURATED SAND/SLIME TAILINGS, NEW RIFLE

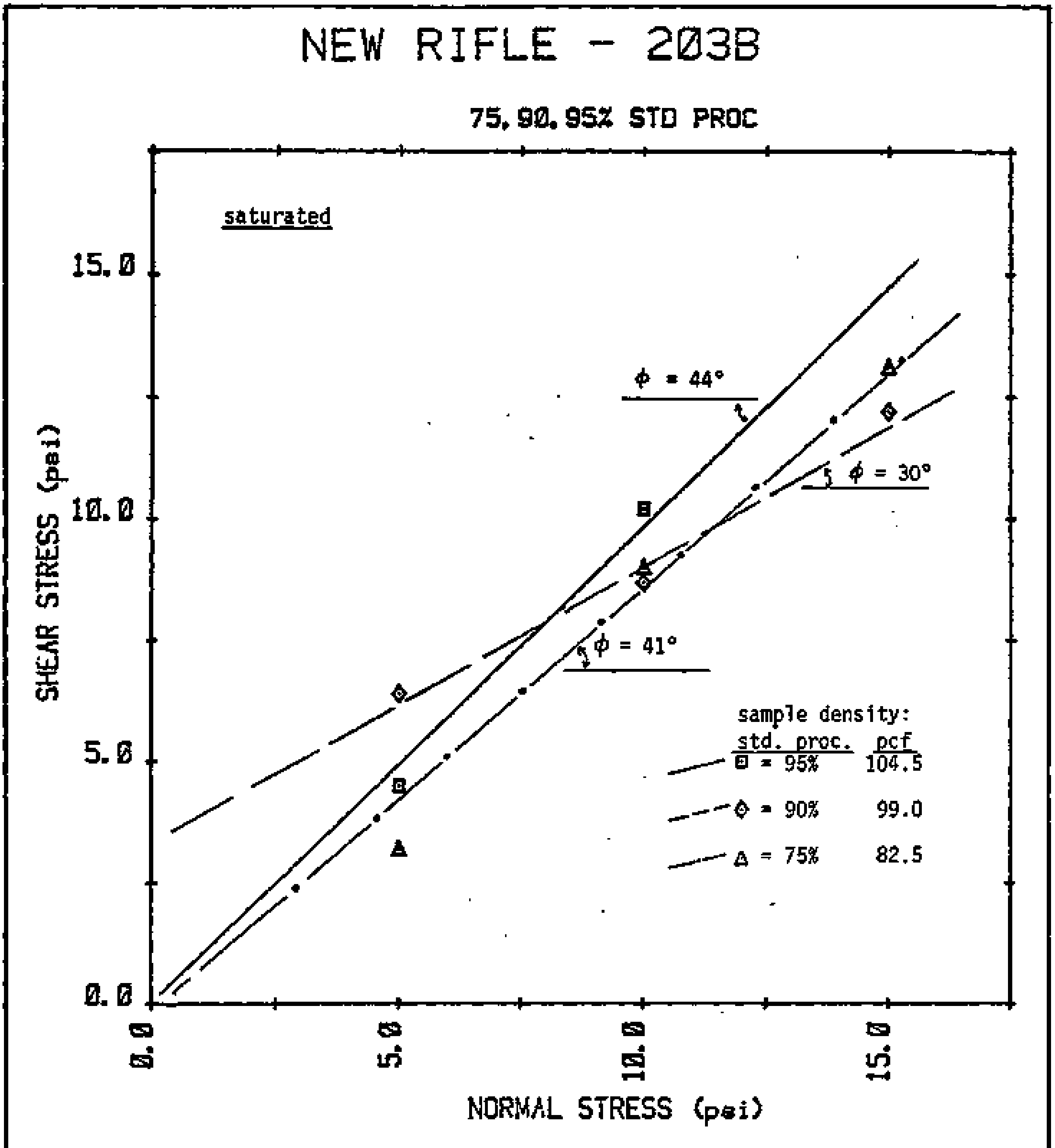
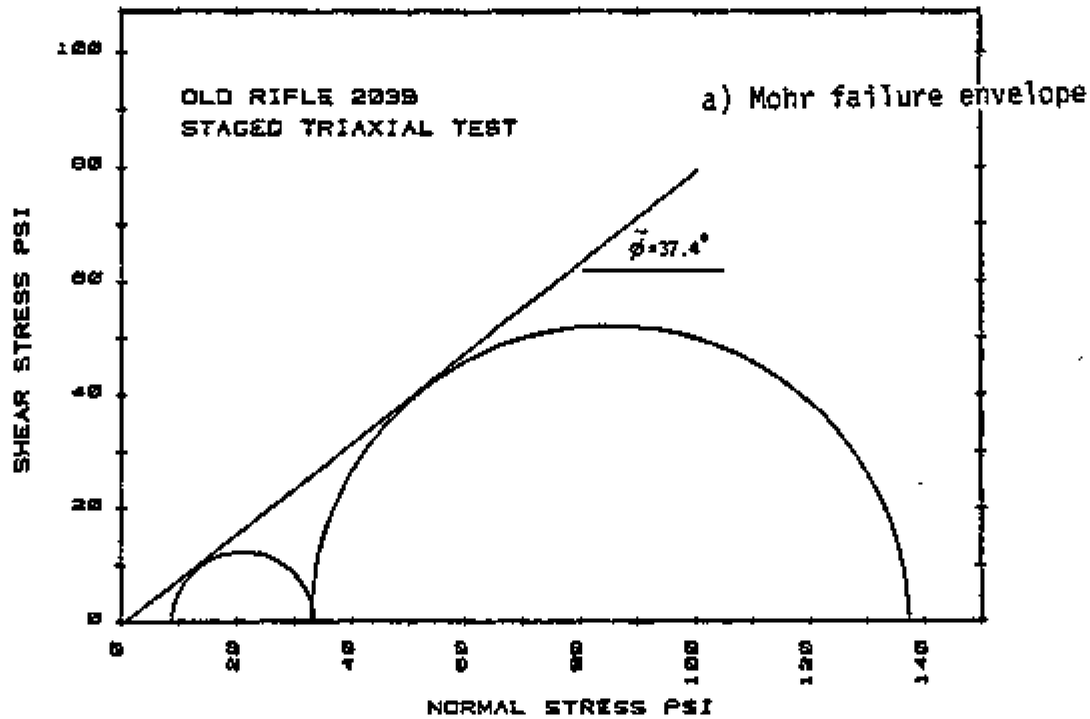
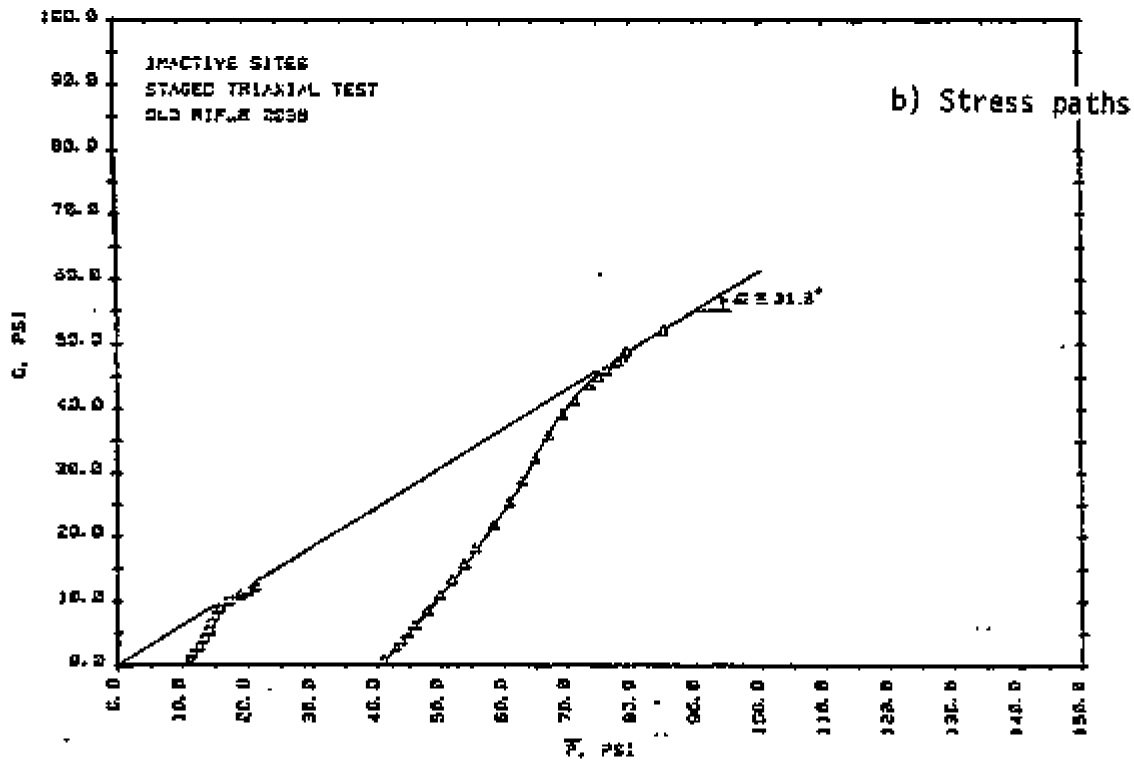


FIGURE D.4.54
DIRECT SHEAR MOHR FAILURE ENVELOPES:
SATURATED SAND/SLIME TAILINGS, NEW RIFLE





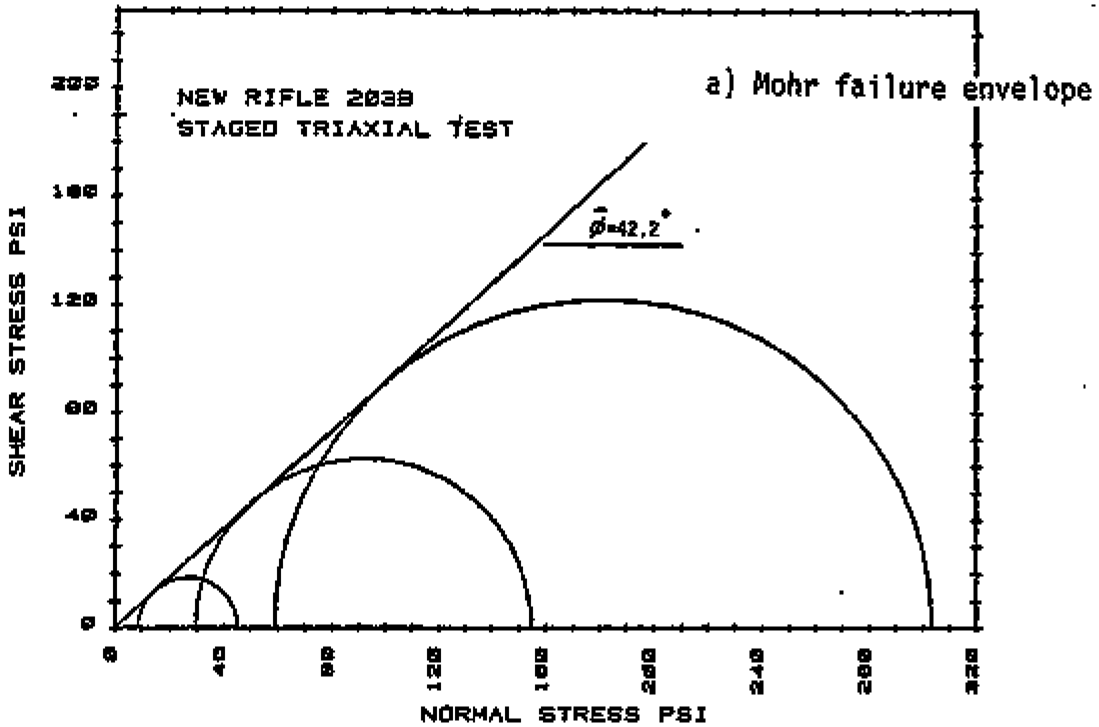
NOTE:

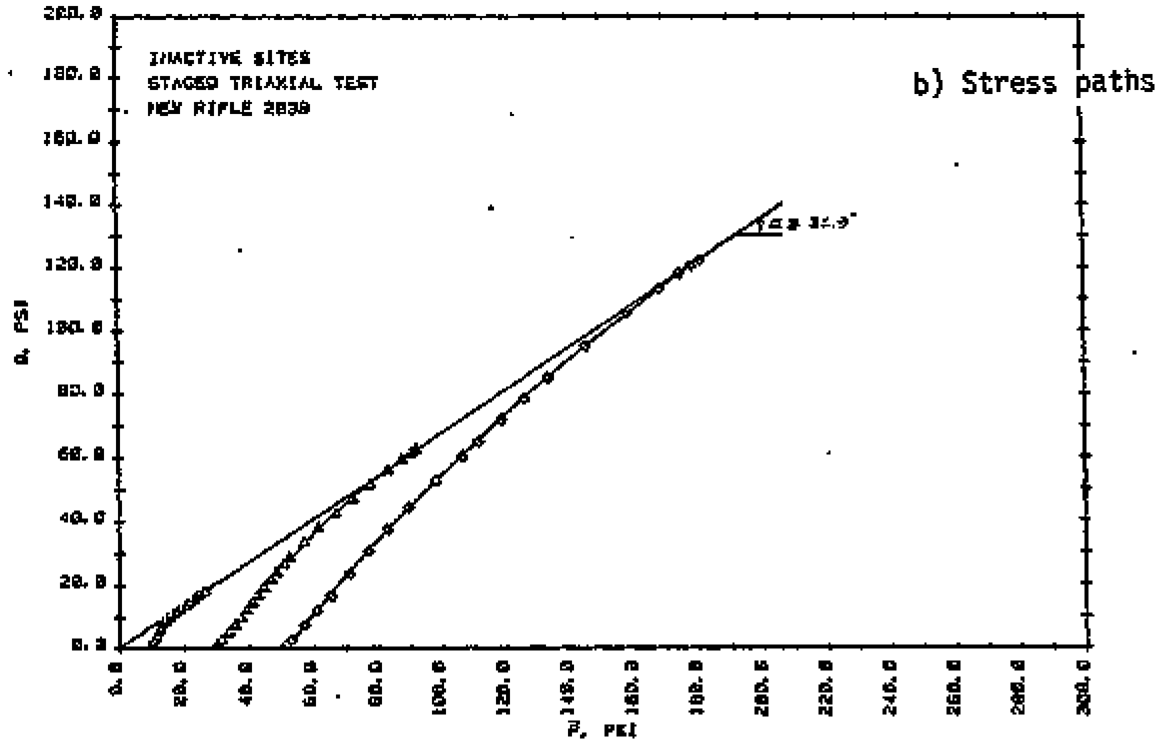
INITIAL WATER CONTENT = 27.6%

INITIAL SAMPLE DRY DENSITY = 127.2 PCF

FIGURE D.4.55

TRIAXIAL TEST RESULTS: OLD RIFLE SLIME TAILINGS





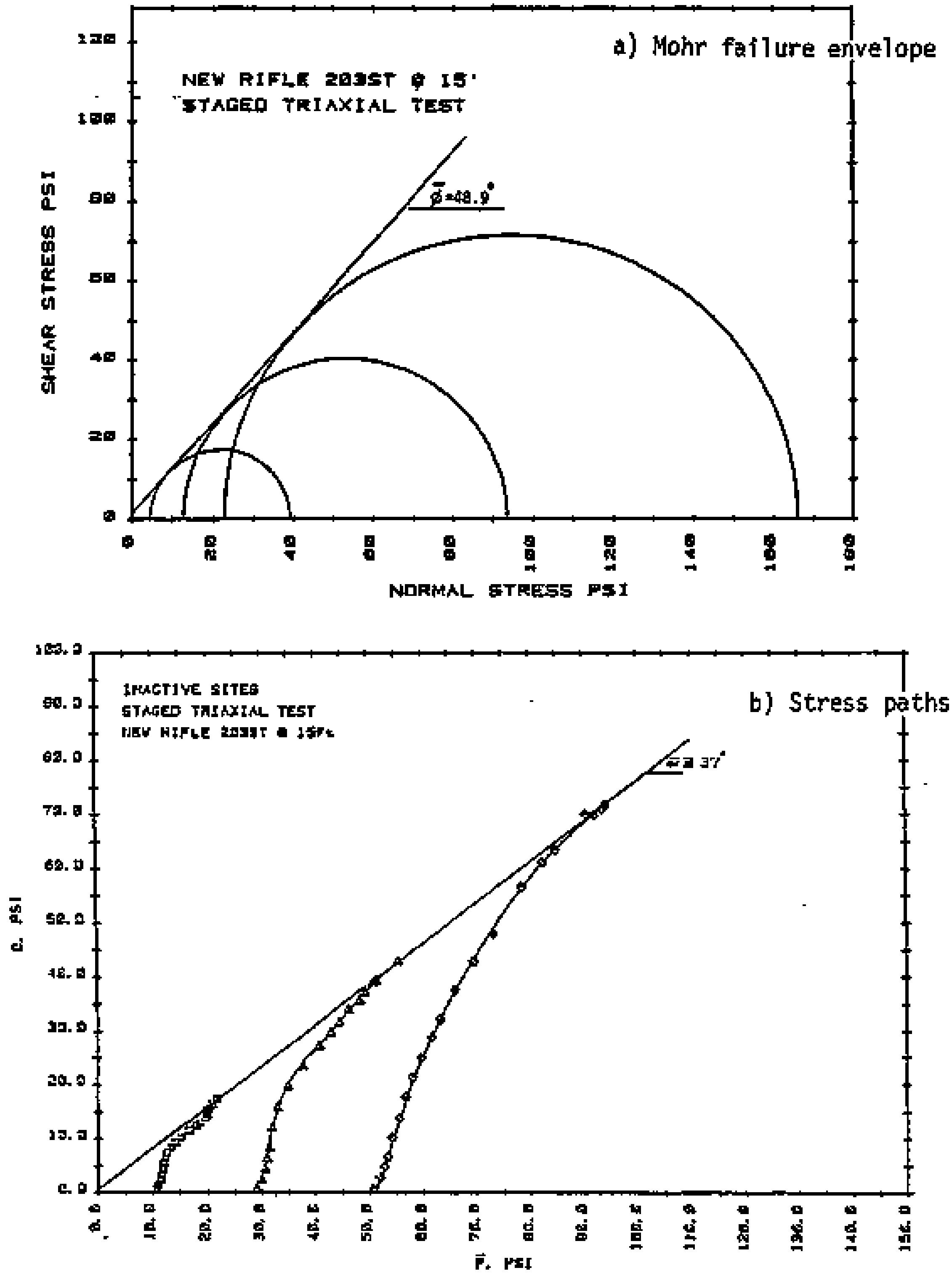
NOTE:

INITIAL WATER CONTENT = 21.4%

INITIAL SAMPLE DRY DENSITY = 110.6 PCF

FIGURE D.4.56

TRIAXIAL TEST RESULTS: NEW RIFLE SAND/SLIME TAILINGS



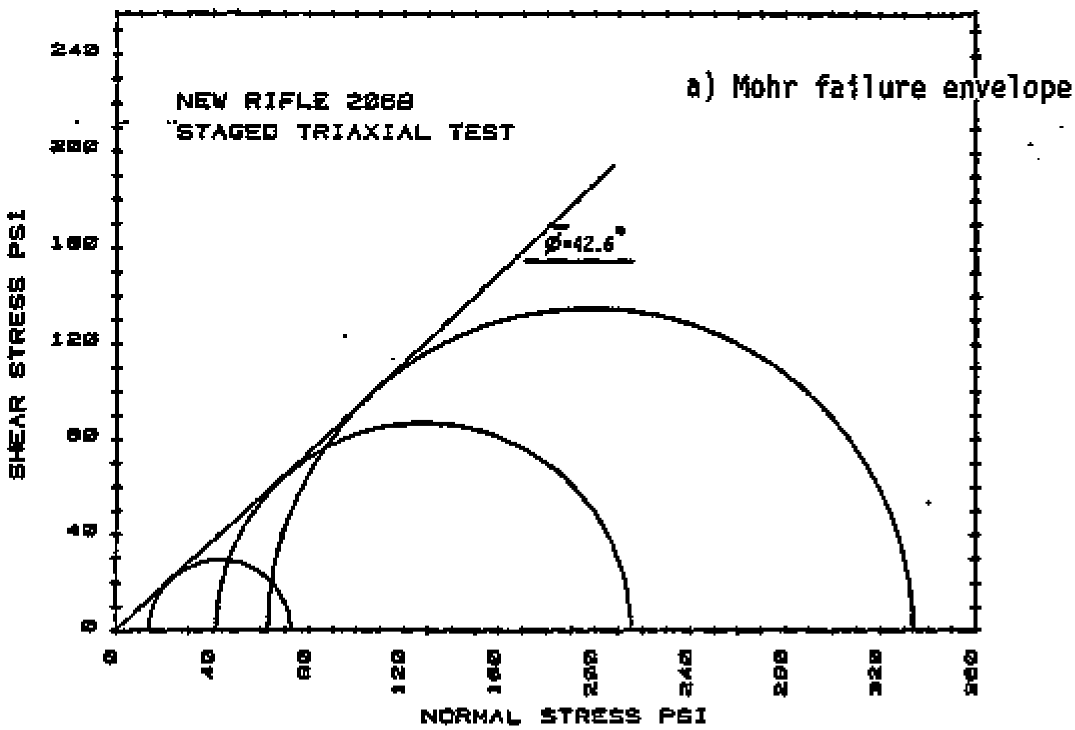
NOTE:

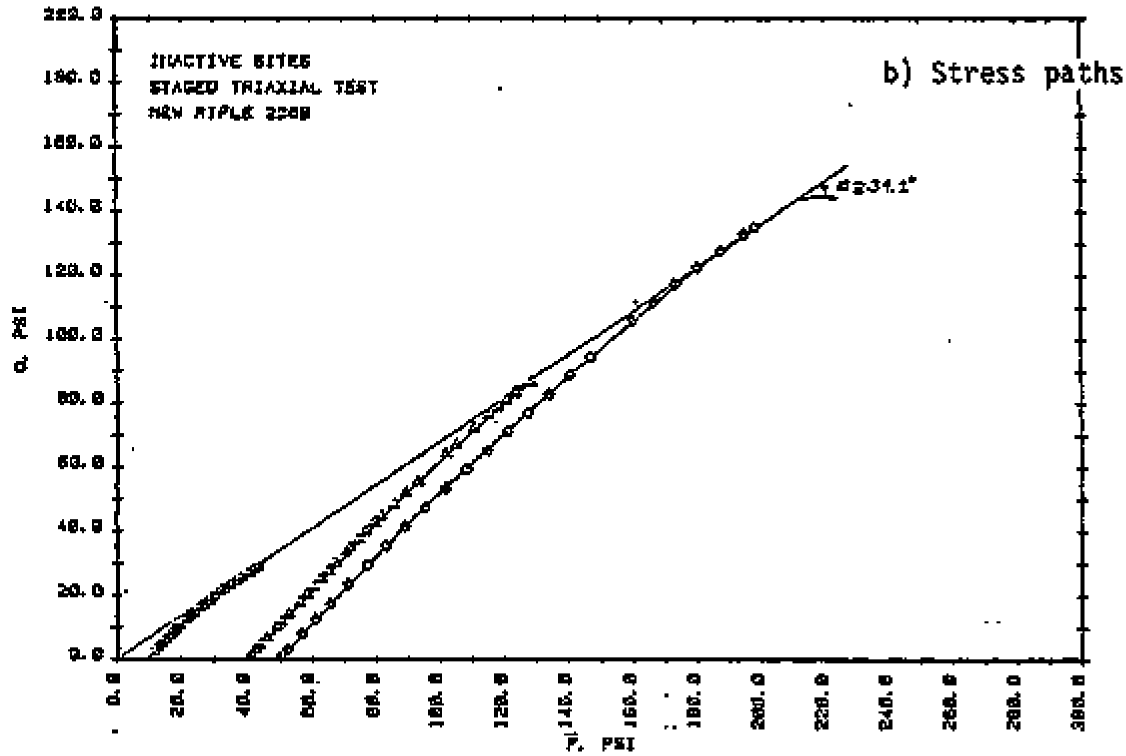
INITIAL WATER CONTENT = 44.1%

INITIAL SAMPLE DRY DENSITY = 77.4 PCF

FIGURE D.4.57

TRIAXIAL TEST RESULTS: NEW RIFLE SAND/SLIME TAILINGS





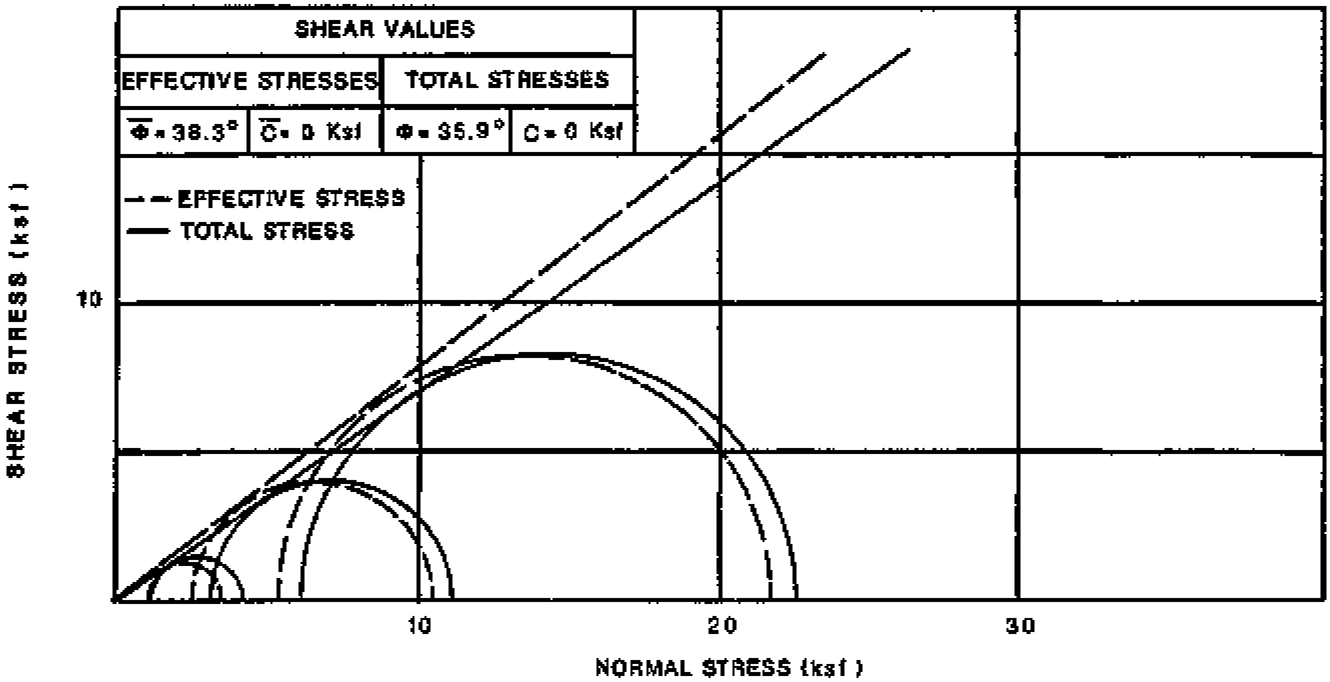
NOTE:

INITIAL WATER CONTENT = 21.5%

INITIAL SAMPLE DRY DENSITY = 101.6 PCF

FIGURE D.4.58

TRIAXIAL TEST RESULTS: NEW RIFLE SAND/SLIME TAILINGS



STAGE NO.	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)	SOIL DESCRIPTION
1	93.8	24.1	SAND TAILINGS
2	95.4	29.6	SAND TAILINGS
3	97.0	28.5	SAND TAILINGS

LOCATION NO.	DEPTH (FT.)	SAMPLE TYPE
RFO-277	9.5-12.0	UNDISTURBED

FIGURE D.4.59

SHEAR STRENGTH OF SOIL IN STAGED TRIAXIAL COMPRESSION, OLD RIFLE

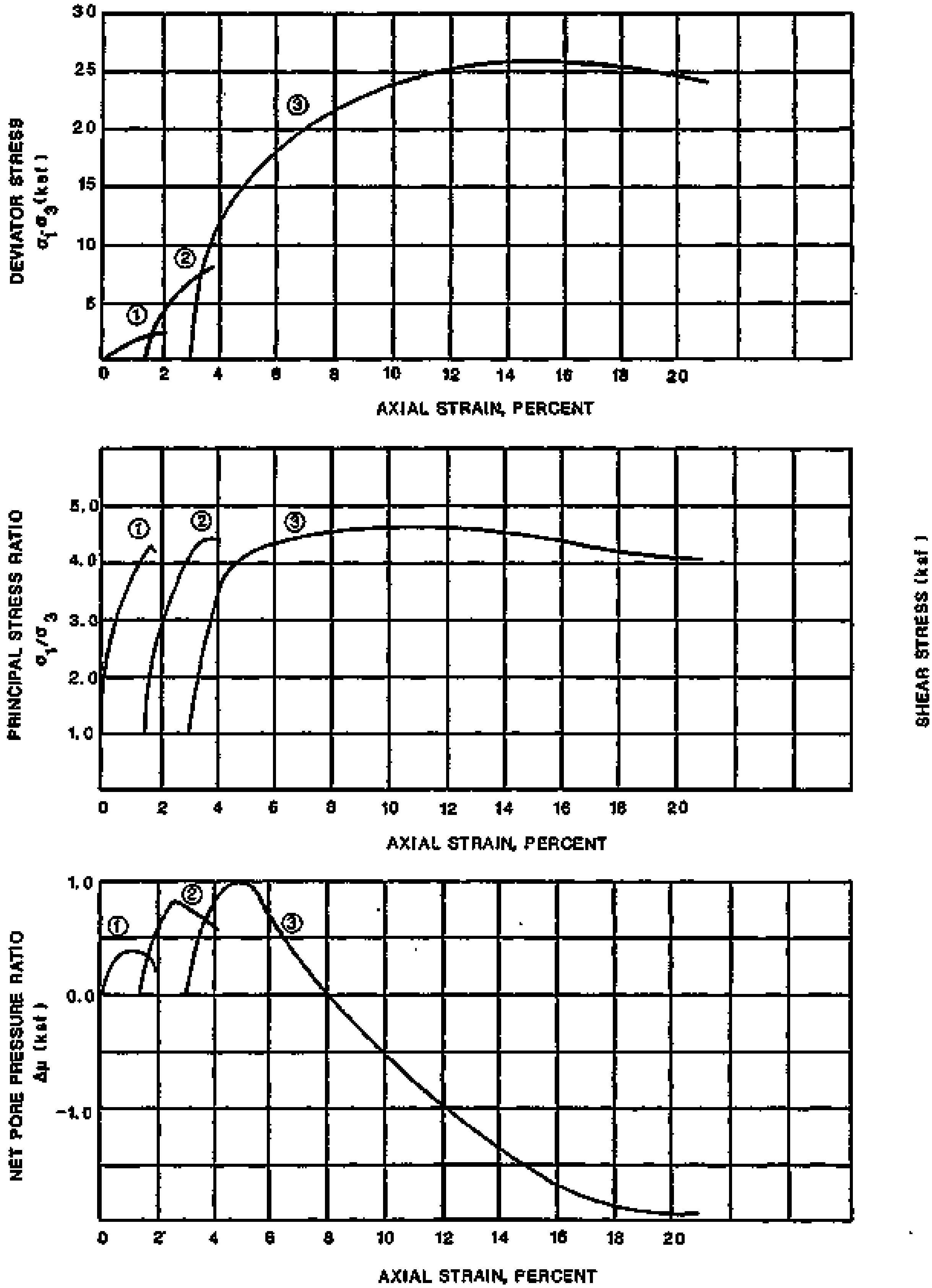
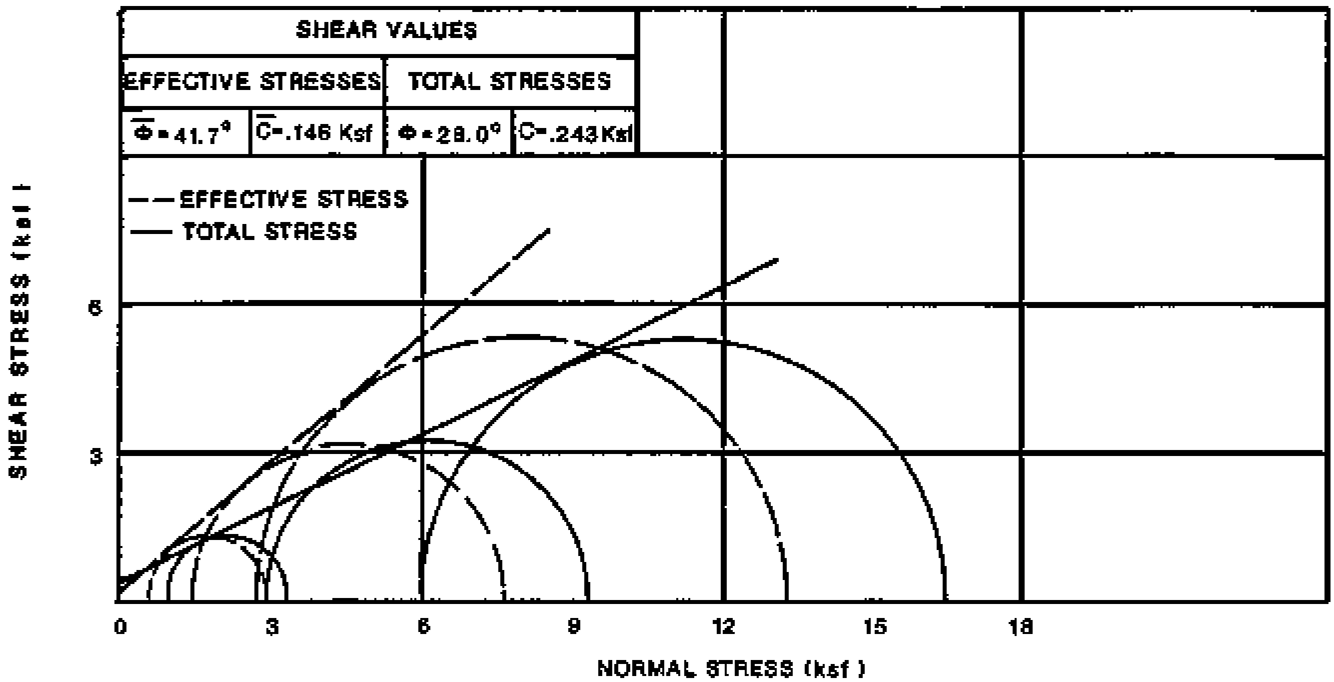


FIGURE D.4.59

SHEAR STRENGTH OF SOIL IN STAGED TRIAXIAL COMPRESSION, OLD RIFLE (CONC.)



STAGE NO.	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)	SOIL DESCRIPTION
1	69.1	53.1	SLIME TAILINGS
2	71.8	52.6	SLIME TAILINGS
3	73.7	50.5	SLIME TAILINGS

LOCATION NO.	DEPTH (FT.)	SAMPLE TYPE
RFN-152	8.0-10.3	UNDISTURBED

FIGURE D.4.60

SHEAR STRENGTH OF SOIL IN STAGED TRIAXIAL COMPRESSION, NEW RIFLE

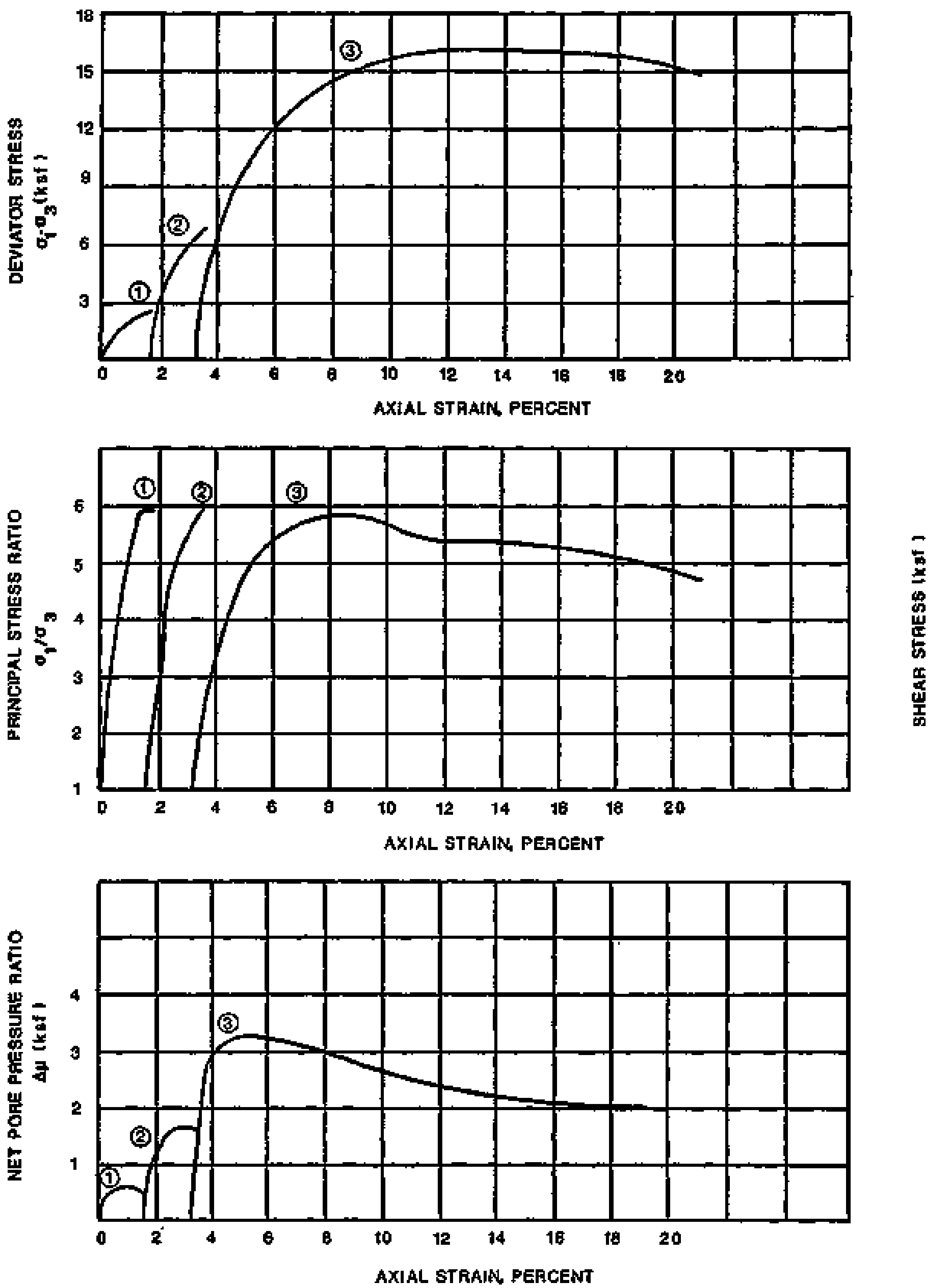
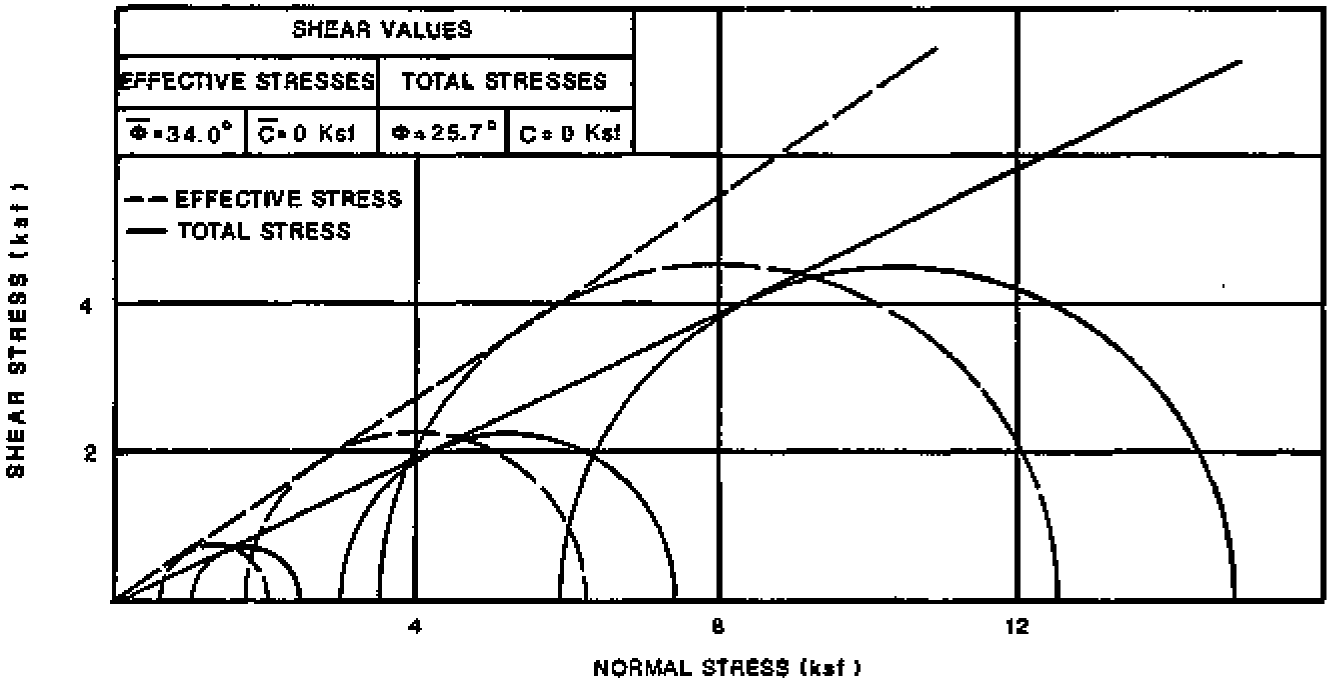


FIGURE D.4.60

SHEAR STRENGTH OF SOIL IN STAGED TRIAXIAL COMPRESSION, NEW RIFLE (CONC.)



STAGE NO.	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)	SOIL DESCRIPTION
1	61.9	12.3	SAND TAILINGS
2	83.8	35.1	SAND TAILINGS
3	66.2	33.0	SAND TAILINGS

LOCATION NO.	DEPTH (FT.)	SAMPLE TYPE
RFN-153	20.5-22.0	UNDISTURBED

FIGURE D.4.61

SHEAR STRENGTH OF SOIL IN STAGED TRIAXIAL COMPRESSION, NEW RIFLE

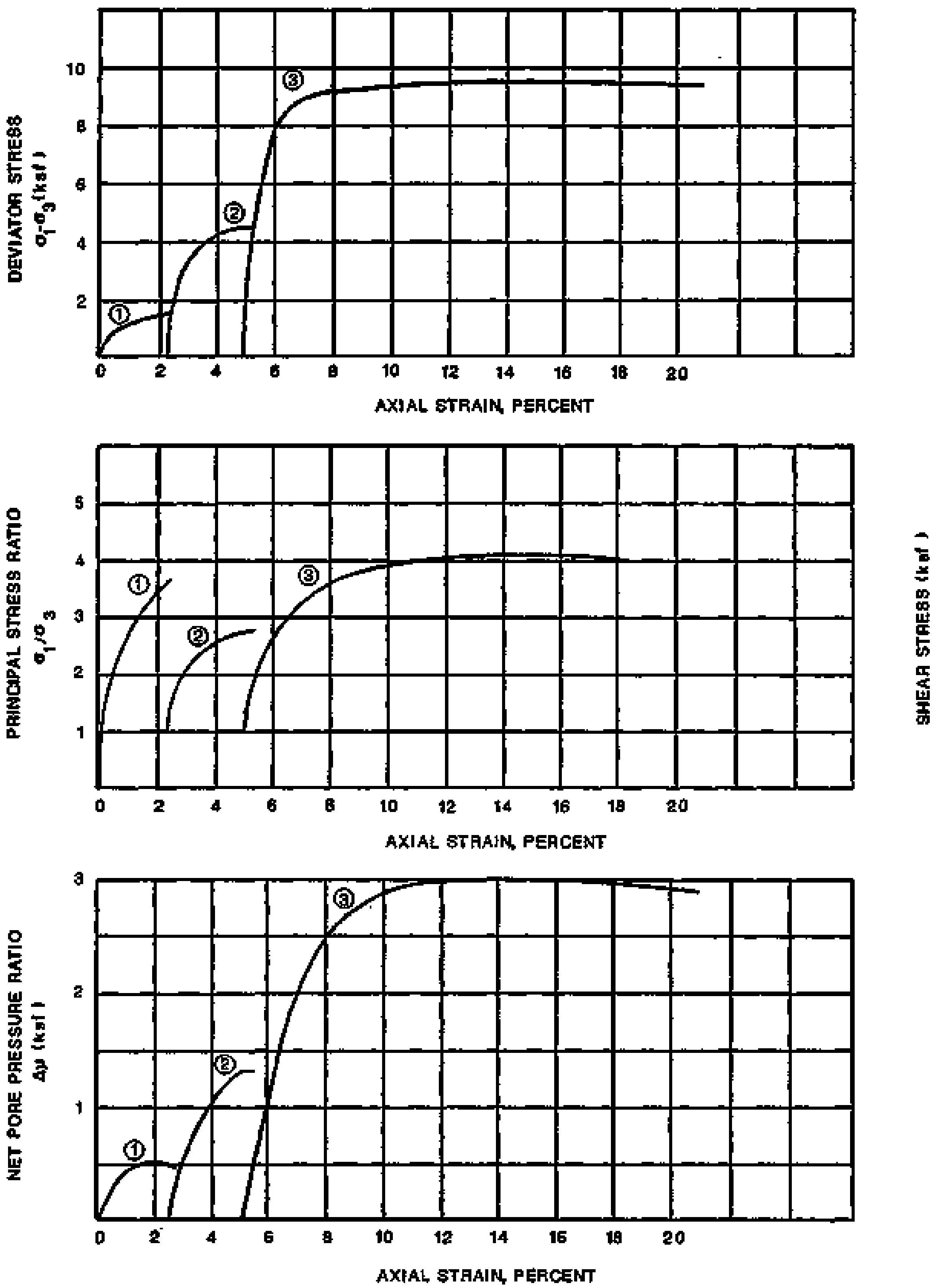


FIGURE D.4.61
SHEAR STRENGTH OF SOIL IN STAGED TRIAXIAL COMPRESSION
NEW RIFLE (CONC.)

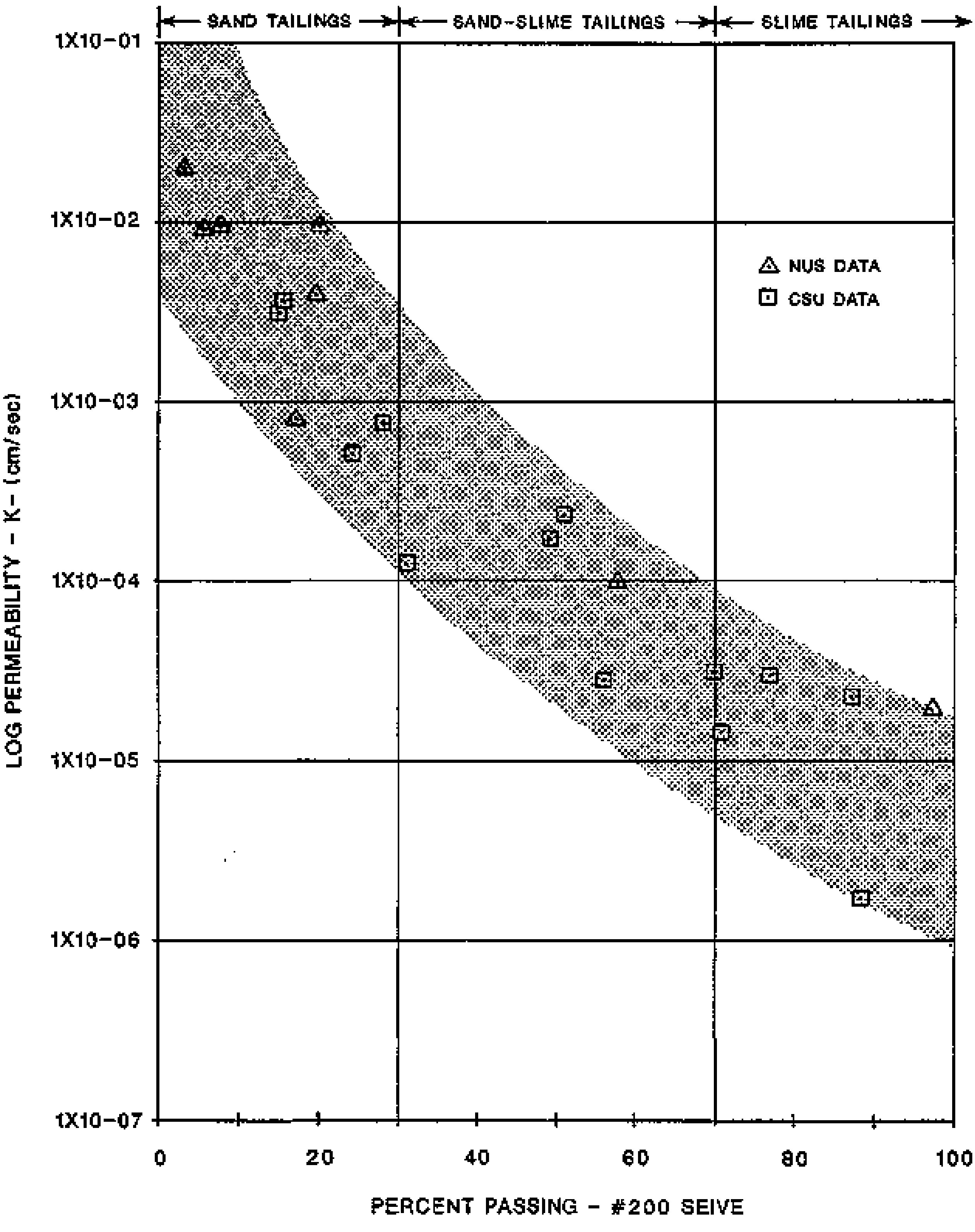
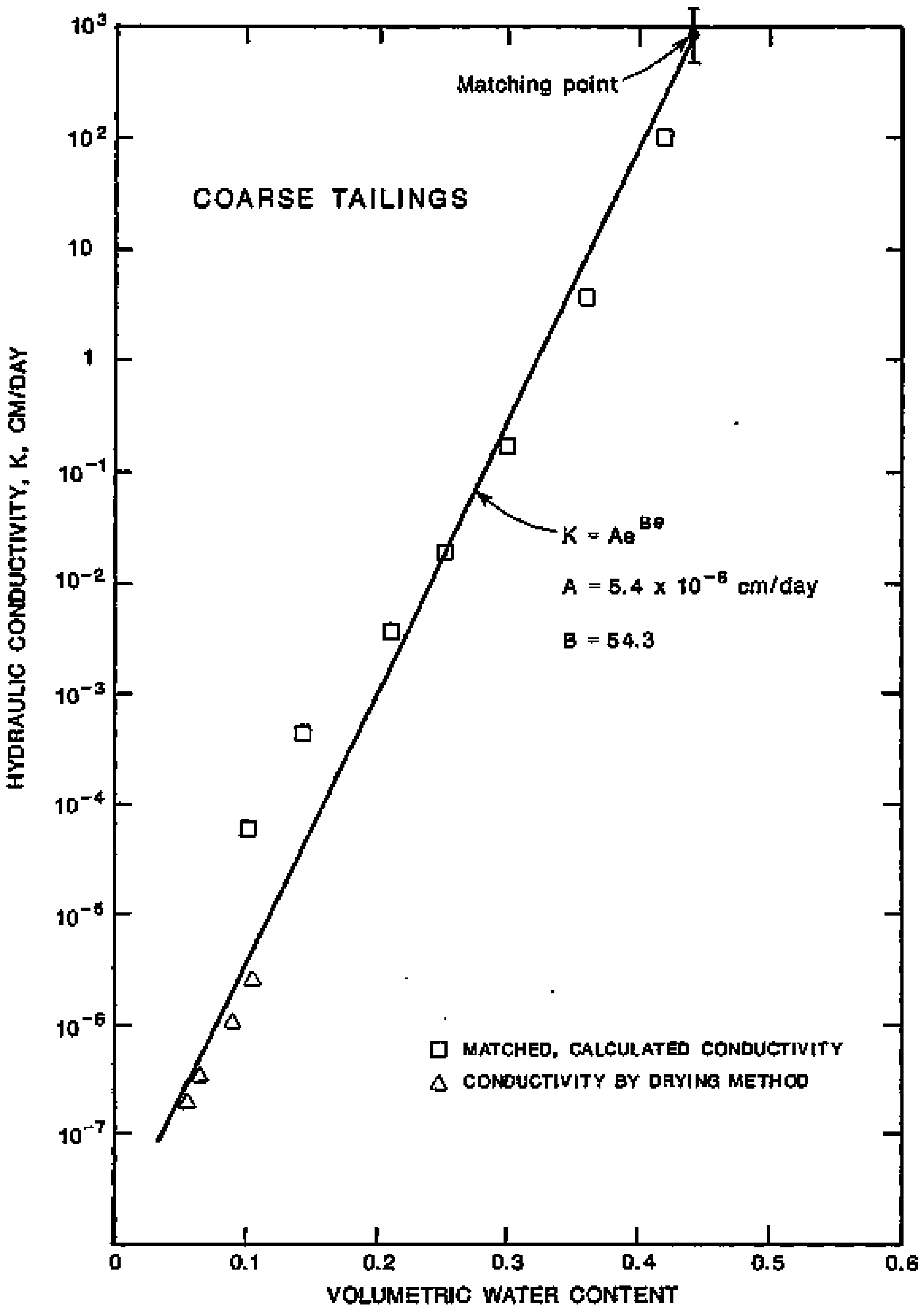
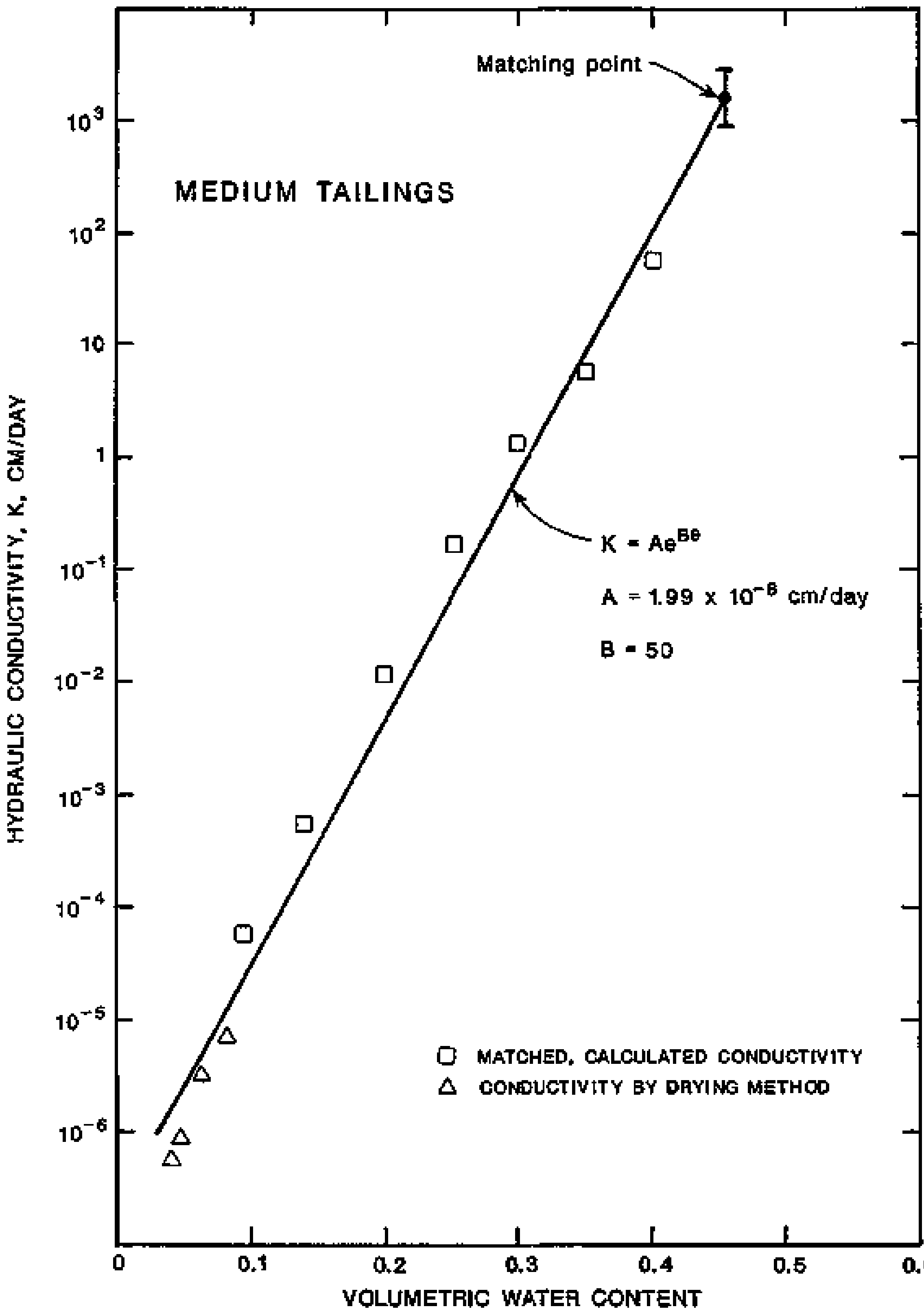


FIGURE D.4.62
SATURATED HYDRAULIC CONDUCTIVITY VS. SLIMES CONTENT



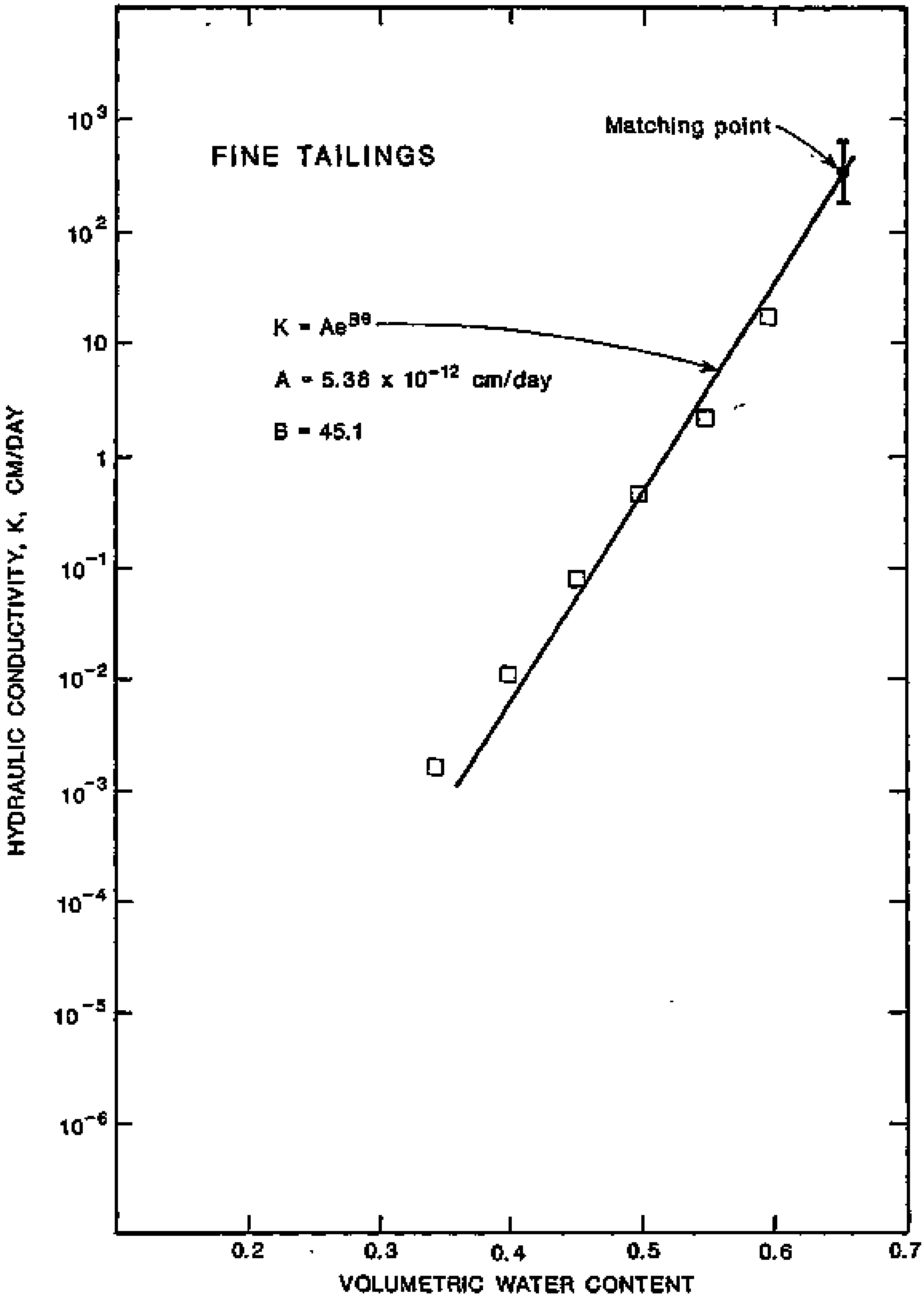
REF: KLUTE AND HEERMANN (1978).

FIGURE D.4.63
HYDRAULIC CONDUCTIVITY - WATER CONTENT FUNCTION FOR COARSE TAILINGS (SAND TAILINGS)



REF: KLUTE AND HEERMANN (1978).

FIGURE D.4.64
HYDRAULIC CONDUCTIVITY - WATER CONTENT FUNCTION FOR MEDIUM TAILINGS (SAND/SLIME TAILINGS)



REF: KLUTE AND HEERMANN (1978).

FIGURE D.4.65
HYDRAULIC CONDUCTIVITY – WATER CONTENT FUNCTION FOR FINE TAILINGS (SLIME TAILINGS)

Table D.4.1 Summary of tailings design parameters

NOTE: These design parameters have been superseded by the Final Design. The Final Design, Volume II, Calculations, Calc. 06-525-05-02, Geotechnical Characteristics, Sheet 4a, contains a summary of design parameters.

Table D.4.2 Summary of mechanical soil properties for Old Rifle site

Boring identification or test pit	Sample depth (ft)	Soil description	Specific gravity	Dry density (psf)	Water content (%)	% finer no. 200 sieve	Plasticity index %	Liquid limit %
OR200[a]	10	Brown to gray sand tailings	--	91.6	4.1	24.2	--	--
OR200	10	Brown to gray sand tailings sand-slime tailings	--	81.2	6.1	29.6	--	--
OR200	20	Brown slime tailings	--	62.5	54.5	88.7	--	--
OR201	10	Brown sand tailings	2.69	--	--	6.0	NP	--
OR201B	auger cuttings	Gray sand tailings	2.70	--	--	7.2	NP	--
OR201B	5	Gray sand tailings	2.69	--	--	7.2	NP	--
OR202	15	Brown sand tailings	--	87.5	23.6	14.8	--	--
OR203	10	Gray sand tailings	2.68	--	--	9.5	NP	--
OR203B	18	Brown slime tailings	--	--	--	--	NP	--
OR205B	5	Gray sand tailings	2.70	--	--	8.4	NP	--
OR205	15	Brown sand-slime tailings	2.72	81.8	--	30.5	NP	--
OR208	10	Brown sand-slime tailings	2.66	84.8	9.1	30.5	NP	--
OR209	5	Gray sand tailings	2.66	--	--	7.4	NP	--
GOR 3[b]	1-3	Sand tailings	--	94.1	3.5	8	--	--
GOR 5	1-3	Sand tailings	--	92.5	3.3	4	--	--
GOR 5	8.5-10.5	Sand tailings	--	89.4	5.1	6	--	--
GOR 6	14-16	Sand tailings	--	85.9	6.3	8	--	--
RFO-275[c]	9.5-12.0	Slime tailings	--	89.7	6.1	72	NP	--
RFO-276	14.5-17.0	Slime tailings	--	51.4	71.8	94	20	59
RFO-277	9.5-12.0	Sand tailings	--	87.7	21.6	6	--	--

Table D.4.2 Summary of mechanical soil properties for Old Rifle site (Concluded)

Boring identification or test pit	Sample depth (ft)	Soil description	Specific gravity	Dry density (psf)	Water content (%)	% finer no. 200 sieve	Plasticity index %	Liquid limit %
RFO-279	6.0-6.5	Slime tailings	–	–	–	100	18	57
RFO-TP4	12.0	Sand-slime tailings	2.74	–	21.7	40	NP	–
RFO-TP5	6.0	Slime tailings	2.92	–	58.1	96	12	49
RFO-TP6	7.0	Sand tailings	2.67	–	11.2	7	–	–

[a]Borings and test data designated as OR were conducted by CSU, 1985.
[b]Borings and test data designated as GOR were conducted by NUS, 1984.
[c]Borings and test data designated as RFO were conducted by Bendix, 1985a, and TAC, 1984a.

Table D.4.3 Summary of mechanical soil properties for New Rifle site

Boring identification or test pit	Sample depth (ft)	Soil description	Specific gravity	Dry density (psf)	Water content (%)	% finer no. 200 sieve	Plasticity index %	Liquid limit %
NR201B	--	Gray sand-slime tailings	2.72	--	--	39.9	NP	--
NR203[a]	5	Gray sand tailings	2.73	88.9	11.4	12.2	NP	--
NR203	10	Gray sand tailings	2.72	84.5	6.2	18.0	NP	--
NR203B	15	Gray sand-slime tailings	2.72	--	30.2	48.5	NP	--
NR203	20	Gray sand tailings	2.79	74.3	32.2	24.3	NP	--
NR203	25	Gray sand tailings	2.75	90.5	8.2	8.3	NP	--
NR203	30	Gray sand tailings	2.79	92.4	16.2	1.2	NP	--
NR203	40	Gray sand tailings	2.81	--	--	1.4	--	--
NR203	45	Gray sand tailings	2.75	83.0	24.7	7.0	NP	--
NR203	55	Gray sand tailings	2.84	--	--	2.9	8.3	45.0
NR203	60	Gray sand tailings	2.76	--	--	6.4	19.2	52.7
NR203	65	Gray sand tailings	2.76	--	--	3.5	6.0	45.9
NR203	70	Gray sand tailings	2.75	87.3	26.6	16.5	NP	--
NR206	5	Gray sand-slime tailings	2.69	86.2	0.1	36.1	NP	--
NR206	10	Gray sand tailings	2.80	84.9	2.6	21.6	NP	--
NR206	15	Gray sand-slime tailings	2.86	--	--	40.5	NP	--
NR206	25	Gray sand tailings	3.06	--	--	16.0	NP	--
NR206	30	Gray sand tailings	2.77	--	--	24.6	NP	--
NR206	35	Gray sand-slime tailings	2.83	--	--	32.1	NP	--
NR206	40	Gray sand tailings	2.69	82.6	5.3	11.1	NP	--
NR206	45	Brown sand-slime tailings	2.73	87.3	12.6	35.0	NP	--

Table D.4.3 Summary of mechanical soil properties for New Rifle site (Continued)

Boring identification or test pit	Sample depth (ft)	Soil description	Specific gravity	Dry density (psf)	Water content (%)	% finer no. 200 sieve	Plasticity index %	Liquid limit %
NR202	10	Gray sand-slime tailings	2.70	75.8	--	51.0	NP	--
NR202	20	Gray slime tailings	2.75	68.9	--	77.0	NP	--
NR204[b]	--	Gray sand tailings	2.69	--	--	28.5	NP	--
NR204	30	Gray sand-slime tailings	2.70	92.5	--	56.1	NP	--
NR205	20	Brown sand tailings	2.68	87.9	--	14.9	NP	--
NR206B	15	Gray sand-slime tailings	2.81	--	--	62.5	NP	--
NR206	30	Gray slime tailings	2.81	91.1	--	70.0	NP	--
NR206	35	Gray slime tailings	2.78	--	--	87.1	NP	--
NR208B	--	Gray sand-slime tailings	2.64	--	--	46.0	NP	--
NR208	45	Gray slime tailings	2.78	77.7	--	71.5	NP	--
NR212	35	Gray sand-slime tailings	2.73	--	--	44.9	NP	--
NR212	65	Gray-brown slime tailings	2.81	--	--	99.4	10.8	52.8
NR203	15	Gray sand-slime tailings	2.76	--	--	69.4	NP	--
GNR-1[b]	53-55	Sand tailings	--	88.9	13.0	26	--	--
GNR-1	63-65	Sand-slime tailings	--	109.8	14.7	42	--	--
GNR-3	28-30	Sand-slime tailings	--	100.0	18.2	58	--	--
GNR-4	18-20	Sand tailings	--	86.0	7.6	20	--	--
GNR-5	8-10	Slime tailings	--	64.7	40.1	97	--	--
GNR-6	1-3	Sand tailings	--	78.7	11.5	19	--	--
GNR-6	28-30	Sand tailings	--	91.6	9.6	16	--	--
RFN-150[c]	59.5-62.0	Sand tailings	--	92.7	17.6	24	NP	--

Table D.4.3 Summary of mechanical soil properties for New Rifle site (Concluded)

Boring identification or test pit	Sample depth (ft)	Soil description	Specific gravity	Dry density (psf)	Water content (%)	% finer no. 200 sieve	Plasticity index %	Liquid limit %
RFN-151	50.0-52.3	Slime tailings	--	77.9	48.5	98	22	--
RFN-152	8.0-10.3	Slime tailings	--	76.2	48.5	100	NP	63
RFN-153	20.5-22.0	Sand tailings	--	72.5	17.7	15	--	--
RFN-TP-1	8.0	Sand-slime tailings	2.76	--	27.2	69	NP	--
RFN-TP-2	8.0	Slime tailings	2.98	--	42.8	98	NP	--
RFN-TP-3	3.0	Sand-slime tailings	2.76	--	11.8	49	--	--

[a]Borings and test data designated as NR were conducted by CSU, 1985.
[b]Borings and test data designated as GNR were conducted by NUS, 1984.
[c]Borings and test data designated as RFN were conducted by TAC, 1985a.

Table D.4.4 Summary of compaction test data

Site identi-fication	Test pit identification	Sample interval of depth (ft)	Soil description	% passing No. 200 sieve	Specific gravity	In situ moisture content	Moisture-density relationships	
							Optimum moisture content (%)	Maximum dry density (pcf)
Old Rifle (RFO)	TP4 RFO	12	Sand-slime tailings	40	2.74	–	22.7	91.0
New Rifle (RFN)	NR 201B[a]	--	Sand-slime tailings	39.9	2.72	--	15.5	109.0
	NR 203B[a]	15	Sand-slime tailings	48.5	2.72	30.2	16.8	110.3
	NR 206B[a]	15	Sand-slime tailings	62.5	2.81	--	21.5	99.5
	NR 208B[a]	--	Sand-slime tailings	46.0	2.84	--	17.0	108.0
	TP-1 RFN	8	Sand-slime tailings	69	2.78	--	24.4	91.0
	TP-3 RFN	3	Sand-slime tailings	49	2.76	--	24.4	92.0

[a]Data labeled as NR and OR were conducted by CSU, 1985. All other data by TAC, 1985a.

Table D.4.5 Saturated laboratory hydraulic conductivities

Boring and/or sample identification	Material type	Initial dry density	% compaction if remolded	Saturated hydraulic conductivity (cm/s)
OR 200a at 10′	Sand tailings	92	--	$5x10^{-4}$
OR 200b at 10′	Sand tailings	81	–	$7.3x10^{-4}$
OR 200 at 20′	Slime tailings	62	--	$1.7x10^{-6}$
OR 202 at 15′	Sand tailings	88	--	$2.9x10^{-3}$
OR 203B	Slime tailings	97	–	$6.8x10^{-5}$
		104	--	$4.6x10^{-5}$
		109	--	$2.3x10^{-5}$
OR 205B	Sand tailings	88	84	$3.1x10^{-3}$
		100	95	$7.2x10^{-4}$
		112	107	$7.9x10^{-5}$
		117	111	$6.4x10^{-5}$
OR 208 at 10′	Sand-slime tailings	88	--	$1.2x10^{-4}$
GOR 5 at 1-3′	Sand tailings	93	--	$2x10^{-2}$
GOR 5 at 8.5′-10.5′	Sand tailings	89	--	$9x10^{-3}$
GOR 6 at 14′-16′	Sand tailings	86	--	$9x10^{-3}$
NR 202 at 10′	Sand-slime tailings	76	--	$2.4x10^{-4}$
NR 202 at 20′	Sand-slime tailings	89	--	$3.0x10^{-5}$
NR 203B	Sand-slime tailings	77	70	$2.0x10^{-3}$
		94	85	$5.0x10^{-5}$
		105	95	$7.2x10^{-7}$
NR 204 at 30′	Sand-slime tailings	92	--	$2.9x10^{-5}$
NR 205 at 20′	Sand tailings	88	–	$3.5x10^{-3}$
NR 206 at 30′	Sand-slime tailings	91	–	$3.2x10^{-5}$
NR 206 at 35′	Slime tailings	--	--	$2.3x10^{-5}$
NR 206B	Sand-slime tailings	75	75	$8.0x10^{-3}$
		85	85	$1.8x10^{-4}$
		95	96	$3.9x10^{-5}$
NR 208 at 45′	Slime tailings	--	78	$1.5x10^{-5}$
NR 212 at 35′	Sand-slime tailings	–	–	$1.7x10^{-4}$

Table D.4.5 Saturated laboratory hydraulic conductivities (Concluded)

Boring and/or sample identification	Material type	Initial dry density	% compaction if remolded	Saturated hydraulic conductivity (cm/s)
NR 212 at 65'	Slime tailings	--	--	7.2×10^{-4}
GNR 1 at 53'-55'	Sand tailings	--	89	8.0×10^{-4}
GNR 3 at 28'-30'	Sand-slime tailings	--	99	1.0×10^{-4}
GNR 4 at 18'-20'	Sand tailings	--	86	1.0×10^{-2}
GNR 5 at 8'-10'	Slime tailings	--	65	2.0×10^{-5}
GNR 6 at 1'-3'	Sand tailings	--	79	4.0×10^{-3}

D.5 DISPOSAL SITE CHARACTERISTICS

D.5.1 DESIGN PARAMETERS OF IN SITU SOILS

The recommended in situ soil parameters for use in designing the tailings pile at Estes Gulch are presented in the Final Design, Volume II, Calculations, Calculation Number 06-525-05-02, Geotechnical Characteristics, Sheet 4a. These parameters are for soils remaining after the required foundation soils have been excavated for radon cover material. Values in the table are derived from laboratory test results.

D.5.2 DESIGN PARAMETERS FOR REMOLDED (COVER MATERIAL) SOILS

Design parameters for remolded foundation soils to be used in the radon cover are presented in the Final Design referenced above. Excavated material is assumed to be thoroughly mixed during placement and thus can be considered a homogeneous material.

D.5.3 MATERIAL PROPERTIES OF IN SITU SOILS

Classification

Thirty-four samples obtained from Estes Gulch exploratory borings and test pits were analyzed to determine the particle size distribution. Sieve analyses were done according to ASTM D136. Fifteen of these samples were further analyzed by the hydrometer method (ASTM D422) to determine the distribution of particles with effective diameters less than 0.074 millimeters (No. 200 sieve). From the distribution of the fine material, the percentage of clay size particles which have an effective diameter less than or equal to two microns can be determined. To further aid in classification, Atterberg limits tests (ASTM D4318) were performed on all 34 samples. Results of these tests are summarized in Table D.5.3. Particle size distribution curves are presented in Figures D.5.1 through D.5.33. See MK report of August 1994 for index property testing of radon barrier stockpile material.

Atterberg limits tests measure the water contents at which the soil behaves as a viscous liquid, a plastic material, and a brittle solid. The water content that differentiates soil behaving as a solid and plastic material is defined as the plastic limit (P.L.). The lowest water content at which the soil behaves as a viscous liquid is defined as the liquid limit (L.L.). The difference between these two water contents is defined as the plasticity index (P.I.). Plasticity index specifies the range of water contents that the soil will behave as a plastic material.

It has also been shown that the L.L., P.L., and P.I. can be empirically correlated to parameters such as shear strength and volume change of fine-grained materials. These correlations provide a useful check for laboratory test results or estimating these parameters when test results are unavailable.

Foundation soils classified by the Unified Soil Classification System (USCS) result in 28 of the 34 samples classifying as sandy clays (CL). The majority of these samples also contain an appreciable amount of silt material. Of the six samples that did not classify as sandy clays, five are clayey sands (SC) while the remaining sample is a silty sand (SM). In the USCS, fines and sands are differentiated by the percentage of fines (No. 200 material). If more than 50 percent of the sample is fine material by weight, the sample is a clay or silt. The samples that classified as sands generally contained between 34 to 40 percent fines and will tend to behave more as a fine material than as a sand.

Liquid limits of the clay material range from 20 to 45 while the plastic limit ranges from 14 to 25 with arithmetic averages of 31 and 16, respectively. The plasticity indices vary from five to 23 with a mean of 15. Thus, the sandy clays are low to medium plastic.

The plasticity index is used to estimate the swell potential of a soil. Swell potential is empirically related to the P.I. with the relationship presented by Mitchell (1976). Using the mean P.I. of 15, the swell potential is 1.6 percent. This can be checked using a similar relationship also presented by Mitchell (1976) involving the activity of the soil. Activity is defined as the P.I. divided by five minus the percent clay-sized particles contained within the sample. The activity relationship is:

$$\text{percent swell} = 3.6 \times 10^{-5} A^{2.44} C^{3.44}$$

where

A is the percent activity, and
C is the percent clay size (< 2 micrometers).

This relationship confirms a swell potential of 1.6 percent. Both of these relationships were derived empirically for soils experiencing a one psi (144 psf) surcharge load upon excessive moisture increase. The activity of 15 samples was determined. The results are presented in Table D.5.3. The mean activity is 0.75. This average value of activity corresponds to the mean of the range of activities for the mineral illite, as presented by Mitchell (1976). This leads to the hypotheses that the clay contains considerable illite.

From the above, it can be seen that the sandy clay foundation soils have a low swell potential. Also, their susceptibility to frost heave, shrinkage, and other volume change phenomena is low.

In situ moisture content, specific gravity, and dry density

The average values for the in situ moisture content, specific gravity, and dry density of the foundation soils have been determined from laboratory analyses. Standard Penetration Tests (SPT) performed in field investigations were used to confirm the unit weight of the soil in the field as determined by laboratory testing. Average laboratory values are recommended as design parameters for the moisture content and specific gravity.

Specific gravities for 13 samples are listed in Table D.5.3. The average is 2.69. Comparing this value to typical published values for soils and minerals provides interesting results. Lambe and Whitman (1969) report the mineral illite has specific gravities ranging from 2.60 to 2.86 while quartz has a specific gravity of 2.65. Lambe (1951) gives a specific gravity of 2.67 for Ottawa Sand. Bowles (1978) reports ranges for silty sand of 2.67 to 2.70 while inorganic clays have specific gravities ranging from 2.70 to 2.80. From the above it appears that the foundation clays possess a specific gravity that is slightly below standard values for clays. The average specific gravity value for illite reported by Lambe and Whitman (1969) is 2.73. This is higher than the tested value of 2.69 but well within the range given by Lambe and Whitman. This further upholds the hypothesis that the clay soils contain appreciable amounts of illite.

The *in situ* dry density for the foundation soils was determined from Shelby tube samples and from 2.5-inch-diameter ring samples. Dry density ranged from 81.3 pcf to 116.3 pcf with an average of 101.8 pcf. Boring logs from exploratory borings give an average SPT blowcount of 81 (corrected for overburden effects). This blowcount is a "hard" value specified by Terzaghi and Peck (1948), which confirms the dry density of 101.8 pcf. This dry density can be compared with typical values in NAVFAC DM-7.1 (U.S. Navy, 1982) and from Hough (1969) of 50 to 112 pcf for clay containing 30 to 50 percent clay-size particles.

Natural moisture content (W_n) for the foundation soils was determined from the arithmetic average of 86 laboratory results listed in Table D.5.3. An average value of 8.2 percent was obtained with a low value of 3.2 percent and a high of 12.6 percent. Using this average value, a Liquidity Index (L.I.) of -0.52 is computed for the foundation soils. The L.I. indicates what type of material the soil will behave as. This index is defined as

$$L.I. = \frac{W_n - P.L.}{P.I.}$$

(Holtz and Kovacs, 1981) where the variables have been previously defined. The computed value of -0.52 indicates the soil will behave as a brittle solid.

Hydraulic conductivity

The hydraulic conductivity of the various soil layers is required to determine groundwater flow patterns and is used in the analysis of slope stability, settlement, and liquefaction.

Triaxial hydraulic conductivity tests were performed on five relatively undisturbed three-inch-inner diameter (I.D.) Shelby tube or 2.5-inch-I.D. ring samples. Results of these tests are presented in Table D.5.4. The hydraulic conductivity ranges from 9.0×10^{-7} cm/s to 1.2×10^{-5} cm/s with a geometric mean of 1.3×10^{-6} cm/s. The maximum value is not considered valid due to sampling disturbance and therefore was not used in computation of the mean. This sample was a ring sample obtained from drive sampling procedures. The sample had the highest dry density and lowest void ratio of samples tested but the highest hydraulic conductivity. This is the opposite of long-established theoretical and empirical relationships. It is hypothesized that microfractures were induced during sampling, and these provided flow channels through the soil which resulted in an uncharacteristically high hydraulic conductivity.

The mean value was compared to published values for typical soils. The mean hydraulic conductivity corresponds to a silt soil (Lambe and Whitman, 1969), an impervious soil affected by vegetation and/or weathering (Holtz and Kovacs, 1981), or a clay soil (Sowers, 1979). It can be seen by the wide range of published values that the mean represents the permeability of a typical impervious material. Thus it is considered representative for fine-grain soil deposits.

Additional in situ testing of bedrock permeability was performed by use of SDRI testing in winter 1992-1993 (MK, 1993), and testing of radon barrier permeability was done in 1994 (see MK reports, August 1994 and February 1995).

Compressibility

To design a radon barrier, the compressibility of all underlying materials needs to be assessed. Once compressibility parameters of materials beneath the cover are known, settlement of the cover can be calculated. Excessive cover settlement can lead to cover cracking and flow concentrations of surface water runoff.

When a soil deposit is subjected to an increase in stress, a volume reduction occurs. This reduction is the result of a decrease in the volume of voids within the soil mass. By reducing the void ratio, the volume decreases and the soil mass settles. Total settlement includes long-term settlement and immediate or elastic settlement. Long-term settlement is the sum of this consolidation or primary settlement remaining following construction and secondary settlement or creep.

Elastic settlements can be evaluated by assuming the soil medium is an elastic material and employing the use of elastic parameters. Elastic settlement is also termed immediate settlement because it occurs almost immediately after the application of load.

Primary or consolidation settlement is the result of dissipation of excess pore pressures rising from application of additional loading to the soil. Thus, for primary settlement to occur, the soil deposit needs to be saturated or become saturated due to a reduction in voids from immediate settlement. The degree of saturation is defined as the volume of fluid within a soil mass divided by the volume of voids. The soil is said to be "saturated" when this ratio is unity. A volume reduction by immediate settlement could cause a void ratio reduction large enough to saturate the soil at a given water content.

Secondary settlement or creep is the result of volume changes that occur under a constant load with time after excess pore pressures have dissipated. This phenomena is not fully understood, but probably is the combination of the compression of bonds between particles and other unknown microscale effects (Holtz and Kovacs, 1981).

Foundation soils exist at an extremely low moisture content and stress increases caused by the application of the tailings will not be large enough to cause saturation; thus, primary consolidation settlement will not occur. Consolidation tests were performed on in situ samples of foundation soils by saturating the samples during the test and the results are presented in Table D.5.5 while consolidation plots are presented in Figures D.5.34 to D.5.37.

Foundation soils will experience immediate compression from the placement of tailings and this compression will occur during and soon after construction. Settlement magnitudes were not determined and elastic parameters are not presented because the majority of this settlement will occur prior to placement of the radon cover.

Secondary settlement is expected to occur over the design life of the disposal pile. Secondary settlement depends on the load increment. A representative secondary compression index for the range of loadings that will occur in the pile is given in Table D.5.1. Actual design values are given in MKE calculation number 06-525-05-02. These values may be computed from the ratio of the secondary compression index to the coefficient of virgin compression for inorganic soils presented by Holtz and Kovacs (1981). Literature values are used because consolidation test load increments were not extended into the secondary compression range.

Shear strength

The shear strength parameters of the in situ foundation soils are required for slope stability analysis. Two types of laboratory test methods were used to model expected field conditions: consolidated undrained direct shear tests without pore pressure measurements and consolidated undrained triaxial shear testing with pore pressure measurements (called R tests). Triaxial tests were performed according to U.S. Army Corps of Engineers procedure EM 1110-2-1906 with the single exception that the tests were conducted as multiphased tests.

All tests were performed on saturated, undisturbed samples. A small seating load was applied to direct shear test samples after saturation to allow for dissipation of excess pore pressures prior to shearing. In the triaxial test the sample was saturated using backpressure (minimum "B" parameter of 0.95), a confining pressure applied, and sample pore pressures allowed to reach equilibrium with the confining pressure.

Effective stress parameters are for use in analyzing long-term stability. Embankment failure under long-term conditions will occur slowly and dissipation of excess pore pressures will have time to occur. Although unlikely, immediately after construction of the embankment excess pore water pressures could exist from increased loads and failure would be rapid without allowing dissipation of pore pressures to occur. Total stress parameters model this situation.

Total stress parameters were found through direct shear testing. Averaging the direct shear test results in a friction angle of 29.25° with a corresponding cohesion of 95 psf (see Table D.5.6). Shear strength graphs are shown in Figures D.5.38 and D.5.39.

One in situ sample was tested by the triaxial R test. These results should be used for long-term stability analyses and are also presented in Table D.5.1. An effective internal friction angle of 30° with no cohesion is the shear strength given in Figures D.5.40a through D.5.40d. When this effective friction angle is compared to a relationship published in Lambe and Whitman (1969) between $_d$ and the plasticity index, it is below predicted values. This published relationship contains generalizations and although the tested value is low, and therefore conservative, it was derived from actual laboratory testing. Actual design values are given in MKE Calculation No. 06-525-05-02, Sheet 4.

D.5.4 MATERIAL PROPERTIES OF REMOLDED (RADON COVER MATERIAL) SOIL

Classification

Excavated foundation soils at the Estes Gulch site will be used for radon cover material. The classification of these materials is presented in Section D.5.3.

Moisture density relationships

Compaction characteristics of radon cover material were obtained by performing the standard Proctor test, ASTM D698, on bulk test pit samples from Estes Gulch. Results from these tests are summarized in Table D.5.7. Indicated along with optimum moisture content (OMC) and maximum dry density, this table lists other physical properties including percent fines (percent passing No. 200 sieve), specific gravity, in situ moisture content, and USCS classification. Moisture density curves are presented in Figures D.5.41 to D.5.45. The arithmetic average of the OMC is 15.9 percent. The average maximum dry density is 110.4 pcf.

Ninety-five percent of maximum dry density determined by ASTM D698, moisture conditioned as discussed above, is recommended for compaction of radon barrier material without bentonite amendment. Placing soils in this manner will result in an average dry density of 104.9 pcf at 17.5 percent moisture. Combining these two parameters produces a total design unit weight of 123.3 pcf for the radon cover.

Additional compaction testing of soil from the radon barrier stockpile was performed in August 1994 (MK, 1994).

Radon cover erosion potential

Foundation soils to be used as radon cover material were tested for erodability by the crumb test (STP 623), the double hydrometer test (ASTM D4221), and the pinhole test (STP 623). Results of these tests are presented in Table D.5.8. As indicated by these results, the materials to be used for the radon cover are considered nondispersive. This indicates a low potential for erosion and piping of the radon cover material.

Hydraulic conductivity and capillary moisture relationships

Hydraulic conductivity or permeability testing of the radon barrier material conducted prior to issuance of the February 1992 RAP was done on test pit samples. During excavation of the Estes Gulch disposal cell, a field geologist inspected and separated the most clayey material into a stockpile for later use in radon barrier construction. As a result of this material inspection and sorting process, the soil stockpiled for radon barrier construction has a much lower permeability than the test pit samples tested earlier. the five triaxial permeability tests performed on test pit samples in 1985 showed an average (geometric mean) hydraulic conductivity of 1.0×10^{-7} cm/s (see Table D.5.9). The five samples (three permeability tests per sample) from the radon barrier stockpile tested in 1994 had an average (geometric mean) hydraulic conductivity of 1.2×10^{-8} cm/s (MK, 1994).

For the 1992 RAP, five samples were obtained from test pit excavations; they were remolded and tested to determine capillary moisture relationships of the cover material. Remolded dry densities obtained were 95 percent of maximum dry density according to ASTM D698 and the capillary moisture test (ASTM D3125) was used to determine relationships. Results of these tests are presented in Figures D.5.46 to D.5.50. Additional tests were performed on samples obtained under the direction of MK. Results from these tests are provided in Volume IV, Information for Bidders.

Samples of stockpiled frost protection material and radon barrier material amended with four percent Wyoming bentonite are currently being tested to determine the capillary moisture relationships of the final cover design. Results of these tests will be used for radon diffusion testing and in final radon diffusion calculations with the RAECOM computer model.

Compressibility

One-dimensional odometer tests were performed on remolded foundation soil samples to determine the compressibility characteristics of the radon cover. Five tests were run on samples compacted to 95 percent of maximum dry density determined by ASTM D698. Results of these tests are given on Table D.5.11, which indicates percent compaction achieved, initial dry density, moisture content in addition to preconsolidation stress estimates, and compression indices. The compression indices are derived from strain expressions as opposed to void ratio relationships and are denoted by the addition of the adjective "modified". Consolidation characteristics are presented in Figures D.5.51 to D.5.56.

The modified virgin compression index ranges from 0.079 to 0.158 with a mean of 0.115. Modified recompression indices are between 0.008 to 0.016 with a mean of 0.011. Preconsolidation stresses varied from 1.35 to 2.25 kip per square foot (ksf) with an average of 1.72 ksf.

The ratio of recompression index to virgin compression generally ranges from 0.20 to 0.25 for natural soils (Das, 1984). This ratio is 0.10 for the Rifle average design parameters. The difference is due to the fact that the soil was remolded prior to testing.

Shear strength parameters

To establish strength parameters for the radon cover, triaxial shear strength tests were performed. Two types of tests were used to model expected field conditions. Multi-phase unconsolidated undrained testing with pore pressure measurements, the R test, was used to model long-term strengths. Unconsolidated undrained tests or the Q test was used to model end-of-construction strengths.

Results of these tests are summarized in Table D.5.12. Shear strength plots indicating long-term strengths are presented in Figures D.5.57a through d, D.5.58a through d, and D.5.59a through d, while plots showing end-of-construction strength parameters are given in Figures D.5.60a through c and D.5.61a through c.

Design values are given in MKE Calculation No. 06-525-05-02.

Shear strength testing of 4 percent bentonite amended radon barrier soil is currently being conducted to confirm results of cover system stability analyses. (See MK Slope Stability Calculation 06-570-13-01.)

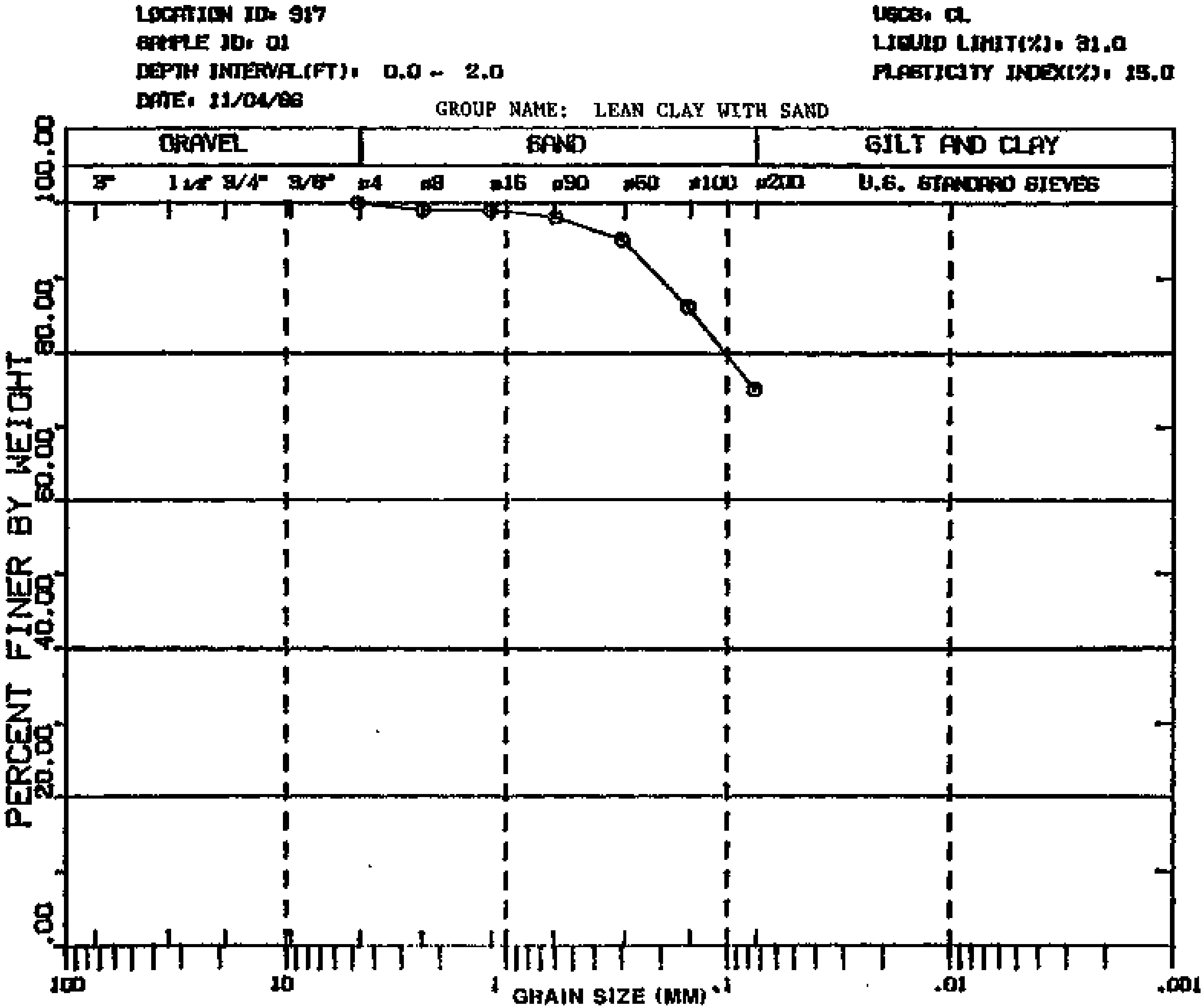


FIGURE D.6.1 PARTICLE SIZE DISTRIBUTION, ESTES GULCH

LOCATION ID: 917
SAMPLE ID: 04
DEPTH INTERVAL(FT): 6.0 - 8.0
DATE: 11/04/88

USCS: CL
LIQUID LIMIT(%): 22.0
PLASTICITY INDEX(%): 8.0

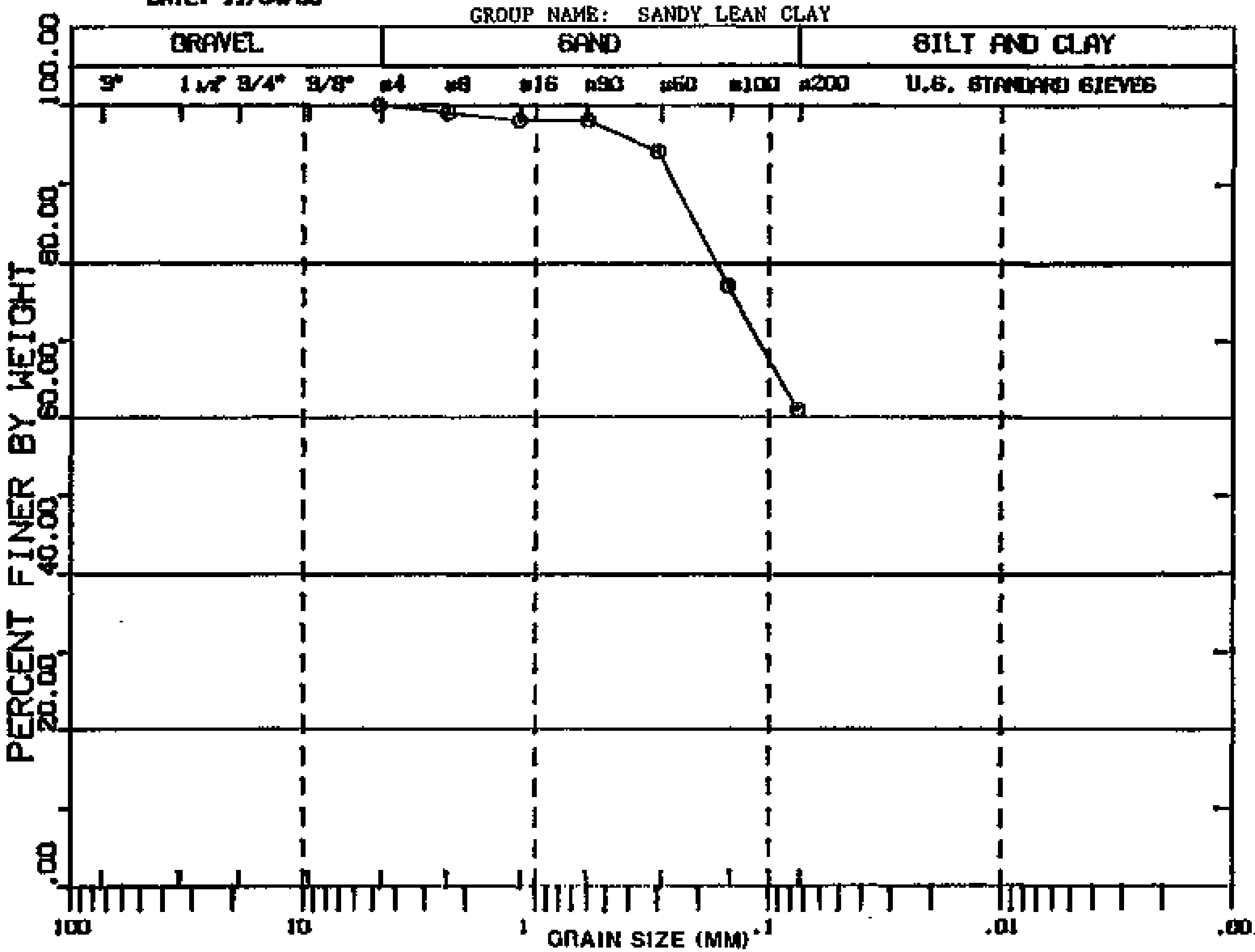


FIGURE D.5.2 PARTICLE SIZE DISTRIBUTION, ESTES GULCH

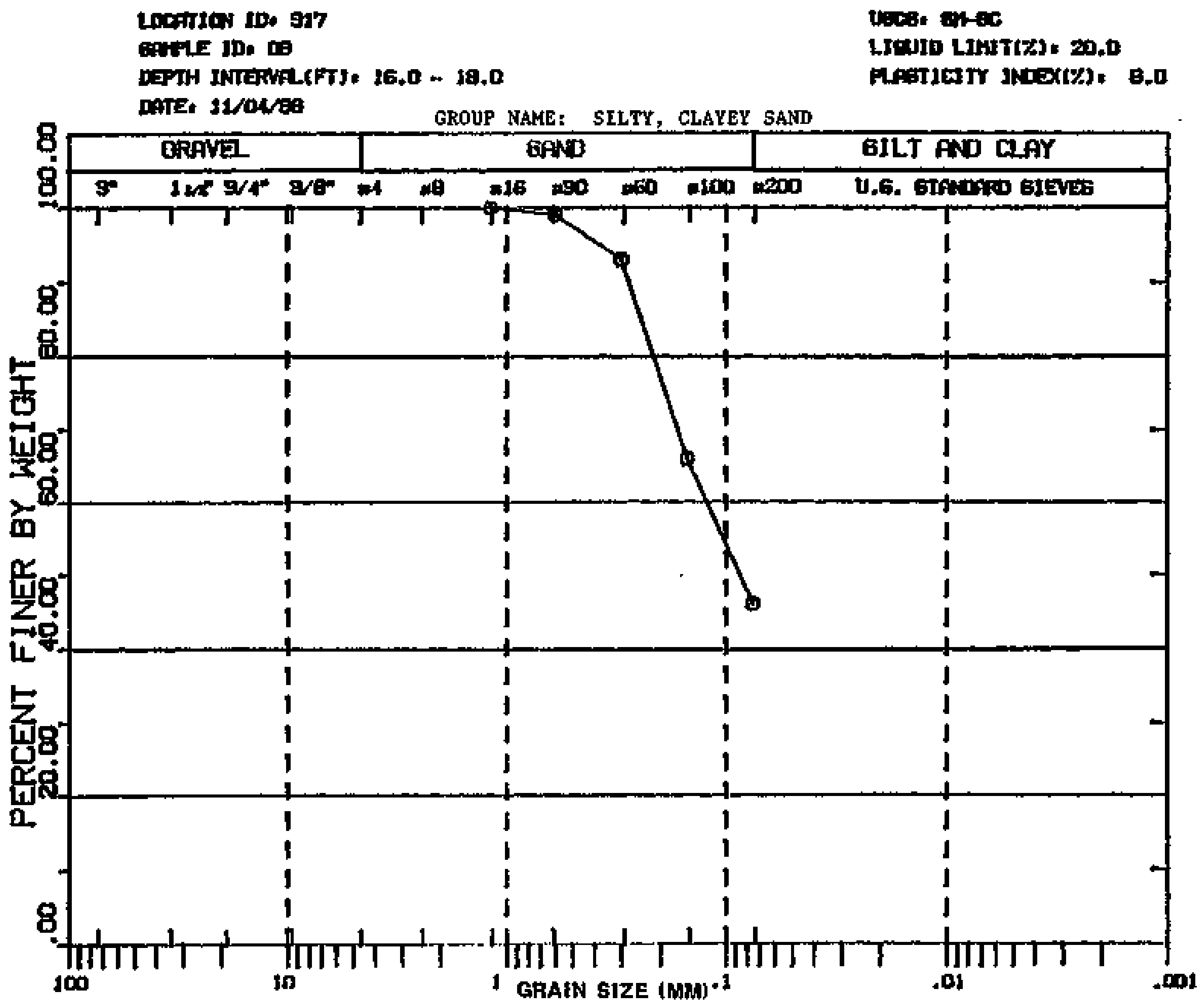


FIGURE D.5.3 PARTICLE SIZE DISTRIBUTION, ESTES GULCH

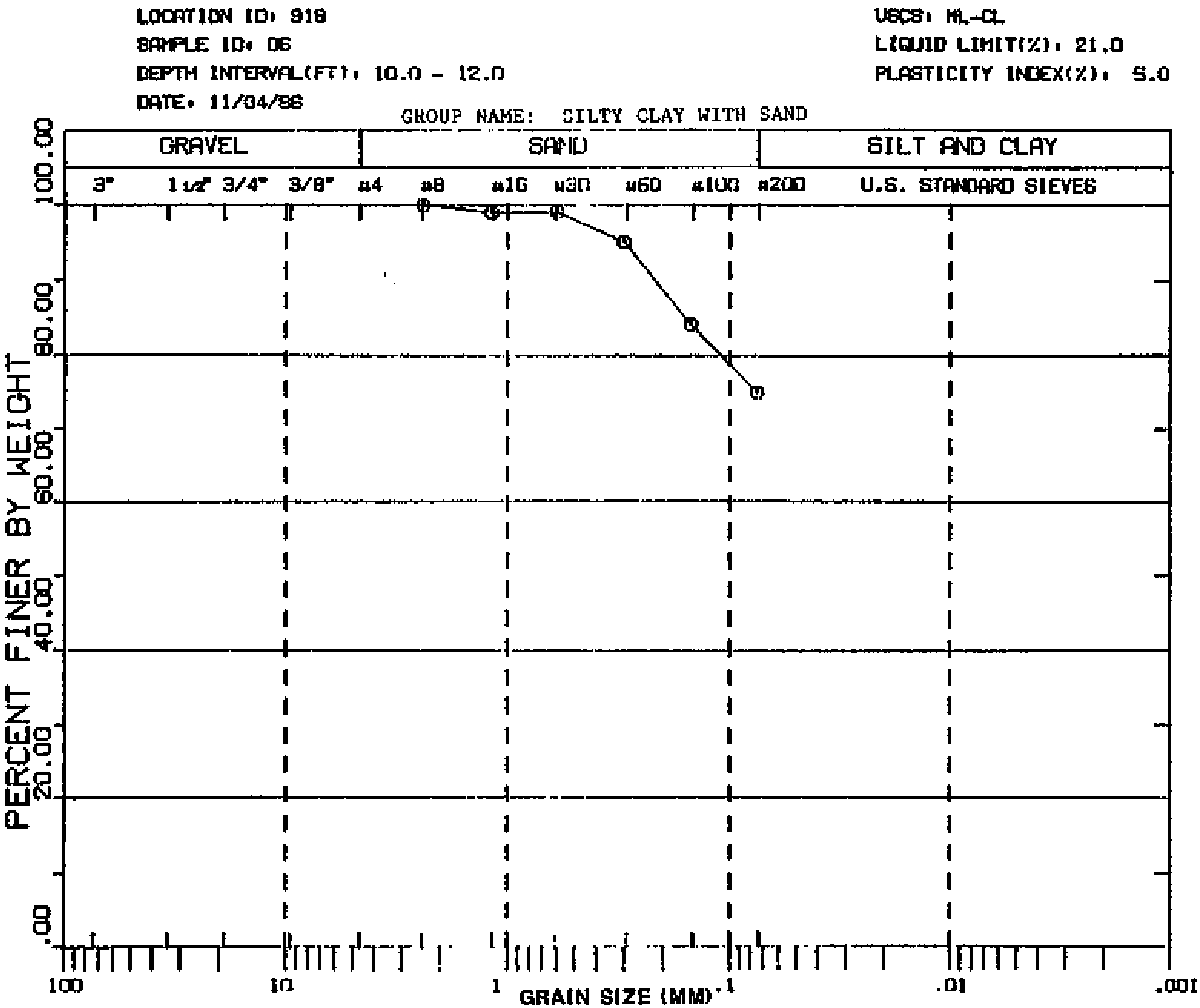


FIGURE D.5.4 PARTICLE SIZE DISTRIBUTION, ESTES GULCH

LOCATION ID: 919
SAMPLE ID: 03
DEPTH INTERVAL(FT): 4.0 - 6.0
DATE: 11/04/86

UBCS: CL
LIQUID LIMIT(%): 29.0
PLASTICITY INDEX(%): 13.0

GROUP NAME: SANDY LEAN CLAY

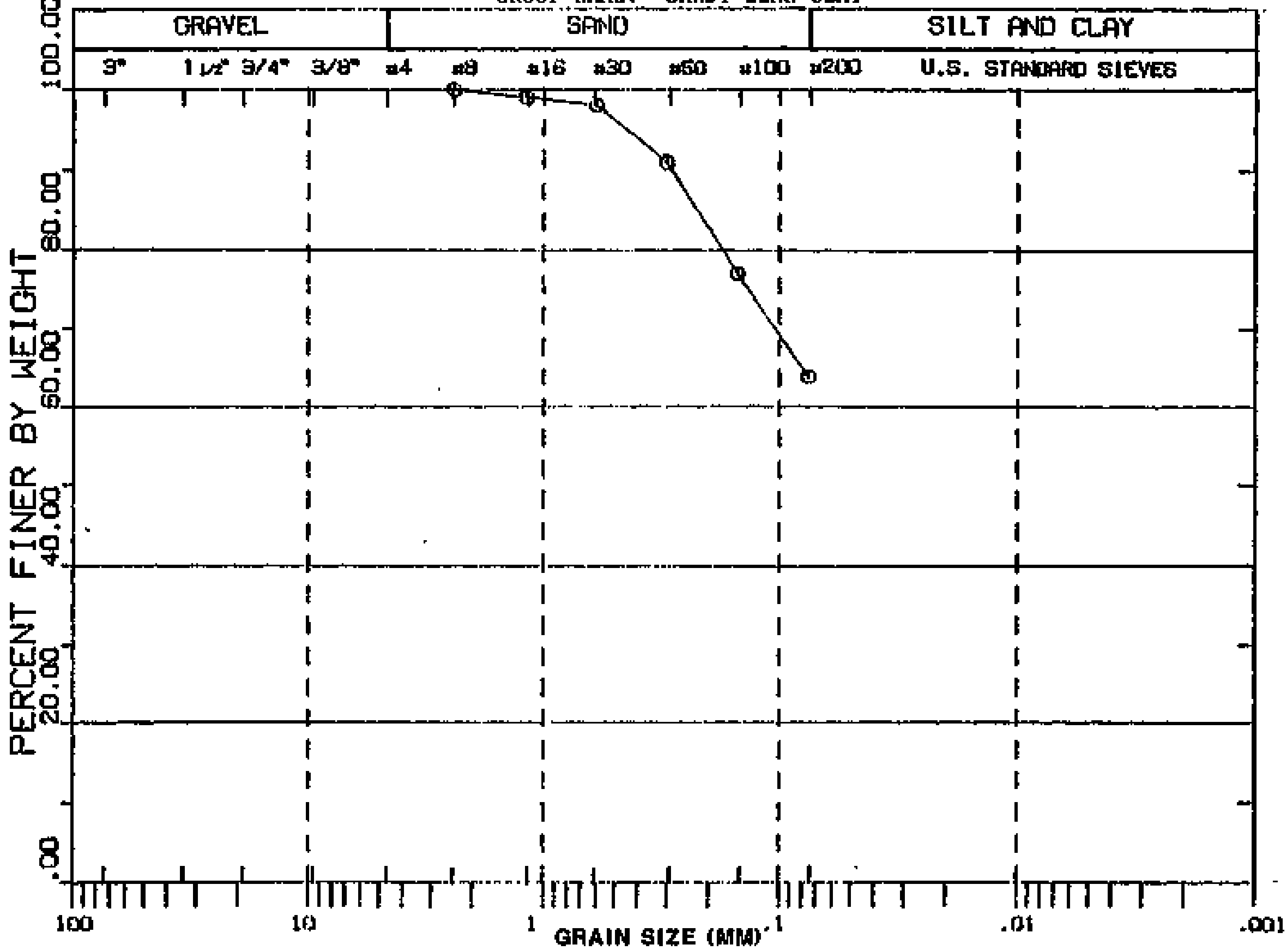


FIGURE D.5.5 PARTICLE SIZE DISTRIBUTION, ESTES GULCH

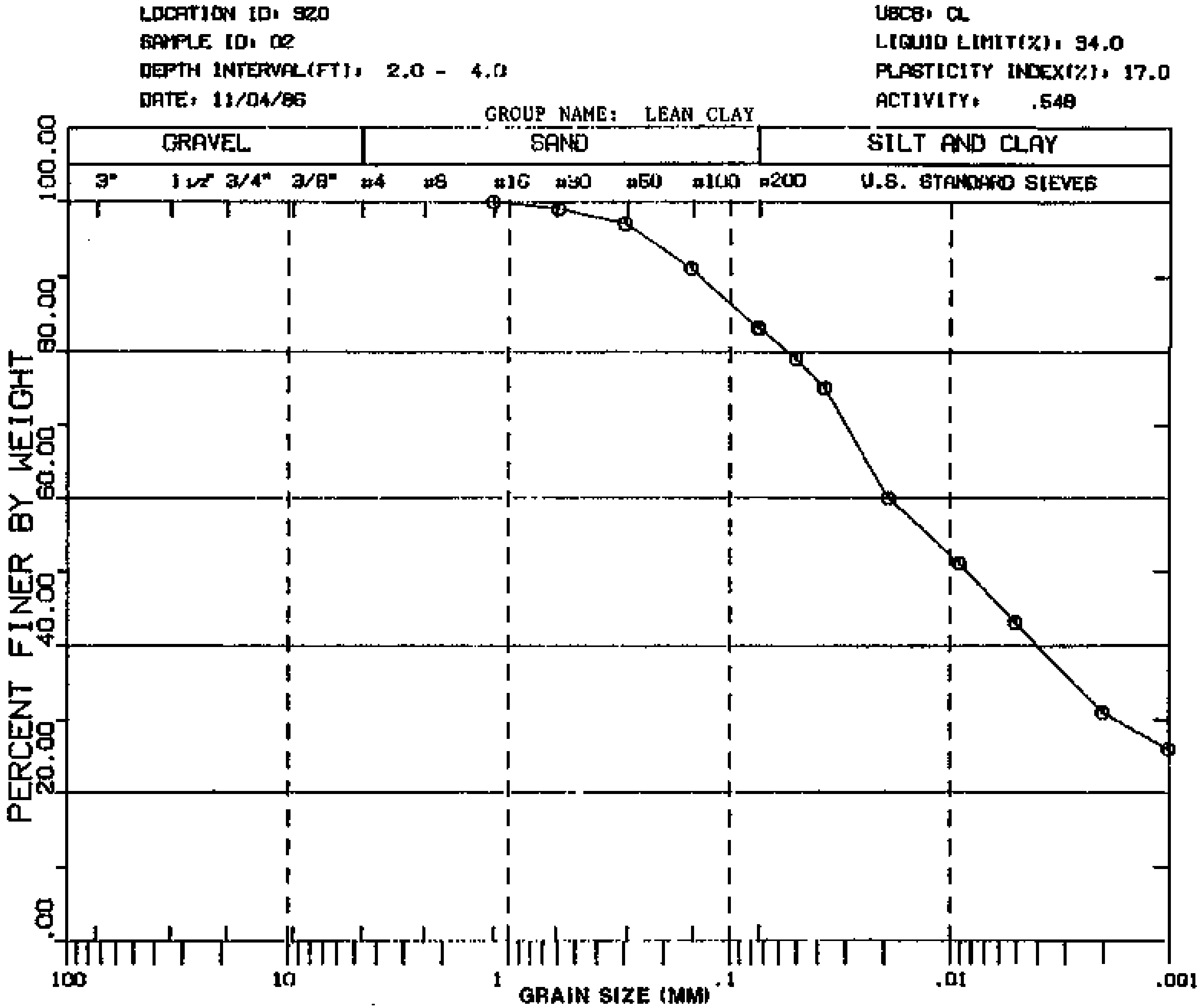


FIGURE D.5.6 PARTICLE SIZE DISTRIBUTION, ESTES GULCH

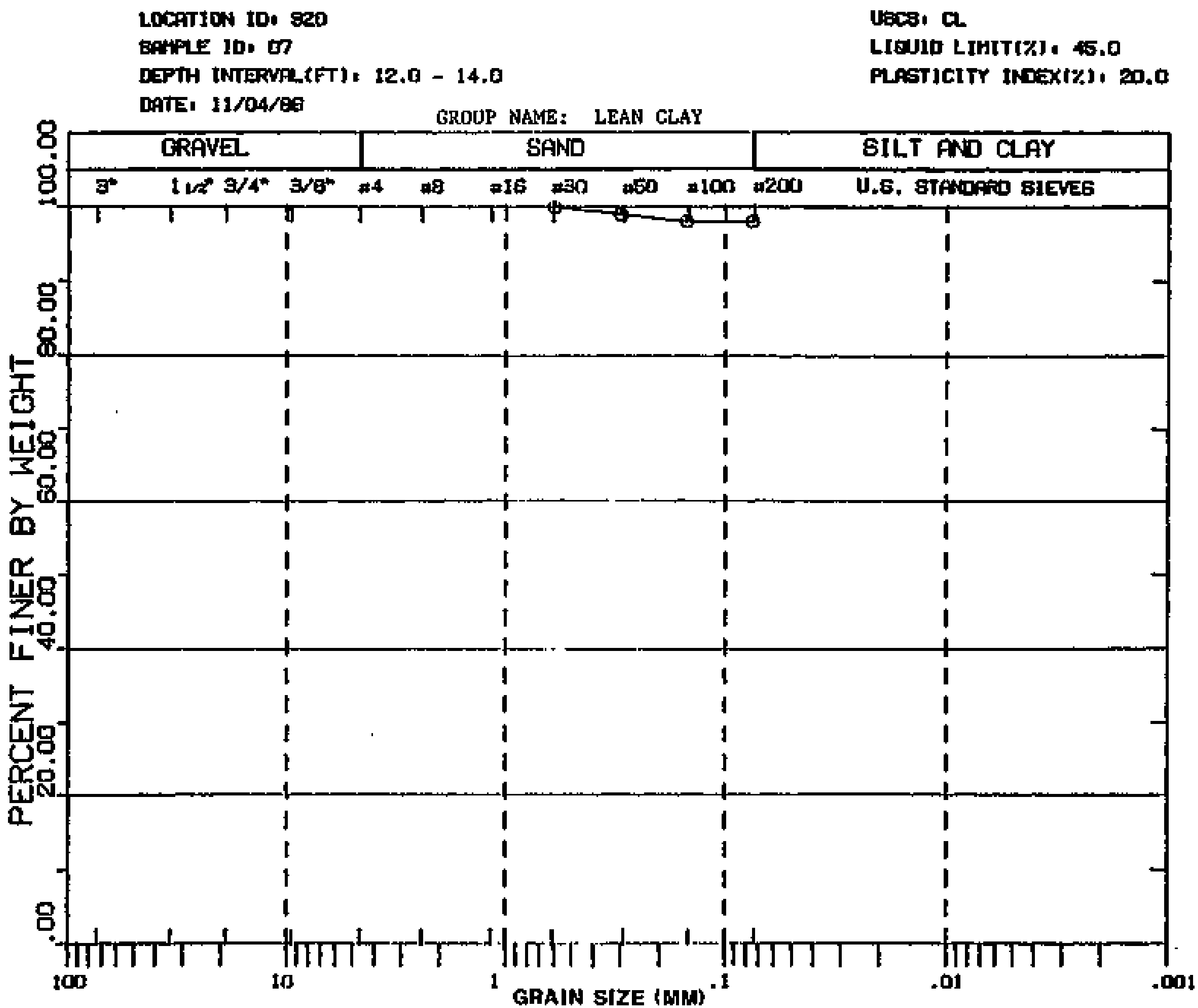


FIGURE D.5.7 PARTICLE SIZE DISTRIBUTION, ESTES GULCH

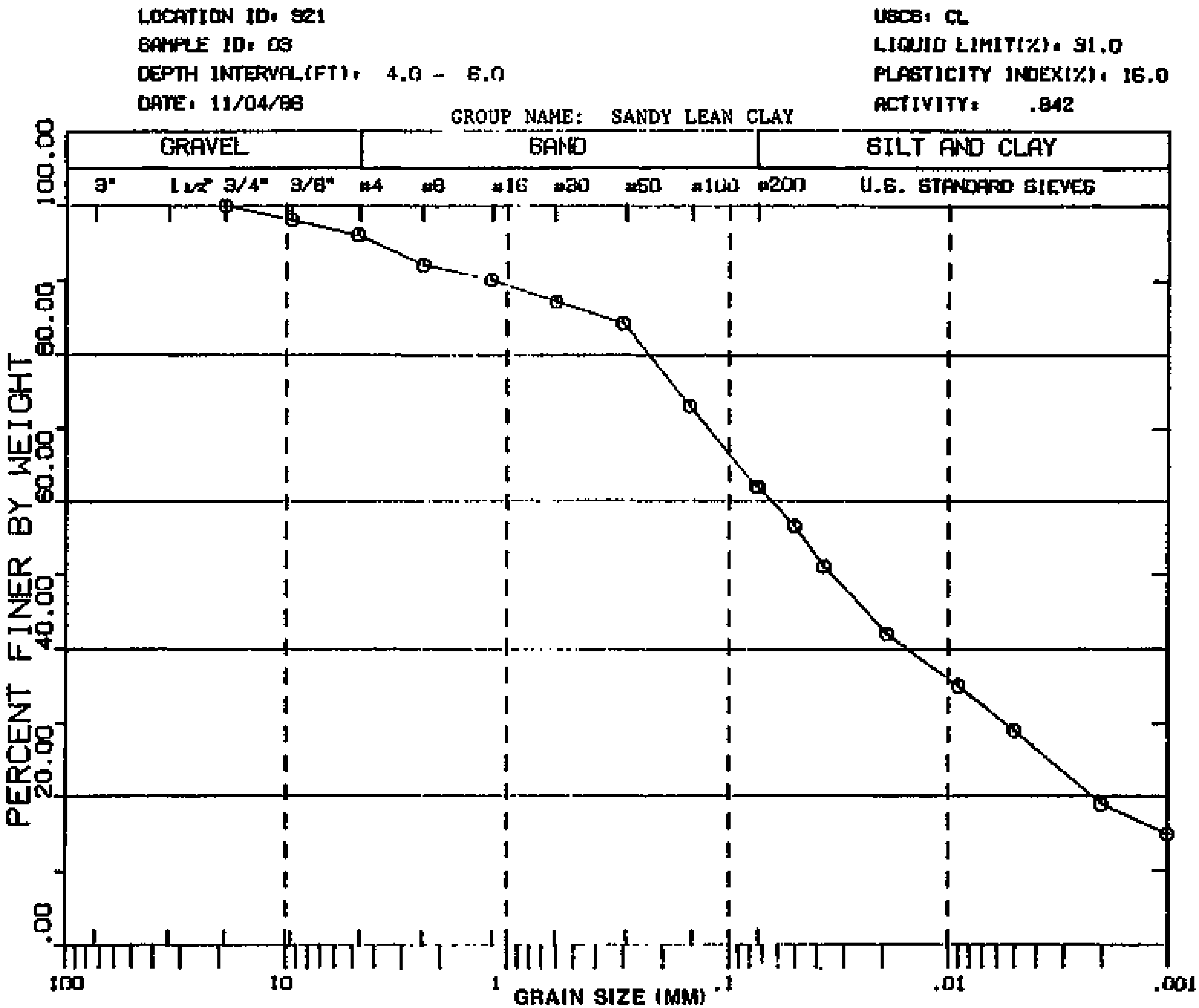


FIGURE D.5.8 PARTICLE SIZE DISTRIBUTION, ESTES GULCH

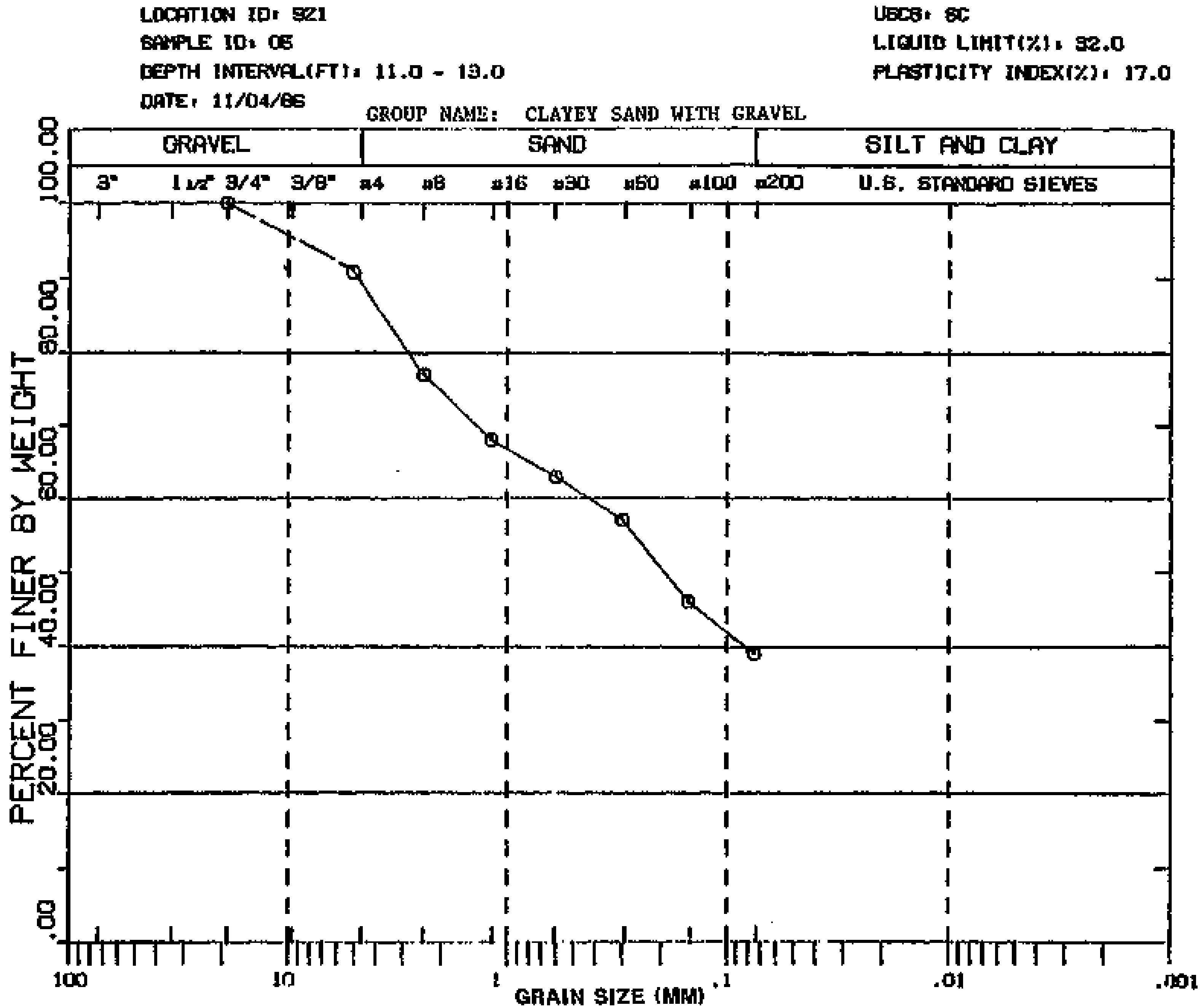


FIGURE D.5.9 PARTICLE SIZE DISTRIBUTION, ESTES GULCH

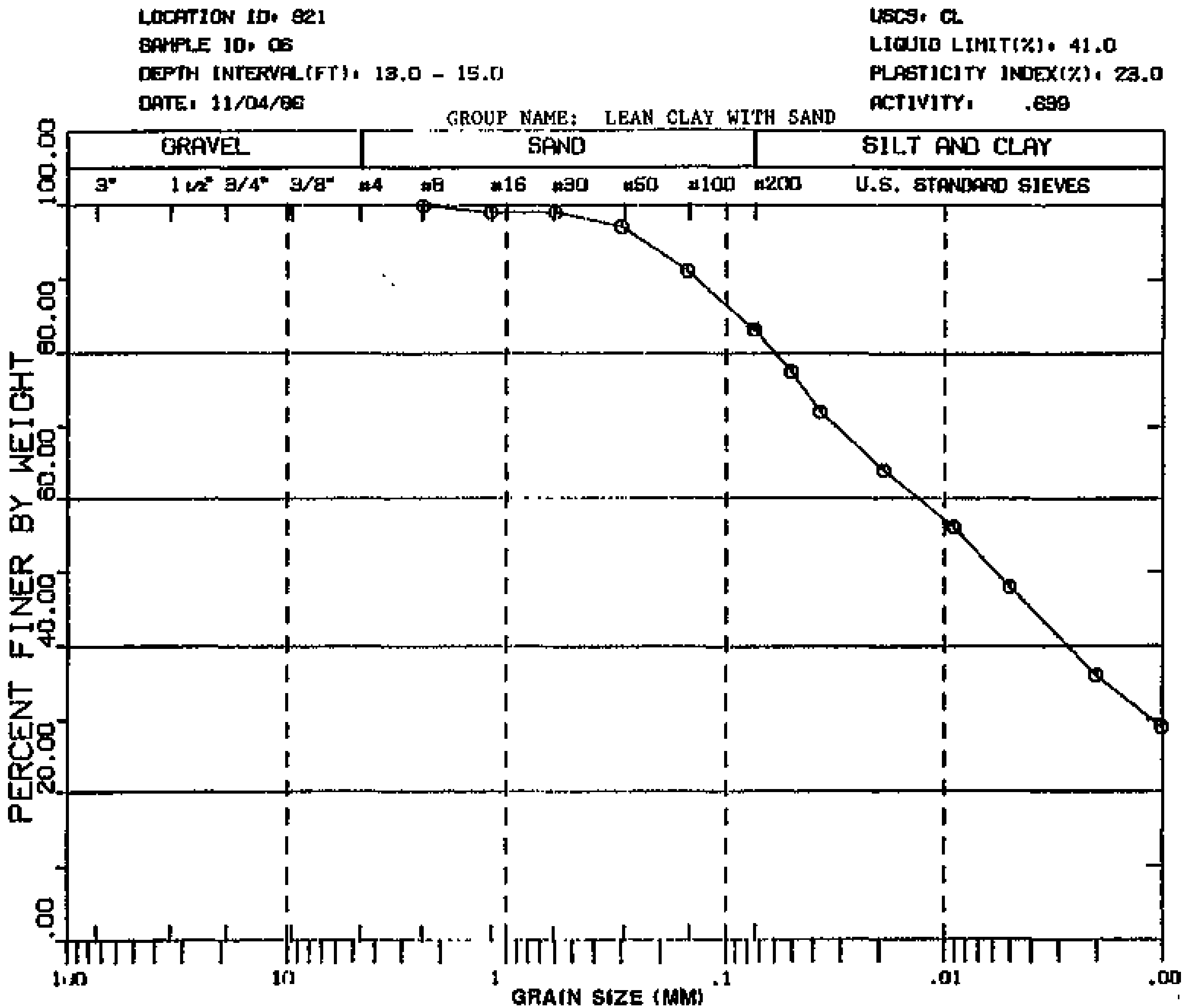


FIGURE D.5.10 PARTICLE SIZE DISTRIBUTION, ESTES GULCH

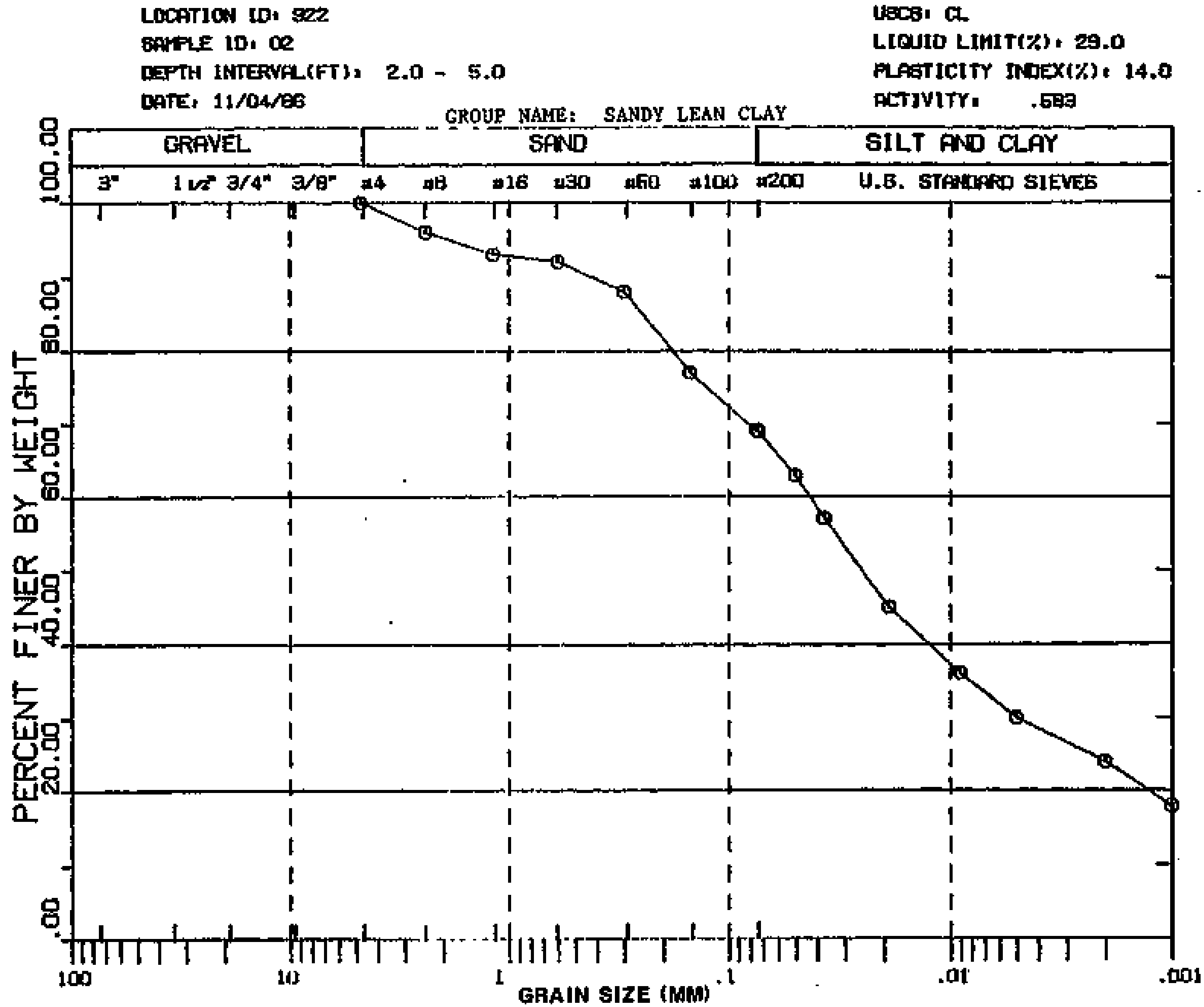


FIGURE D.5.11 PARTICLE SIZE DISTRIBUTION, ESTES GULCH

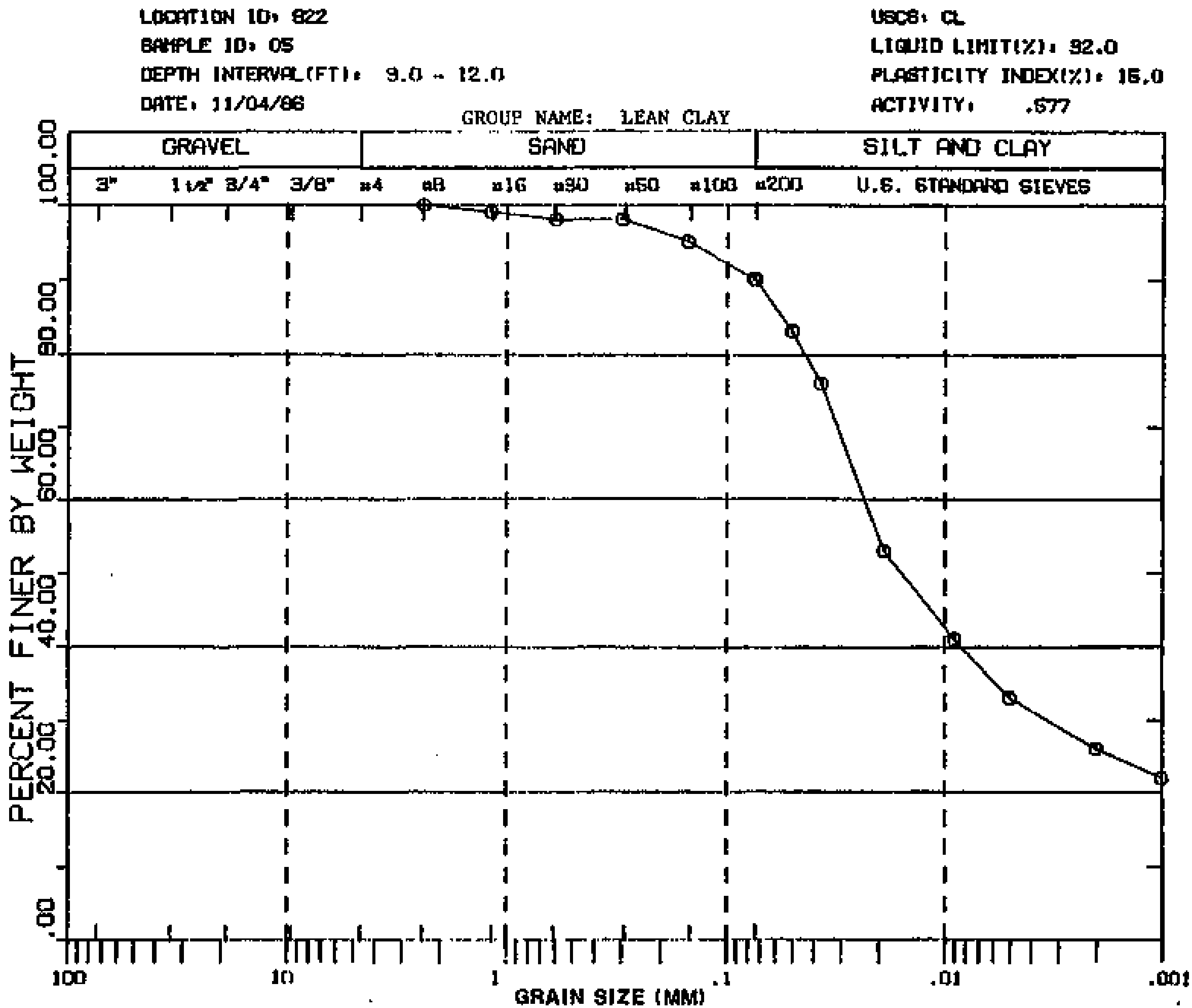


FIGURE D.5.12 PARTICLE SIZE DISTRIBUTION, ESTES GULCH

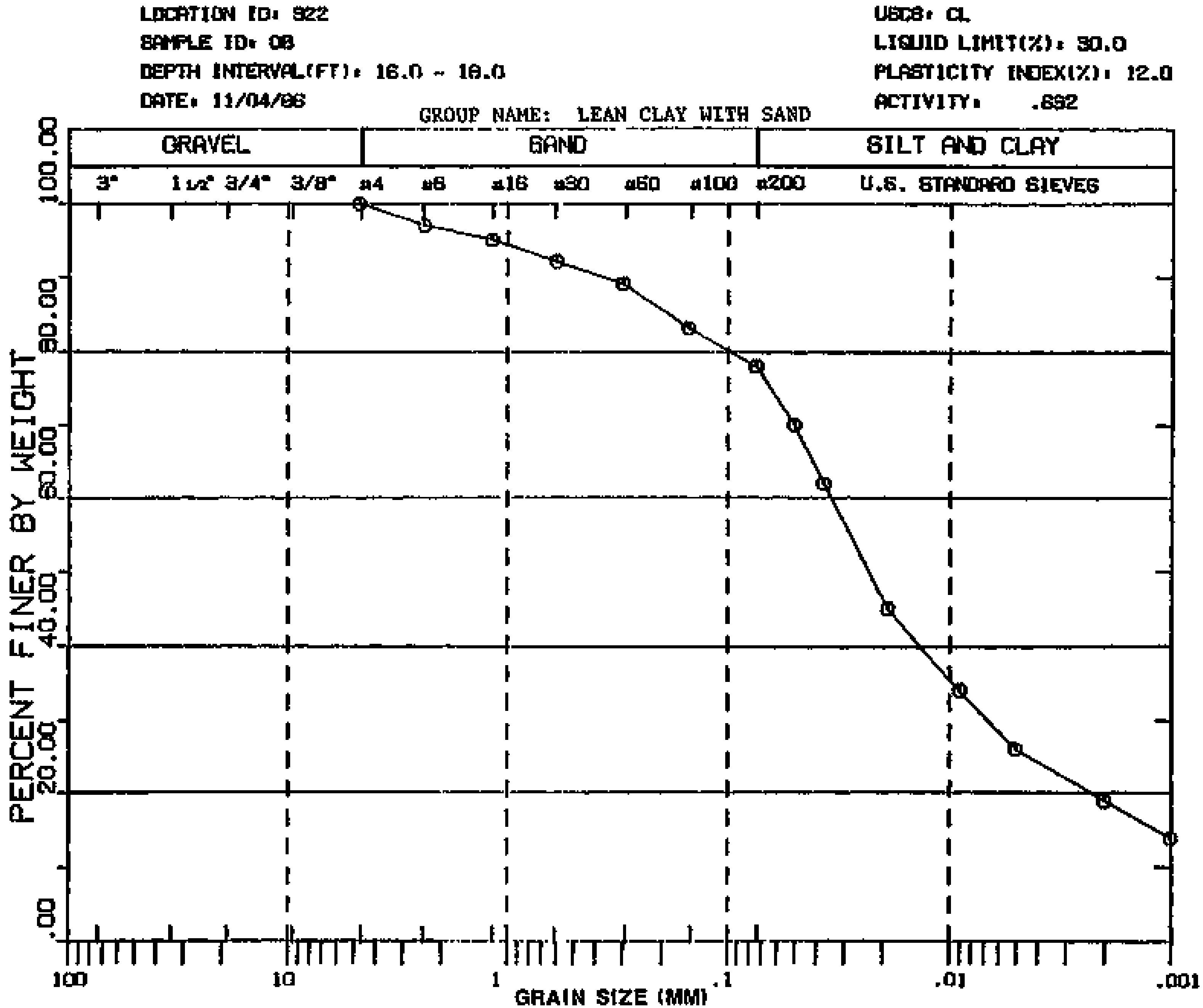


FIGURE D.5.13 PARTICLE SIZE DISTRIBUTION, ESTES GULCH

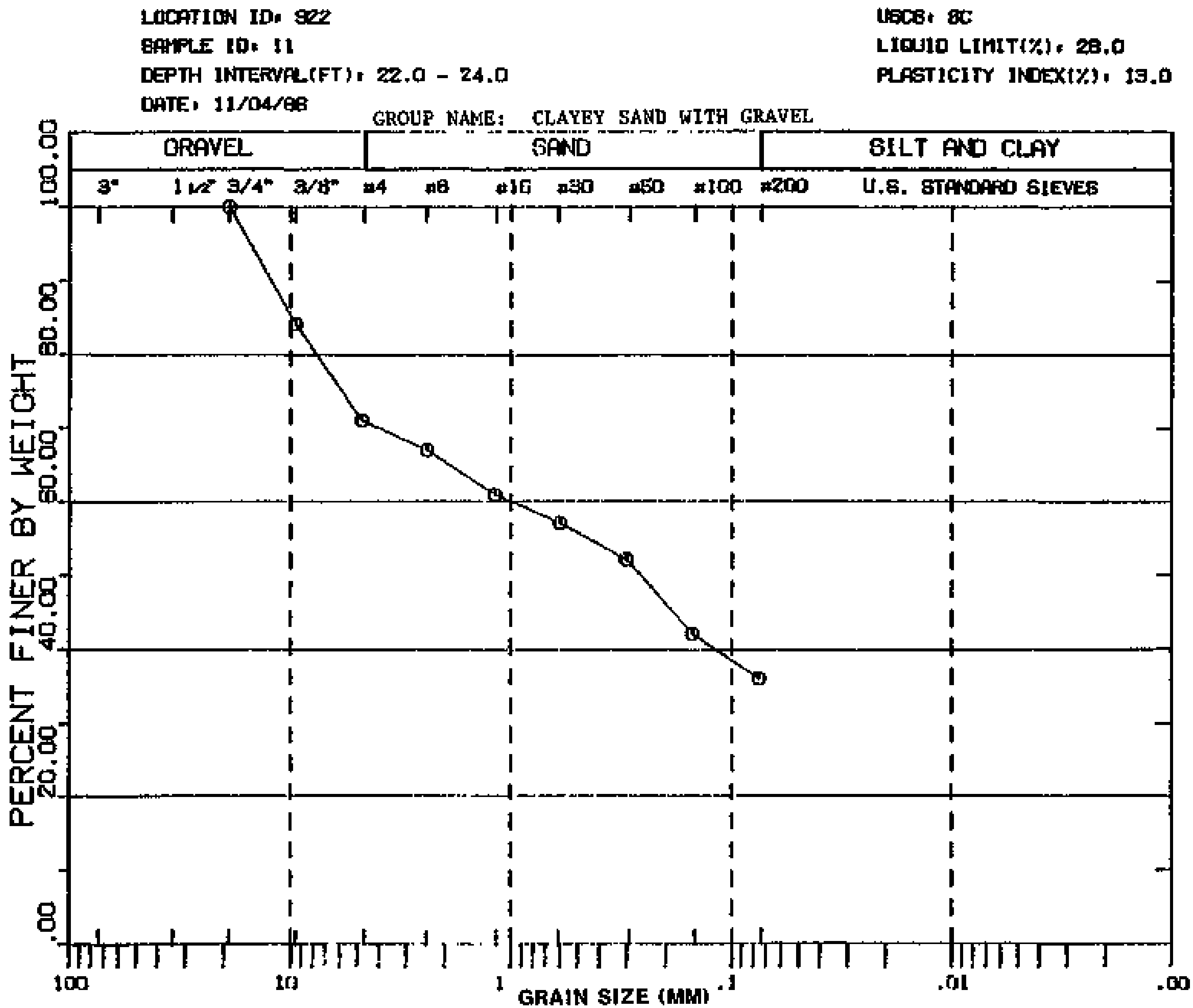


FIGURE D.5.14 PARTICLE SIZE DISTRIBUTION, ESTES GULCH

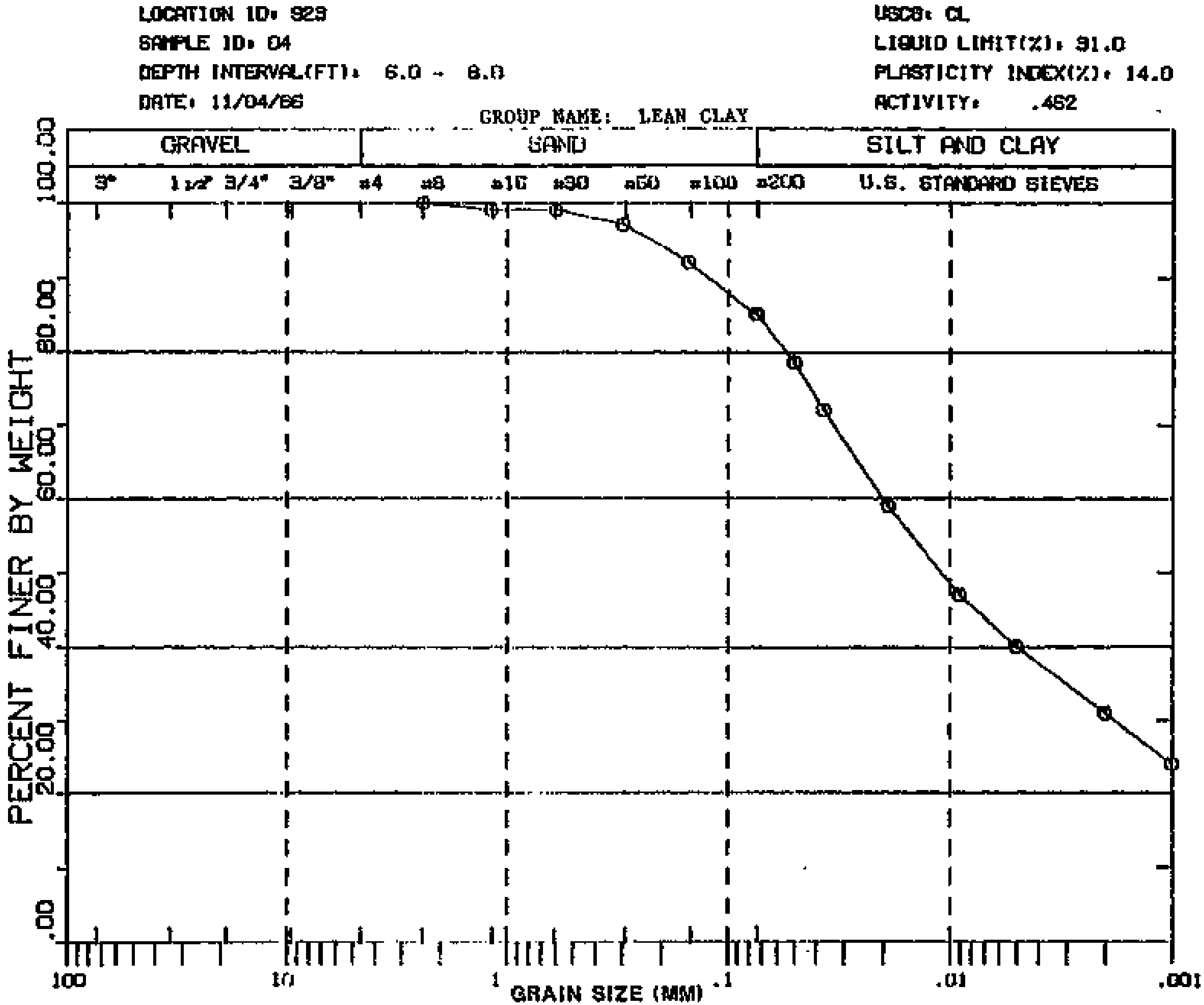


FIGURE D.5.15 PARTICLE SIZE DISTRIBUTION, ESTES GULCH

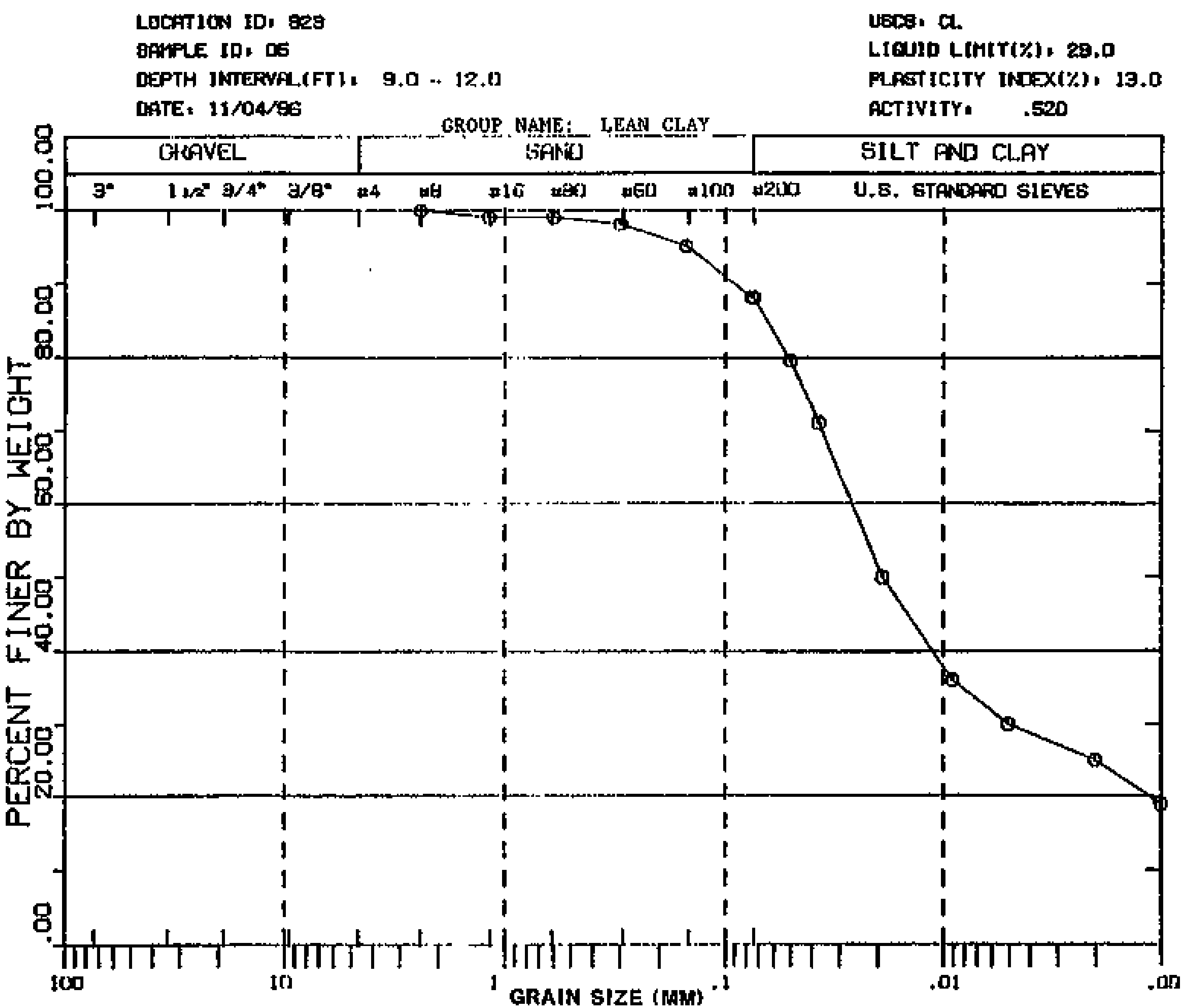


FIGURE D.5.16 PARTICLE SIZE DISTRIBUTION, ESTES GULCH

LOCATION ID: 923
SAMPLE ID: 07
DEPTH INTERVAL(FT): 14.0 - 16.0
DATE: 11/04/86

USCS: CL
LIQUID LIMIT(%): 38.0
PLASTICITY INDEX(%): 22.0

GROUP NAME: LEAN CLAY WITH SAND

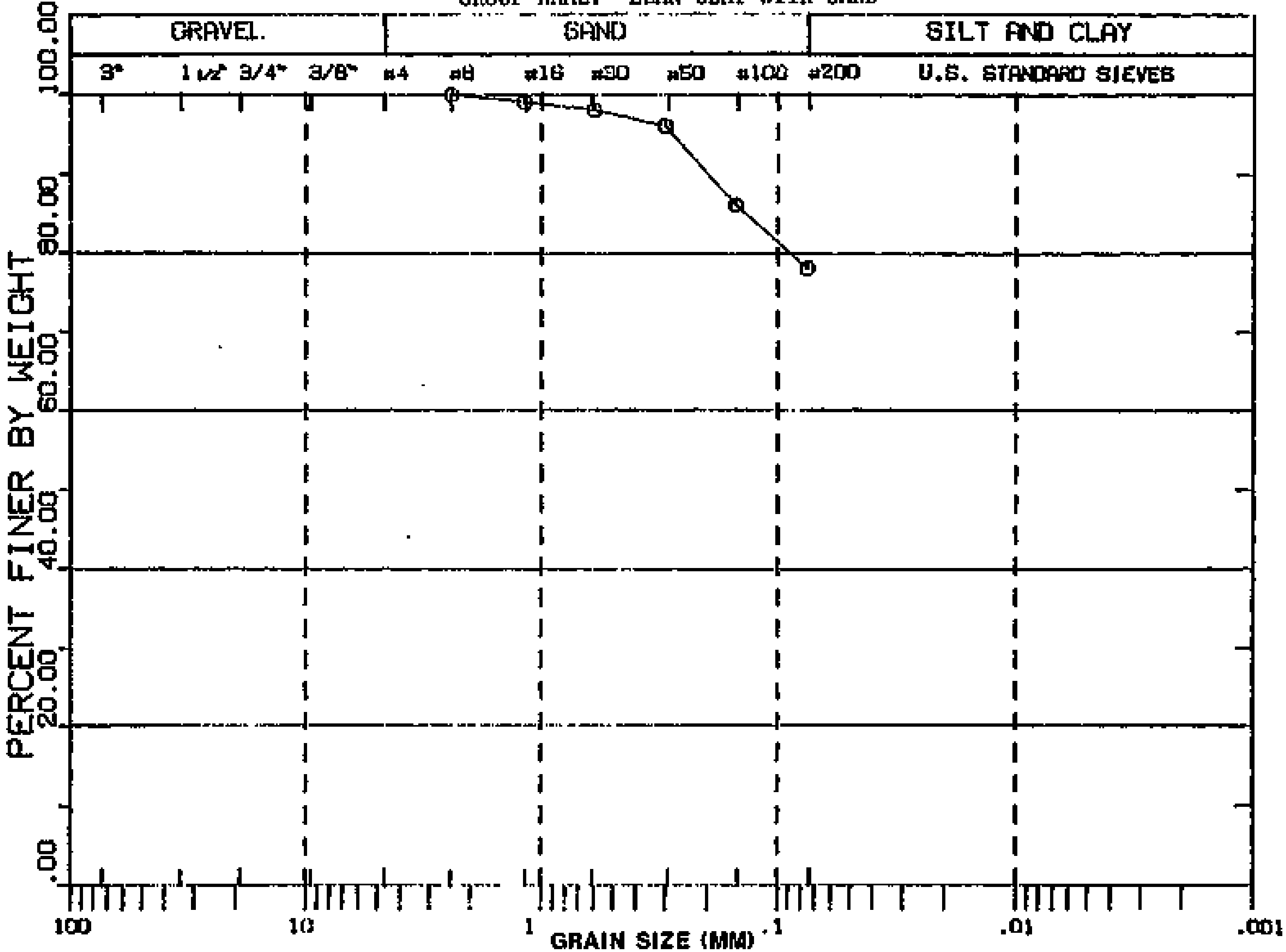


FIGURE D.5.17 PARTICLE SIZE DISTRIBUTION, ESTES GULCH

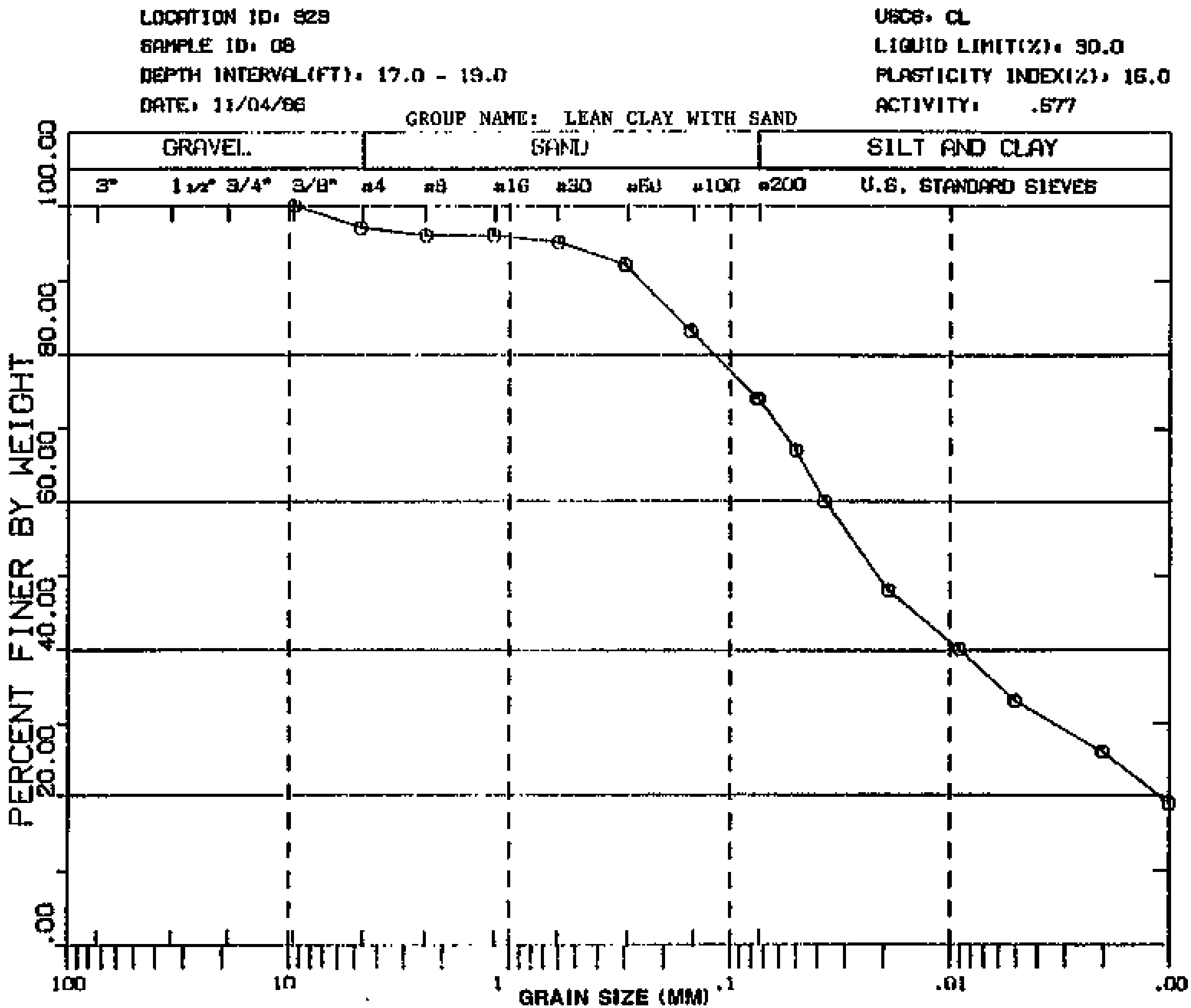


FIGURE D.5.18 PARTICLE SIZE DISTRIBUTION, ESTES GULCH

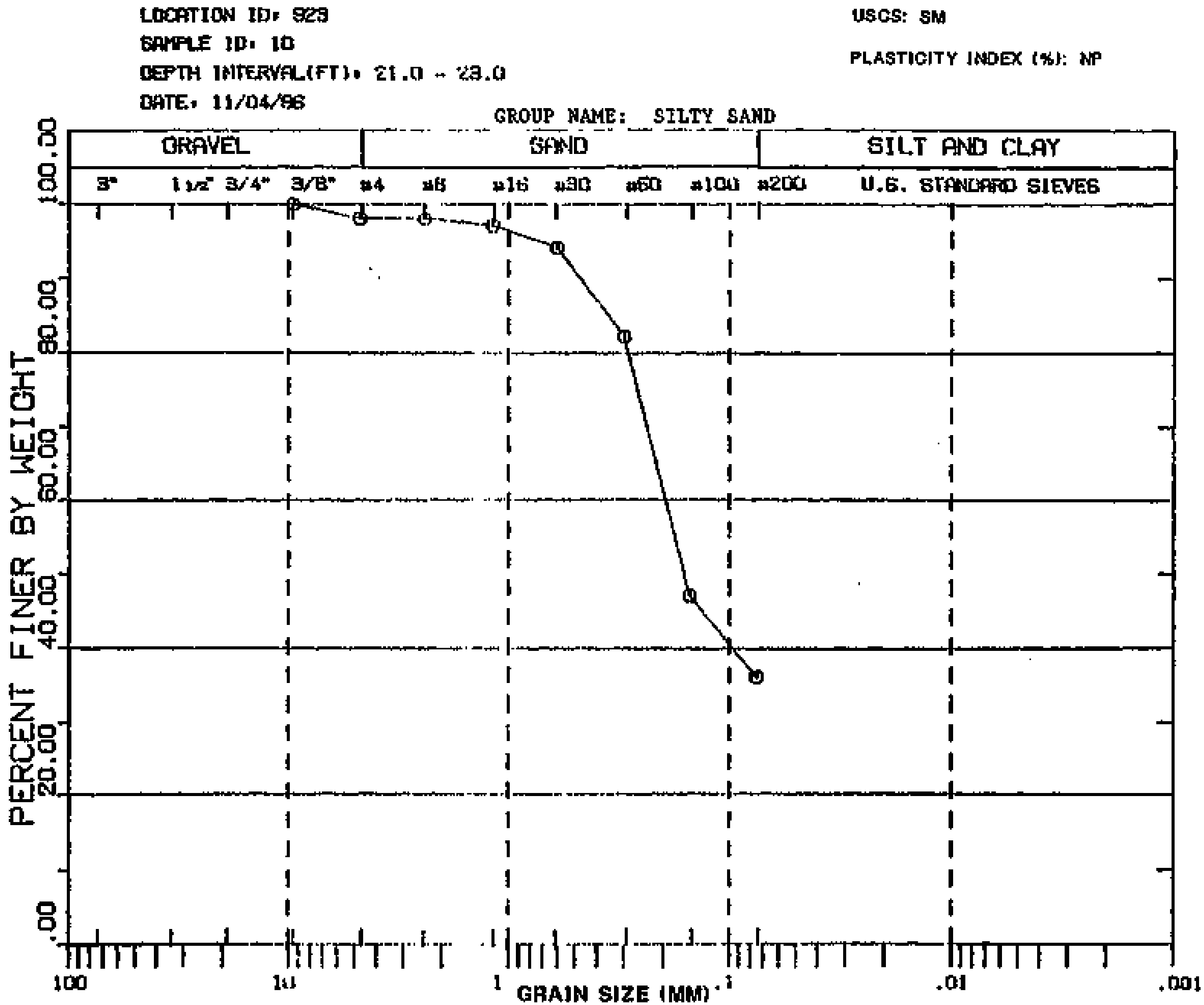


FIGURE D.5.19 PARTICLE SIZE DISTRIBUTION, ESTES GULCH

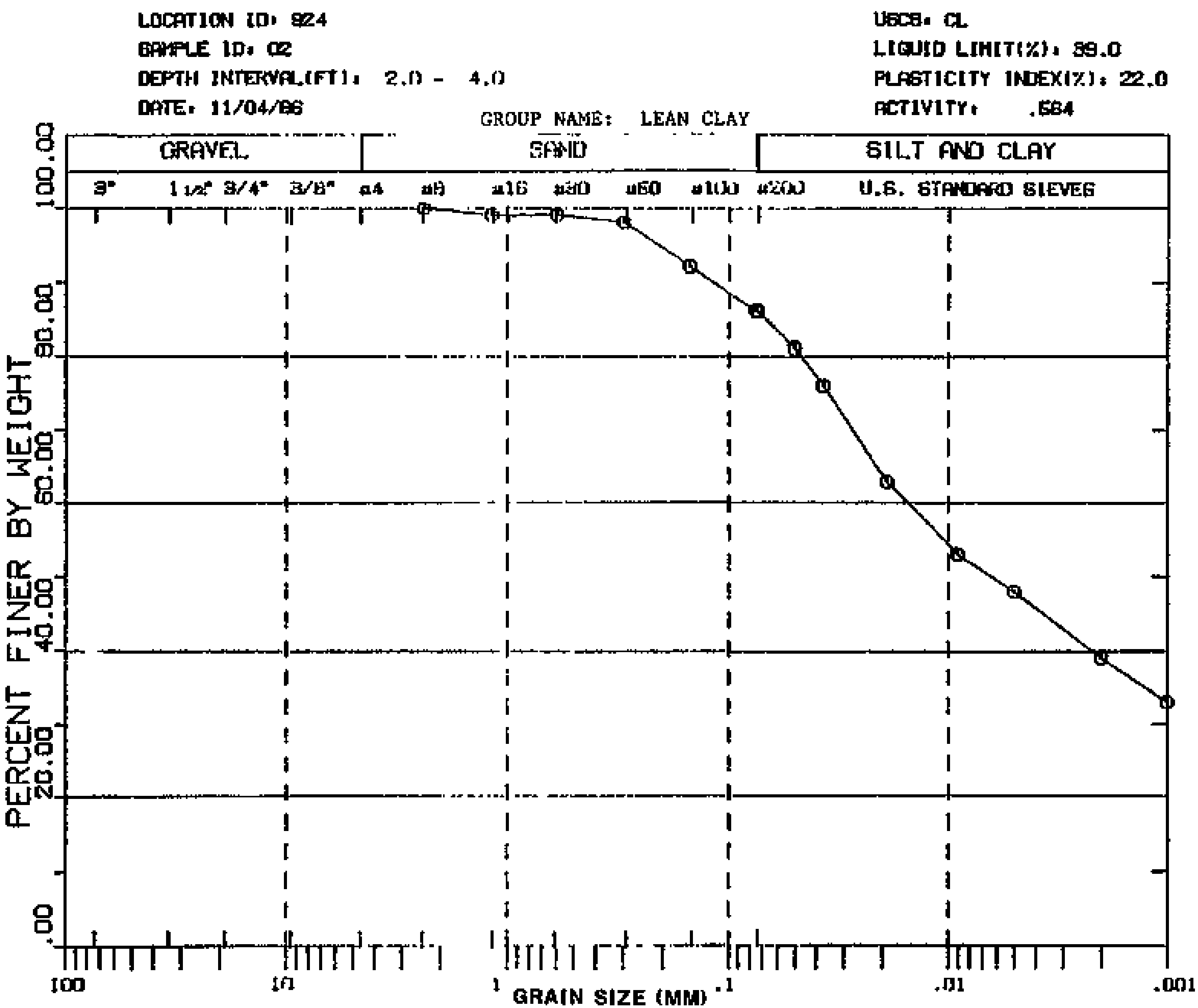


FIGURE D.5.20 PARTICLE SIZE DISTRIBUTION, ESTES GULCH

LOCATION ID: 924
SAMPLE ID: 04
DEPTH INTERVAL(FT): 6.0 - 8.0
DATE: 11/04/86

USCS: CL
LIQUID LIMIT(%): 34.0
PLASTICITY INDEX(%): 18.0

GROUP NAME: LEAN CLAY WITH SAND

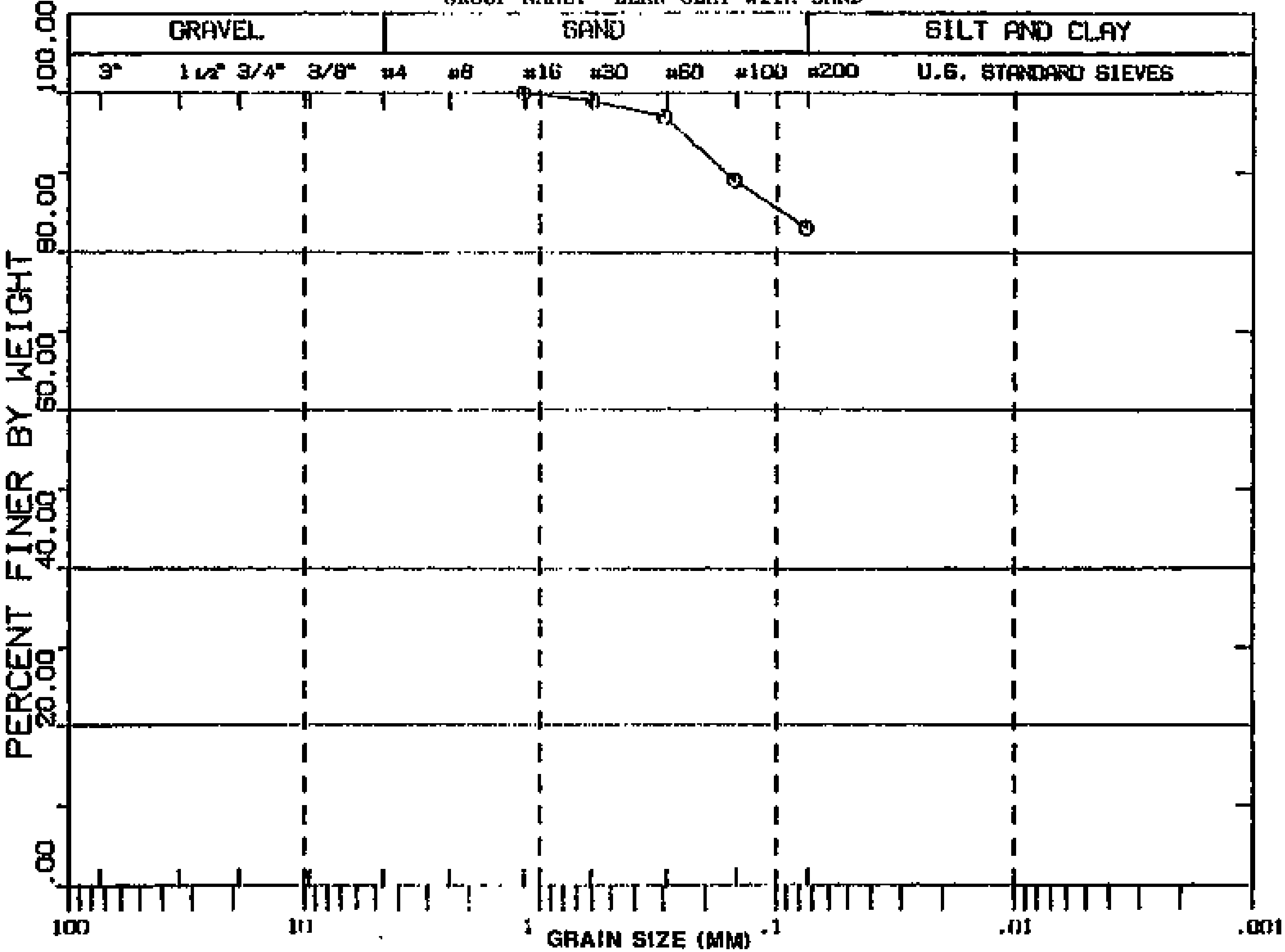


FIGURE D.5.21 PARTICLE SIZE DISTRIBUTION, ESTES GULCH

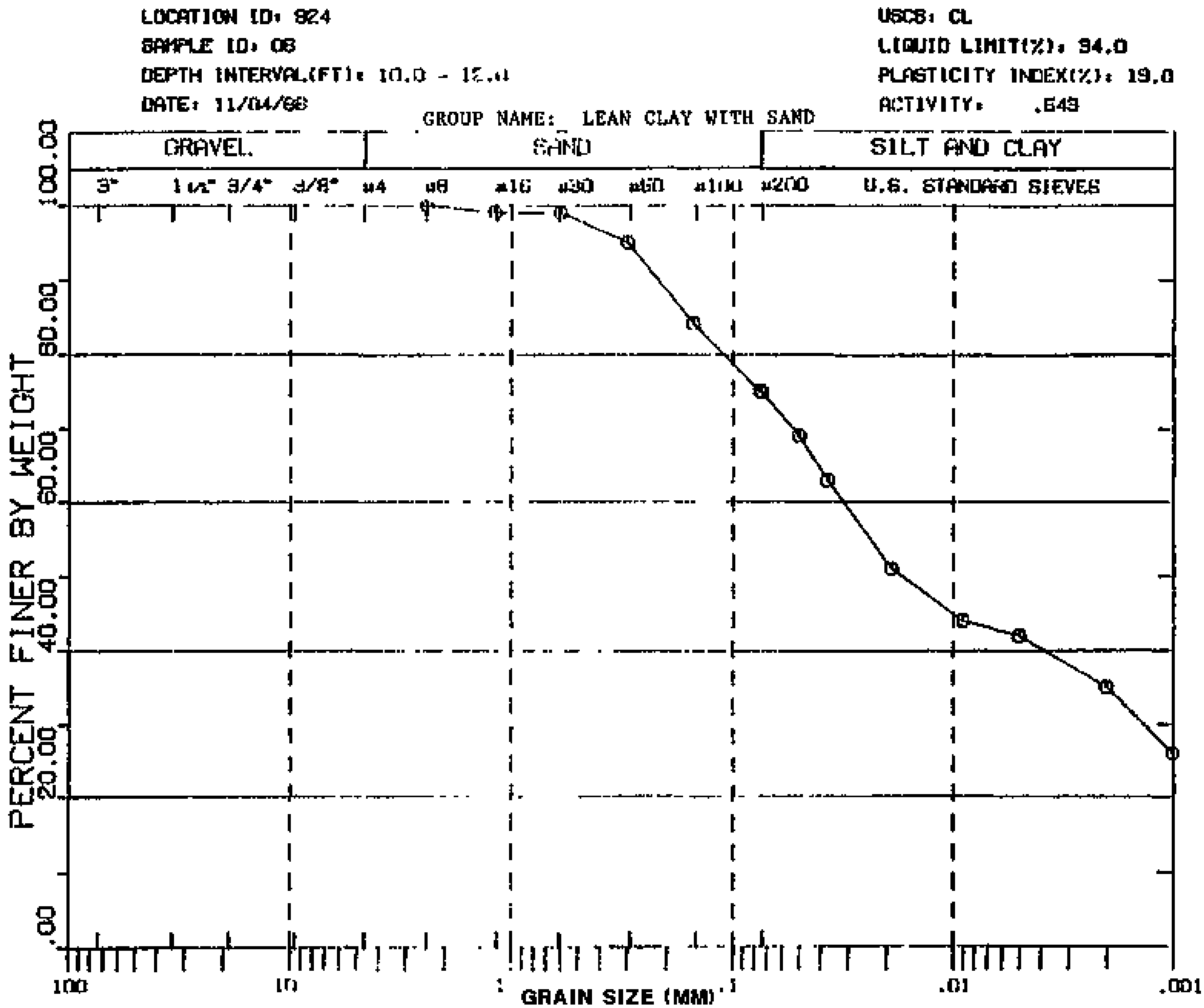


FIGURE D.5.22 PARTICLE SIZE DISTRIBUTION, ESTES GULCH

LOCATION ID: 824
SAMPLE ID: 09
DEPTH INTERVAL(FT): 16.0 - 18.0
DATE: 11/04/86

USCS: CL
LIQUID LIMIT(%): 39.0
PLASTICITY INDEX(%): 23.0
ACTIVITY: .857

GROUP NAME: LEAN CLAY WITH SAND

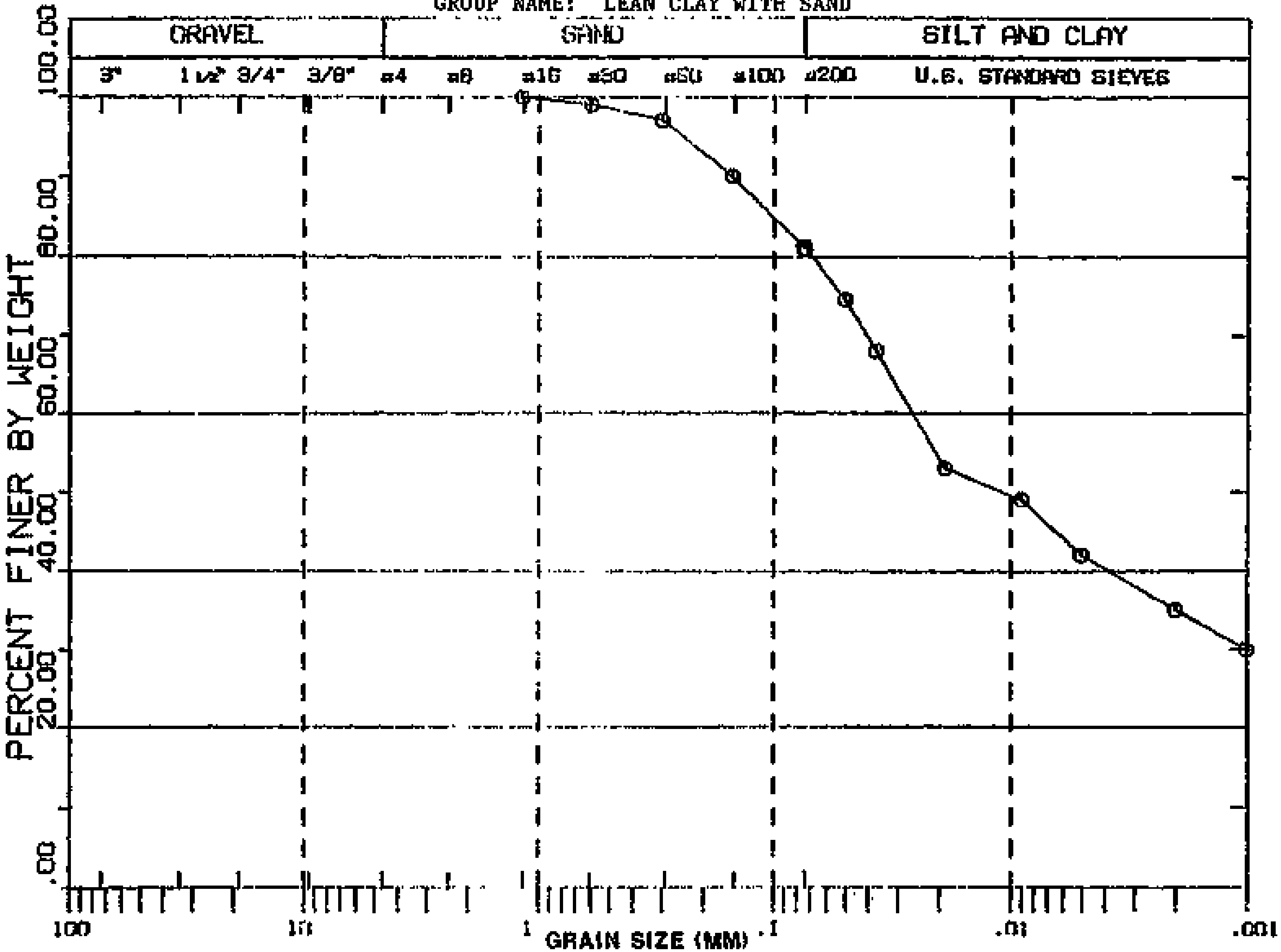


FIGURE D.5.23 PARTICLE SIZE DISTRIBUTION, ESTES GULCH

LOCATION ID: 924
SAMPLE ID: 13
DEPTH INTERVAL(FT): 24.0 - 26.0
DATE: 11/04/86

USCS: CL
LIQUID LIMIT(%): 28.0
PLASTICITY INDEX(%): 14.0

GROUP NAME: SANDY LEAN CLAY

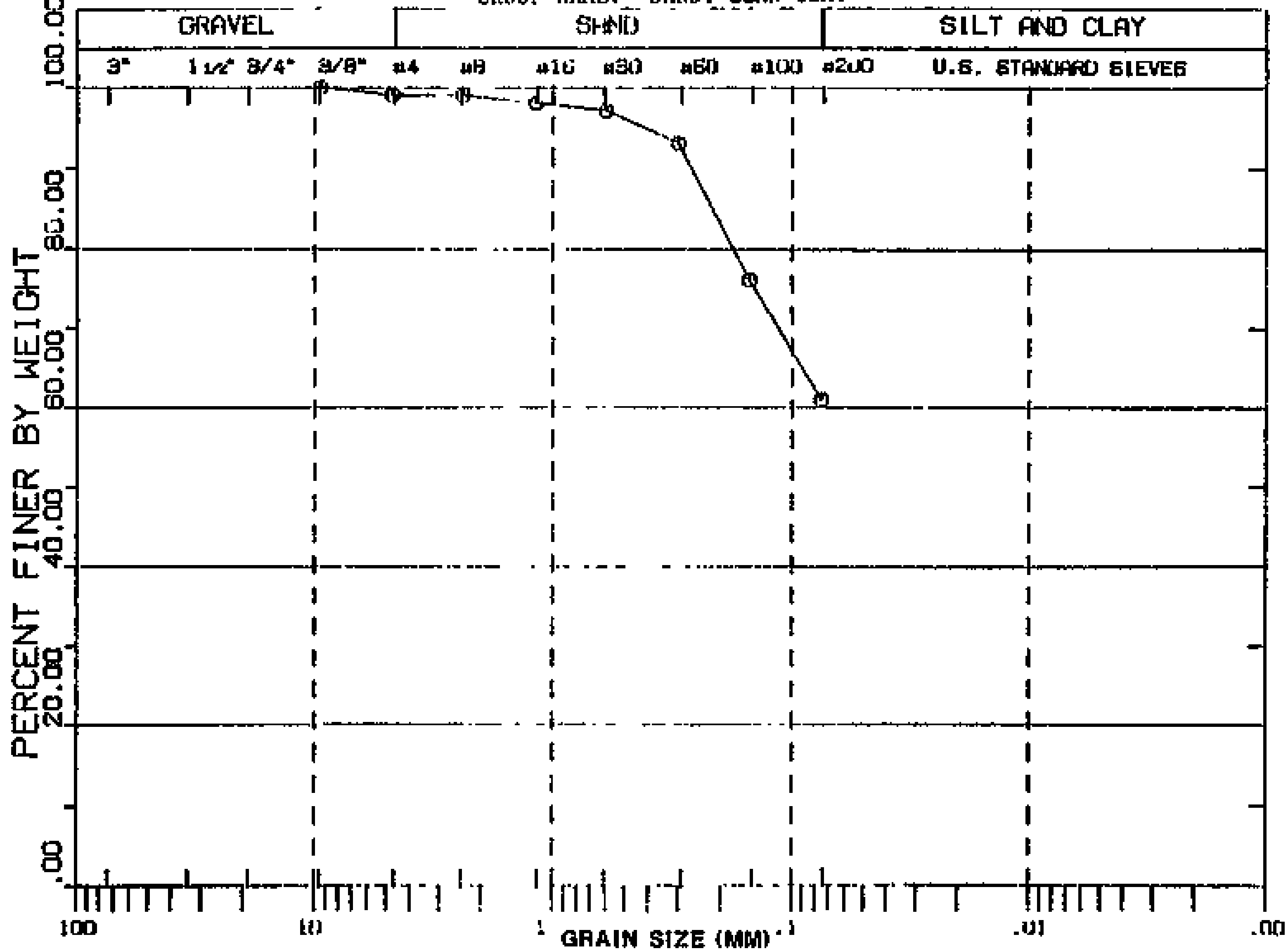


FIGURE D.5.24 PARTICLE SIZE DISTRIBUTION, ESTES GULCH

LOCATION ID: S30
SAMPLE ID: 03
DEPTH INTERVAL(FT): 8.0 - 10.0
DATE: 11/04/88

USCS: CL
LIQUID LIMIT(%): 28.0
PLASTICITY INDEX(%): 13.0
ACTIVITY: .565

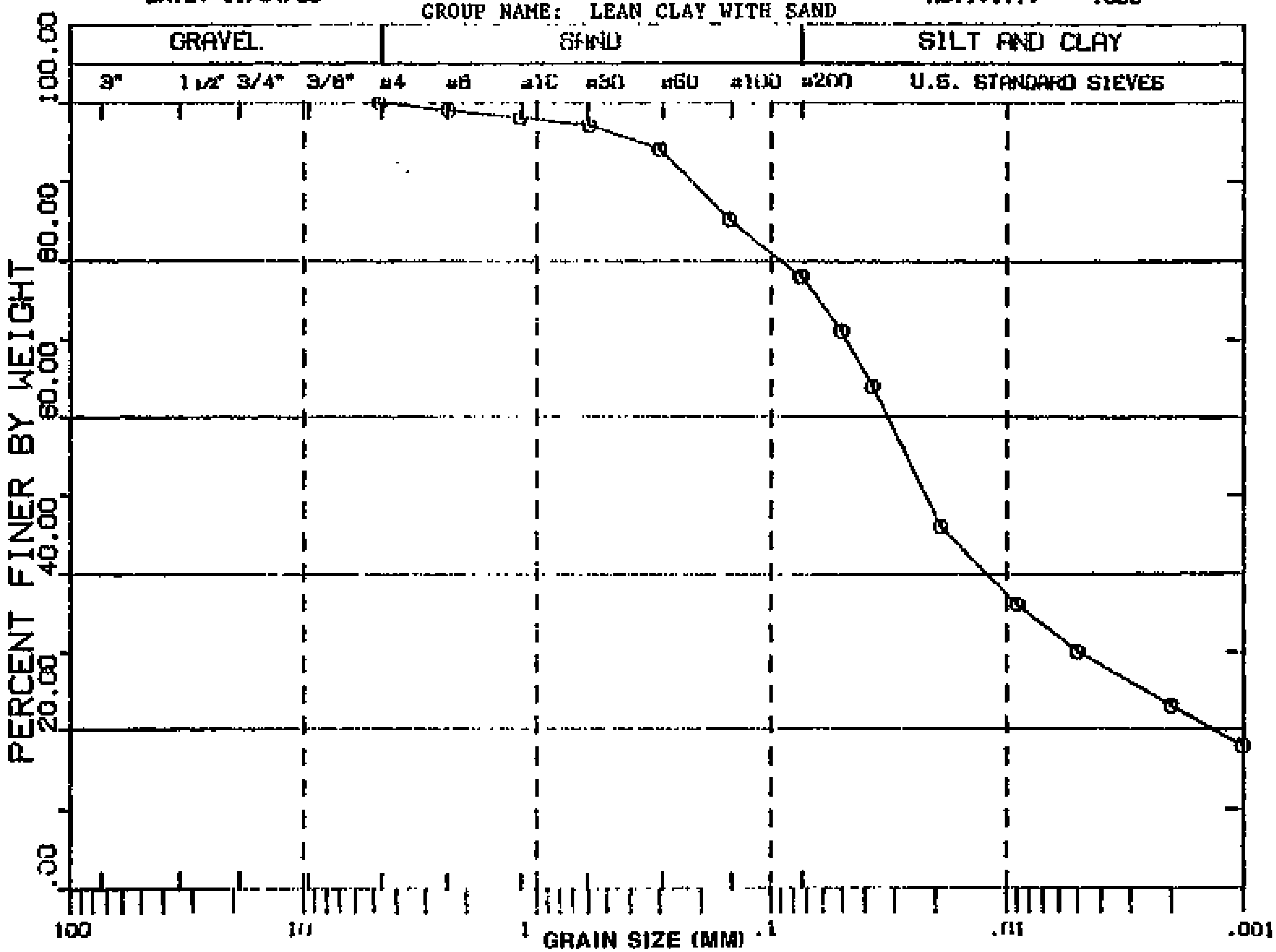


FIGURE D.5.25 PARTICLE SIZE DISTRIBUTION, ESTES GULCH

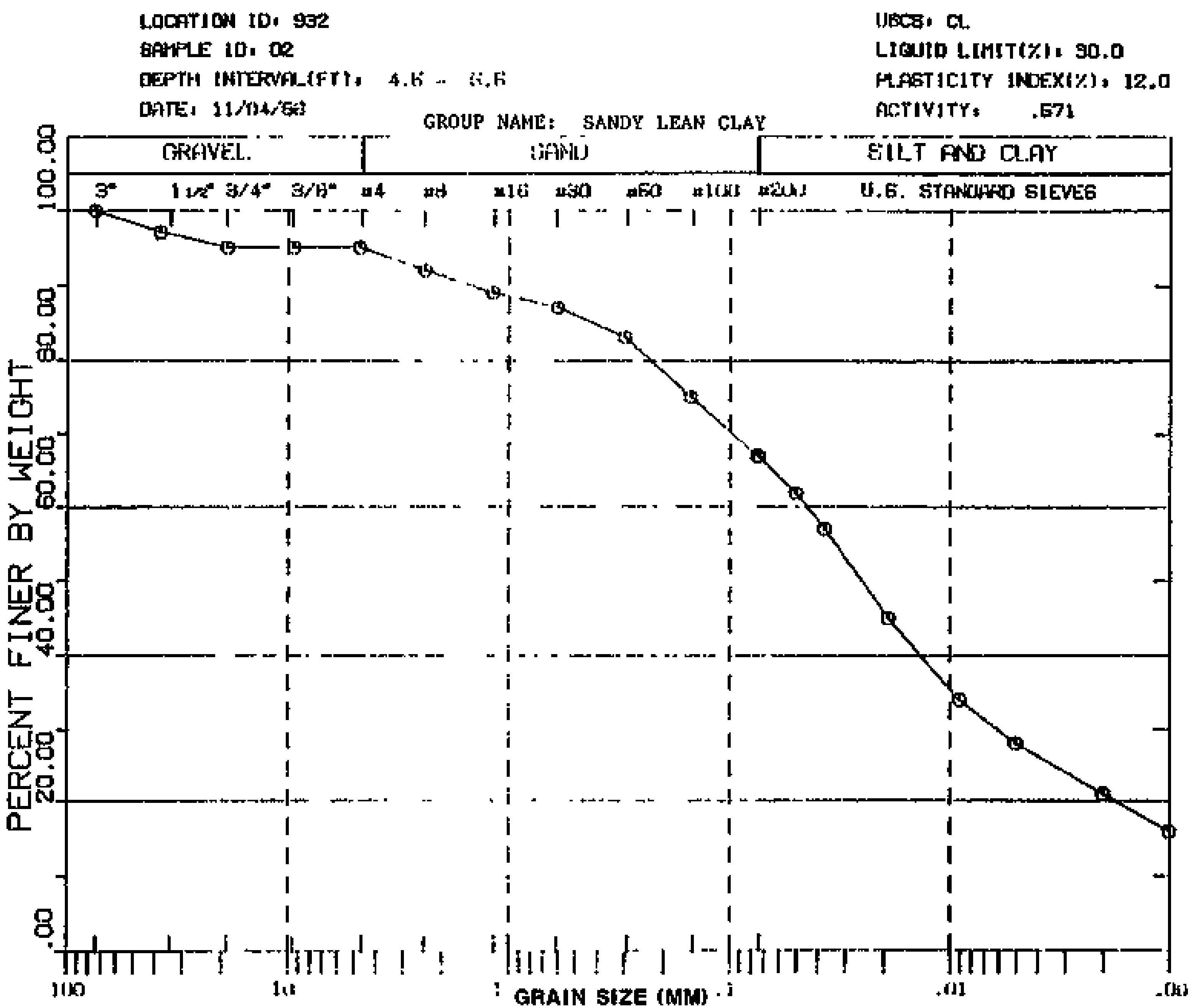


FIGURE D.5.26 PARTICLE SIZE DISTRIBUTION, ESTES GULCH

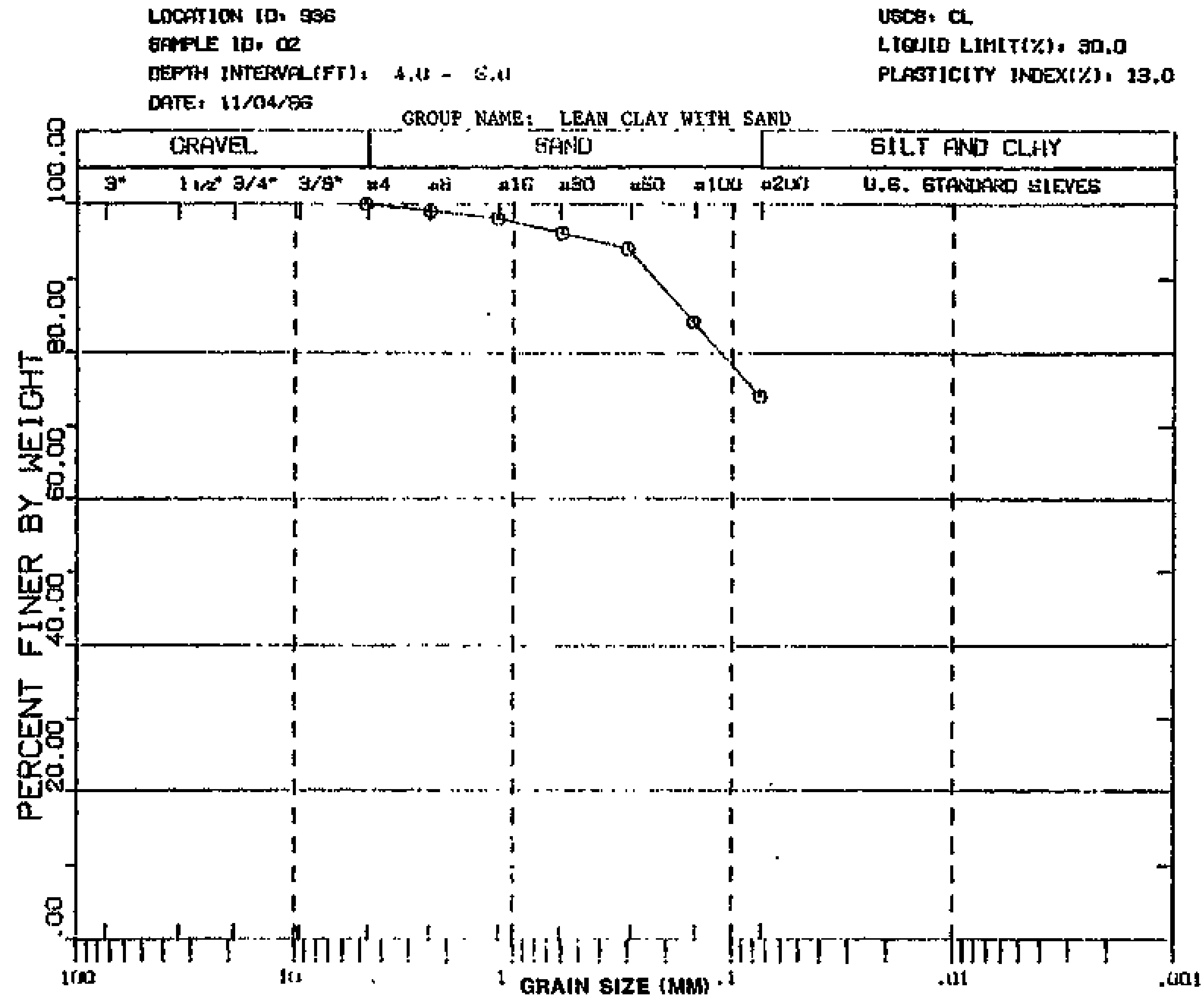


FIGURE D.5.27 PARTICLE SIZE DISTRIBUTION, ESTES GULCH

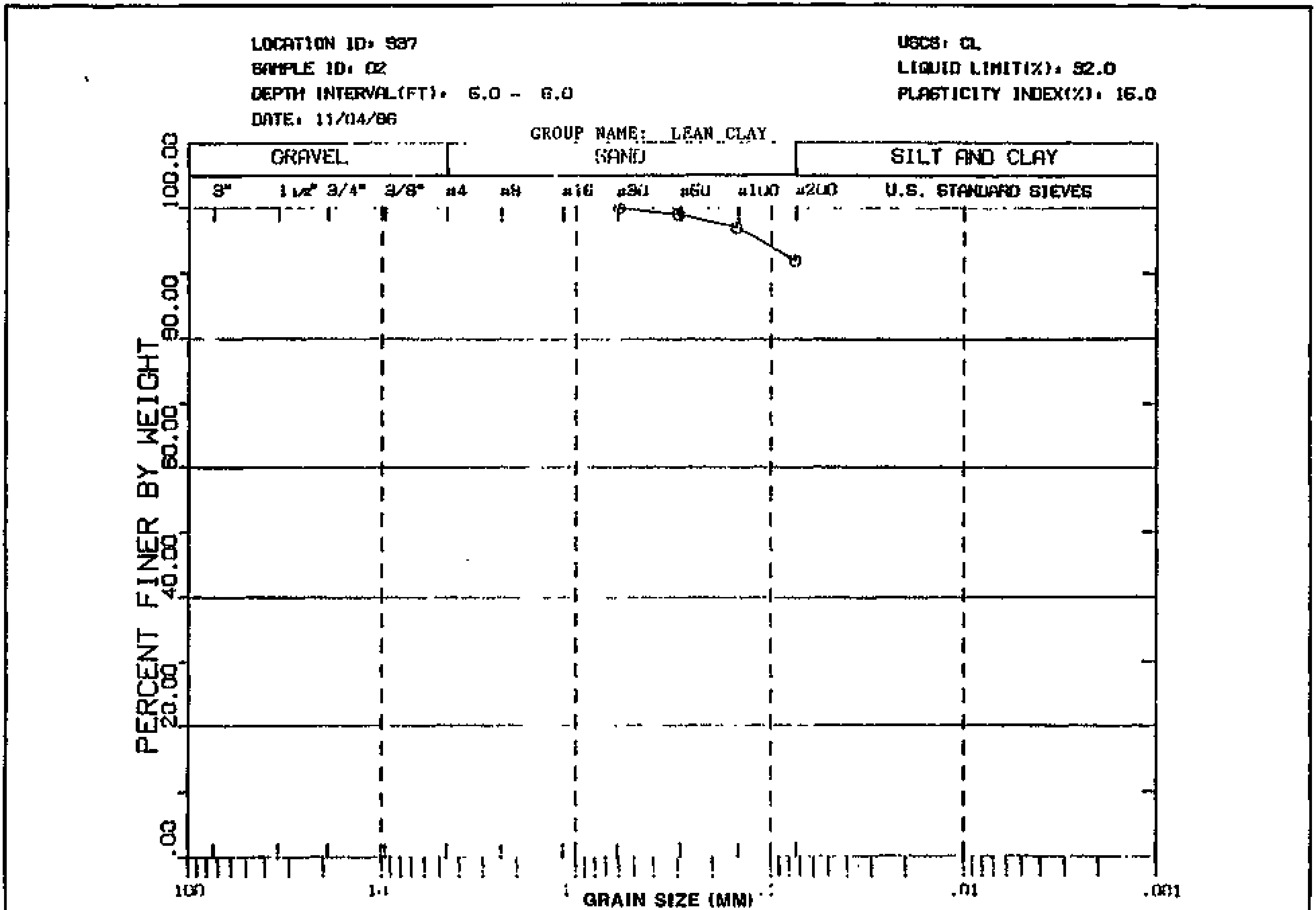


FIGURE D.5.28 PARTICLE SIZE DISTRIBUTION, ESTES GULCH

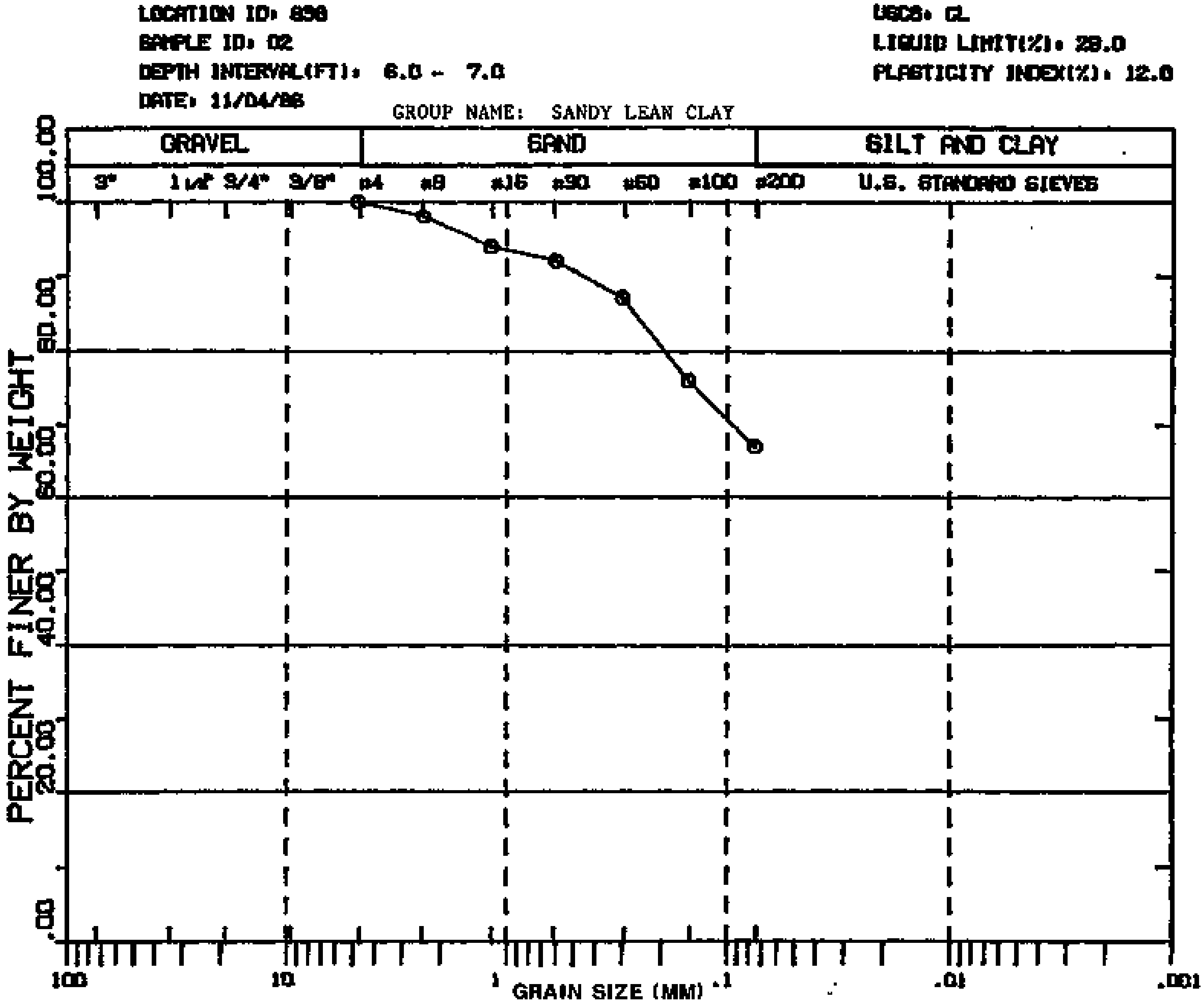


FIGURE D.5.29 PARTICLE SIZE DISTRIBUTION, ESTES GULCH

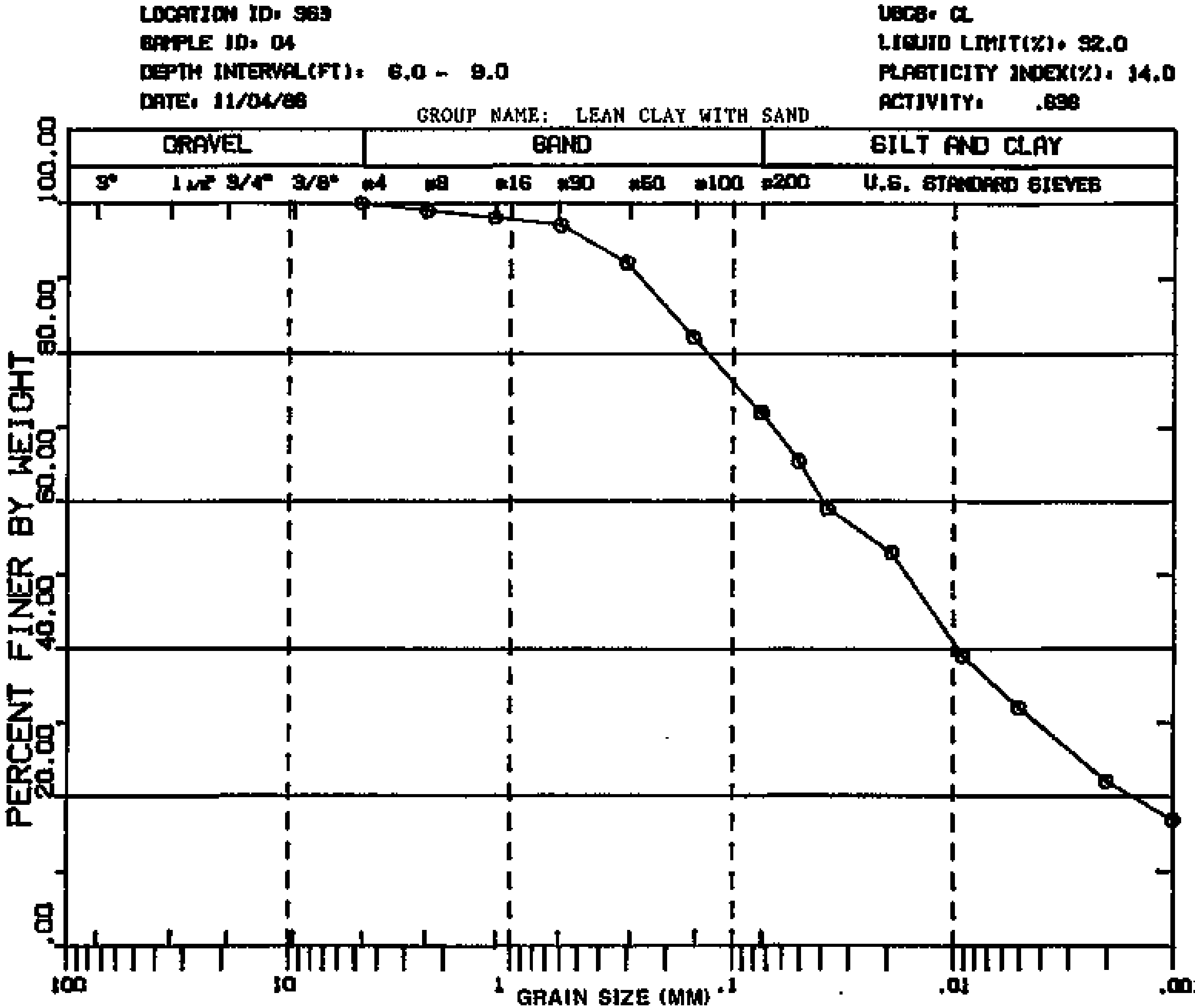


FIGURE D.5.30 PARTICLE SIZE DISTRIBUTION, ESTES GULCH

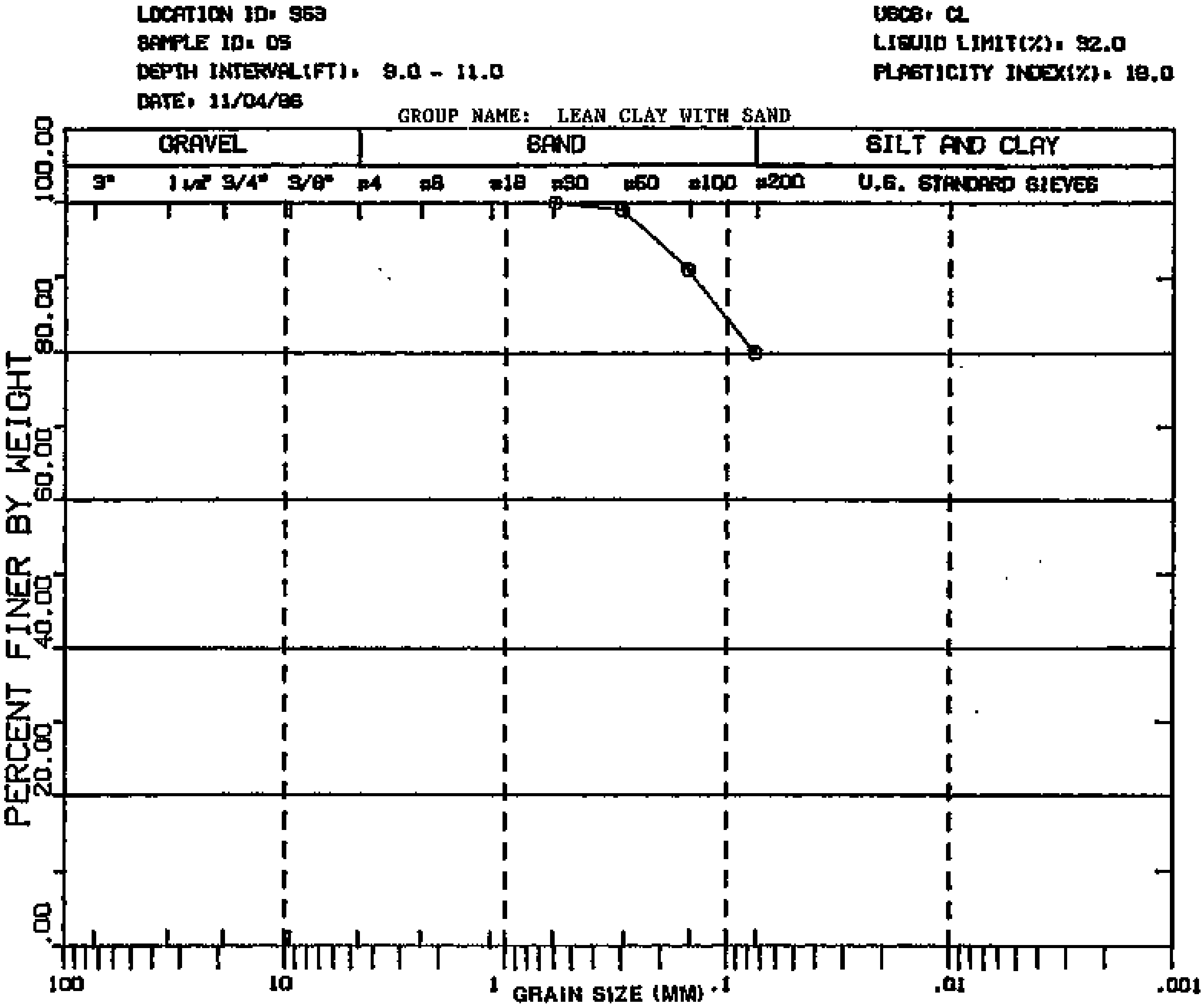


FIGURE D.5.31 PARTICLE SIZE DISTRIBUTION, ESTES GULCH

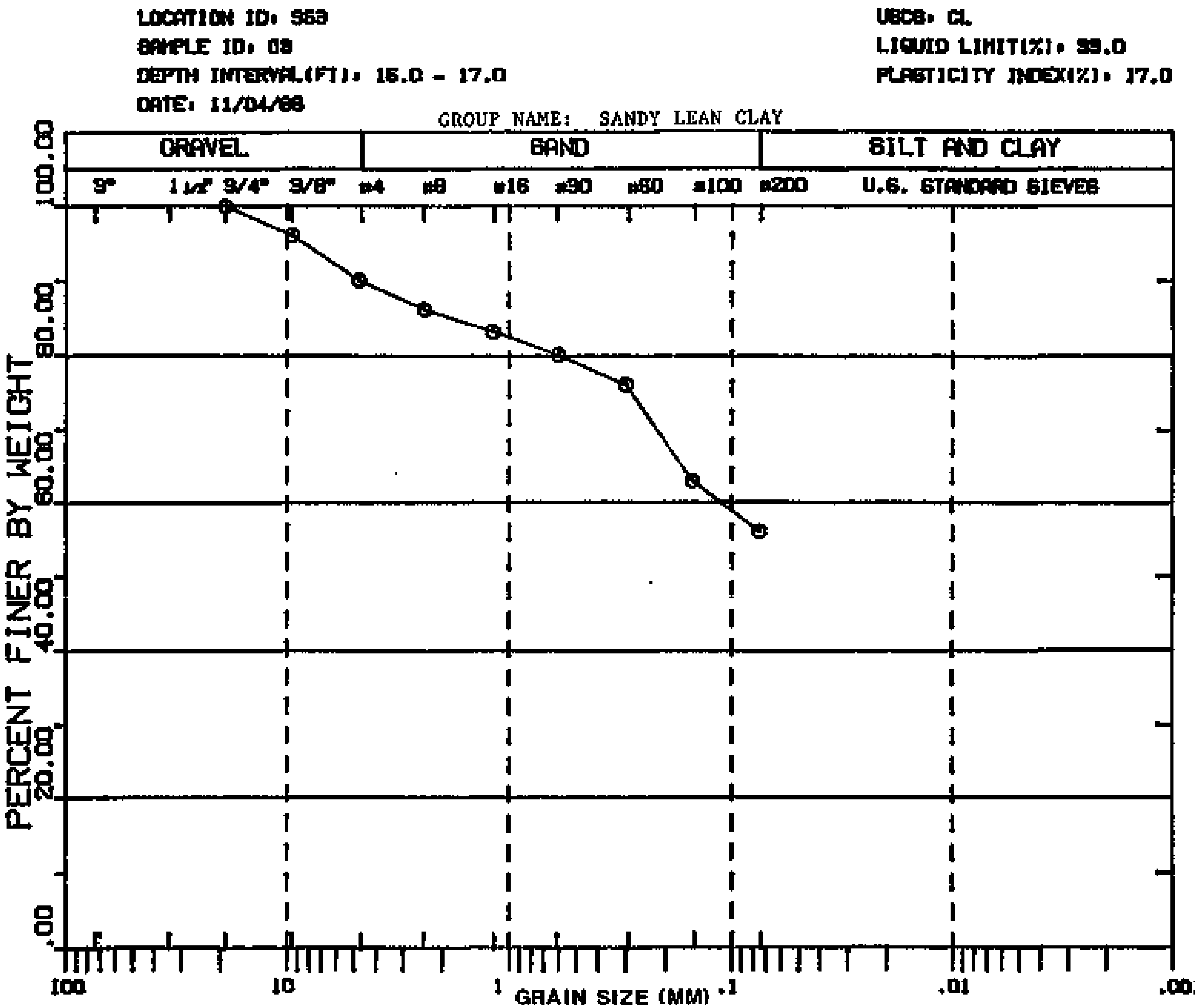


FIGURE D.5.32 PARTICLE SIZE DISTRIBUTION, ESTES GULCH

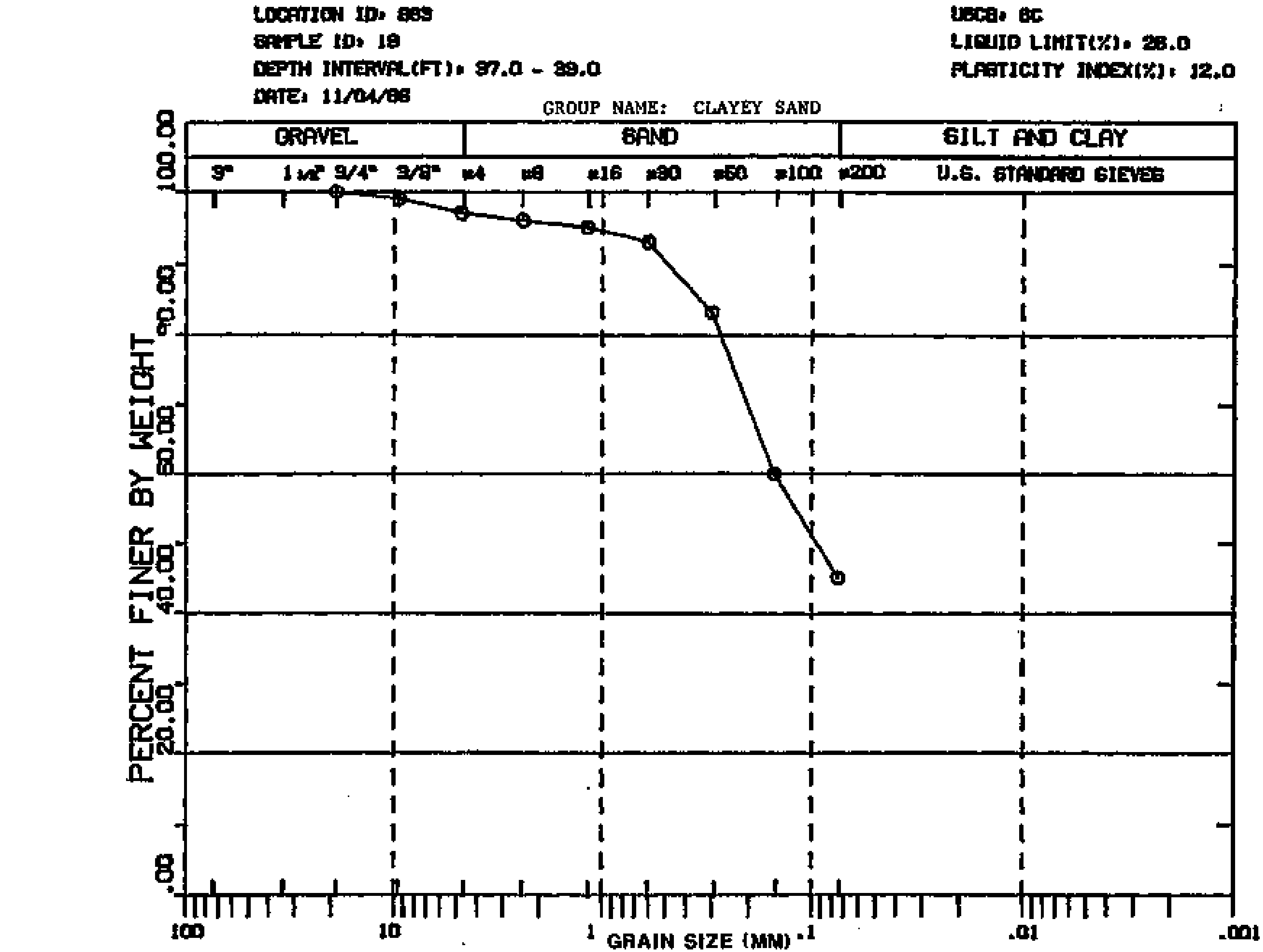
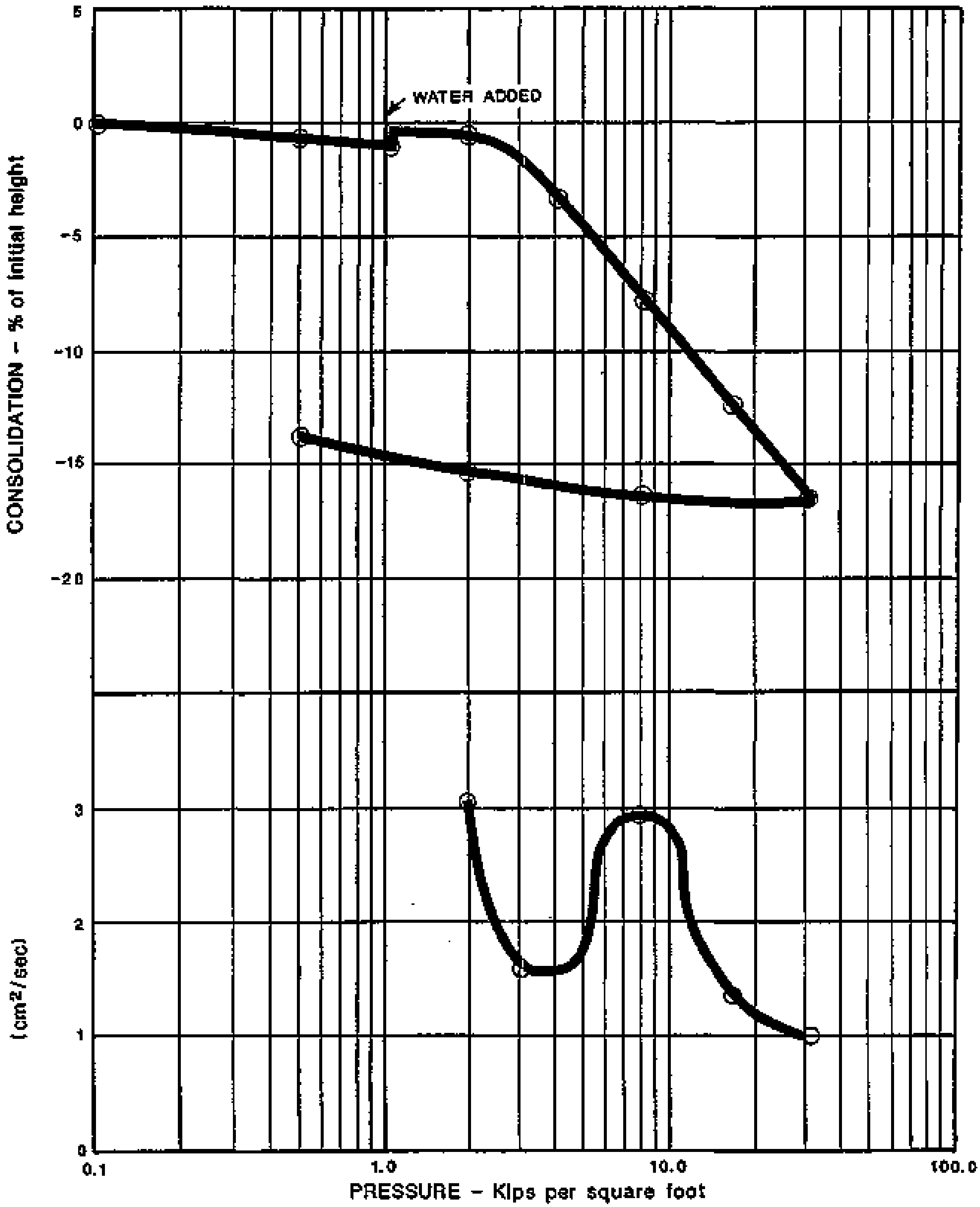
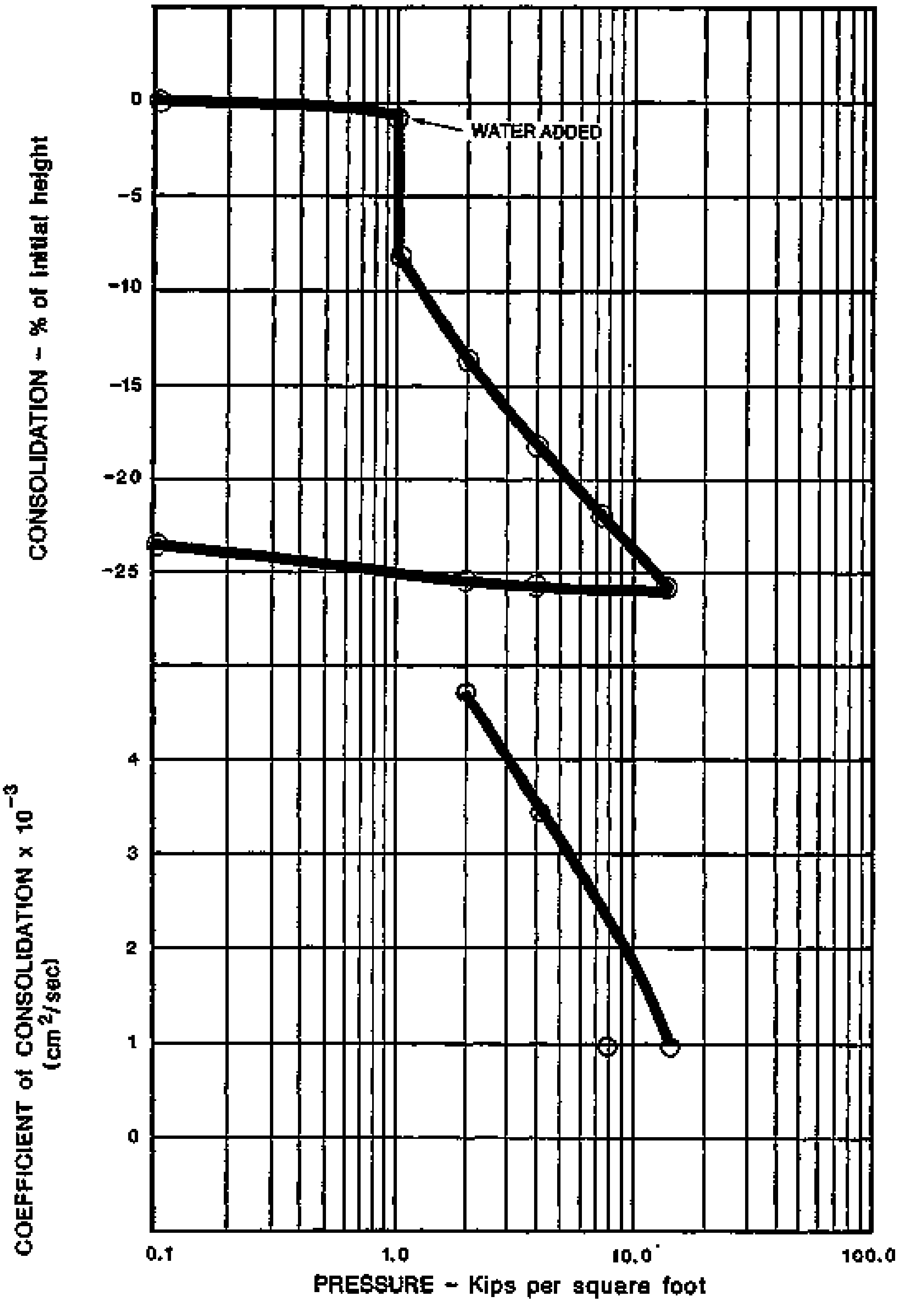


FIGURE D.5.33 PARTICLE SIZE DISTRIBUTION, ESTES GULCH



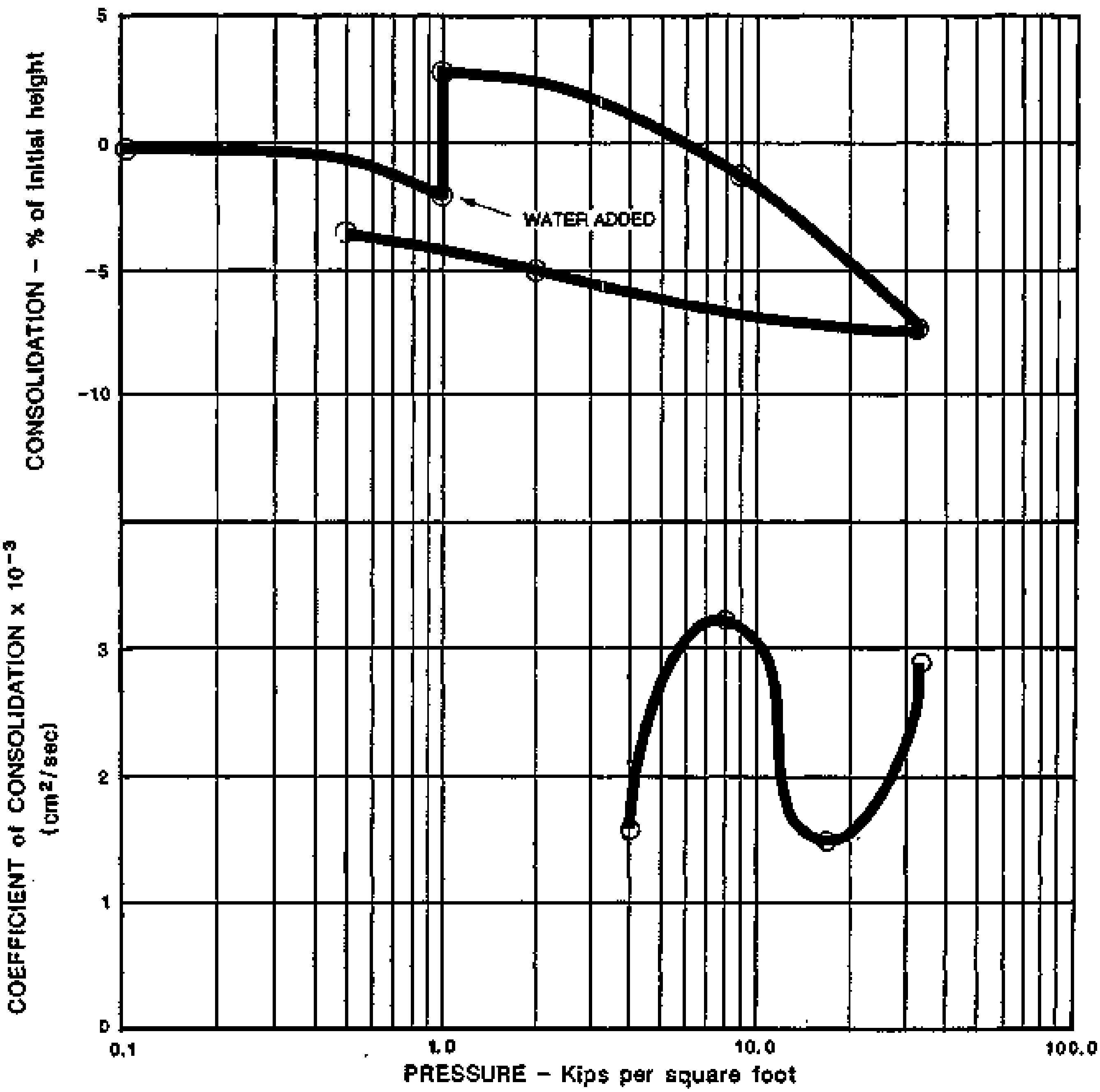
SAMPLE	DEPTH INTERVAL (FT.)	DRY DENSITY (pcf)		MOISTURE CONTENT (%)		UNIFIED SOIL CLASSIFICATION
		INITIAL	FINAL	INITIAL	FINAL	
922-02	2'-5'	99.3	115.3	10.2	18.0	SANDY LEAN CLAY (CL)

FIGURE D.5.34
SUMMARY OF CONSOLIDATION TESTS



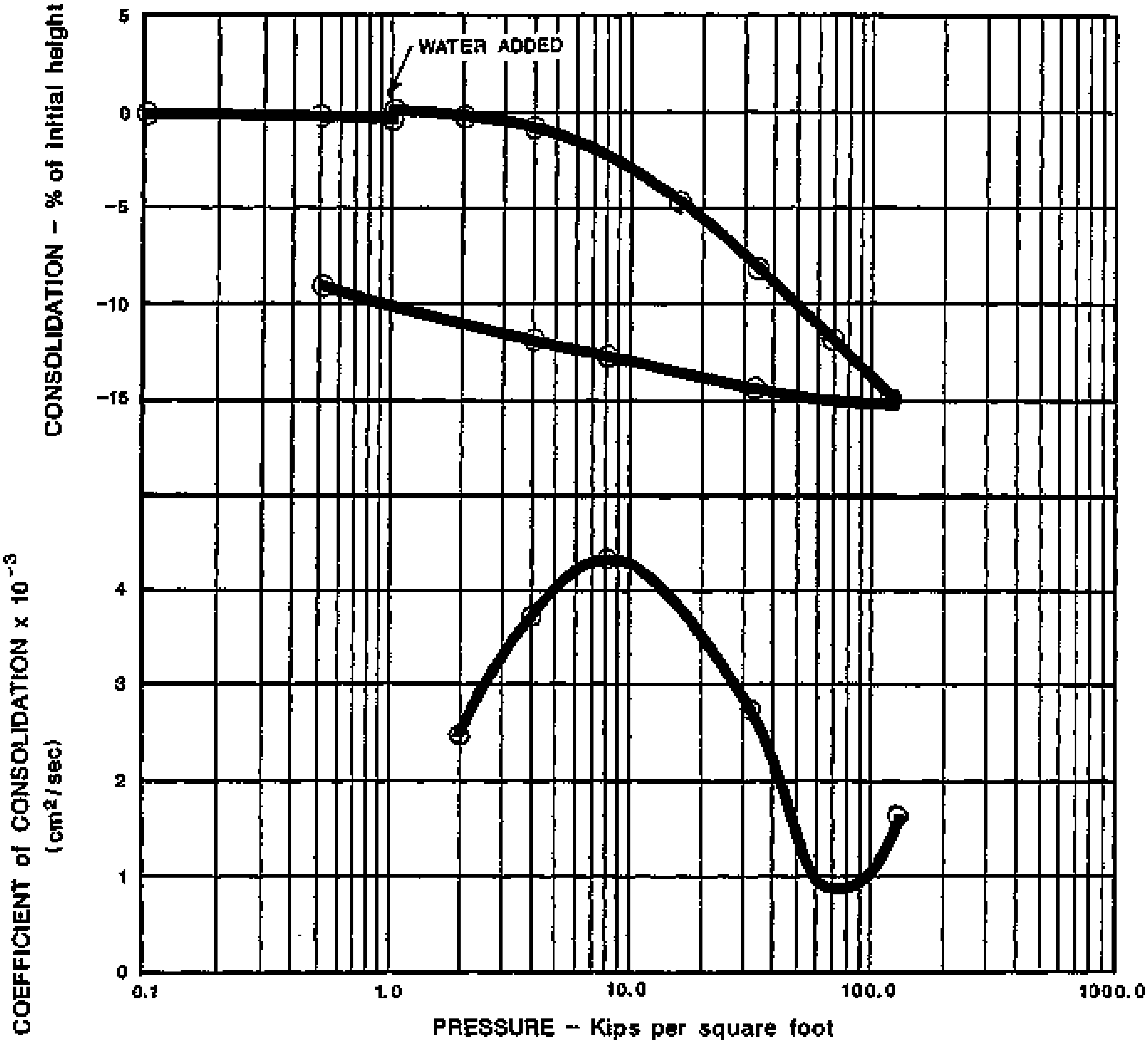
SAMPLE	DEPTH INTERVAL (FT.)	DRY DENSITY (pcf)		MOISTURE CONTENT (%)		UNIFIED SOIL CLASSIFICATION
		INITIAL	FINAL	INITIAL	FINAL	
923-04	6'-8'	85.4	111.4	10.0	19.3	LEAN CLAY (CL)

FIGURE D.5.35
SUMMARY OF CONSOLIDATION TESTS



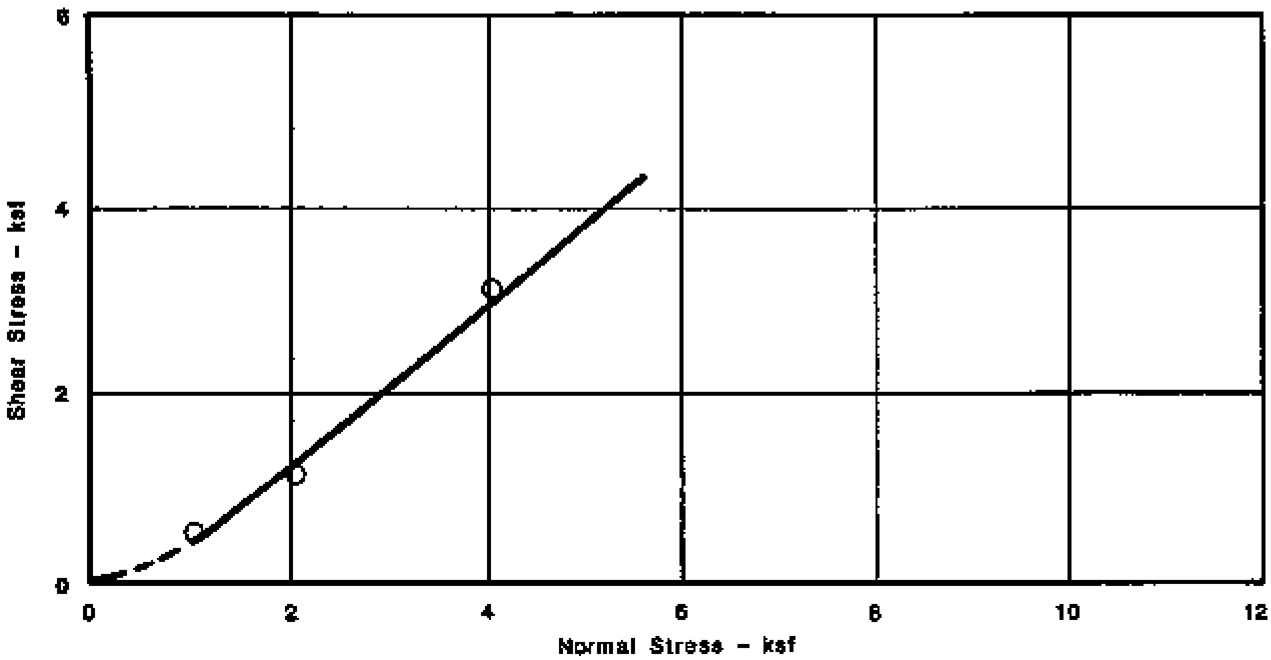
SAMPLE	DEPTH INTERVAL (FT.)	DRY DENSITY (pcf)		MOISTURE CONTENT (%)		UNIFIED SOIL CLASSIFICATION
		INITIAL	FINAL	INITIAL	FINAL	
924-02	2.0'-3.2'	109.4	114.0	13.4	18.7	LEAN CLAY (CL)

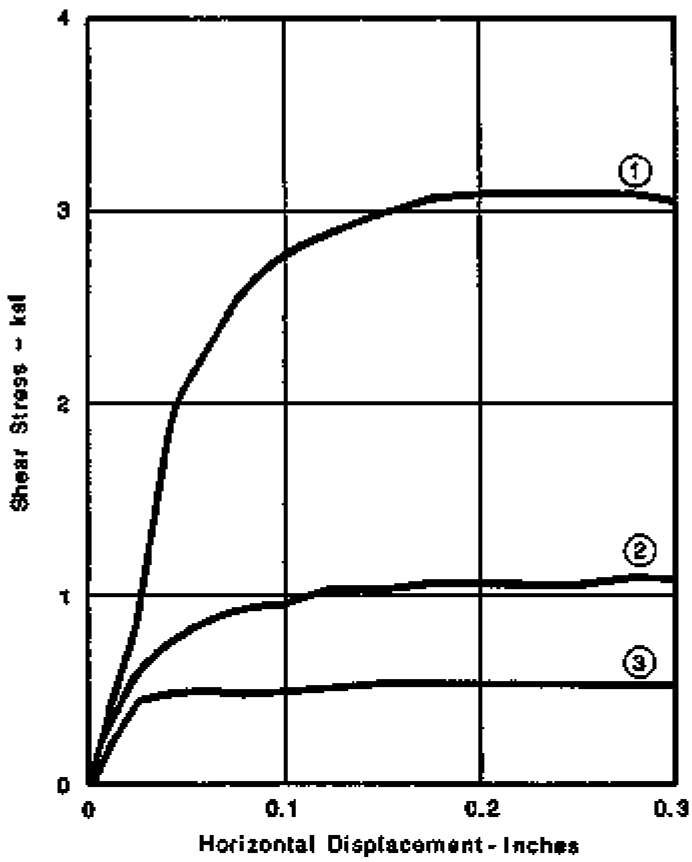
FIGURE D.5.36
SUMMARY OF CONSOLIDATION TESTS



SAMPLE	DEPTH INTERVAL (FT.)	DRY DENSITY (pcf)		MOISTURE CONTENT (%)		UNIFIED SOIL CLASSIFICATION
		INITIAL	FINAL	INITIAL	FINAL	
924-09	16'-18'	106.8	117.7	11.5	16.3	LEAN CLAY WITH SAND (CL)

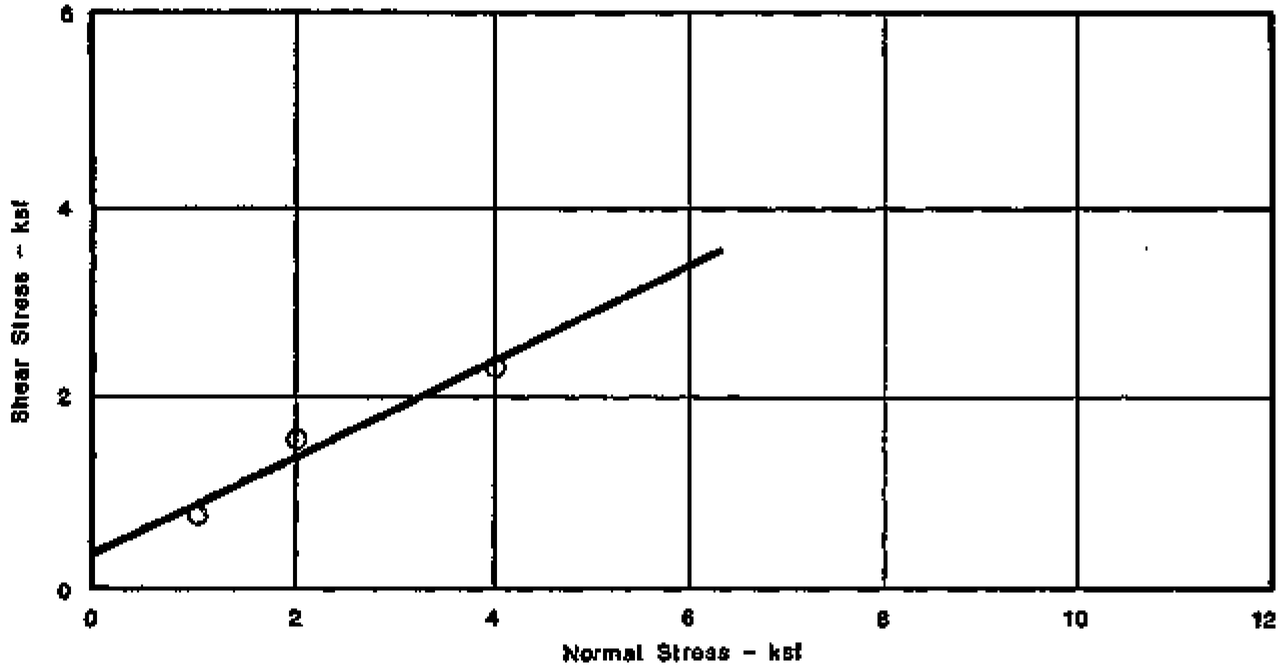
FIGURE D.5.37
SUMMARY OF CONSOLIDATION TESTS

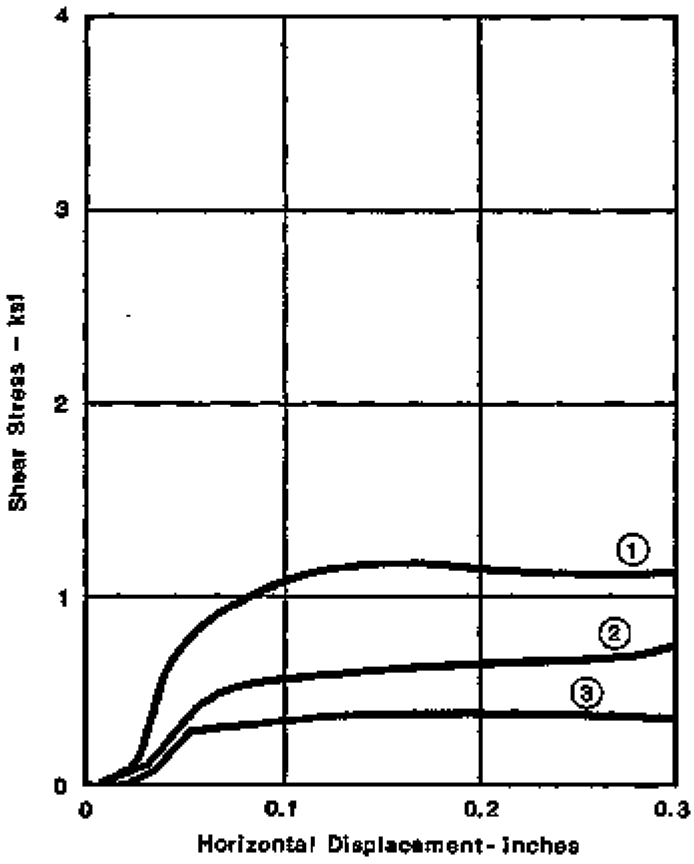




SAMPLE ID	DEPTH (FT.)	SHEAR VALUES		INITIAL DRY DENSITY (pcf)
921-03	4 - 6	Φ= 41.3	C= 0	108.8

FIGURE D.5.38
DIRECT SHEAR TEST RESULTS





SAMPLE ID	DEPTH (FT.)	SHEAR VALUES		INITIAL DRY DENSITY (pcf)
922-02	2 - 5	Φ= 26.2	C= 0.38	97.5

FIGURE D.5.39

DIRECT SHEAR TEST RESULTS

TRIAXIAL 'R' TEST

ESTES GULCH

LOCATION ID: 969
SAMPLE ID: 04

DATE: 11/13/86
DEPTH INTERVAL(FT): 6.0 - 9.0

GROUP NAME: LEAN CLAY WITH SAND (CL)

STAGE N NUMBER	INITIAL CONDITION		FINAL CONDITION		PERCENT INITIAL COMPACTION	"B" PARAMETER	CONFINING PRESSURE (PSF)
	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	MOISTURE CONTENT (%)			
1	93.2	30.2	96.4	26.8	--	0.97	677
2	96.4	26.8	102.1	23.2	--	--	2088
3	102.1	23.2	105.8	21.0	--	--	4306

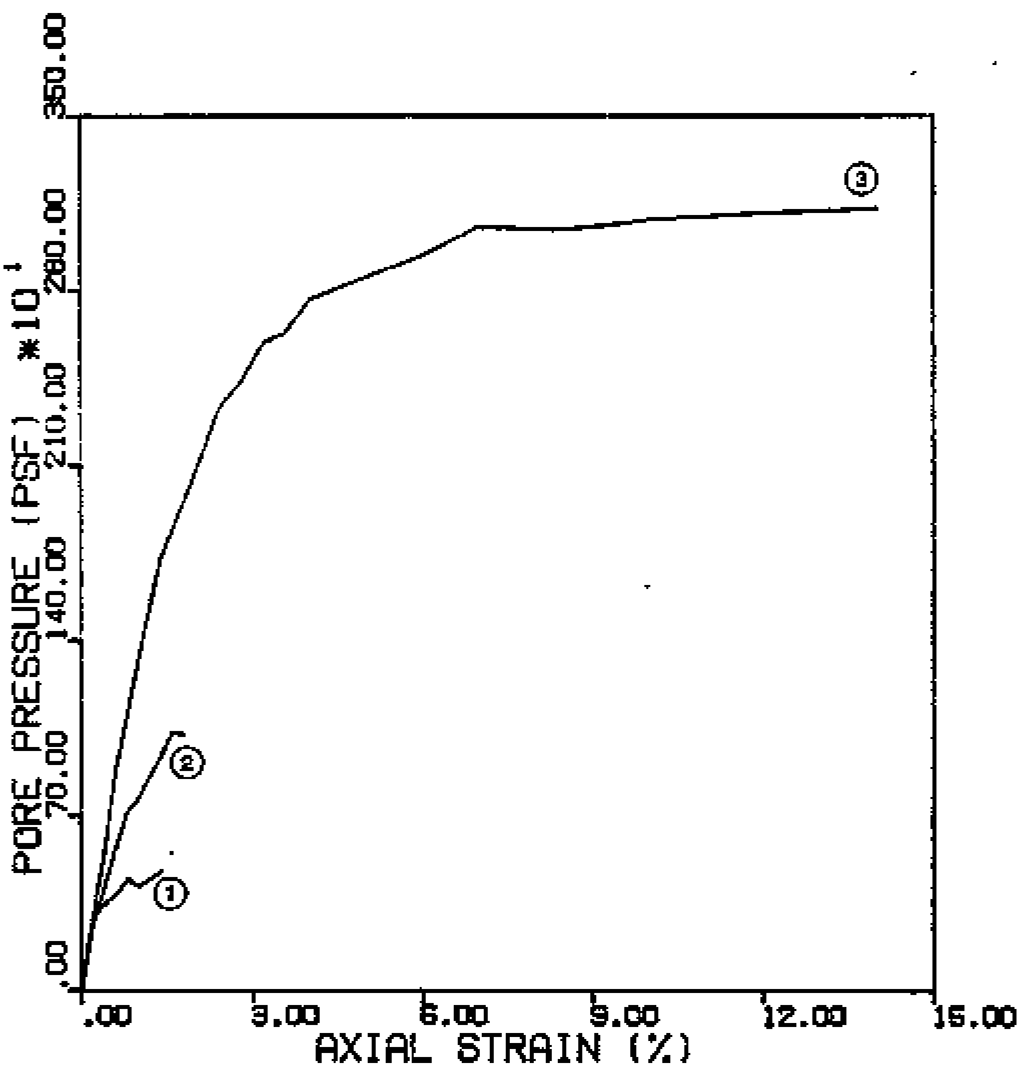


FIGURE D.5.40a TRIAXIAL SHEAR STRENGTH RESULTS

TRIAXIAL 'R' TEST

ESTES GULCH

LOCATION ID: 869
SAMPLE ID: 04

DATE: 11/19/88
DEPTH INTERVAL(FT): 6.0 - 9.0

CELL CONFINING PRESSURE(PSF)

STAGE 1: 577.
STAGE 2: 2088.
STAGE 3: 4306.

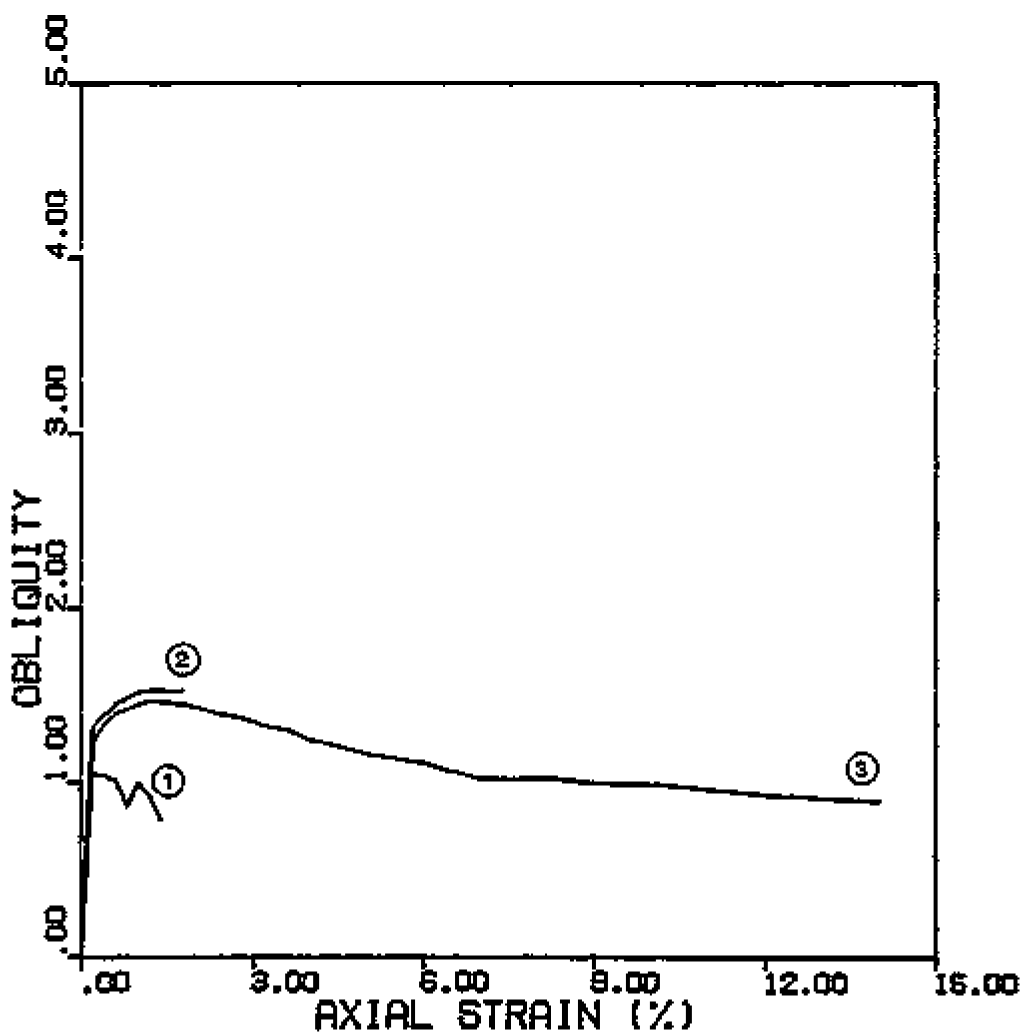


FIGURE D.5.40b TRIAXIAL SHEAR STRENGTH RESULTS

TRIAXIAL 'R' TEST
ESTES GULCH

LOCATION ID: 863
SAMPLE ID: 04

DATE: 11/13/86
DEPTH INTERVAL(FT): 6.0 - 9.0

CELL CONFINING PRESSURE(PSF)

STAGE 1: 677.
STAGE 2: 2088.
STAGE 3: 4306.

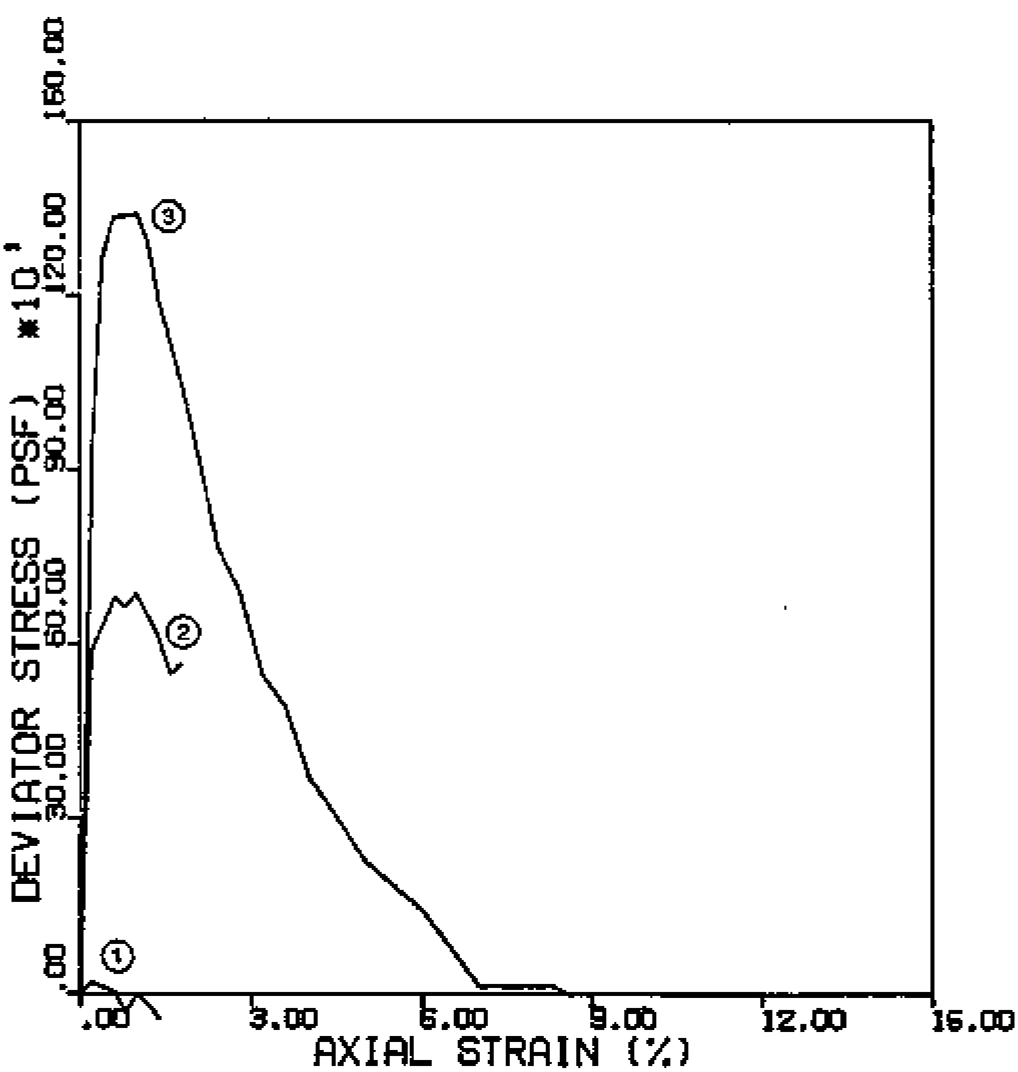


FIGURE D.5.40c TRIAXIAL SHEAR STRENGTH RESULTS

TRIAXIAL 'R' TEST

ESTES GULCH

LOCATION ID: 963

DEPTH INTERVAL(FT): 8.0 - 9.0

SAMPLE ID: 04

DATE: 11/18/86

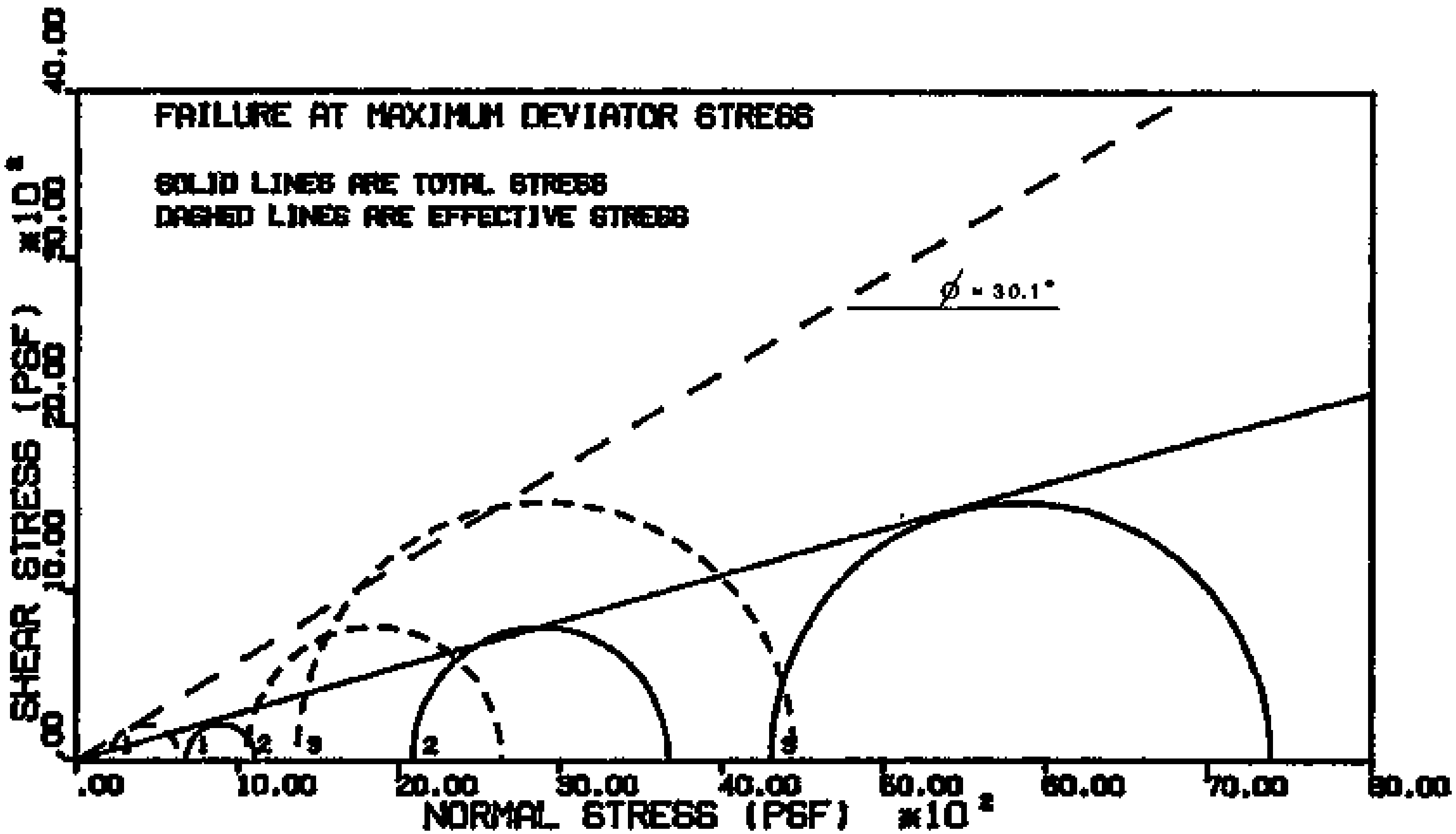
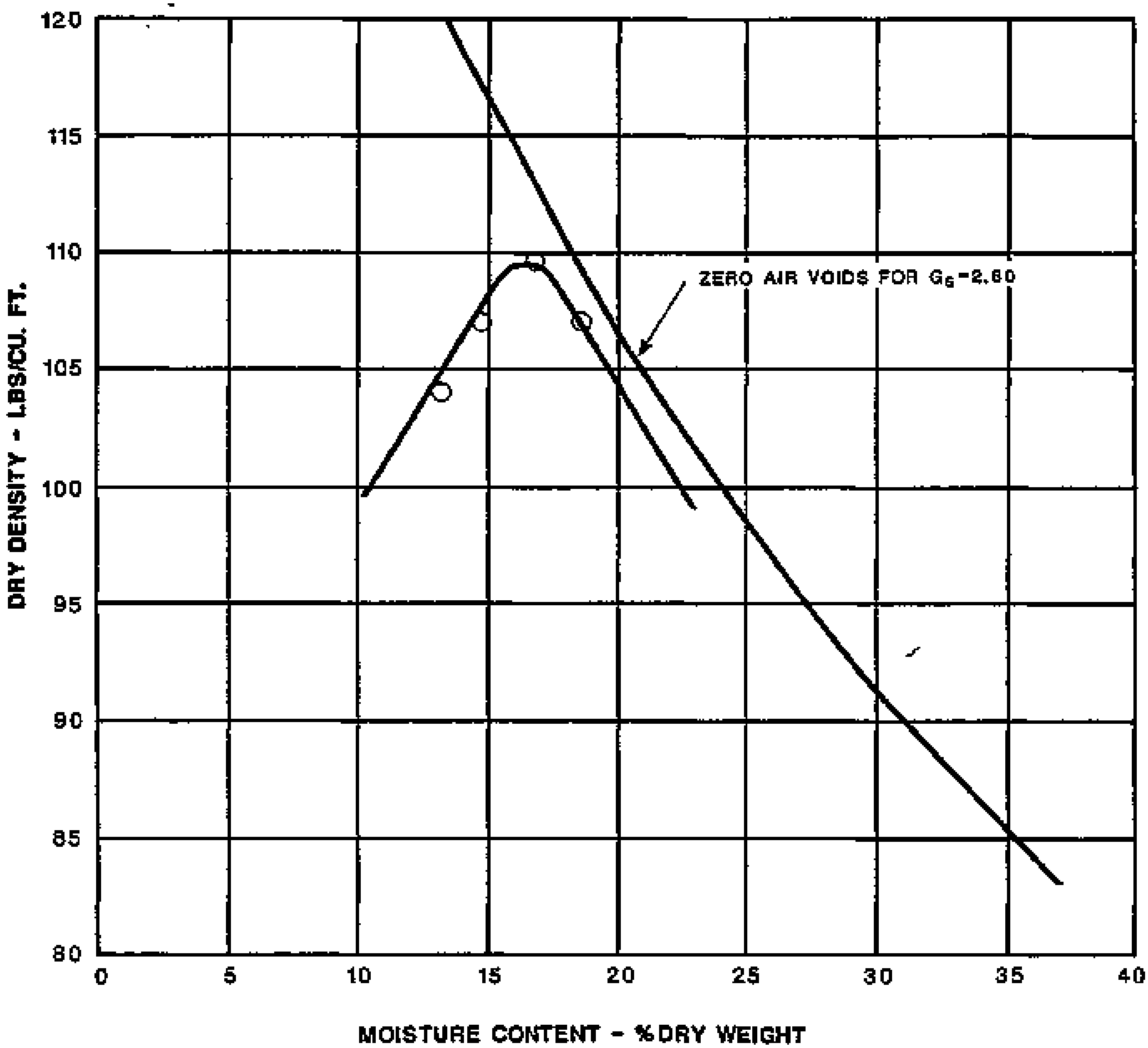


FIGURE D.5.40d TRIAXIAL SHEAR STRENGTH RESULTS

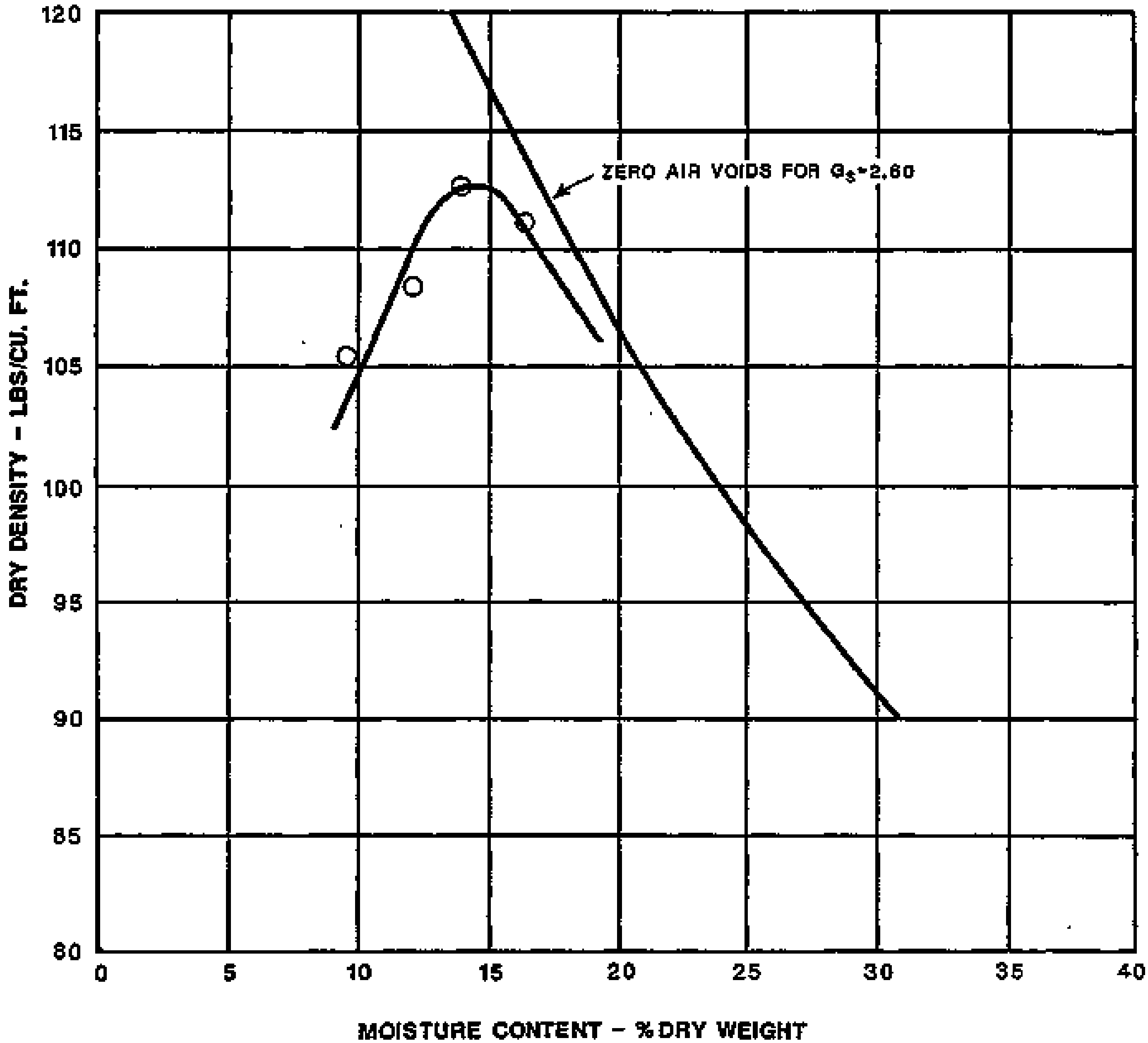


LEGEND			
SAMPLE RFL-08	DEPTH INTERVAL (FT.)	OPTIMUM MOISTURE CONTENT (%)	MAXIMUM DRY DENSITY LBS/CU. FT.
930-03	8' - 10'	16.8	109.7

GROUP NAME: LEAN CLAY WITH SAND (CL)

FIGURE D.5.41

SUMMARY OF MOISTURE-DENSITY RELATIONSHIP TESTS

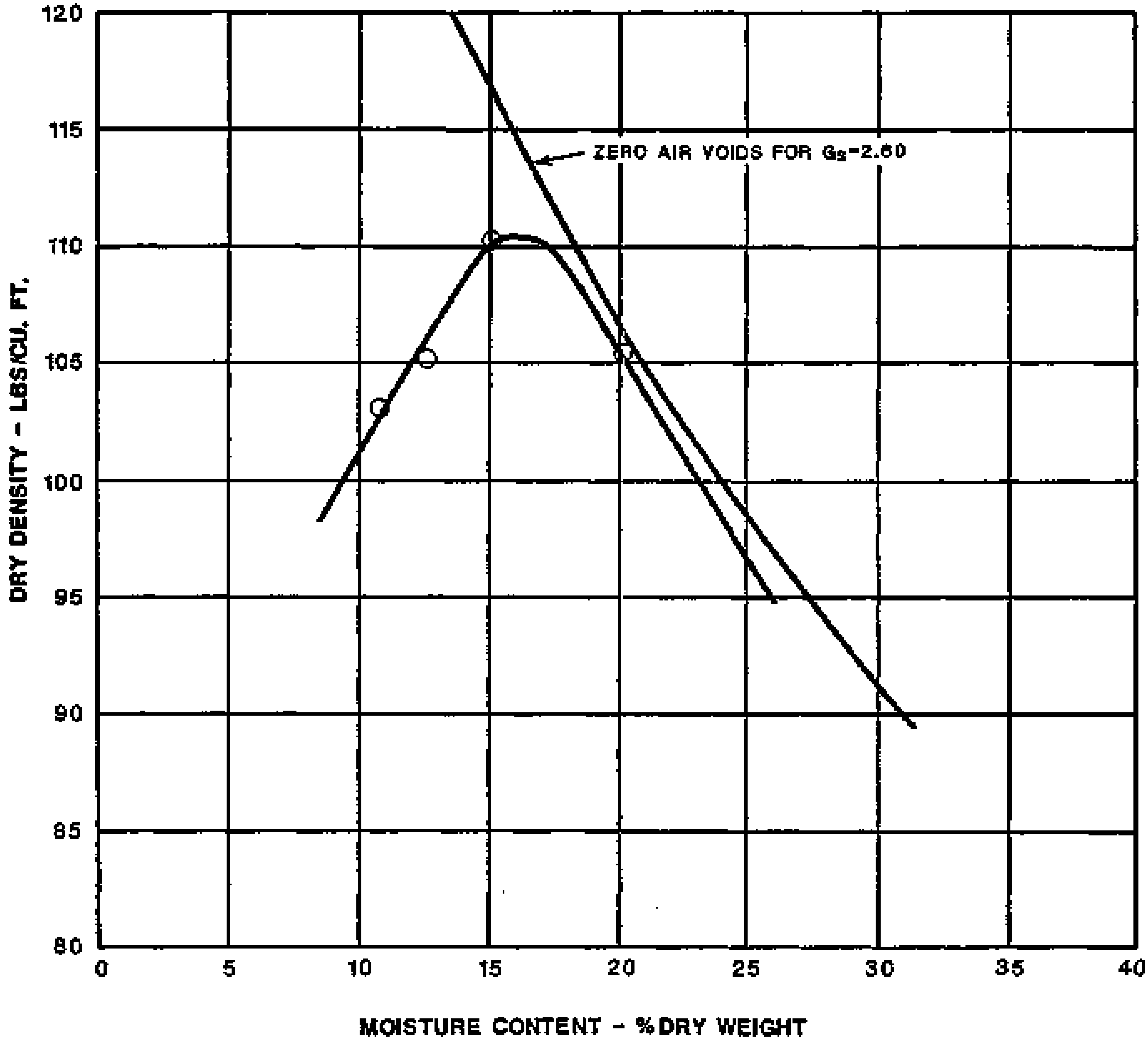


LEGEND			
SAMPLE RFL-08	DEPTH INTERVAL (FT.)	OPTIMUM MOISTURE CONTENT (%)	MAXIMUM DRY DENSITY LBS/CU. FT.
932-02	4.5' - 5.5'	14.7	112.7

GROUP NAME: SANDY LEAN CLAY (CL)

FIGURE D.5.42

SUMMARY OF MOISTURE-DENSITY RELATIONSHIP TESTS

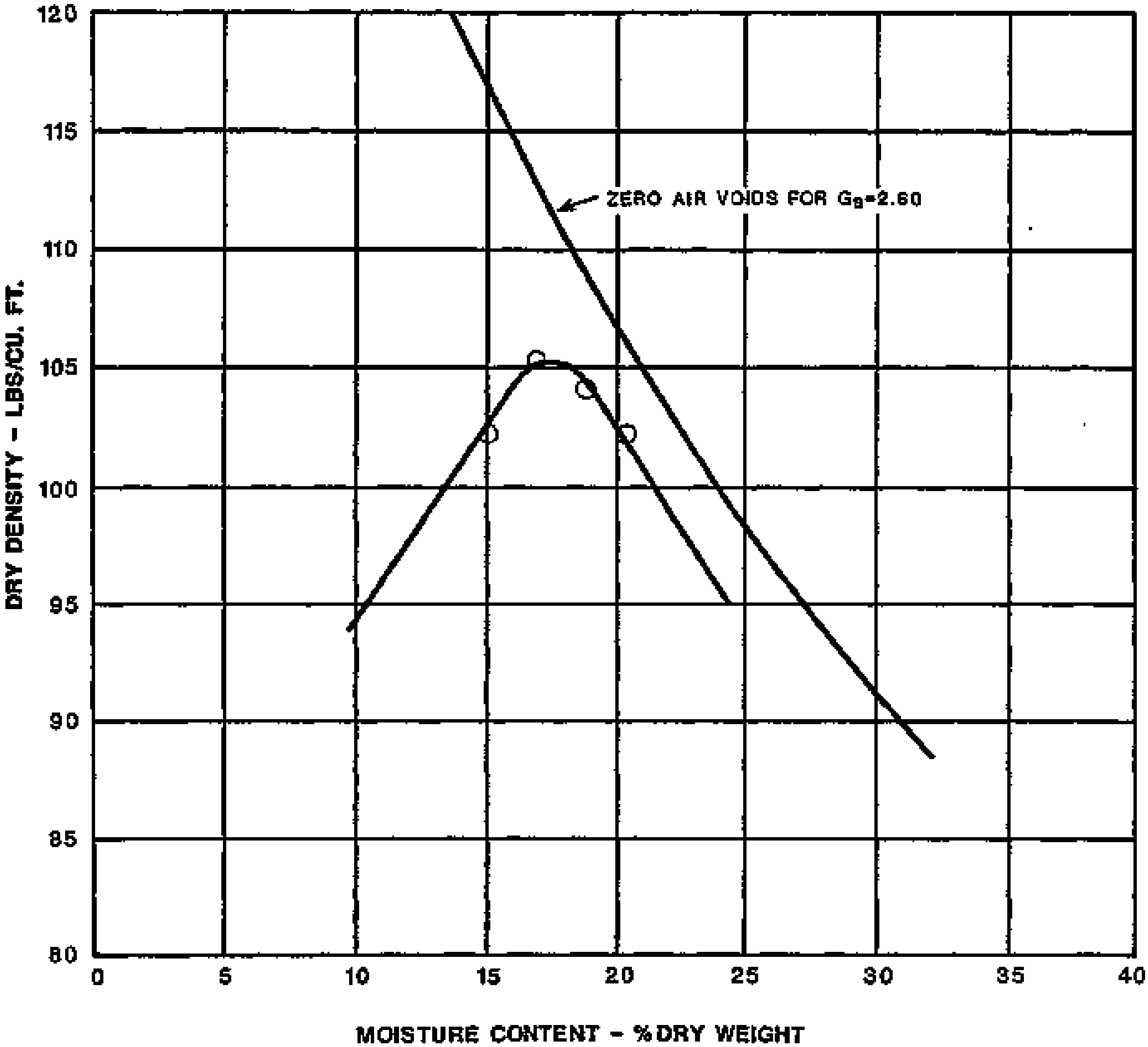


LEGEND			
SAMPLE RFL-08	DEPTH INTERVAL (FT.)	OPTIMUM MOISTURE CONTENT (%)	MAXIMUM DRY DENSITY LBS/CU. FT.
936-02	4' - 5'	16.2	110.5

GROUP NAME: LEAN CLAY WITH SAND (CL)

FIGURE D.5.43

SUMMARY OF MOISTURE-DENSITY RELATIONSHIP TESTS

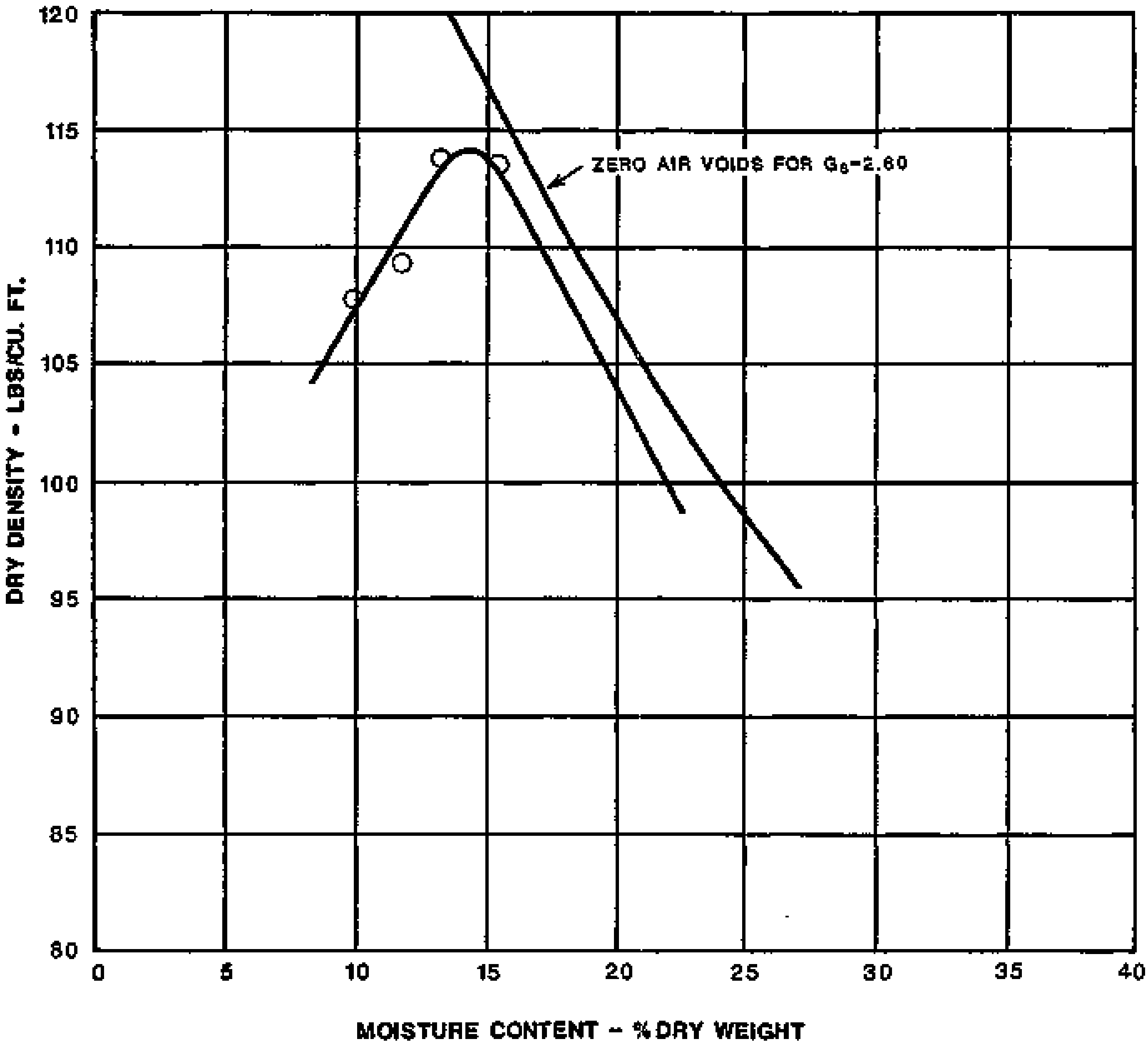


LEGEND			
SAMPLE RFL-08	DEPTH INTERVAL (FT.)	OPTIMUM MOISTURE CONTENT (%)	MAXIMUM DRY DENSITY LBS/CU. FT.
937-02	5' - 6'	17.6	105.2

GROUP NAME: LEAN CLAY (CL)

FIGURE D.5.44

SUMMARY OF MOISTURE-DENSITY RELATIONSHIP TESTS



LEGEND			
SAMPLE RFL-08	DEPTH INTERVAL (FT.)	OPTIMUM MOISTURE CONTENT (%)	MAXIMUM DRY DENSITY LBS/CU. FT.
938-02	6' - 7'	14.2	114.1

GROUP NAME: SANDY LEAN CLAY (CL)

FIGURE D.5.45

SUMMARY OF MOISTURE-DENSITY RELATIONSHIP TESTS

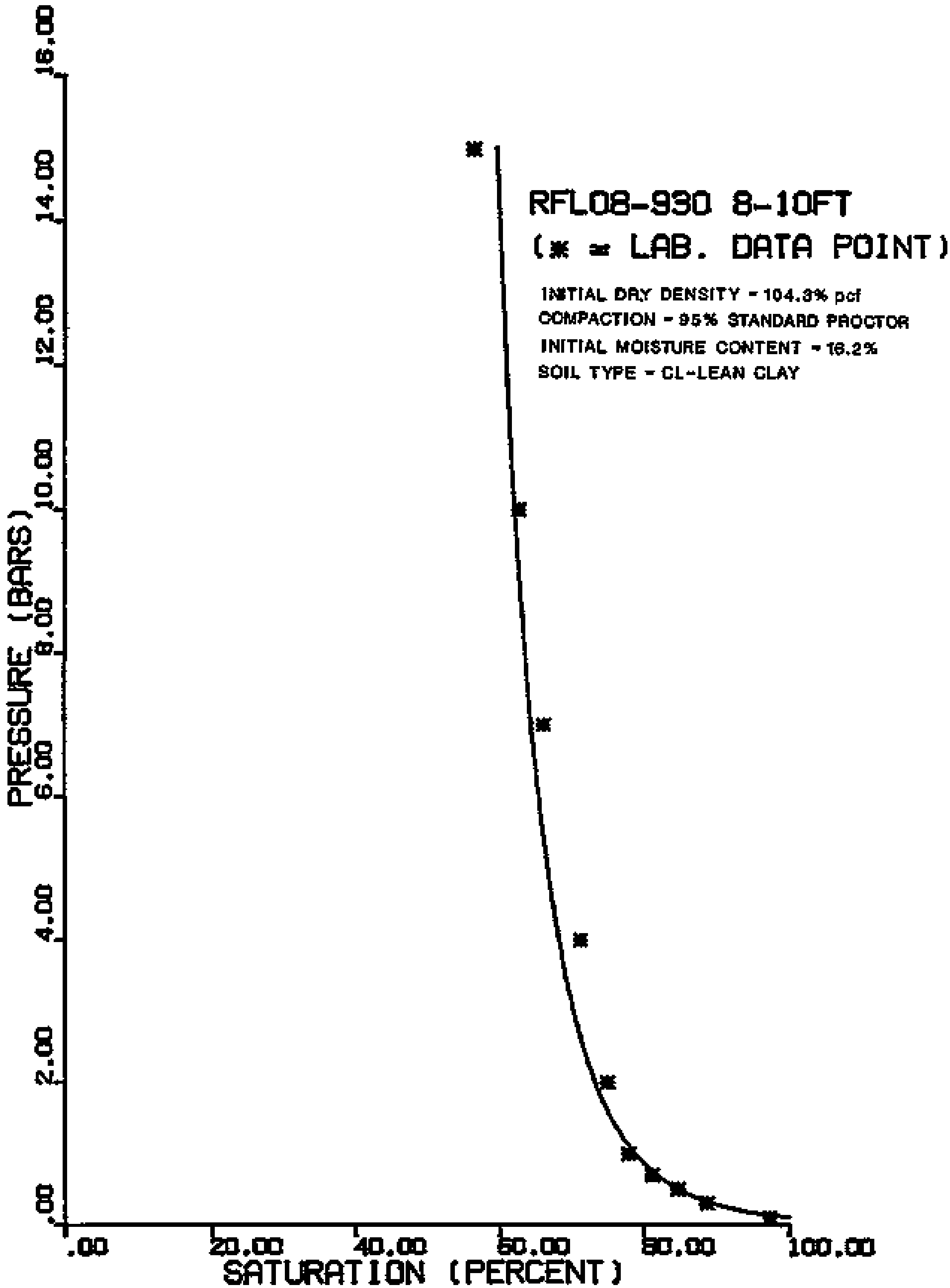


FIGURE D.5.46 CAPILLARY MOISTURE CURVE

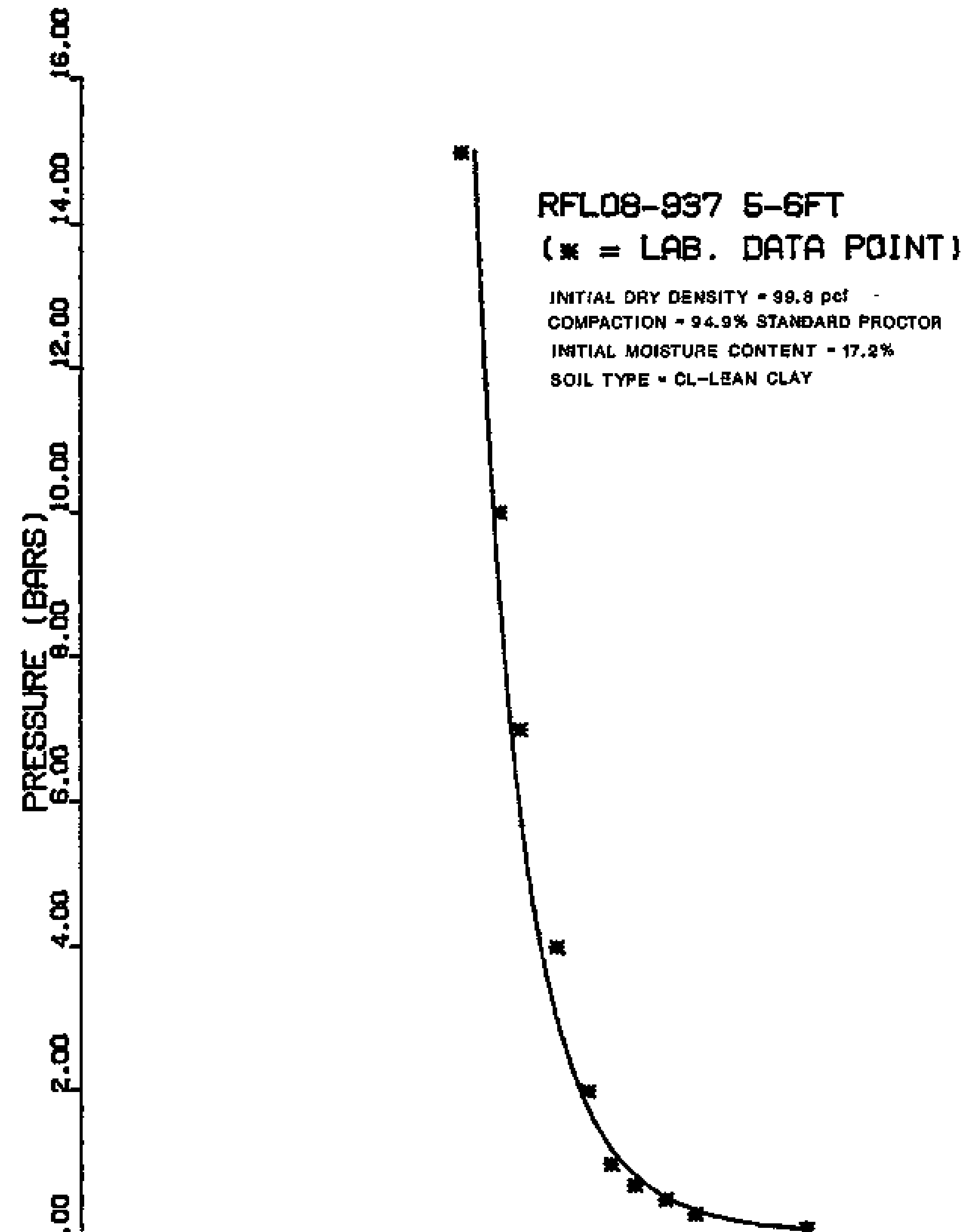


FIGURE D.5.47 CAPILLARY MOISTURE CURVE

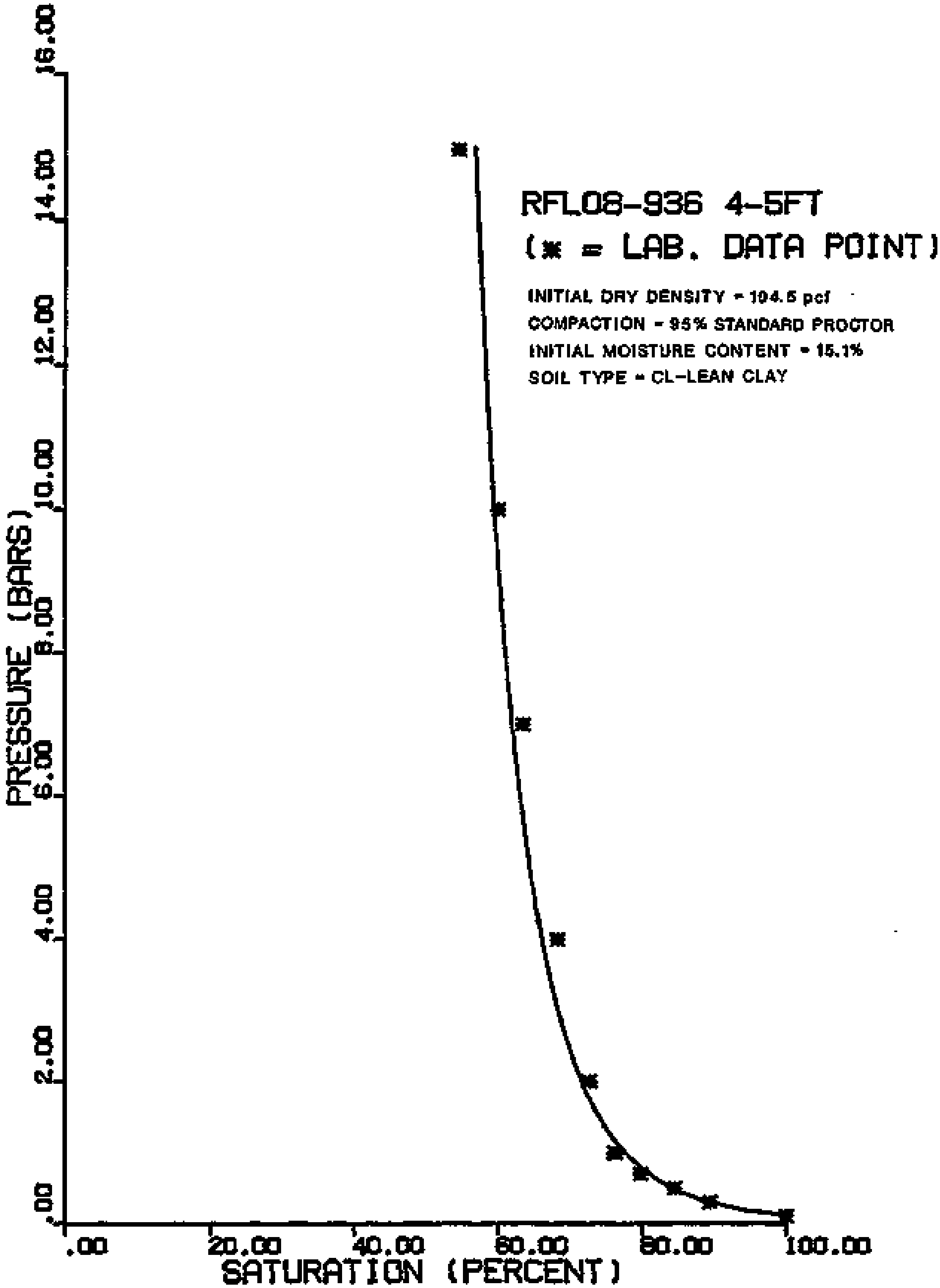


FIGURE D.5.48 CAPILLARY MOISTURE CURVE

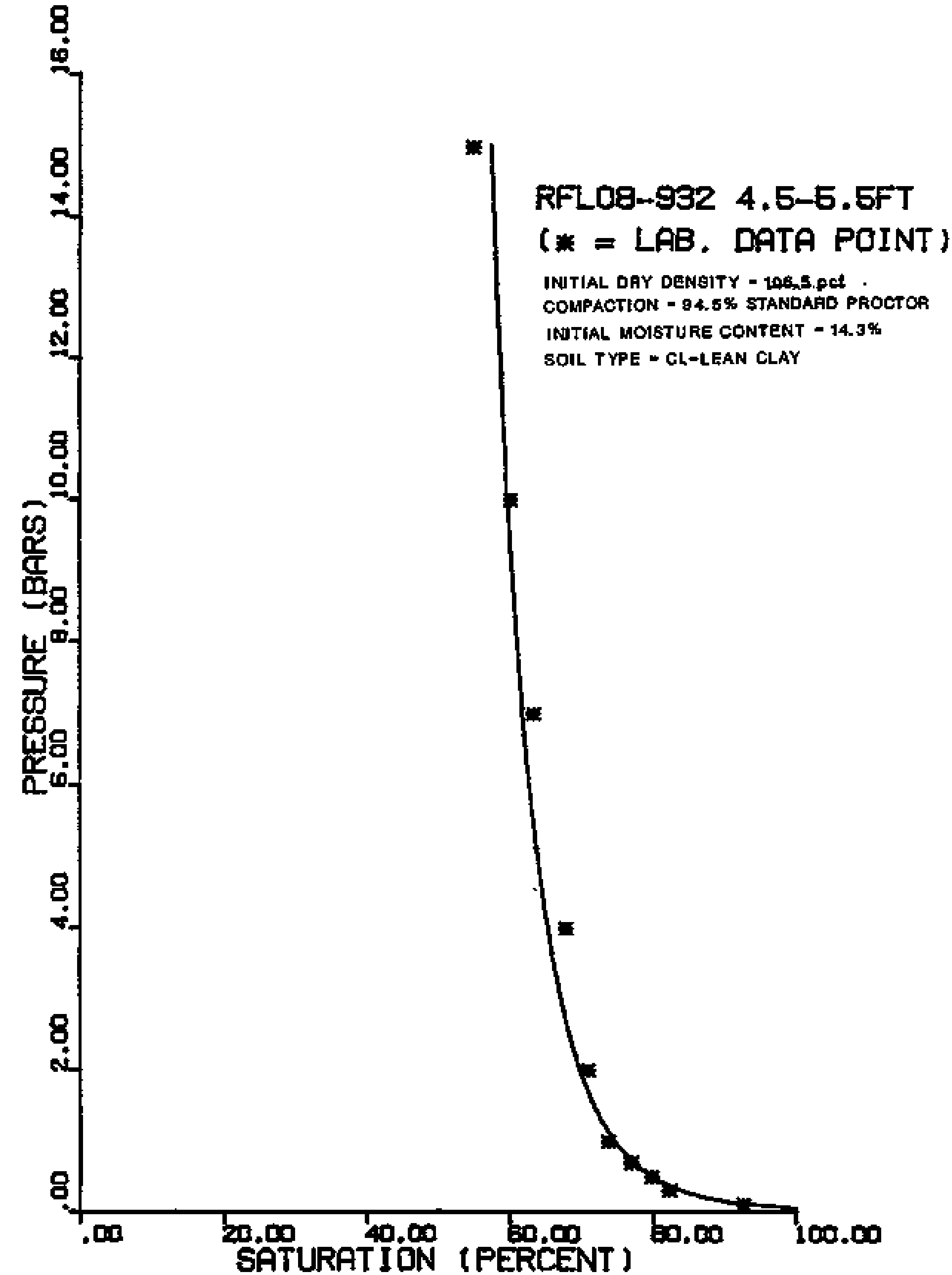


FIGURE D.5.49 CAPILLARY MOISTURE CURVE

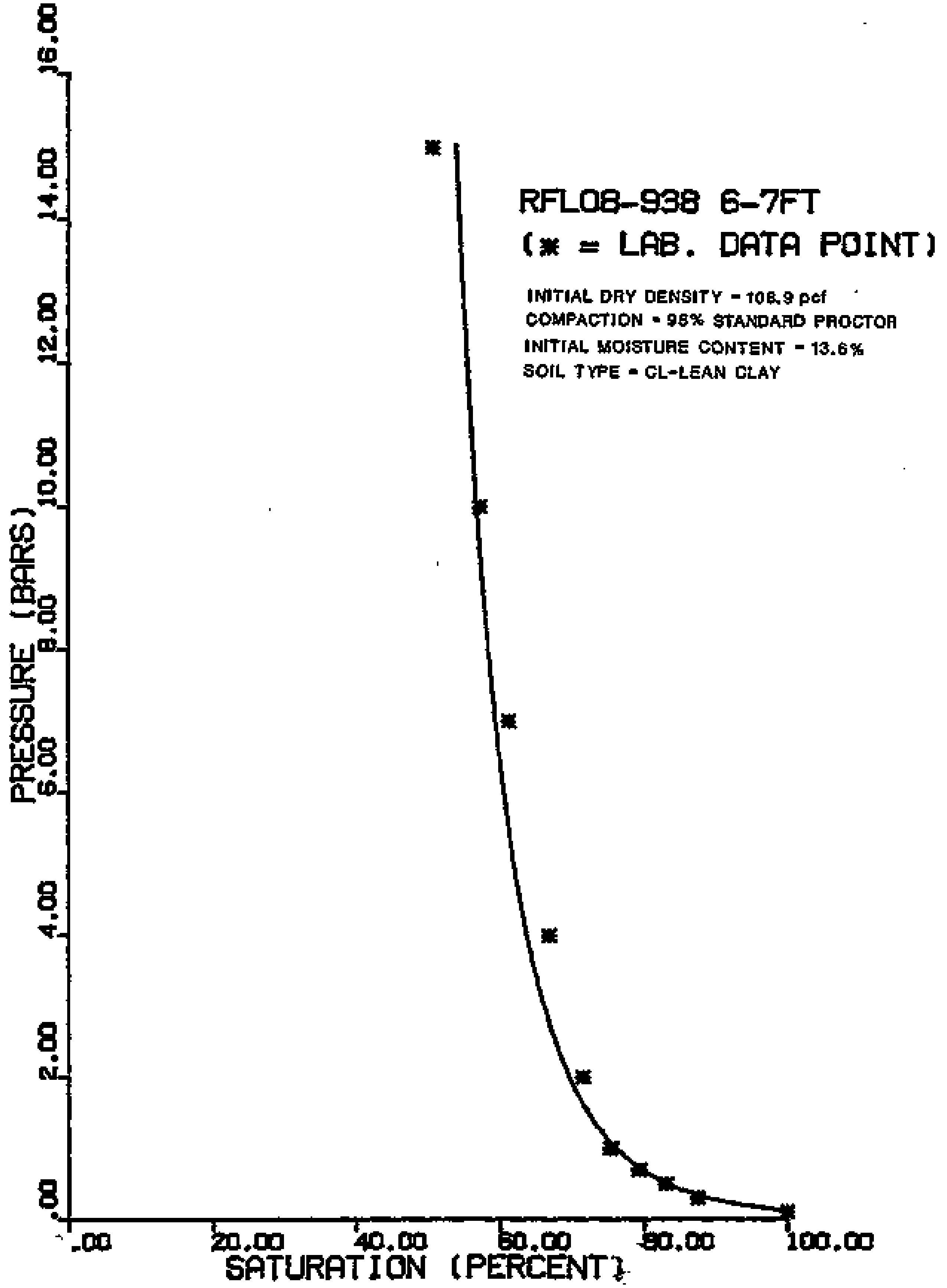
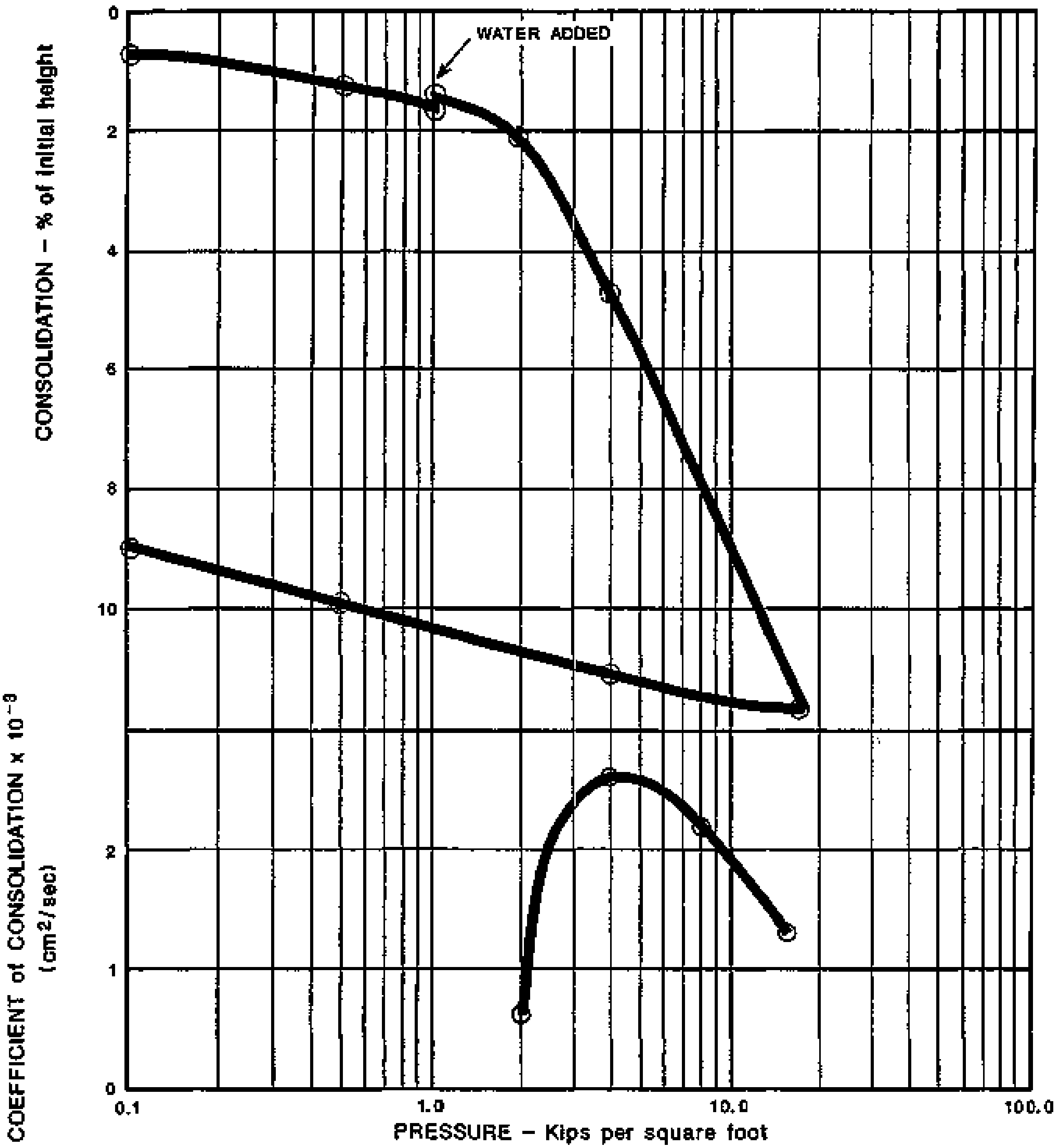
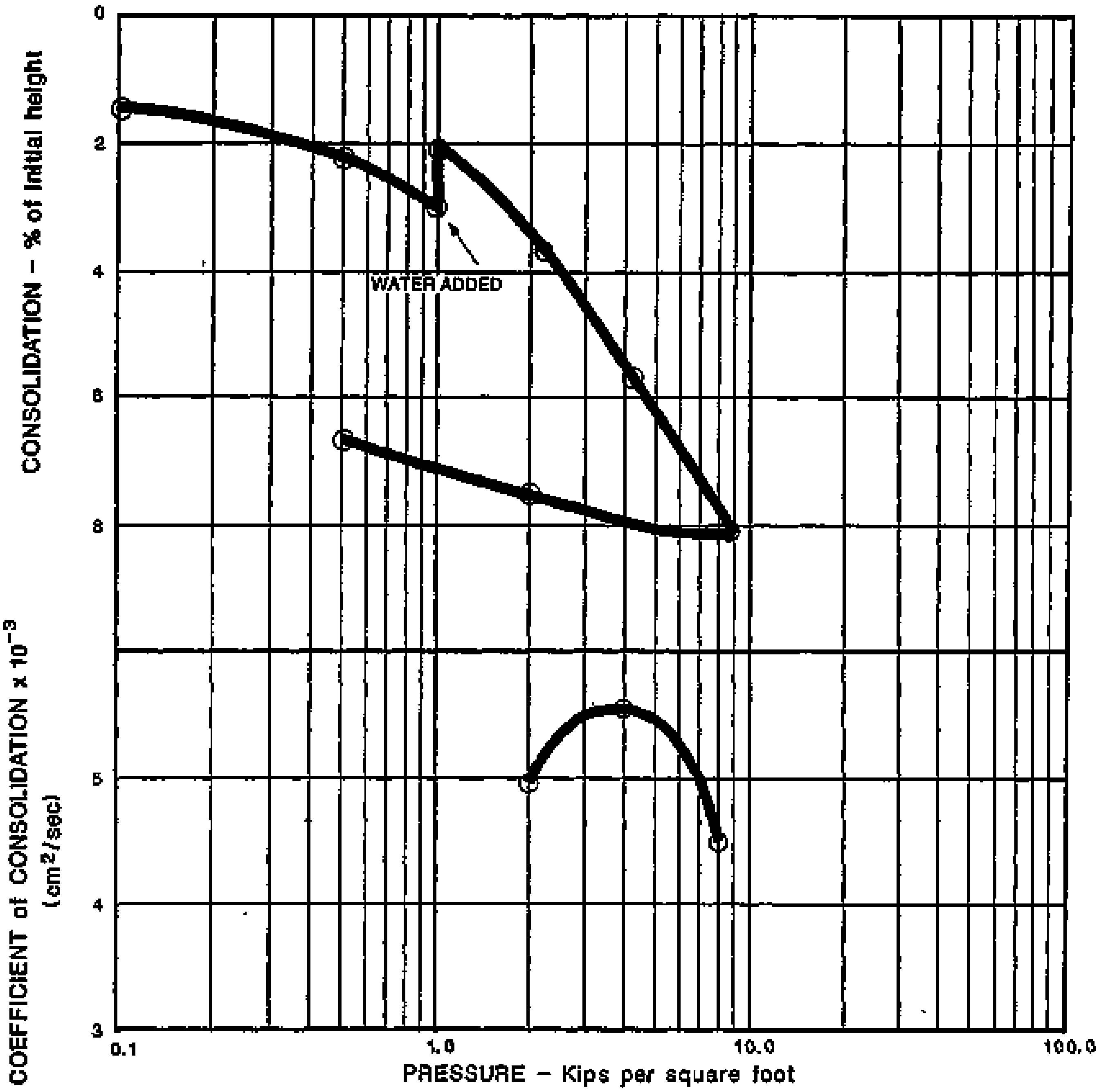


FIGURE D.5.50 CAPILLARY MOISTURE CURVE



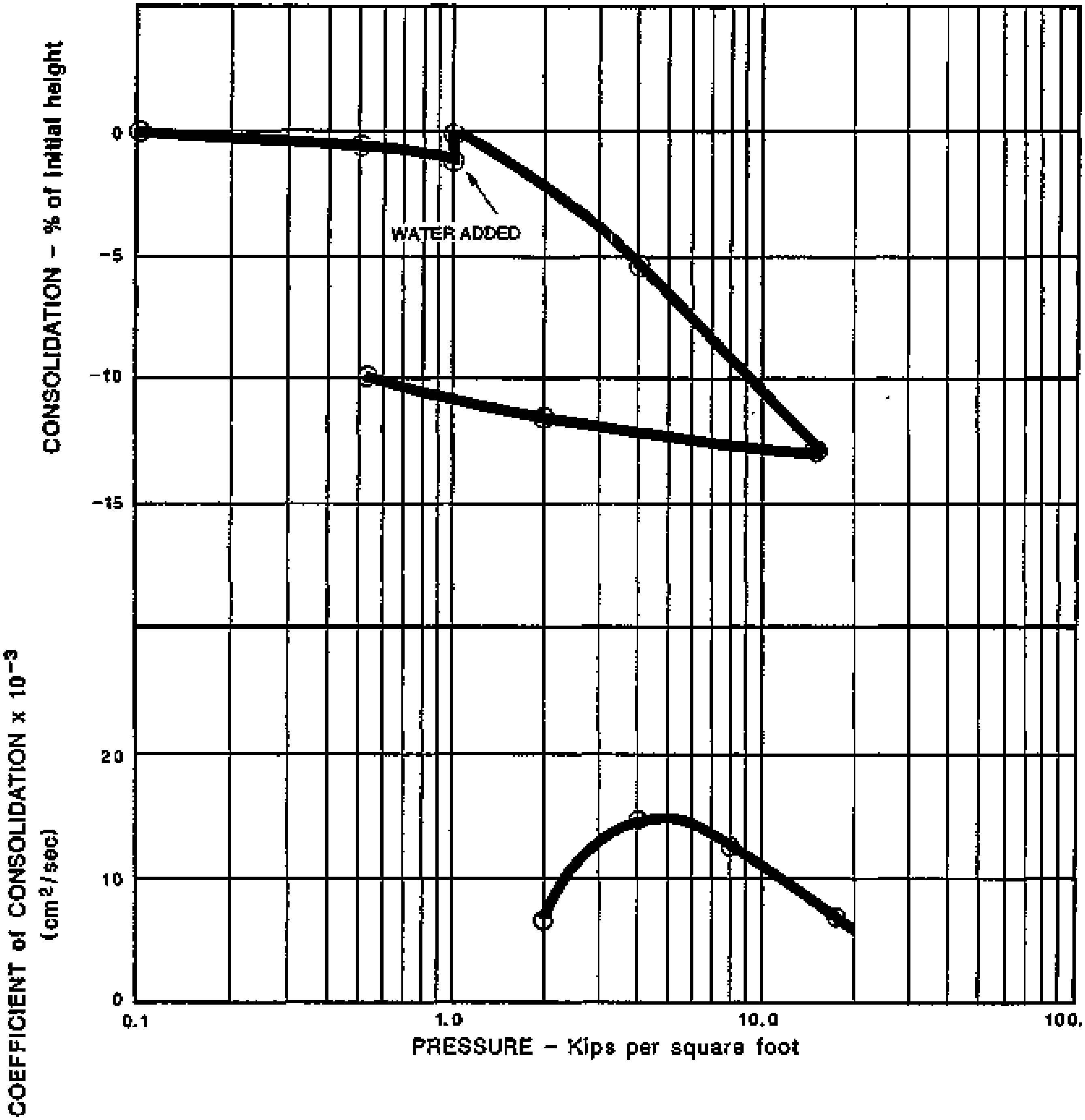
SAMPLE	DEPTH INTERVAL (FT.)	DRY DENSITY (pcf)		MOISTURE CONTENT (%)		UNIFIED SOIL CLASSIFICATION
		INITIAL	FINAL	INITIAL	FINAL	
930-03	8'-10'	104.9	115.1	16.3	17.9	LEAN CLAY WITH SAND (CL)

FIGURE D.5.51
SUMMARY OF CONSOLIDATION TESTS



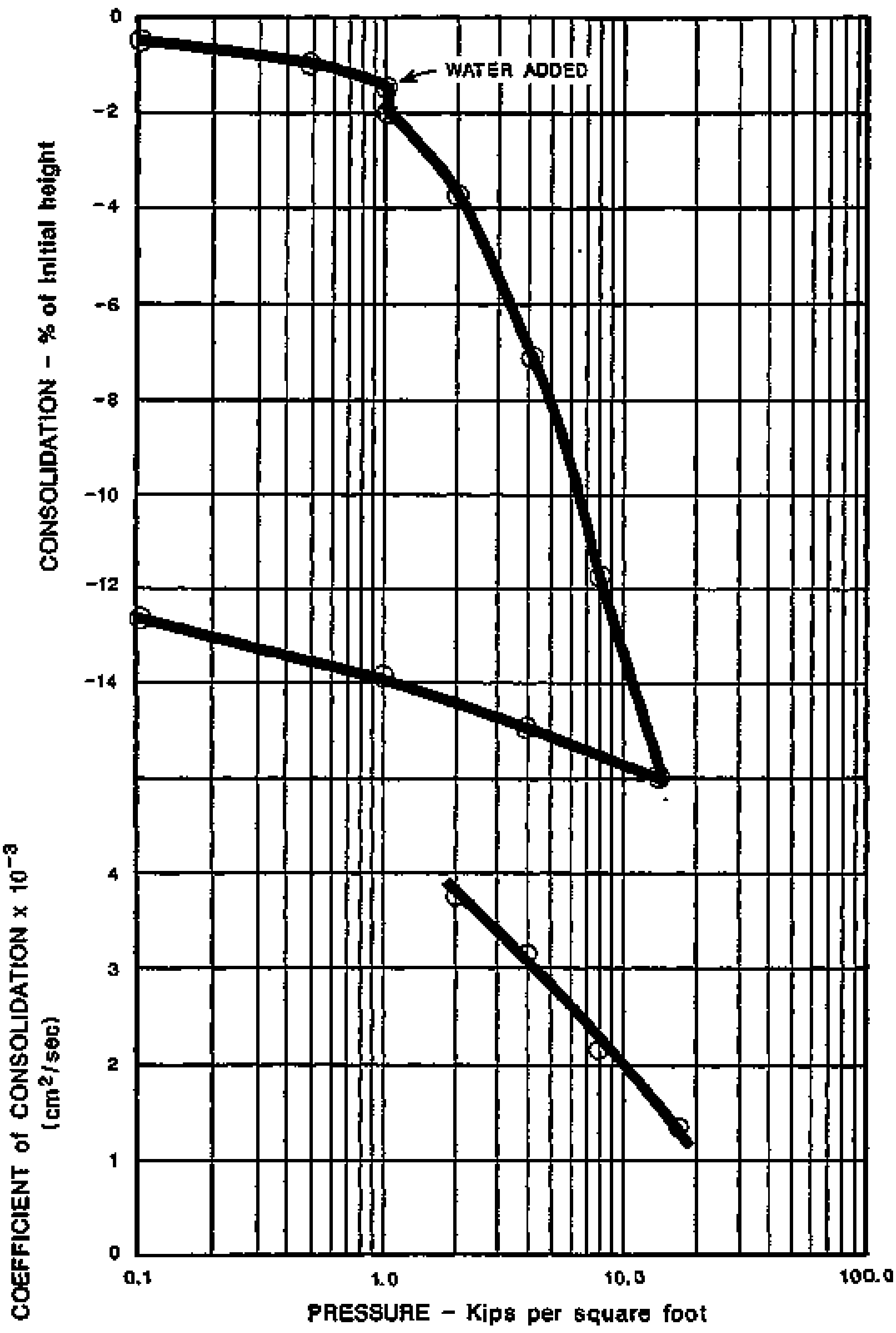
SAMPLE	DEPTH INTERVAL (FT.)	DRY DENSITY (pcf)		MOISTURE CONTENT (%)		UNIFIED SOIL CLASSIFICATION
		INITIAL	FINAL	INITIAL	FINAL	
932-02	4.5'-5.5'	107.0	114.6	15.1	16.8	SANDY LEAN CLAY (CL)

FIGURE D.5.52
SUMMARY OF CONSOLIDATION TESTS



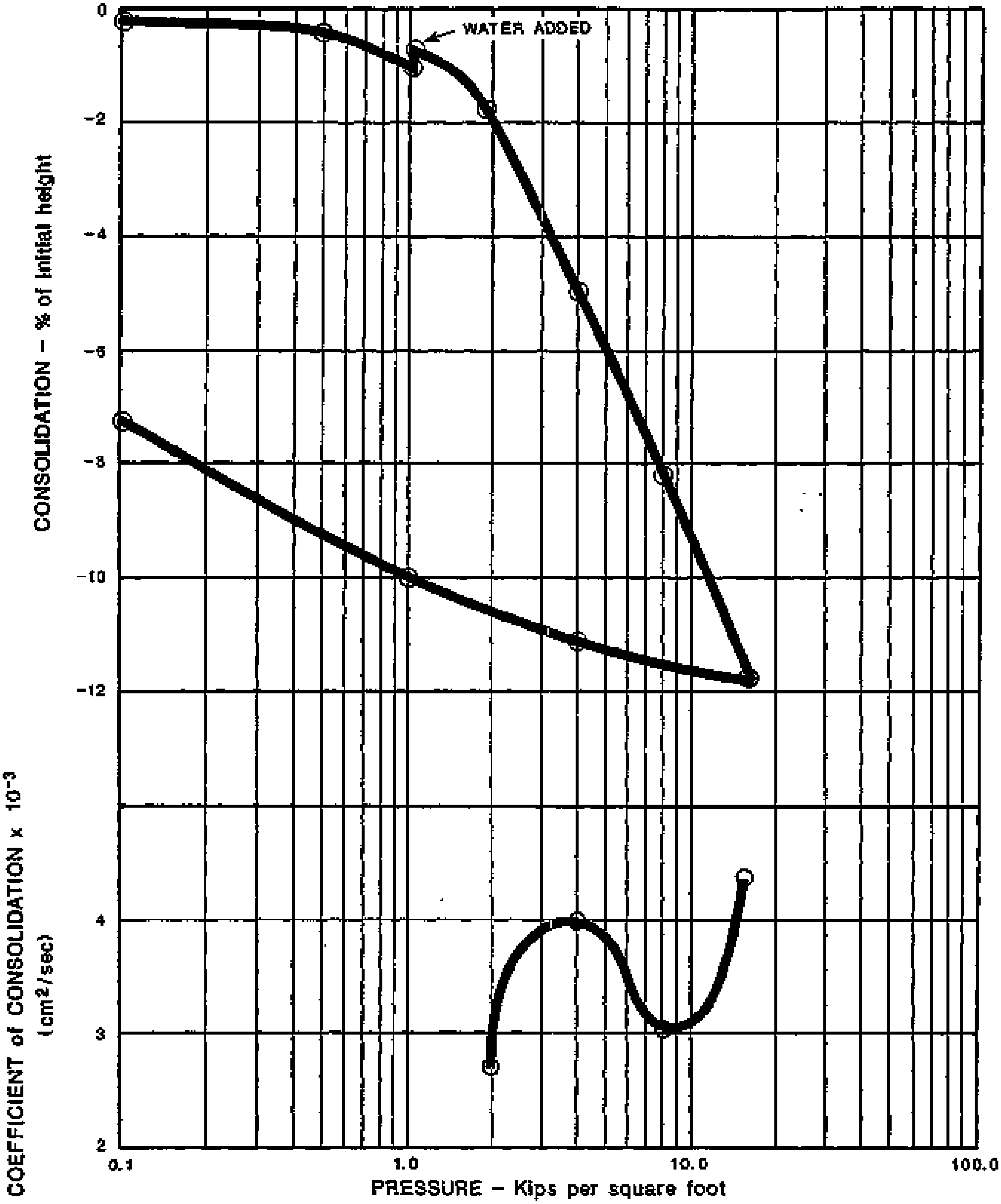
SAMPLE	DEPTH INTERVAL (FT.)	DRY DENSITY (pcf)		MOISTURE CONTENT (%)		UNIFIED SOIL CLASSIFICATION
		INITIAL	FINAL	INITIAL	FINAL	
936-02	4'-5'	105.1	116.6	15.3	18.1	LEAN CLAY WITH SAND (CL)

FIGURE D.5.53
SUMMARY OF CONSOLIDATION TESTS



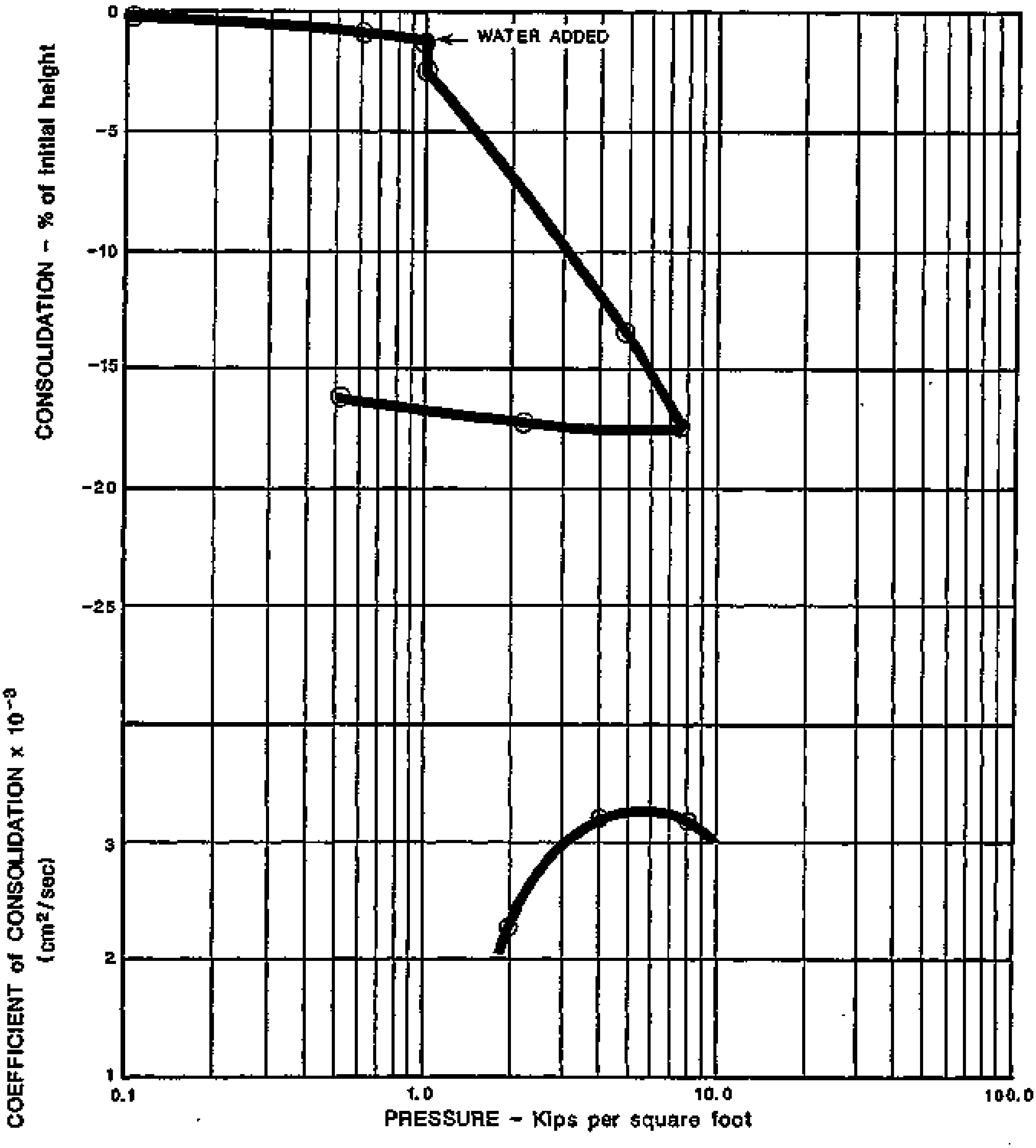
SAMPLE	DEPTH INTERVAL (FT.)	DRY DENSITY (pcf)		MOISTURE CONTENT (%)		UNIFIED SOIL CLASSIFICATION
		INITIAL	FINAL	INITIAL	FINAL	
937-02	5'-6'	98.1	112.4	19.5	20.4	LEAN CLAY (CL)

FIGURE D.5.54
SUMMARY OF CONSOLIDATION TESTS



SAMPLE	DEPTH INTERVAL (FT.)	DRY DENSITY (pcf)		MOISTURE CONTENT (%)		UNIFIED SOIL CLASSIFICATION
		INITIAL	FINAL	INITIAL	FINAL	
938-02	6'-7'	108.8	117.5	14.0	18.0	SANDY LEAN CLAY (CL)

FIGURE D.5.55
SUMMARY OF CONSOLIDATION TESTS



SAMPLE	DEPTH INTERVAL (FT.)	DRY DENSITY (pcf)		MOISTURE CONTENT (%)		UNIFIED SOIL CLASSIFICATION
		INITIAL	FINAL	INITIAL	FINAL	
963-04	6'-9'	86.4	103.7	10.5	23.9	LEAN CLAY WITH SAND (CL)

FIGURE D.5.56
SUMMARY OF CONSOLIDATION TESTS

TRIAXIAL 'R' TEST
ESTES GULCH

LOCATION ID: 990
SAMPLE ID: 09

DATE: 11/19/86
DEPTH INTERVAL(FT): 8.0 - 10.0

GROUP NAME: LEAN CLAY WITH SAND (CL)

STAGE NUMBER	INITIAL CONDITION DRY DENSITY (PCF)	INITIAL CONDITION MOISTURE CONTENT (%)	FINAL CONDITION DRY DENSITY (PCF)	FINAL CONDITION MOISTURE CONTENT (%)	PERCENT INITIAL COMPACTION	"B" PARAMETER	CONFINING PRESSURE (PSF)
1	104.7	22.1	106.6	21.0	95.4	0.95	720
2	106.6	21.0	109.6	19.4	--	--	2160
3	109.6	19.4	112.5	17.9	--	--	4320

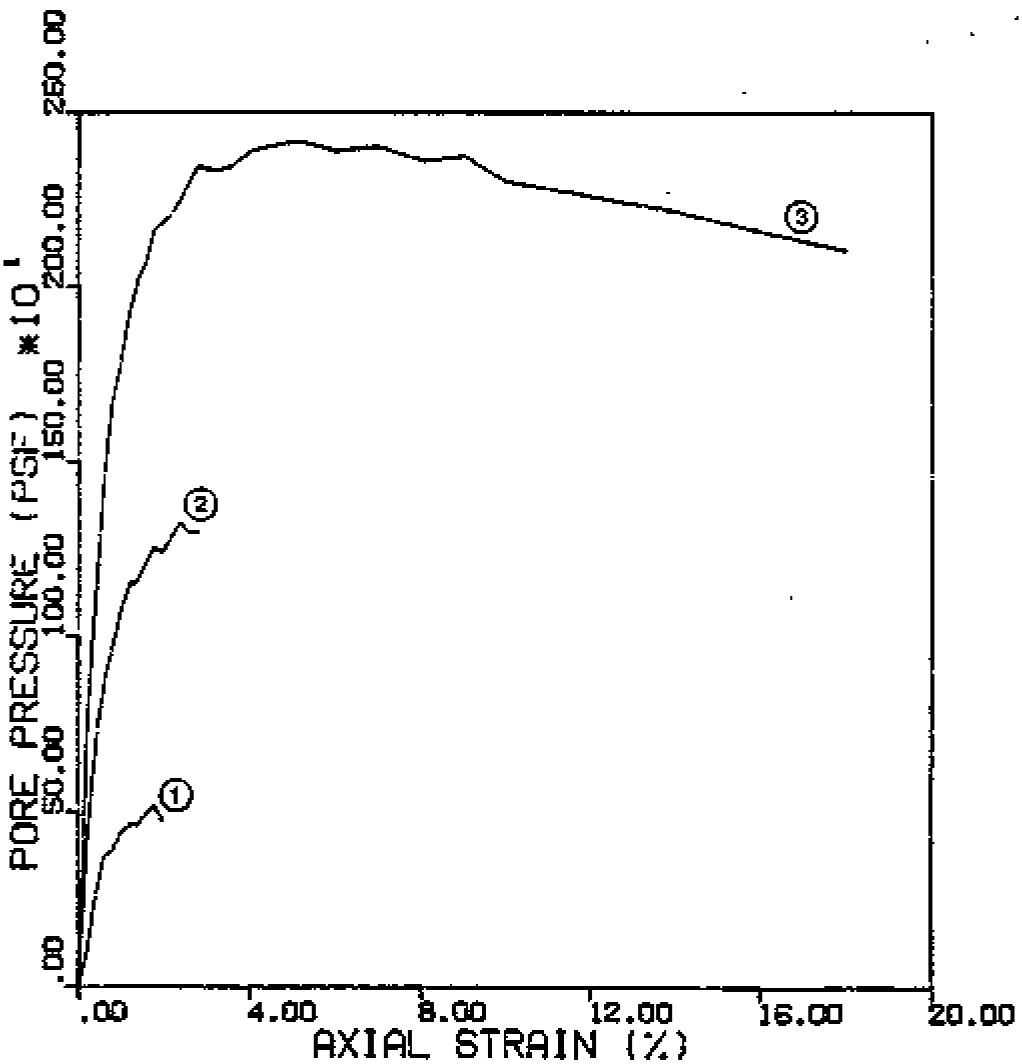


FIGURE D.5.57a TRIAXIAL SHEAR STRENGTH RESULTS

TRIAXIAL 'R' TEST
ESTES GULCH

LOCATION ID: 930
SAMPLE ID: 03

DATE: 11/13/86
DEPTH INTERVAL(FT): 9.0 - 10.0

CELL CONFINING PRESSURE(PSF)

STAGE 1: 720.
STAGE 2: 2160.
STAGE 3: 4320.

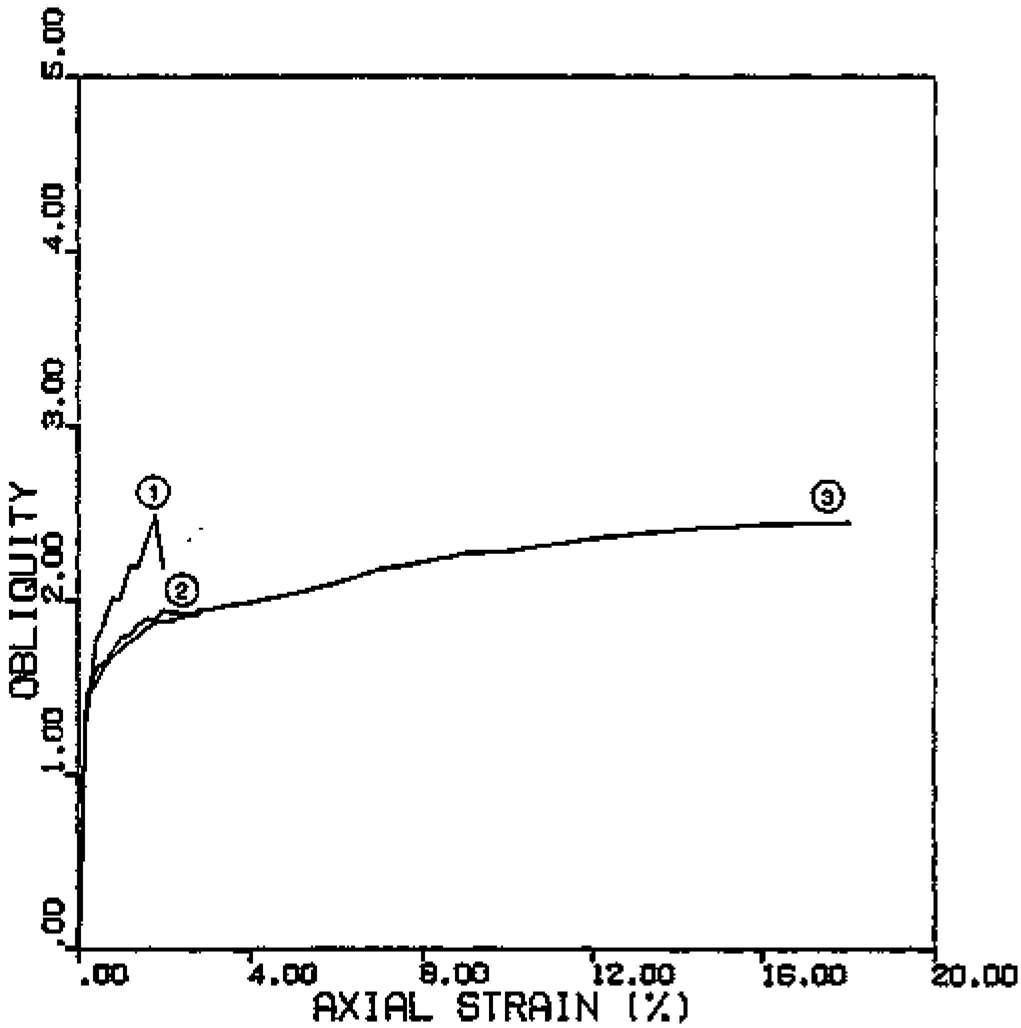


FIGURE D.5.57b TRIAXIAL SHEAR STRENGTH RESULTS

TRIAXIAL 'R' TEST

ESTES GULCH

LOCATION ID: 880
SAMPLE ID: 09

DATE: 11/19/88
DEPTH INTERVAL(FT): 8.0 - 10.0

CELL CONFINING PRESSURE(PSF)

STAGE 1: 720.
STAGE 2: 2160.
STAGE 3: 4320.

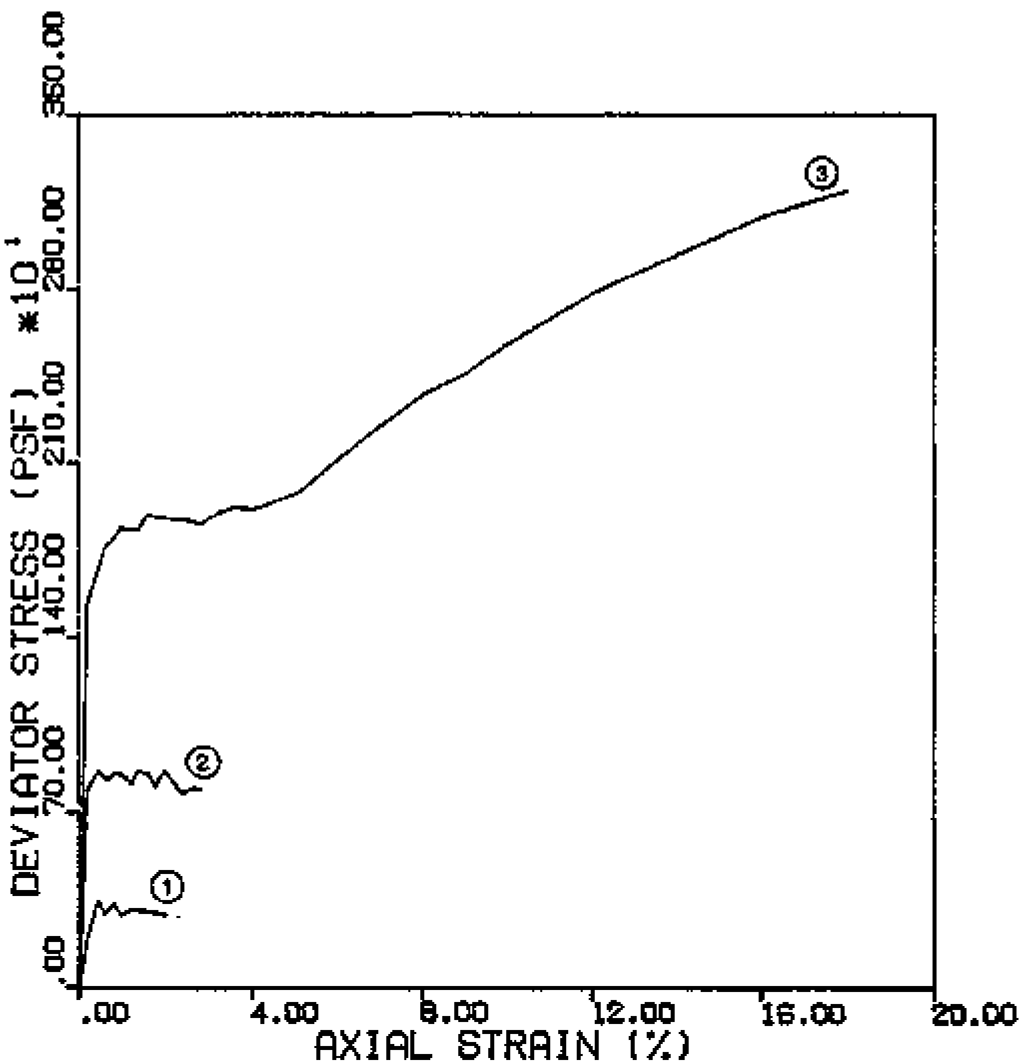


FIGURE D.5.57c TRIAXIAL SHEAR STRENGTH RESULTS

TRIAXIAL 'R' TEST

ESTES GULCH

LOCATION ID: 980

SAMPLE ID: 03

DEPTH INTERVAL(FT): 8.0 - 10.0

DATE: 11/19/86

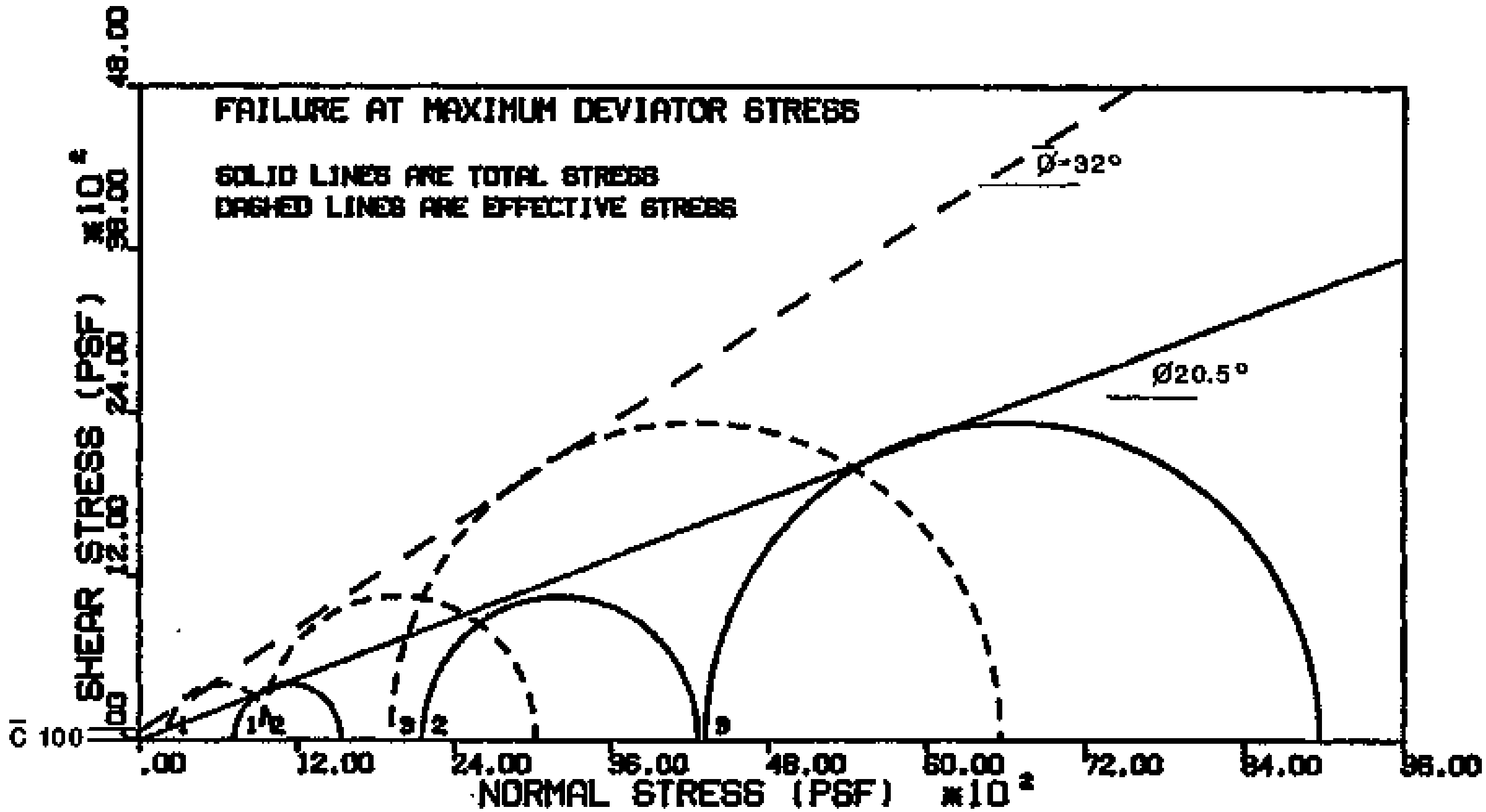


FIGURE D.6.57d TRIAXIAL SHEAR STRENGTH RESULTS

TRIAXIAL 'R' TEST

ESTES GULCH

LOCATION ID: 992
SAMPLE ID: 02

DATE: 11/12/86
DEPTH INTERVAL(FT): 4.5 – 5.5

GROUP NAME: SANDY LEAN CLAY (CL)

STAGE NUMBER	INITIAL CONDITION		FINAL CONDITION		PERCENT INITIAL COMPACTION	'B' PARAMETER	CONFINING PRESSURE (PSF)
	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	MOISTURE CONTENT (%)			
1	107.6	22.5	110.3	21.0	95.5	0.95	720
2	110.3	21.0	113.4	19.5	--	--	2088
3	113.4	19.5	116.6	18.0	--	--	4320

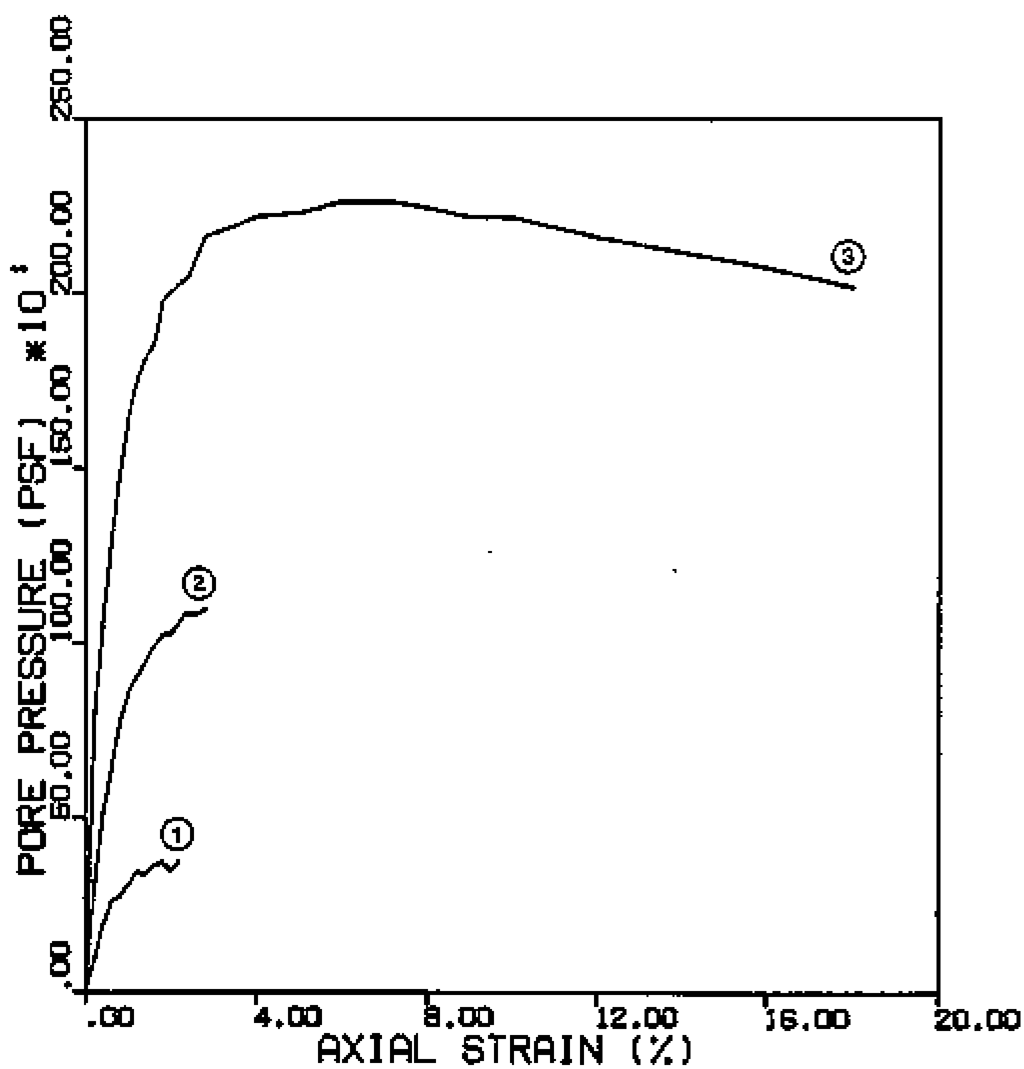


FIGURE D.5.58a TRIAXIAL SHEAR STRENGTH RESULTS

TRIAXIAL 'R' TEST

ESTES GULCH

LOCATION ID: 592
SAMPLE ID: 02

DATE: 11/19/86
DEPTH INTERVAL(FT): 4.5 - 5.5

CELL CONFINING PRESSURE(PSF)

STAGE 1: 720.
STAGE 2: 2088.
STAGE 3: 4920.

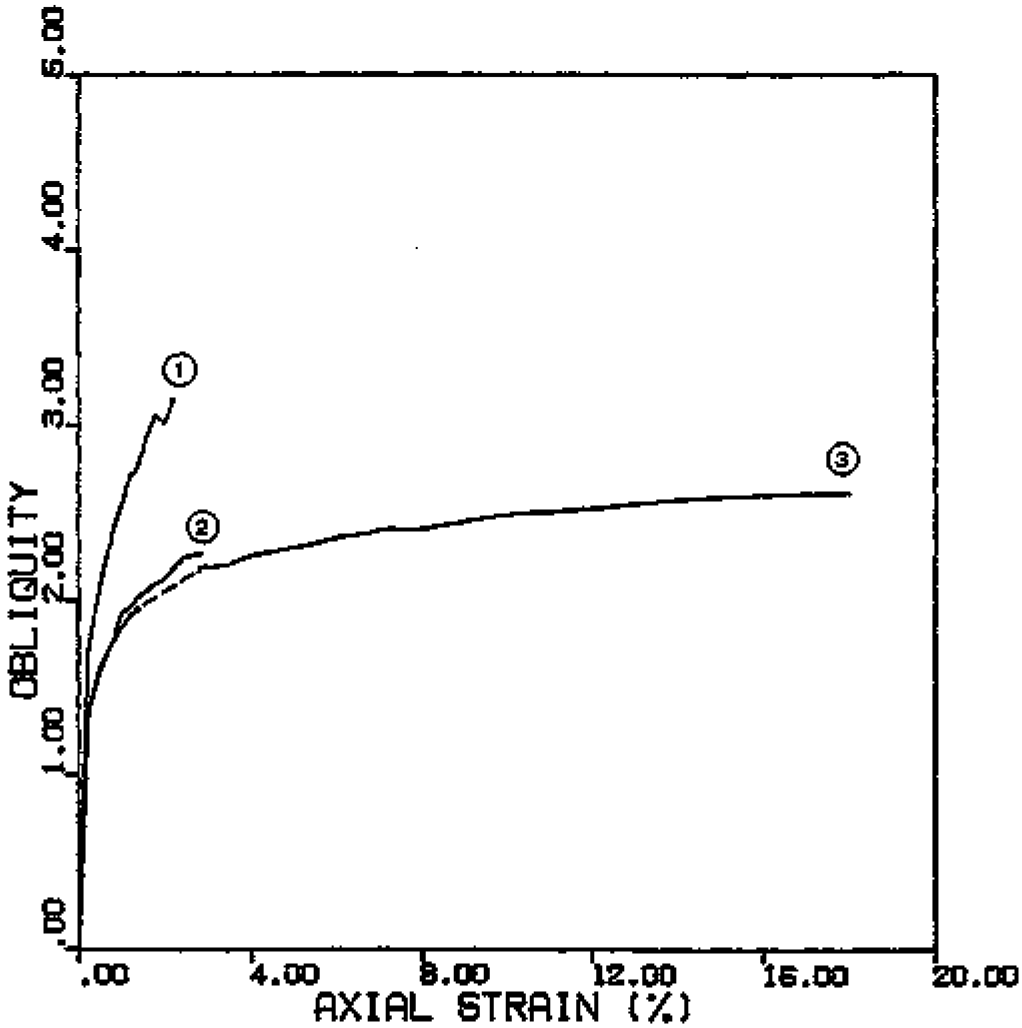


FIGURE D.5.58b TRIAXIAL SHEAR STRENGTH RESULTS

TRIAXIAL 'R' TEST
ESTES GULCH

LOCATION ID: 592
SAMPLE ID: 02

DATE: 11/13/86
DEPTH INTERVAL(FT): 4.5 - 6.5

CELL CONFINING PRESSURE(PSF)

STAGE 1: 720.
STAGE 2: 2088.
STAGE 3: 4320.

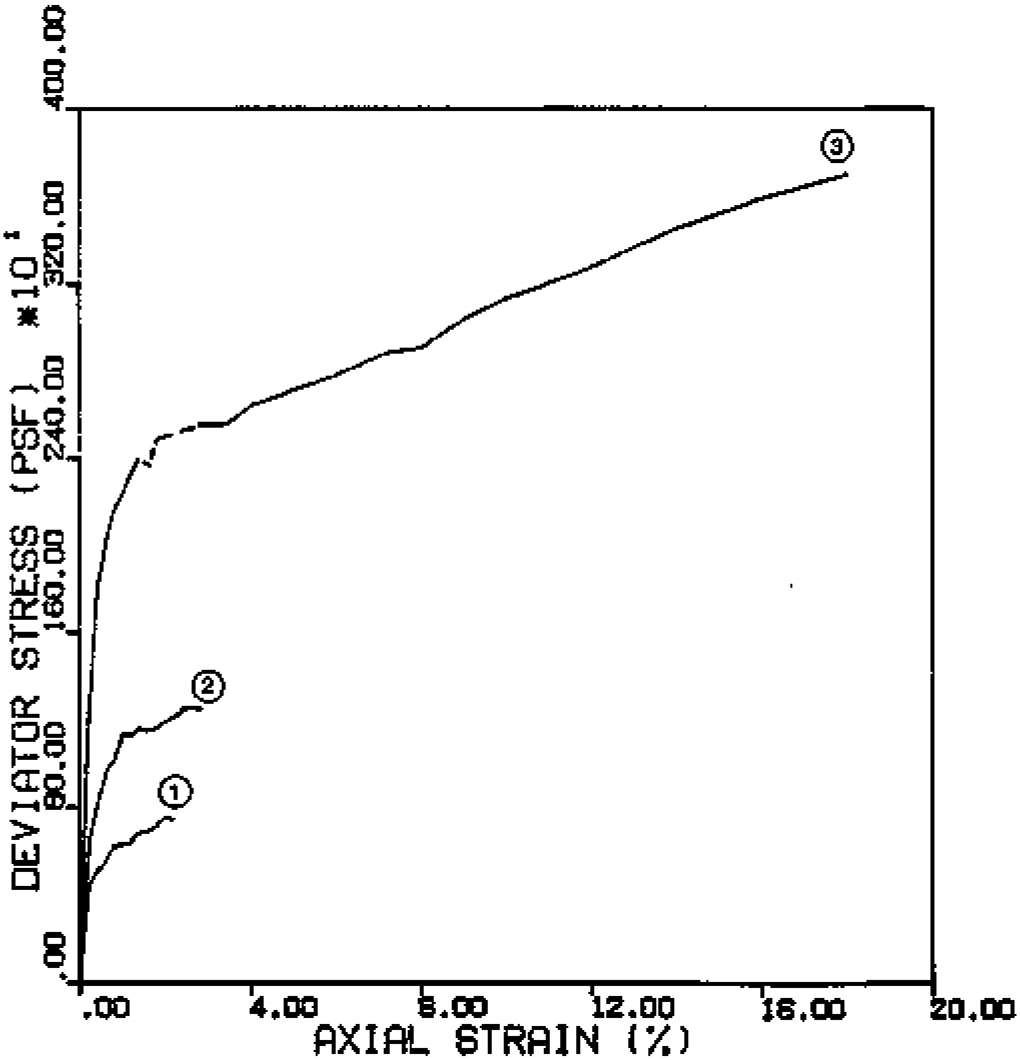


FIGURE D.5.58c TRIAXIAL SHEAR STRENGTH RESULTS

TRIAXIAL 'R' TEST
ESTES GULCH

LOCATION ID: SS2 | DEPTH INTERVAL(FT): 4.5 - 5.5

SAMPLE ID: 02 | DATE: 11/19/88

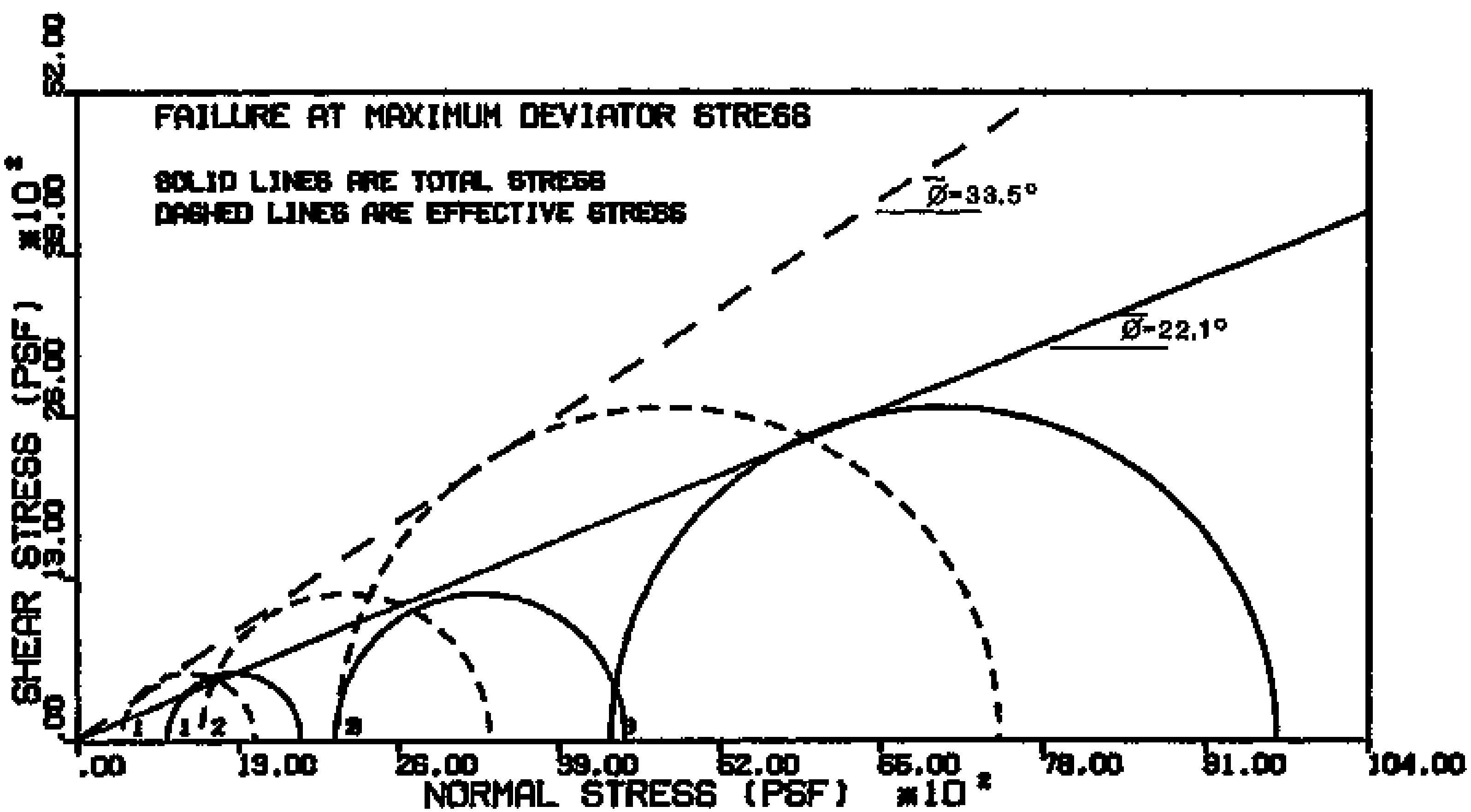


FIGURE D.5.58d TRIAXIAL SHEAR STRENGTH RESULTS

TRIAXIAL 'R' TEST

ESTES GULCH

LOCATION ID: 898
SAMPLE ID: 02

DATE: 11/18/88
DEPTH INTERVAL(FT): 6.0 - 7.0

GROUP NAME: SANDY LEAN CLAY (CL)

STAGE N NUMBER	INITIAL CONDITION		FINAL CONDITION		PERCENT INITIAL COMPACTION	'B' PARAMETER	CONFINING PRESSURE (PSF)
	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	MOISTURE CONTENT (%)			
1	108.7	22.3	111.4	22.3	95.3	0.95	677
2	111.4	20.9	115.1	19.1	--	--	2174
3	115.1	19.1	118.2	17.7	--	--	4277

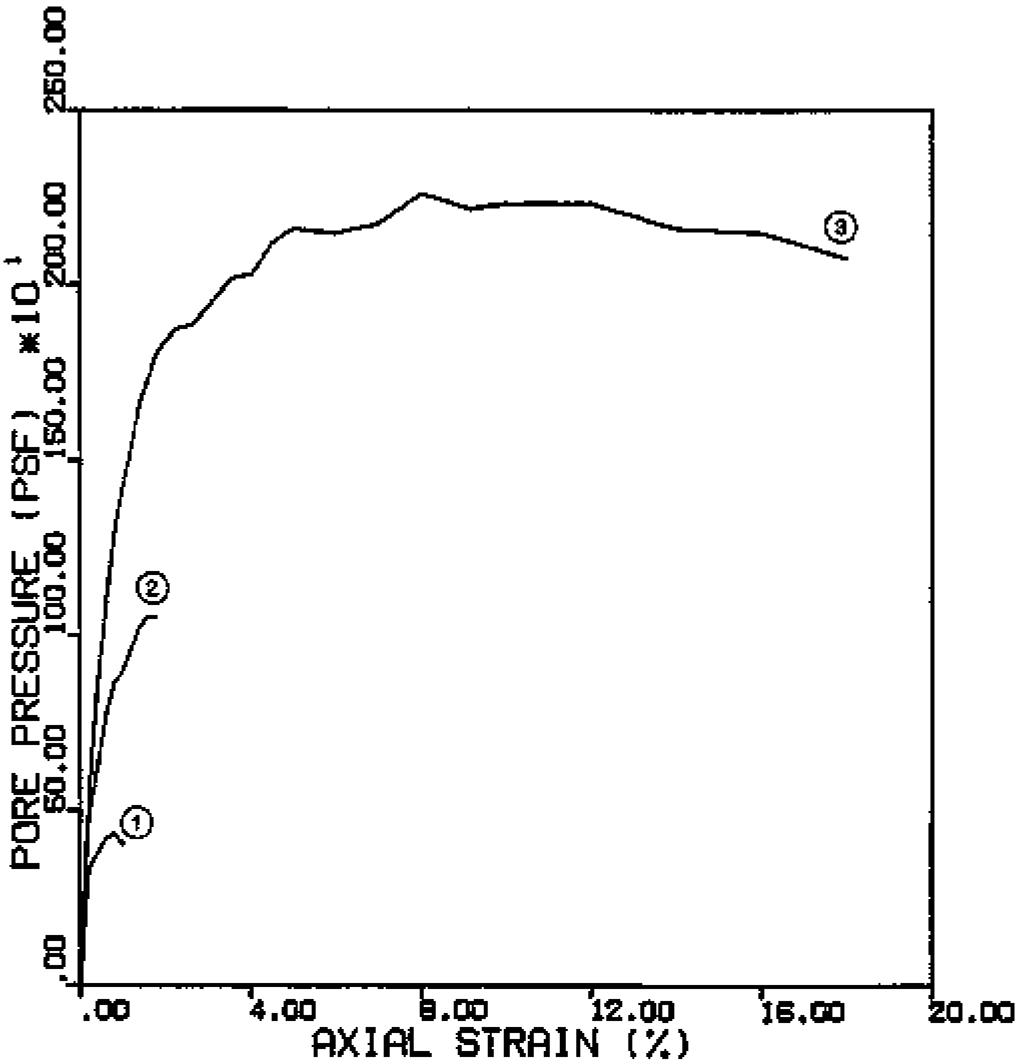


FIGURE D.5.59a TRIAXIAL SHEAR STRENGTH RESULTS

TRIAXIAL 'R' TEST

ESTES GULCH

LOCATION ID: 398 DATE: 11/19/86
SAMPLE ID: 02 DEPTH INTERVAL(FT): 6.0 - 7.0

CELL CONFINING PRESSURE(PSF)

STAGE 1: 677.
STAGE 2: 2174.
STAGE 3: 4277.

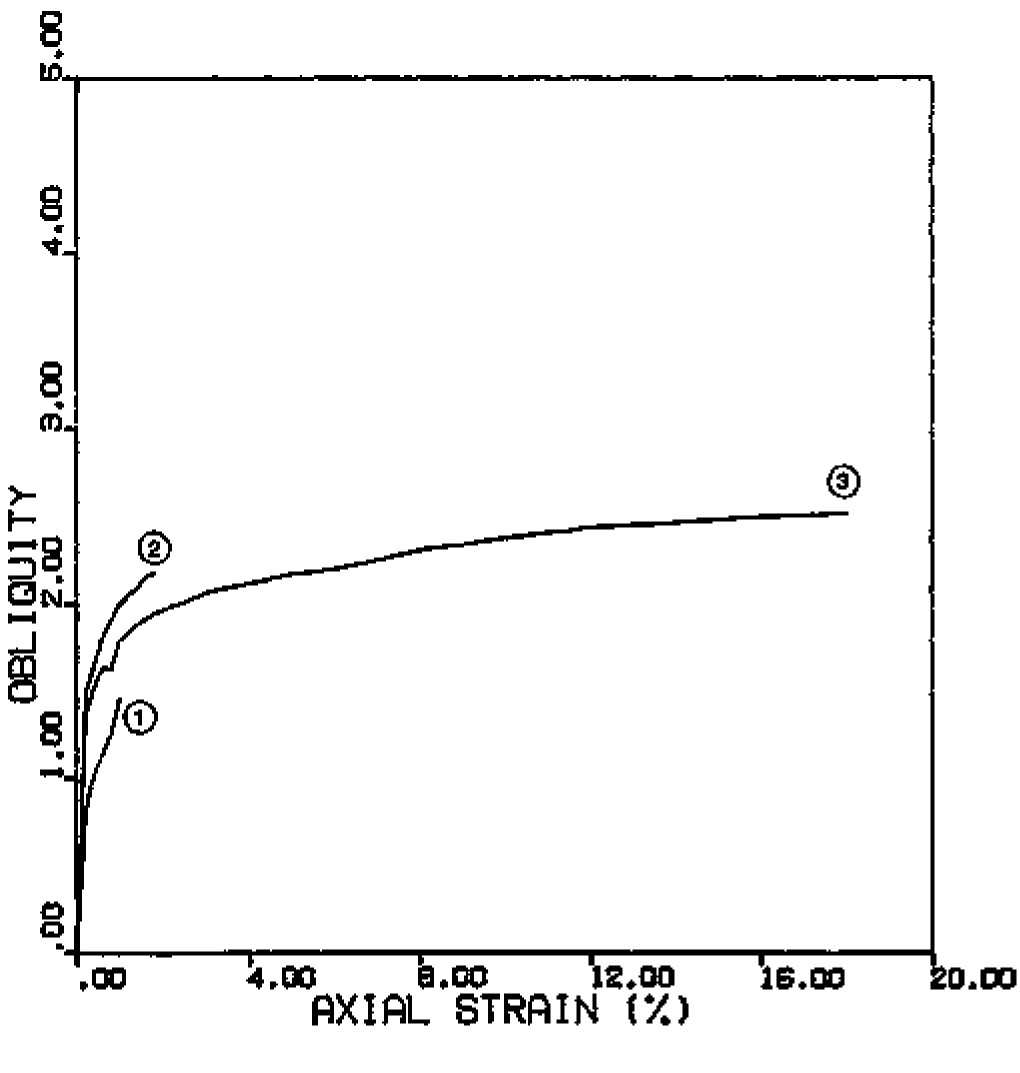


FIGURE D.5.59b TRIAXIAL SHEAR STRENGTH RESULTS

TRIAXIAL 'R' TEST

ESTES GULCH

LOCATION ID: 938
SAMPLE ID: 02

DATE: 11/19/86
DEPTH INTERVAL(FT): 6.0 - 7.0

CELL CONFINING PRESSURE(PSF)

STAGE 1: 677.
STAGE 2: 2174.
STAGE 3: 4277.

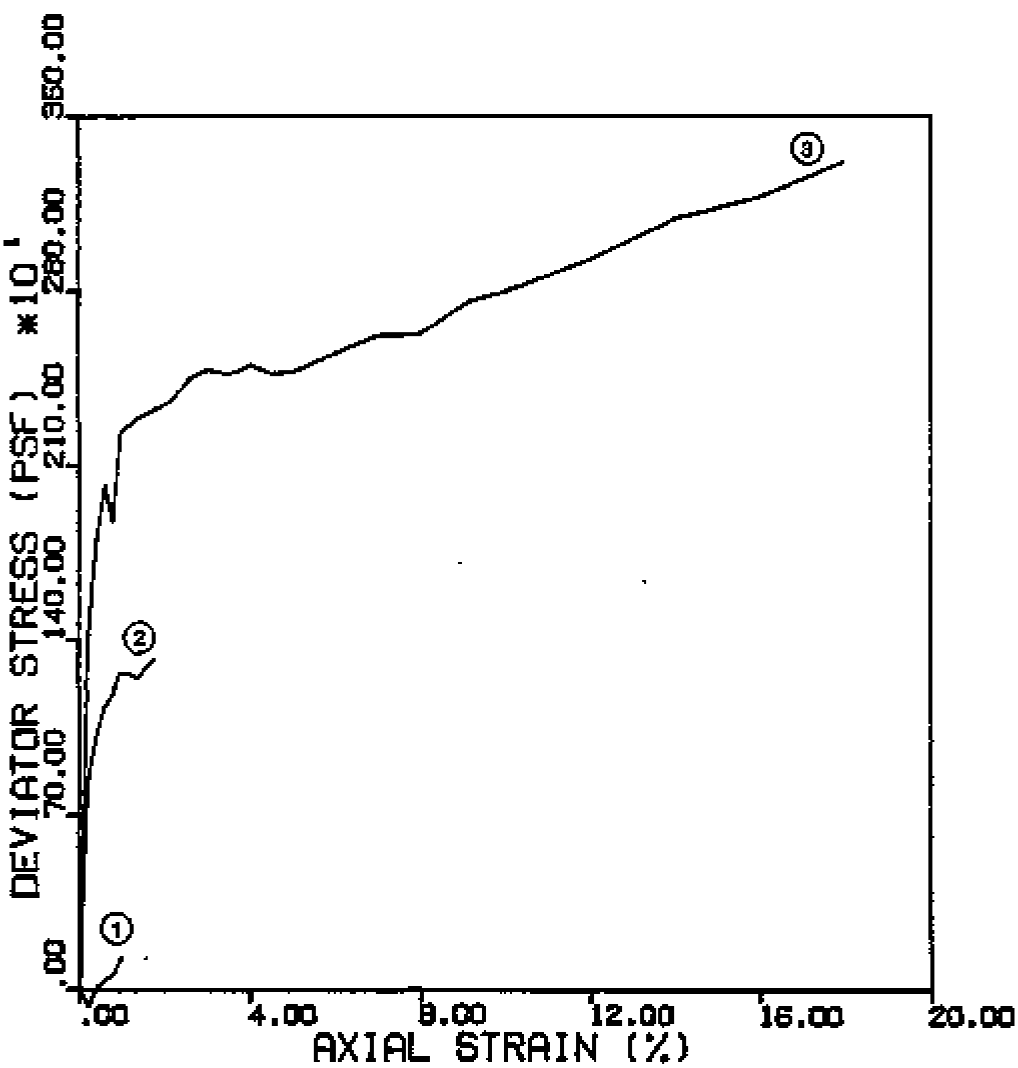


FIGURE D.5.59c TRIAXIAL SHEAR STRENGTH RESULTS

TRIAXIAL 'R' TEST

ESTES GULCH

LOCATION ID: 898

SAMPLE ID: 02

DEPTH INTERVAL(FT): 6.0 - 7.0

DATE: 11/18/86

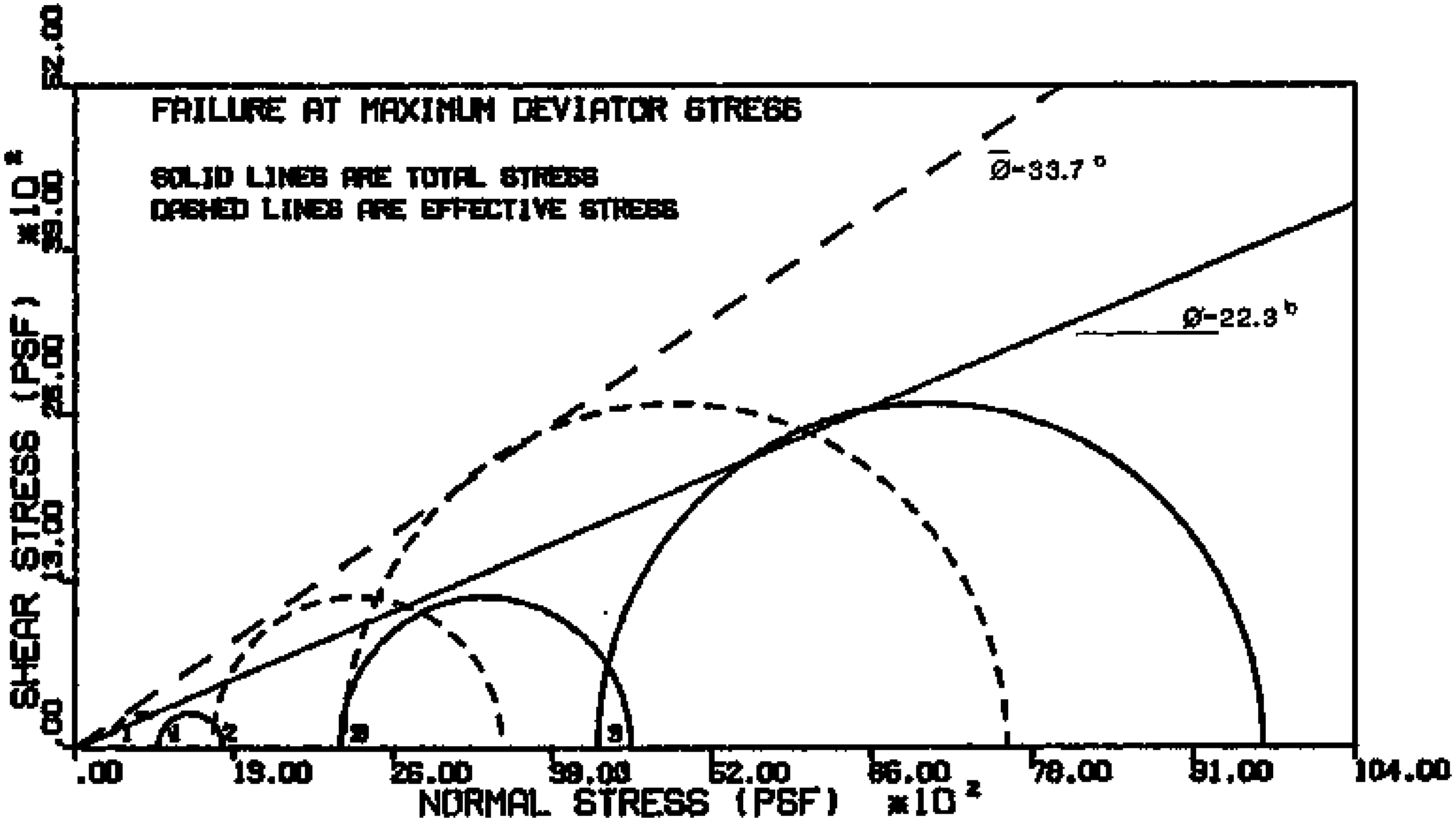


FIGURE D.5.59d TRIAXIAL SHEAR STRENGTH RESULTS

TRIAXIAL 'Q' TEST
ESTES GULCH

LOCATION ID: 9SZ
SAMPLE ID: 2C

DATE: 11/12/86
DEPTH INTERVAL(FT): 4.5 - 5.5

GROUP NAME: SANDY LEAN CLAY (CL)

STAGE N NUMBER	INITIAL CONDITION		FINAL CONDITION		PERCENT INITIAL COMPACTION	"B" PARAMETER	CONFINING PRESSURE (PSF)
	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	MOISTURE CONTENT (%)			
1	107.1	14.4	--	--	95.0	--	720
2	107.1	14.6	--	--	95.0	--	2160
3	107.4	14.4	--	--	95.3	--	4320

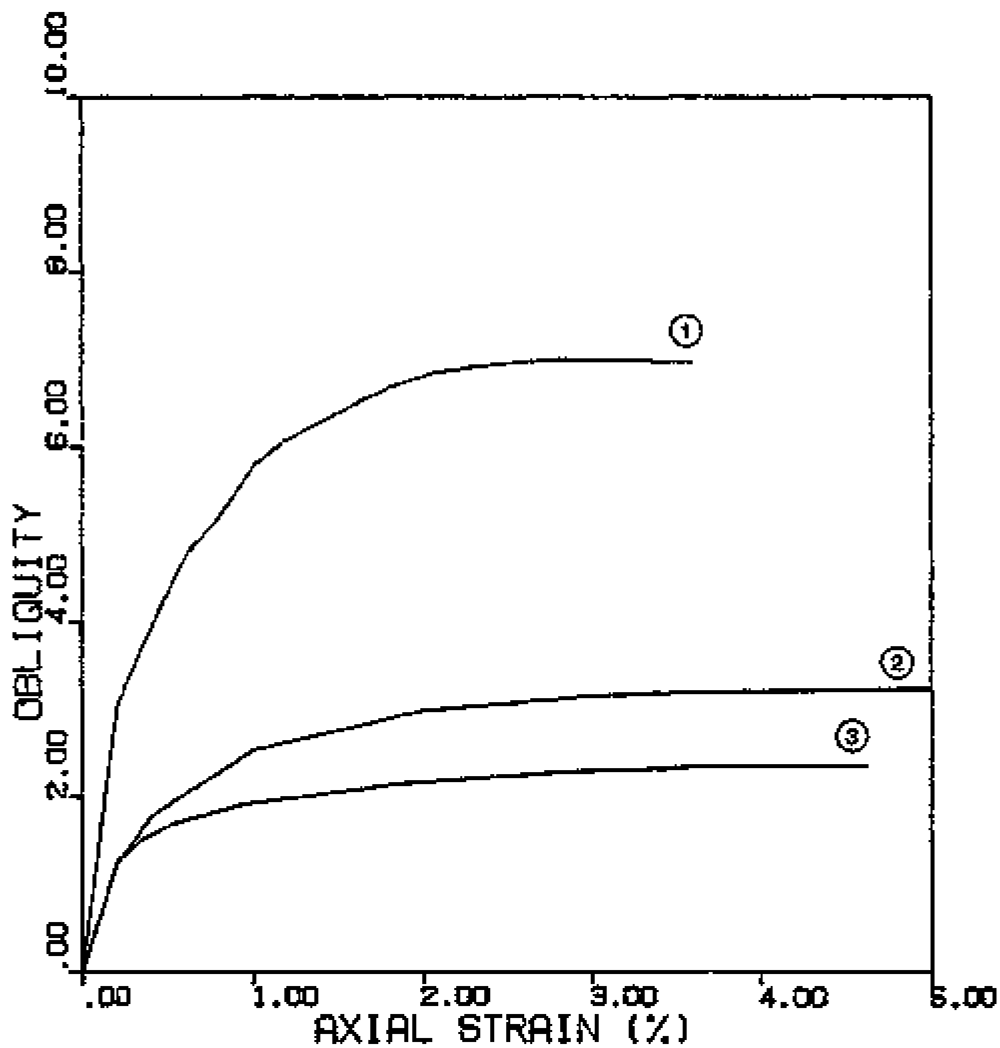


FIGURE D.5.60a TRIAXIAL SHEAR STRENGTH RESULTS

TRIAXIAL 'Q' TEST
ESTES GULCH

LOCATION ID: 832
SAMPLE ID: 2C

DATE: 11/13/86
DEPTH INTERVAL(FT): 4.5 - 5.5

CELL CONFINING PRESSURE(PSF)

TEST 1: 720.
TEST 2: 2160.
TEST 3: 4320.

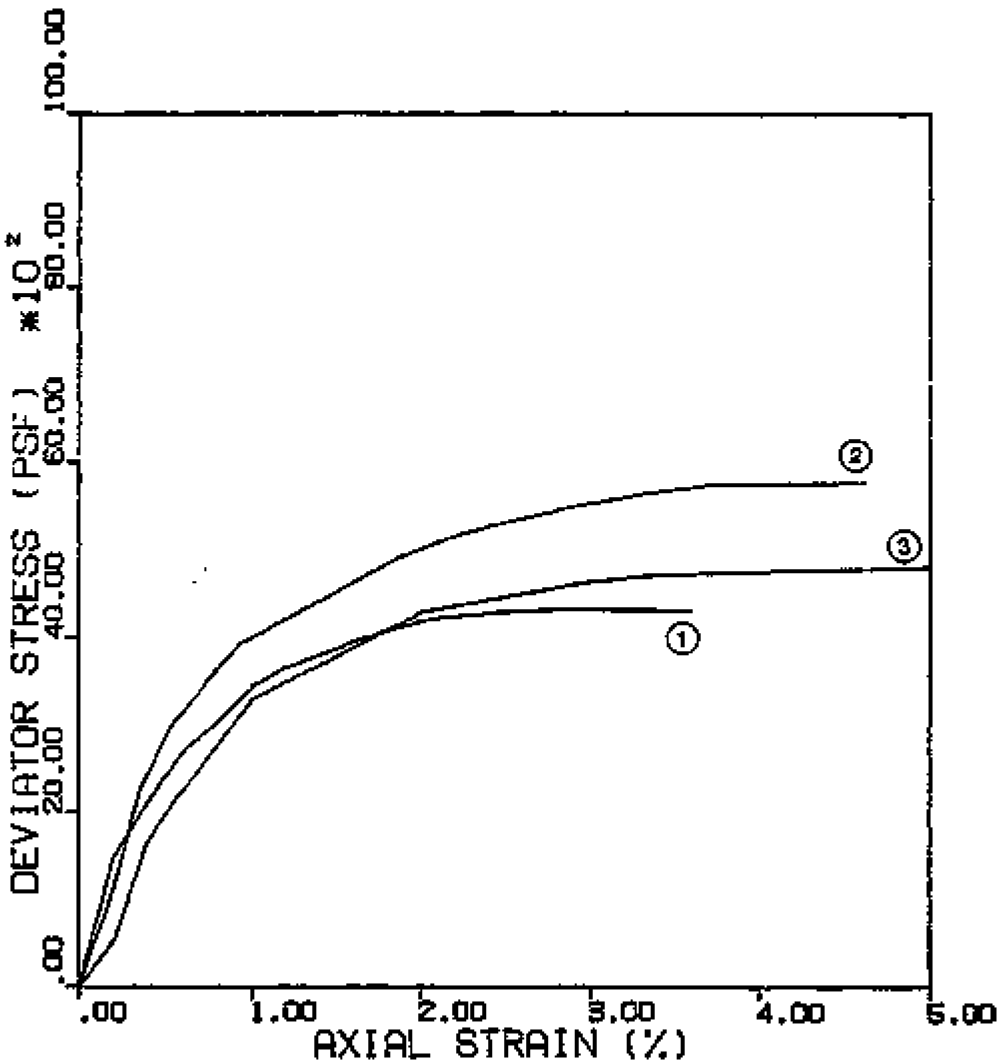


FIGURE D.5.60b TRIAXIAL SHEAR STRENGTH RESULTS

TRIAXIAL 'Q' TEST

ESTES GULCH

LOCATION ID: 932

SAMPLE ID: 2C

DEPTH INTERVAL(FT): 4.5 - 5.5

DATE: 11/19/86

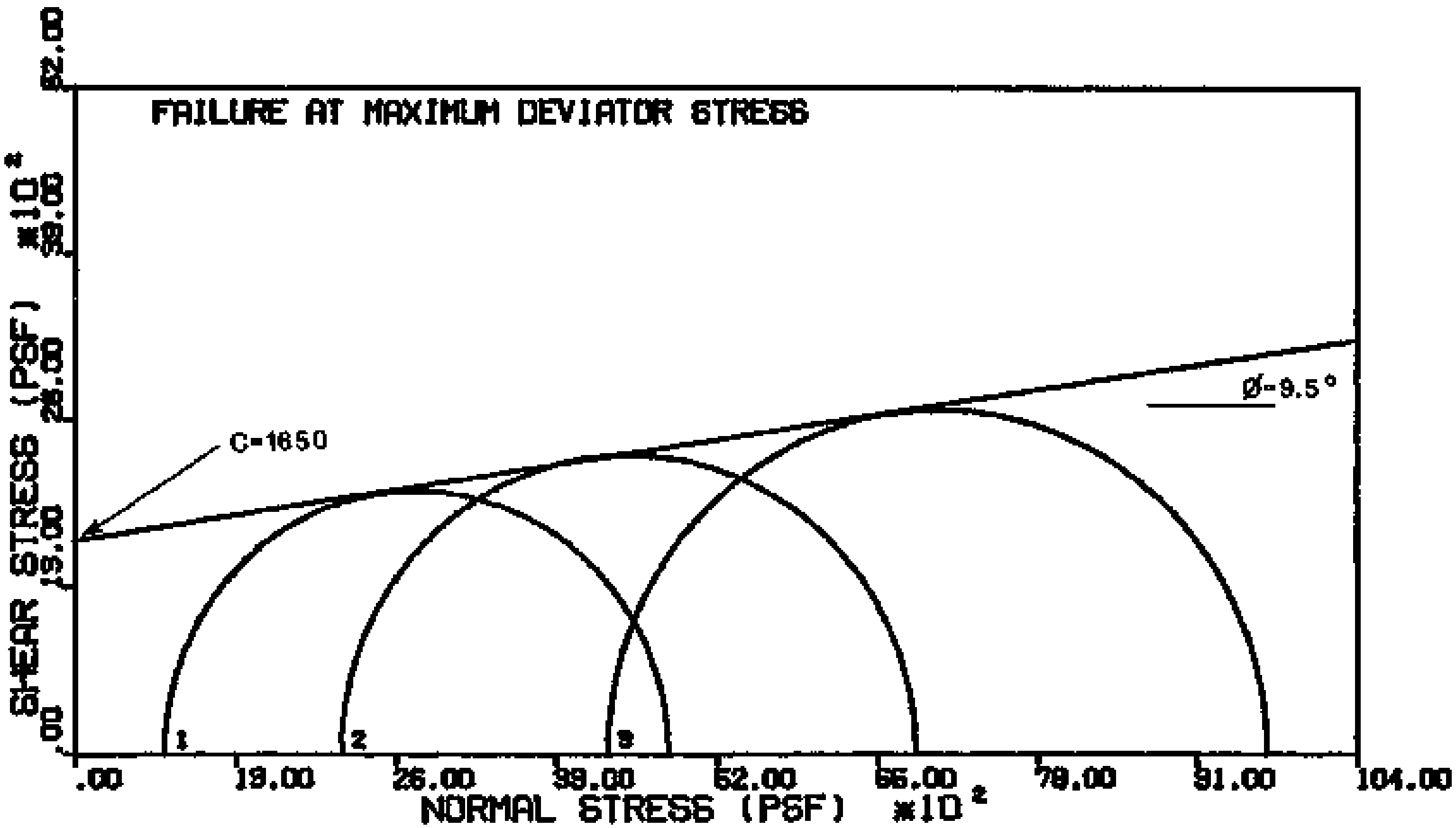


FIGURE D.5.60c TRIAXIAL SHEAR STRENGTH RESULTS

TRIAXIAL 'Q' TEST
ESTES GULCH

LOCATION ID: 998
SAMPLE ID: 2C

DATE: 11/12/86
DEPTH INTERVAL(FT): 6.0 - 7.0

GROUP NAME: SANDY LEAN CLAY (CL)

STAGE N NUMBER	INITIAL CONDITION		FINAL CONDITION		PERCENT INITIAL COMPACTION	'B' PARAMETER	CONFINING PRESSURE (PSF)
	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	MOISTURE CONTENT (%)			
1	109.7	13.7	--	--	96.1	--	720
2	108.9	13.8	--	--	95.4	--	2160
3	108.9	13.8	--	--	95.4	--	4320

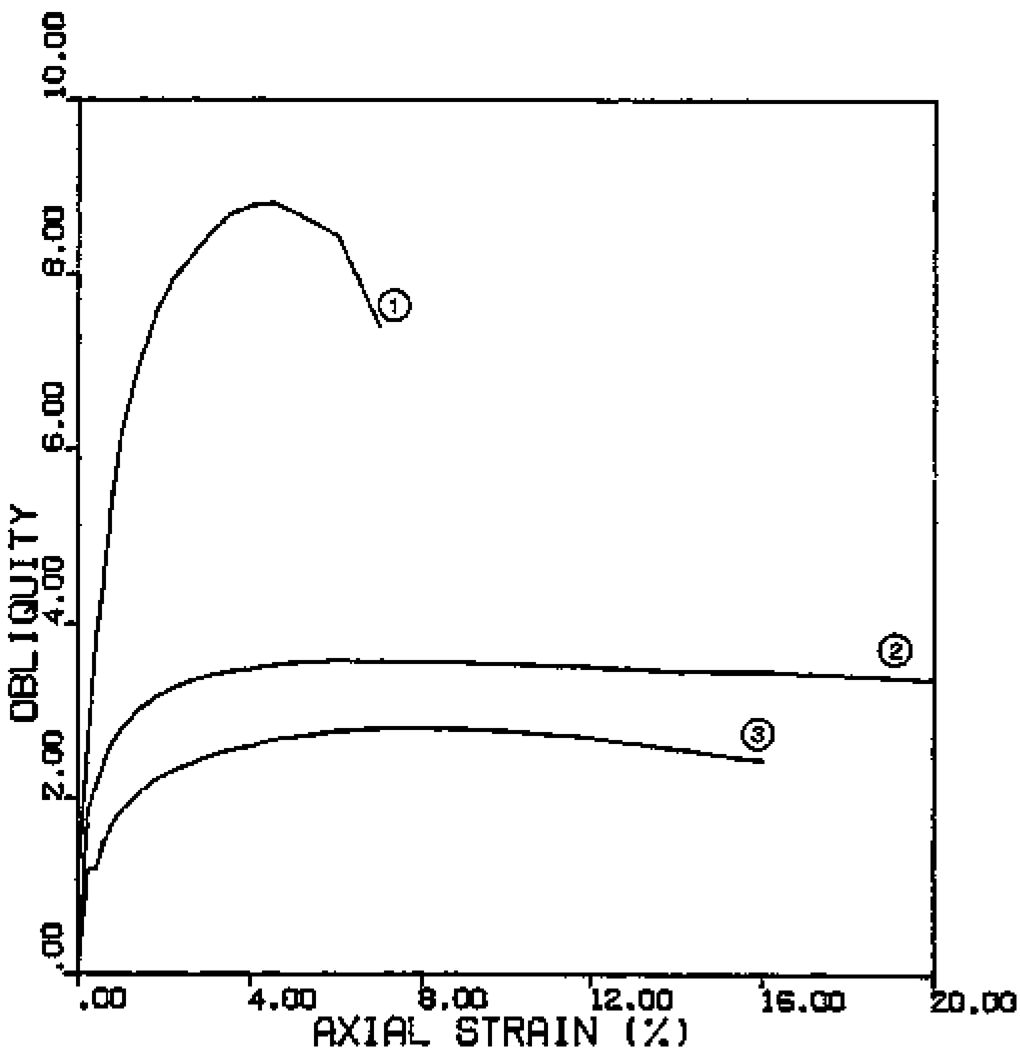


FIGURE D.5.61a TRIAXIAL SHEAR STRENGTH RESULTS

TRIAXIAL 'Q' TEST
ESTES GULCH

LOCATION ID: 998
SAMPLE ID: 2C

DATE: 11/13/86
DEPTH INTERVAL(FT): 6.0 - 7.0

CELL CONFINING PRESSURE(PSF)

TEST 1: 720.
TEST 2: 2180.
TEST 3: 4320.

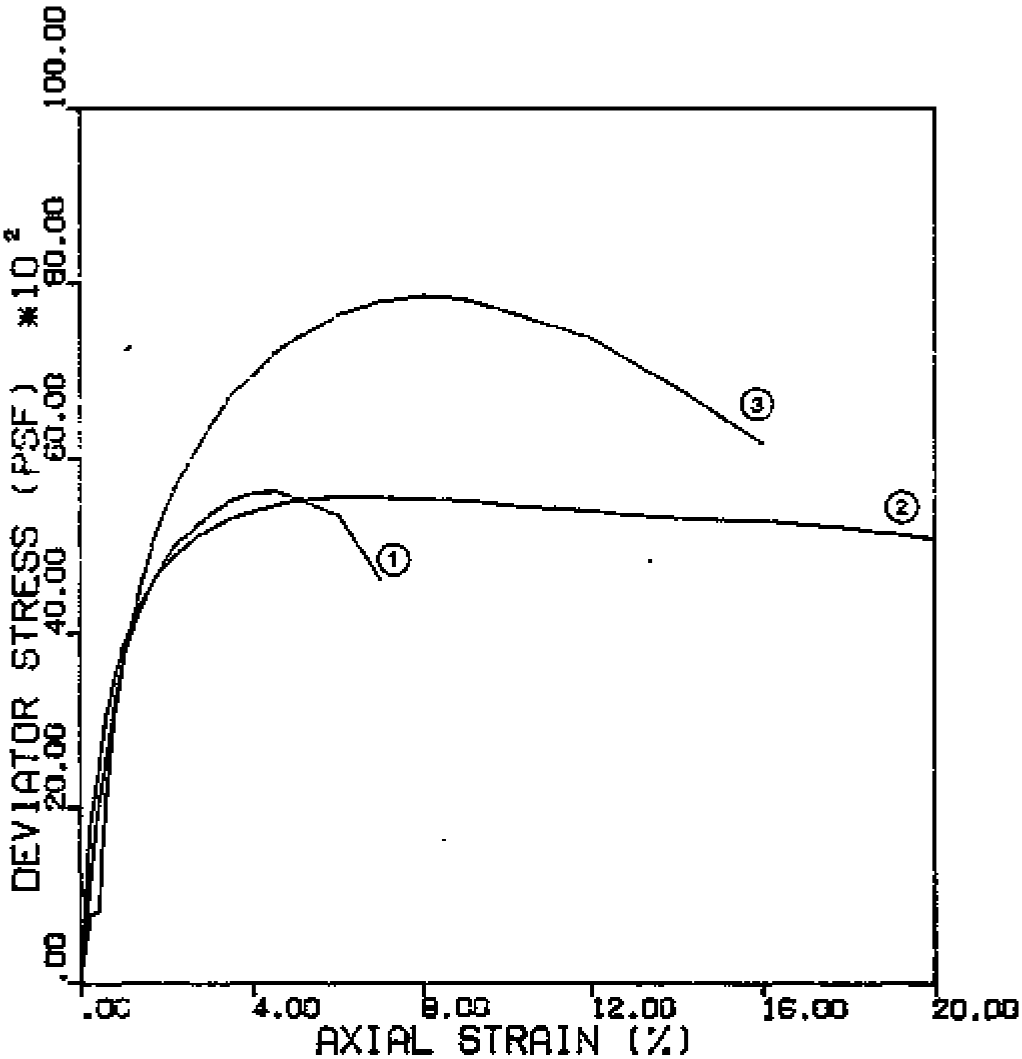


FIGURE D.5.61b TRIAXIAL SHEAR STRENGTH RESULTS

FIGURE D.5.61c TRIAXIAL SHEAR STRENGTH RESULTS

TRIAXIAL 'Q' TEST

ESTES GULCH

LOCATION ID: 998

SAMPLE ID: 2C

DEPTH INTERVAL(FT): 6.0 - 7.0

DATE: 11/19/86;

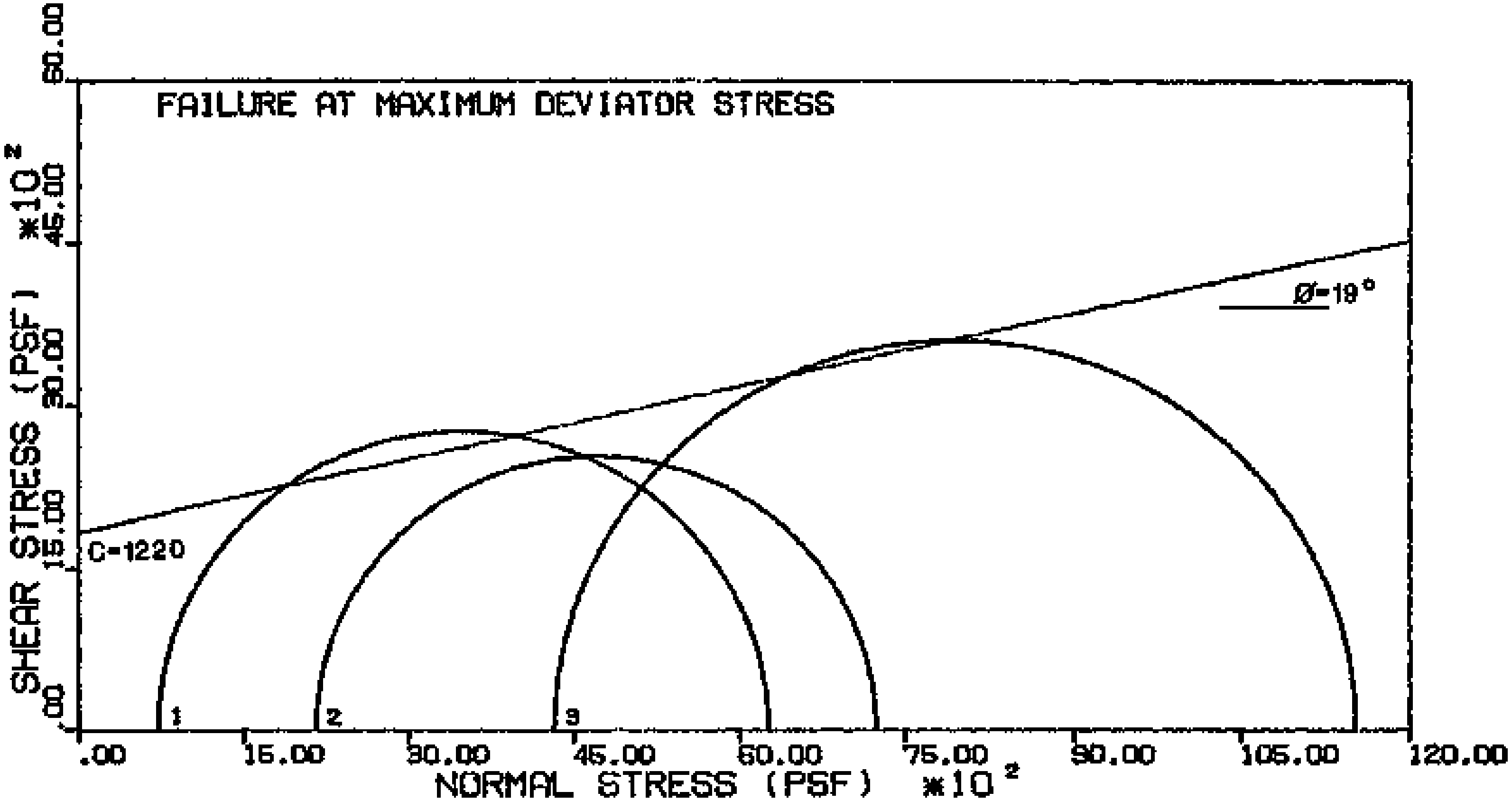


Table D.5.1 Design parameters of in situ soils

NOTE: These design parameters are superseded by the Final Design. The Final Design, Volume II, Calculations, Calc. 06-525-05-02, Geotechnical Characteristics, Sheet 4a, contains a summary of design parameters. Additional in situ and laboratory permeability tests were conducted in 1993 and 1994 for use in modelling transient drainage in the Rifle Estes Gulch disposal cell. Results of these tests and modelling to evaluate potential impacts of transient drainage on the "bathtub" effect were transmitted to NRC for evaluation and concurrence.

Table D.5.2 Design parameters for remolded (cover material) foundation soils

NOTE: These design parameters have been superseded by the Final Design. The Final Design, Volume II, Calculations, Calc. 06-525-05-02, Geotechnical Characteristics, Sheet 4a, contains a summary of design parameters.

RFL001F2.A07

Table D.5.3 Summary of mechanical soil properties for Estes Gulch site[a]

Boring or test pit	Depth interval (ft)	% GVL	% Sand	% -200	% Clay -2μ	L.L. %	P.L. %	P.I. %	Activity PI%/(% clay-5)	Specific gravity	USCS	In situ moisture content %	In situ dry density (pcf)
917-01	0-2.0	0	25	75	--	31	16	15	--	--	CL	7.9	--
	2.0-4.0	--	--	--	--	--	--	--	--	--		8.1	102.0
	4.0-6.0	--	--	--	--	--	--	--	--	--		7.6	--
-04	6.0-8.0	0	39	61	--	22	14	8	--	--	CL	6.0	--
	8.0-10.0	--	--	--	--	--	--	--	--	--		8.8	99.2
	10.0-12.0	--	--	--	--	--	--	--	--	--		8.6	--
	12.0-14.0	--	--	--	--	--	--	--	--	--		8.8	--
	14.0-16.0	--	--	--	--	--	--	--	--	--		6.9	--
-08	16.0-18.0	0	54	46	--	20	14	6	--	--	SC	5.3	--
	18.0-20.0	--	--	--	--	--	--	--	--	--		6.8	--
	20.0-22.0	--	--	--	--	--	--	--	--	--		9.0	--
	22.0-24.0	--	--	--	--	--	--	--	--	--		7.1	--
	24.0-26.0	--	--	--	--	--	--	--	--	--		6.8	--
	26.0-28.0	--	--	--	--	--	--	--	--	--		7.6	--
918	0-2.0	--	--	--	--	--	--	--	--	--		9.4	--
	2.0-4.0	--	--	--	--	--	--	--	--	--		7.2	--
	4.0-6.0	--	--	--	--	--	--	--	--	--		7.6	--
	6.0-8.0	--	--	--	--	--	--	--	--	--		9.5	--
	8.0-10.0	--	--	--	--	--	--	--	--	--		7.3	--
-06	10.0-12.0	0	25	75	--	21	16	5	--	--	CL	5.3	--
	12.0-14.0	--	--	--	--	--	--	--	--	--		12.1	--
919	0-2.0	--	--	--	--	--	--	--	--	--		9.1	--
	2.0-4.0	--	--	--	--	--	--	--	--	--		10.5	--
-03	4.0-6.0	0	36	64	--	29	16	13	--	--	CL	8.7	--
	6.0-8.0	--	--	--	--	--	--	--	--	--		5.7	--
	8.0-10.0	--	--	--	--	--	--	--	--	--		8.7	--
920-02	2.0-4.0	0	17	83	31	34	17	17	0.65	--	CL	9.0	--
	6.0-8.0	--	--	--	--	--	--	--	--	--		7.2	--
	8.0-10.0	--	--	--	--	--	--	--	--	--		10.9	--
	10.0-12.0	--	--	--	--	--	--	--	--	--		10.8	--

Table D.5.3 Summary of mechanical soil properties for Estes Gulch site (Continued)

Boring or test pit	Depth interval (ft)	% GVL	% Sand	% -200	% Clay -2μ	L.L. %	P.L. %	P.I. %	Activity PI%/(% clay-5)	Specific gravity	USCS	In situ moisture content %	In situ dry density (pcf)
-07	12.0-14.0	0	2	98	--	45	25	20	--	--	CL	12.6	110.1
	14.0-16.0	--	--	--	--	--	--	--	--	--		11.7	111.8
	16.0-18.0	--	--	--	--	--	--	--	--	--		11.4	--
	18.0-20.0	--	--	--	--	--	--	--	--	--		10.7	--
921-03	4.0-6.0	4	34	62	19	31	15	16	1.14	--	CL	8.1	109.1
	6.0-9.0	--	--	--	--	--	--	--	--	--		5.6	94.8
-05	11.0-13.0	10	51	39	--	32	15	17	--	--	SC	5.8	--
-06	13.0-15.0	0	17	83	35.8	41	18	23	0.74	--	CL	11.3	116.3
922-02	2.0-5.0	0	31	69	24	29	15	14	0.74	2.69	CL	10.2	99.3
-03	5.0-7.0	0	29	71	--	27	15	12	--	--	CL	7.8	--
	7.0-9.0	--	--	--	--	--	--	--	--	--		8.9	--
-05	9.0-12.0	0	10	90	26	32	17	15	0.71	2.73	CL	8.9	98.1
	12.0-14.0	--	--	--	--	--	--	--	--	--		5.5	--
	14.0-16.0	--	--	--	--	--	--	--	--	--		10.5	--
-08	16.0-18.0	0	22	78	19	30	18	12	0.86	2.71	CL	8.2	102.6
	18.0-20.0	--	--	--	--	--	--	--	--	--		8.1	103.5
	20.0-22.0	--	--	--	--	--	--	--	--	--		8.2	--
-11	22.0-24.0	29	35	36	--	28	15	13	--	--	SC	5.7	--
	28.0-30.0	--	--	--	--	--	--	--	--	--		5.0	--
923-04	6.0-8.0	0	15	85	31	31	17	14	0.54	2.67	CL	8.3	85.9
-05	9.0-12.0	0	12	88	25	29	16	13	0.65	--	CL	7.4	81.3
	12.0-14.0	--	--	--	--	--	--	--	--	--		9.3	--
-07	14.0-16.0	0	22	78	--	38	16	22	--	--	CL	9.8	--
-08	17.0-19.0	3	22	74	26	30	15	15	0.71	--	CL	6.5	106.7
	19.0-21.0	--	--	--	--	--	--	--	--	--		6.4	--
-10	21.0-23.0	2	62	36	--	NP	NP	NP	--	--	SM	3.2	--
	23.0-25.0	--	--	--	--	--	--	--	--	--		4.2	--
	25.0-27.0	--	--	--	--	--	--	--	--	--		8.4	--

Table D.5.3 Summary of mechanical soil properties for Estes Gulch site (Concluded)

Boring or test pit	Depth interval (ft)	% GVL	% Sand	% -200	% Clay -2μ	L.L. %	P.L. %	P.I. %	Activity PI%/(% clay-5)	Specific gravity	USCS	In situ moisture content %	In situ dry density (pcf)
924-02	2.0-4.0	0	14	86	39	39	17	22	0.65	2.69	CL	11.6	102.3
-04	6.0-8.0	0	17	83	--	34	16	18	--	--	CL	9.2	--
	8.0-10.0	--	--	--	--	--	--	--	--	--		11.3	--
	10.0-12.0	0	25	75	35	34	15	19	0.63	2.71	CL	9.2	100.8
-06	12.0-14.0	--	--	--	--	--	--	--	--	--		9.6	--
	14.0-16.0	--	--	--	--	--	--	--	--	--		7.8	--
-09	16.0-18.0	0	19	81	35	39	16	23	0.77	2.69	CL	11.5	106.8
	18.0-20.0	--	--	--	--	--	--	--	--	--		6.3	--
	20.0-22.0	--	--	--	--	--	--	--	--	--		7.7	--
	22.0-24.0	--	--	--	--	--	--	--	--	--		7.2	--
-13	24.0-26.0	1	38	61	--	28	14	14	--	--	CL	7.7	109.3
	26.0-28.0	--	--	--	--	--	--	--	--	--		8.9--	
	28.0-30.0	--	--	--	--	--	--	--	--	--		6.8	--
963	2.0-4.0	--	--	--	--	--	--	--	--	--		10.0	103.4
	4.0-6.0	--	--	--	--	--	--	--	--	--		9.9	--
-04	6.0-9.0	0	28	72	22	32	18	14	0.82	2.73	CL	8.8	90.8
-05	9.0-11.0	0	20	80	--	32	16	16	--	--	CL	8.8	99.2
	11.0-13.0	--	--	--	--	--	--	--	--	--		7.6	--
	13.0-15.0	--	--	--	--	--	--	--	--	--		10.0	--
-08	15.0-17.0	10	34	56	--	33	16	17	--	--	CL	7.0	106.2
	23.0-25.0	--	--	--	--	--	--	--	--	--		4.7	--
	31.0-33.0	--	--	--	--	--	--	--	--	--		6.5	--
-19	37.0-39.0	3	52	45	--	26	14	12	--	--	SC	6.7	--
930-03	8.0-10.0	0	22	78	23	28	--	13	0.72	2.67	CL	8.0	--
932-02	4.5-5.5	5	28	67	21	30	--	12	0.75	2.68	CL	8.4	--
936-02	4.0-5.0	0	26	74	--	30	--	13	--	2.68	CL	8.5	--
937-02	5.0-6.0	0	8	92	--	32	--	15	--	2.67	CL	8.9	--
938-02	6.0-7.0	0	33	67	--	29	--	12	--	2.70	CL	6.8	--

Table D.5.4 Summary of saturated undisturbed hydraulic conductivity tests

Site identification	Boring[a] or test pit identification	Depth interval (ft)	Soil description	Sample type[b]	Initial dry density (pcf)	Type of test[c]	Hydraulic conductivity (k_p cm/s)
Estes Gulch (RFL-08)	922	9-12	CL	T	98.1	Tx	2.8×10^{-6}
	923	9-12	CL	T	81.3	Tx	1.0×10^{-6}
	923	17-19	CL	R	106.7	Tx	1.2×10^{-5}
	900	2-4	CL	T	102.3	Tx	9.0×10^{-7}
	963	6-9	CL	T	90.8	Tx	1.2×10^{-6}

[a]Test data identified as OR and NR were conducted by CSU, 1985; test data listed as GOR were conducted by NUS, 1984; all other data by TAC, 1985a.
[b]RM = Remolded.
T = Shelby tube.
R = 2.5-inch-diameter ring sample.
[c]Tx = Falling head triaxial permeability.
Geometric mean = 2.1×10^{-6}.

Note: For test results on material from the radon barrier stockpile, see MK report, August 1994.

Table D.5.5 Summary of undisturbed consolidation test data

Site identification	Boring or test pit identification	Depth interval (ft)	Soil description or classification	Initial dry density (pcf)	Initial moisture content (%)	C_{ce}[b]	C_{re}[b]	Over-consolidation ratio (OCR)
Estes Gulch (RFL-08)	922[c]	2-5	CL	99.3	10.2	0.145	0.009	6.9
	923	6-8	CL	85.4	10.0	0.145	0.010	--
	924	2-4.0	CL	109.4	13.4	0.115	0.014	18.8
	924	16-18	CL	106.8	11.5	0.112	0.016	4.9
	963	6.0-9.0	CL	86.4	10.5	0.175	0.010	1.1

[a]This value is given for remolded tests only.
[b]Values of C_{ce} and C_{re} are based on strain-related consolation curves.
[c]RFO, RFN, and number only designations indicated sampling and testing conducted by TAC, 1985a.

Table D.5.6 Summary of undisturbed shear strength data

Site identification	Boring[a] identification	Depth interval (ft)	Soil type	Initial moisture content	Initial dry density	Test type	Strength test results: Total C (psf)	Total φ (°)	Effective C (psf)	Effective φ (°)
Estes Gulch (RFL-08)	963	6.0-9.0	CL	8.0	93.2	Tx(R)	0	16.9	0	23.9
	921	4.0-6.0	CL	7.8-8.6	105-114	DS_s	0	29	--	--
	922	2.0-5.0	CL	8.0-8.4	97-99	DS_s	380	26.2	--	--
	923	9.0-12.0	CL	5.7-9.0	86-91	DS_s	0	31.8	--	--
	963	9.0-11.0	CL	7.6-9.9	88.6-112	DS_s	0	30	--	--
						Avg. =	95	29.25		

[a]Data labeled as OR and NR were conducted by CSU, 1985. All other data by TAC, 1985a, unless otherwise noted.

Note: Additional shear strength testing on 4 percent bentonite amended radon barrier material is in progress, March 1995.

Table D.5.7 Summary of compaction test data

Site identification	Test pit identification	Sample interval of depth (ft)	Soil description	% passing No. 200 sieve	Specific gravity	In situ moisture content	Moisture-density relationships: Optimum moisture content (%)	Moisture-density relationships: Maximum dry density (pcf)
Estes Gulch (RFL-08)	930	8-10	CL	78	2.67	8.0	16.8	109.7
	932	4.5-5.5	CL	67	2.68	8.4	14.7	112.7
	936	4-5	CL	74	2.68	8.5	16.2	110.5
	937	5-6	CL	92	2.67	8.9	17.6	105.2
	938	6-7	CL	67	2.70	6.8	14.2	114.1

Table D.5.8 Soil erodibility test data summary for radon cover material

Location ID	Depth (ft)	Soil type	Results[a] of crumb test	Results of double hydrometer tests (Percent dispersion)	Results[b] of pinhole test
655	4.0-5.0	CL	1	55.3	ND2
658	3.0-4.0	CL	1	48.2	ND1
Combined sample					
674	6.0-7.0	CL	1	24.8	ND1
675	5.0-6.0				
676	12.0-13.0				
Combined sample					
677	10.0-11.0	CL		30.4	ND1
678	9.0-10.0				
679	15.0-16.0				

[a]Crumb test gradings: 1 = no reaction; 2 = slight reaction; 3 = moderate reaction; 4 = strong reaction.
[b]Pinhole dispersive rating: D2 and D1 = dispersive; ND4 and ND3 = intermediate; ND2 and ND1 = nondispersive.

Table D.5.9 Summary of saturated remolded hydraulic conductivity tests

Site identification	Boring[a] or test pit identification	Depth interval (ft)	Soil description	Sample type[b]	Initial dry density (pcf)	% of standard Proctor	Type of test[c]	Hydraulic conductivity (k_p cm/s)
Estes Gulch (RFL-08)	930	8-10	CL	RM	104.2	95	Tx	1.7×10^{-8}
	932	4.5-5.5	CL	RM	107.5	96	Tx	3.8×10^{-8}
	936	4-5	CL	RM	104.4	94	Tx	1.8×10^{-8}
	937	5-6	CL	RM	101.1	96	Tx	2.0×10^{-7}
	938	6-7	CL	RM	108.8	95	Tx	1.3×10^{-8}

[a]Test data identified as OR and NR were conducted by CSU, 1985; test data listed as GOR were conducted by NUS, 1984; all other data by TAC, 1985a.
[b]RM = Remolded.
T = Shelby tube.
R = 2.5-inch-diameter ring sample.
[c]Tx = Falling head triaxial permeability.

Note: Also see MK reports, August 1994 and February 1995.

Table D.5.10 Hydraulic conductivity from consolidation tests

Location ID	Depth (ft)	Soil type	Initial dry density (pcf)	Initial moisture content (%)	Load increment (pcf)	Average hydraulic conductivity (cm/s)
930	8.0-10.0	CL	105	16.3	2006	6.3×10^{-9}
					4007	7.3×10^{-8}
					7973	3.9×10^{-8}
					15,896	1.2×10^{-8}
932	4.5-5.5	CL	107	16.8	2025	1.8×10^{-7}
					4037	1.2×10^{-7}
					8054	5.9×10^{-8}
936	4.0-5.0	CL	105	15.3	2024	2.2×10^{-8}
					3998	6.0×10^{-8}
					8018	2.5×10^{-8}
					16,008	7.3×10^{-9}
937	5.0-6.0	CL	98	19.5	1977	1.4×10^{-7}
					3949	1.2×10^{-7}
					7895	5.5×10^{-8}
					16,017	1.8×10^{-8}
938	6.0-7.0	CL	109	14.0	2044	5.3×10^{-8}
					4078	1.4×10^{-9}
					8146	5.4×10^{-8}
					16,261	4.1×10^{-8}

Table D.5.11 Summary of consolidation test data

Site identi-fication	Boring or test pit identification	Depth interval (ft)	Soil description or classification	Compaction[a] (% of standard Proctor)	Initial dry density (pcf)	Initial moisture content (%)	$C_{c\varepsilon}$[b]	$C_{r\varepsilon}$[b]	Over-consolidation ratio (OCR)
Estes Gulch (RFL-08)	930	8-10	CL	96	104.9	16.3	0.116	0.008	2.5
	932	4.5-5.5	CL	95	107.0	16.8	0.079	0.010	2.2
	936	4.0-5.0	CL	95	105.1	15.3	0.120	0.008	2.6
	937	5.0-6.0	CL	93	98.1	19.5	0.158	0.016	2.8
	938	6.0-7.0	CL	95	108.8	14.0	0.103	0.012	2.2

[a]This value is given for remolded tests only.
[b]Values of $C_{c\varepsilon}$[b] and $C_{r\varepsilon}$[b] are based on strain-related consolidation curves.

Table D.5.12 Summary of shear strength data

Site identi-fication	Boring[a] identification	Depth interval (ft)	Soil type	Initial moisture content	Initial dry density	% of standard Proctor	Strength test results					
							Test type	C (psf)	ϕ (°)	C (psf)	ϕ (°)
Estes Gulch (RFL-08)	930	8-10	CL	16.4	104.7	95	Tx(R)	0	20.5	100	32
	932	4.5-5.5	CL	14.6	107.6	96	Tx(R)	0	22.1	0	33.5
	938	6-7	CL	14.3	108.7	95	Tx(R)	0	22.3	0	33.7
	932	4.5-5.5	CL	14.4	107.1	95	Tx(Q)	1650	9.5	--	--
	938	6-7	CL	13.7	109.7	96	Tx(Q)	1220	19	--	--

[a]Data labeled as OR and NR were conducted by CSU, 1985. All other data by TAC, 1985a, unless otherwise noted.

NA - indicates information not available.

D.6 ROCK BORROW CHARACTERISTICS

Final selection of borrow sources (other than radon cover) is left to the construction contractor for economic reasons. However, sufficient test data are available for the sites previously identified to show that suitable material is available in the Rifle area.

Large diameter rock and gravel sources have been identified at Glenwood Springs and Rifle Gap. The Glenwood Springs pit had been visually identified as limestone from the same formation as the Rifle Gap pit. Testing on the Rifle Gap material has been completed and includes sulfate soundness, absorption, specific gravity, Los Angeles abrasion, and petrographic analysis. The results are summarized in Table D.6.1. Since the material source is quarried rock, any size material can be prepared depending on design requirements. The material has been visually identified as suitable for both infrequently and frequently inundated zones on the embankment. The Final Design contains detailed evaluation on the new quarry at Glenwood Springs (MK-E, 1988).

Gravel-sized rock borrow materials have been identified at the New Rifle Pit and the Anderson pit. Rock durability data for these pits are summarized in Tables D.6.2, and D.6.3, respectively. These materials meet or exceed the NRC (1986) criteria for rock located in infrequently inundated areas.

Laboratory test results on several potential riprap sources, including the Glenwood Springs source, are included in Addendum D8 to this Appendix.

Table D.6.1 Rock quality data for Rifle Gap borrow source

Material type	Petrographic description	Specific gravity		Los Angeles abrasion 250 cycles (%)	Absorption (%)	Sodium sulfate soundness (% loss)
		Apparent	Bulk			
Oolitic Limestone	Fine grained, sedimentary rock composed of oolites and composite oolites cemented with sparry calcite. Devoid of pore space. Mineralogically: 95% calcite with trace of clay.	2.71	2.69	13.6	0.20	2.2

Table D.6.2 Rock quality test data for New Rifle borrow source

Petrographic analysis rock description	Percentages							Comments
	Diameter in inches or by sieve size							
	1 1/2-3/4	3/4-1/2	1/2-3/8	3/8	3/8-No.4	No.4-No.8	No.8-No.16	
Granite - Angular, unweathered, moderate grain size	14.7	12.7	19.8	20.4	19.0	41.1	57.9	
Angular, unweathered, very coarse grained	3.3	2.3	—	—	—	—	—	
Angular, moderately weathered, coarse grained	—	2.2	4.5	3.4	—	—	—	
Partly rounded, unweathered, moderately grained	14.7	7.3	16.1	7.2	—	—	—	
Well rounded, moderately weathered, moderately grained	6.1	10.9	6.7	6.1	5.1	6.6	—	
Deeply weathered, porous	—	—	—	1.9	3.6	—	—	Weak particles
Diorite - Angular, unweathered, moderately grained	6.7	2.4	3.6	2.3	2.9	6.1	15.1	
Partly rounded, unweathered, moderately grained	1.4	3.2	—	—	—	2.6	—	
Rounded, moderately weathered	—	1.0	—	—	2.2	—	—	
Gabbro - Angular, unweathered, coarse grained	—	3.4	—	2.1	—	—	—	
Gneiss - Angular, unweathered, coarse grained	4.3	2.7	1.0	1.7	3.2	—	—	
Rounded, moderately weathered	—	3.7	—	—	2.3	—	—	
Basalt Porphyry - Angular to rounded	0.9	1.3	0.4	1.1	2.2	—	—	
Basalt - Angular, unweathered	3.4	2.3	4.5	3.1	3.1	6.6	12.5	
Rounded, moderately unweathered	5.9	2.9	1.8	2.0	4.7	2.6	—	
Andesite - Angular, unweathered	1.6	3.0	3.5	4.8	3.0	3.7	2.6	Alkali-silica reactive
Partly rounded, unweathered	3.8	2.0	2.2	1.8	—	—	—	Alkali-silica reactive
Rounded, moderately unweathered	1.3	0.9	1.0	0.9	—	0.5	—	Alkali-silica reactive
Rhyolite - Angular, hard	—	—	2.1	0.6	2.1	1.2	0.6	Alkali-silica reactive
Siliceous Siltstone - Hard, angular	0.5	2.6	1.7	6.5	2.7	—	—	
Shale - Flat, soft	—	—	—	0.2	1.9	2.4	—	Weak particles
Red Sandstone - Angular, coarse grained, micaceous	1.4	1.2	0.9	0.3	2.1	—	—	
Maroon, angular, micaceous	5.3	1.9	3.5	2.3	2.3	5.5	—	
Rounded, fine sand	1.2	1.3	—	1.9	4.5	0.8	3.7	
Light red, angular, fine sand	0.6	0.8	1.1	2.3	1.8	0.6	—	
Chert, Cherty Carbonates	—	—	—	0.4	4.2	0.9	—	
Quartzite - White to light gray, angular, hard	6.3	13.4	12.1	13.3	8.7	9.3	1.6	
White to light gray, partly rounded, hard	7.4	5.9	2.0	3.7	4.0	—	—	
White to light gray, rounded, hard	4.2	2.3	1.6	1.2	1.8	—	—	

Table D.6.2 Rock quality test data for New Rifle borrow source (Concluded)

Petrographic analysis rock description	Percentages: Diameter in inches or by sieve size 1 1/2-3/4	3/4-1/2	1/2-3/8	3/8	3/8-No.4	No.4-No.8	No.8-No.16	Comments
Dolomite - Gray, fine grained, mostly angular	1.5	1.2	1.7					For large size aggregates dolomite and limestones were both separated out.
Gray, fine grained, rounded	---	1.1	1.7					
Limestone - White to gray, mostly angular, fine to medium	1.4	0.9	1.0					
Gray to dark gray, rounded, fine grained	2.0	2.2	3.6					
Clayey, dark gray, mostly angular, fine grained	---	1.1	---					
Carbonates - (dolomite and limestone collectively)								
Angular, unweathered				1.3	2.2	—	6.0	For 3/8 inch size and smaller, no distinction between dolomite and limestone was used.
Rounded in part, moderately weathered				7.1	7.6	2.9	—	
Rounded, weathered				0.5	2.8	6.5	—	

Gradation[a] Fine aggregate Sieve size	Fine aggregate Percent passing	Coarse aggregate Sieve size	Coarse aggregate Percent passing	Sodium soundness Fine aggregate % loss, 5 cycle	Sodium soundness Coarse aggregate % loss, 5 cycle	Bulk specific gravity Fine aggregate	Bulk specific gravity Coarse aggregate	Absorption percent Fine aggregate	Absorption percent Coarse aggregate	LA abrasion Coarse aggregate percent loss at 500 revolutions
#4	100	1"	100	5.8	1.7	2.60	2.60	2.1	1.4	23.2%
#8	72	3/4"	76							
#16	62	1/2"	37							
#30	37	3/8"	23							
#50	15	#4	1							
#100	8	#200	0.2							
#200	5.8									

[a]Screening was done for concrete aggregate. Large-sized rock is present in this deposit.

Table D.6.3 Rock quality test data for the Anderson borrow source

Sample no.	Depth (ft)	Gradation: Sieve size	Gradation: Percent passing	Sodium[a] soundness % loss, 5 cycle	Bulk specific gravity	Absorption (percent)	LA Abrasion (percent loss at 500 revolutions)
RFL-05-663	7-8	5"	100	5.6	2.62	0.7	8.6
	7-8	3"	90				
	7-8	1-1/2"	62				
	7-8	3/4"	43				
	7-8	3/8"	35				
	7-8	#4	32				
	7-8	#8	29				
	7-8	#30	20				
	7-8	#100	7				
	7-8	#200	4				
RFL-05-662	3-10	5"	100	6.9	2.61	0.7	10.9
	3-10	3"	93				
	3-10	1-1/2"	61				
	3-10	3/4"	35				
	3-10	3/8"	27				
	3-10	#4	26				
	3-10	#8	25				
	3-10	#30	18				
	3-10	#100	4				
	3-10	#200	3				

[a]For 3/8" plus material. Percent loss for #5 to 3/8" material is 39.7% on sample 662, 40.6% on sample 663.

D.7 GROUNDWATER

D.7.1 INTRODUCTION

The EPA has established health and environmental regulations to correct and prevent groundwater contamination resulting from former uranium processing activities at inactive milling sites (40 CFR 192). According to the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA), the DOE is responsible for assessing the inactive uranium processing sites. The DOE has decided that each assessment shall include:

- Definition of the hydrogeologic characteristics of the environment including hydrostratigraphy, aquifer parameters, areas of aquifer recharge and discharge, potentiometric surfaces, and groundwater velocities.
- Comparison of the existing water quality with background water quality and with the proposed EPA groundwater quality standards.
- Evaluation of the physical and chemical characteristics of the contaminant source.
- Description of water resource utilization including availability, current and future use and value, and alternate water supplies.
- Evaluation of current and potential influence of groundwater quality resulting from uranium processing activities and remedial actions.

In January of 1983, the EPA promulgated final standards for the cleanup of the inactive uranium processing sites under the UMTRCA (48 Federal Register 590-604). On September 3, 1985, the U.S. Tenth Circuit Court of Appeals remanded the groundwater standards 40 CFR 192.20(a)(2)-(3). The EPA issued proposed standards for comment on September 24, 1987. Prior to promulgation of the final standards, the DOE intends to implement the provisions of Subpart A and C to the extent reasonably achievable within the UMTRA Project regulatory framework. When the final EPA standards are promulgated, the DOE will re-evaluate its groundwater protection plan and undertake such action as is necessary to ensure that the revised standards are met. The need for and extent of aquifer restoration will be evaluated in a separate decision-making process under the National Environmental Policy Act.

Water quality at the Old and New Rifle tailings sites was characterized by comparing it with background water quality and with the EPA's proposed groundwater protection standards for inactive uranium processing sites (Table D.7.1). All further discussions of water quality in this appendix will refer to only these standards.

The DOE has sufficiently characterized hydrogeologic conditions at the Old and New Rifle tailings sites and at the Estes Gulch alternate disposal site, and does not anticipate that substantial changes to the remedial action will be required by the final EPA groundwater standards.

D.7.2 HYDROGEOLOGICAL SITE CHARACTERIZATION SUMMARY

The DOE has characterized the hydrogeology, water quality, and water resources at the Old and New Rifle tailings sites and at the Estes Gulch disposal site. Major points are summarized below:

Old and New Rifle processing sites

- o Both the Old and New Rifle processing sites are underlain by two water-bearing hydrogeologic units consisting of a shallow, unconfined aquifer in the alluvium lining the Colorado River and a semiconfined aquifer in the Wasatch Formation bedrock beneath the alluvium.

- o Groundwater flow in the alluvium and the Wasatch Formation is toward the west, roughly parallel to the flow in the Colorado River.

- o Hydraulic conductivities at the Old Rifle site average 200 feet per day (ft/day) or 7.0×10^{-2} centimeters per second (cm/s) in the alluvium and 0.02 ft/day (7.0×10^{-6} cm/s) in the Wasatch Formation. Average linear groundwater velocities are 840 feet per year (ft/yr) or 256 meters per year (m/yr) in the alluvium and 0.3 ft/yr (0.09 m/yr) in the Wasatch Formation.

- o Hydraulic conductivities at the New Rifle site average 70 ft/day in the alluvium and 0.09 ft/day or 3.2×10^{-5} cm/s in the Wasatch Formation. Average linear groundwater velocities are 280 ft/yr or 85 m/yr in the alluvium and 3.0 ft/yr or 0.9 m/yr in the Wasatch Formation.

- o Background water quality in the alluvium at the Old Rifle site is characterized by concentrations of molybdenum, selenium, and net gross alpha activity that exceed the maximum concentration limits (MCLs) of the proposed EPA groundwater protection standards. Background groundwater quality in the Wasatch Formation at the Old Rifle site is characterized by concentrations of molybdenum, selenium, uranium, and net gross alpha activity that exceed the proposed EPA MCLs.

- o Background water quality in the alluvium at the New Rifle site is characterized by concentrations of chromium, molybdenum, selenium, uranium, and net gross alpha activity that exceed the proposed EPA MCLs. Background groundwater quality in the Wasatch Formation at the New Rifle site is characterized by concentrations of barium, molybdenum, selenium, and activities of radium-226 and -228 combined that exceed the proposed EPA groundwater protection standard MCLs.

- o Most of the contamination at the Old Rifle site discharges to the Colorado River approximately 200 feet downgradient of the tailings. At this location, weathered Wasatch Formation claystone forces groundwater out of the alluvium into the Colorado River.

- o Although upward potentiometric gradients from the Wasatch Formation to the alluvium occur naturally at the Old Rifle site, historical groundwater mounding in the alluvium resulting from a culvert that previously discharged on site has driven contaminants downward into the Wasatch Formation. The extent of contamination in the Wasatch Formation is less than in the alluvium due to the lower hydraulic conductivity of the Wasatch Formation. During the demolition of abandoned structures (Phase I, 1987-88) the culvert that previously discharged on the site has been temporarily diverted by a pipe buried underneath the site. The current plan calls for removal of this pipeline following the remedial action; this will essentially establish pre-project hydraulic conditions. However, due to the cleanup of the contaminants, any further groundwater contamination by groundwater mounding cannot occur. The other alternative, to be discussed with D&RGW Railroad, CDH and the City of Rifle, would be not to remove the diversion pipeline; this would prevent groundwater mounding due to accumulation of major storm runoff. If agreement is reached to leave this pipeline in place, a change order can be issued while construction is in progress.

- o At the Old Rifle site, groundwater in the alluvium on the site and downgradient of the tailings contains concentrations of arsenic, chromium, molybdenum, selenium, and uranium and activities of net gross alpha and radium-226 and -228 combined that exceed the MCLs. In addition, tailings seepage at the Old Rifle site has generated concentrations of antimony, fluoride, strontium, vanadium, and zinc that are elevated above statistical maximum background concentrations in groundwater.

- o Limited sampling for organic contaminants in alluvial groundwater at the Old Rifle site revealed concentrations of the herbicide alpha-BHC. Although these chemicals were not used in the milling process, they may have been used on site during the milling operation.

- o Groundwater from monitor wells completed on the Old Rifle site in the Wasatch Formation contains concentrations of barium, cadmium, chromium, lead, molybdenum, selenium, and activities of net gross alpha and radium-226 and -228 combined that exceed the statistical maximum background concentrations. In addition, tailings seepage has generated concentrations of antimony, strontium, vanadium, and zinc that are elevated above statistical maximum background concentrations in the Wasatch Formation.

- o At the New Rifle site, a perched groundwater system of tailings fluids partially recharges the underlying alluvium with contaminated seepage. The total seepage flux from the tailings pile is approximately 3.8 gallons per minute (gpm).

- o The contaminant plume at the New Rifle site extends more than 8000 feet downgradient from the tailings in the alluvium. Contaminant concentrations are generally higher than at the Old Rifle site, and are greatest beneath the vanadium ponds and the tailings pile.

- Groundwater in the alluvium on the site and downgradient of the tailings at the New Rifle site contains concentrations of arsenic, cadmium, chromium, molybdenum, nitrate, selenium, uranium, and net gross alpha activity that exceed the MCLs. In addition, concentrations of antimony, cobalt, fluoride, strontium, thallium, tin, vanadium, and zinc are elevated above statistical maximum background concentrations.

- Limited sampling for organic contaminants in monitor wells completed in the alluvium at the New Rifle site revealed low concentrations of the solvents di-n-octylphthalate, toluene, and the herbicide 2,4,5-TP. These chemicals may have been used on site during the milling operation.

- Groundwater in the Wasatch Formation on the site and downgradient of the tailings at the New Rifle site contains concentrations of arsenic, barium, lead, molybdenum, selenium, uranium, and activities of radium-226 and -228 combined and net gross alpha which exceed statistical maximum background concentrations. Tailings seepage has also resulted in concentrations of antimony, fluoride, strontium, sulfide, vanadium, and zinc that are elevated above statistical maximum background concentrations in Wasatch Formation groundwater.

- A low concentration of the organic constituent toluene has been detected in one monitor well completed in the Wasatch Formation at the New Rifle site.

- Contamination in the Wasatch Formation at the New Rifle site extends more than 3500 feet downgradient to a depth of at least 90 feet.

- Several domestic and commercial wells downgradient or crossgradient of the New and Old Rifle sites have yielded groundwater with concentrations of uranium, selenium, and/or activities of net gross alpha that exceed the MCLs. One commercial well (the Northwest Pipeline well) had a nitrate concentration greater than the MCL.

<u>Estes Gulch alternate disposal site</u>

- The Estes Gulch site is underlain by the Wasatch Formation which overlies the Williams Fork and Ohio Creek Formations of the Mesaverde Group. The Wasatch Formation is an aquitard due to its low permeability, and the Williams Fork Formation is the uppermost aquifer beneath the disposal site. The thin Ohio Creek Formation is not known to be a regional aquifer.

- Limited groundwater occurs in the Wasatch Formation aquitard at Estes Gulch. Localized groundwater is found at depths ranging from 150 feet to 467 feet in more permeable fracture zones or sandstone lenses.

- Groundwater in the Williams Fork Formation is confined and flow is structurally controlled. Groundwater flows downdip, away from the Grand Hogback toward the axis of the Piceance Creek Basin.

- o The average hydraulic conductivity of the upper, weathered Wasatch Formation at the low portion of the Estes Gulch disposal cell is (1×10^{-3}) ft/day $(4 \times 10^{-7}$ cm/s), and the average conductivity of the lower, nonweathered Wasatch bedrock is 6×10^{-5} ft/day $(2 \times 10^{-8}$ cm/s).

- o The hydraulic conductivity of the Williams Fork Formation is probably greater than that of the Wasatch Formation.

- o Background groundwater quality in the Wasatch Formation beneath the Estes Gulch site is poor. Water quality from three monitor wells at the disposal site had a total dissolved solids (TDS) content ranging from 8,260 to 25,100 milligrams per liter (mg/l) and concentrations of barium, cadmium, chromium, lead, molybdenum, selenium, and activities of net gross alpha and radium-226 and -228 combined that exceed the EPA MCLs.

- o Regional groundwater quality in the Mesaverde Group is good, with TDS ranging from 41 to 235 mg/l (Giles, 1980).

- o The Wasatch Formation aquitard beneath the Estes Gulch disposal cell is projected to be more than 3800 feet thick, and the disposal cell is geologically isolated from the uppermost aquifer (the Williams Fork Formation). Because of the aquitard's low hydraulic conductivity, contaminant seepage from the disposal cell is unlikely to reach the uppermost aquifer.

- o Groundwater beneath the Estes Gulch disposal site has relatively low value and is not likely to be used in the future. Groundwater in the Williams Fork Formation is too deep to be economically utilized for domestic or stock watering purposes.

D.7.3 GROUNDWATER INVESTIGATIONS

Several hydrologic and geologic studies have been completed for the Old and New Rifle tailings sites. These investigations varied in scope and detail.

In 1977, Ford, Bacon & Davis Utah Inc. (FBDU, 1977) prepared a preliminary, reconnaissance-level investigation of the hydrology and geology at the uranium mill tailings sites at Rifle. This investigation included a general characterization of the local geology and surface and groundwater hydrology and a summary of water use for the region. The investigation concluded that groundwater had been affected by milling activities at the sites but did not delineate the shape or extent of the contaminant plumes in the alluvium. It also concluded that contamination of the Wasatch Formation beneath the sites was virtually impossible due to the formation's low hydraulic conductivity and its confined potentiometric surface.

Ford, Bacon & Davis Utah Inc. (FBDU, 1981) also prepared an engineering assessment of the Old and New Rifle tailings sites that included a brief review of the hydrology and geology of the area. FBDU again concluded that there was groundwater contamination within the alluvium and that the upper siltstones and claystones in the Wasatch Formation prevented downward migration of contamination.

The Colorado Geologic Survey (CGS, 1982) conducted a regional search for sites that were suitable for the relocation and reprocessing of the Rifle and Grand Junction uranium mill tailings. The CGS evaluated the hydrogeology of nine potential sites for possible disposal of tailings from both sites.

Markos and Bush (1983) performed a geochemical study of the Old and New Rifle tailings sites. Groundwater from several background Wasatch Formation wells and surface water from on-site and off-site sampling locations were analyzed, and geochemical acid and water extracts from tailings samples were evaluated. The analytical data were published, but no interpretive report was released.

The NUS Corporation issued a preliminary environmental impact statement (DOE, 1983) for the Rifle tailings sites. This statement included a hydrogeologic study based on data from 10 newly installed monitor wells at each of the Old and New Rifle tailings sites and pumping tests conducted on these wells. However, the complete extent of contamination in the alluvium at both sites was not defined, and contamination within the Wasatch Formation was not adequately addressed.

The UMTRA Project site characterization program conducted by the DOE at the Rifle tailings sites and the Estes Gulch alternate disposal site included extensive hydrogeological investigations. These investigations consisted of the following activities:

- o The installation of 15 additional monitor wells in the alluvium and 13 monitor wells in the Wasatch Formation at the Old Rifle site in 1985.
- o The installation of 23 additional monitor wells in the alluvium and 28 monitor wells in the Wasatch Formation at the New Rifle site in 1985.
- o Installing 13 monitor wells at the Estes Gulch alternate disposal site.
- o Drilling boreholes and lithologic sampling at all sites.
- o Drilling slant boreholes and conducting packer tests to assess subsurface lithology and to determine hydraulic conductivities with depth at the Estes Gulch disposal site.
- o Borehole geophysical logging (gamma, self-potential, resistivity, neutron porosity, caliper, and temperature logs) at all sites.
- o Surveying all well locations including ground surface and casing elevations.
- o Conducting aquifer pumping tests on four Old Rifle and ten New Rifle alluvial monitor wells and falling head slug tests on three Old Rifle and 12 New Rifle Wasatch Formation monitor wells.

- o Measuring the groundwater elevations in monitor wells at the Old and New Rifle tailings sites and at the Estes Gulch site.

- o Conducting four constant head injection tests and three rising head tests at the Estes Gulch site.

- o Sampling groundwater at the Estes Gulch site in May of 1986, November of 1987, August of 1988, April and September of 1989, and March of 1990.

- o Sampling groundwater at the Rifle tailings sites in June and December of 1985, May of 1986, October of 1987, and August of 1990.

- o Performing laboratory analyses of the samples for major ions, trace elements, metals, uranium, radium, and other radionuclides.

- o Installing five lysimeters in the tailings at the Old Rifle processing site and five lysimeters in the tailings and vanadium ponds at the New Rifle processing site.

- o Sampling the lysimeters for inorganic constituents to characterize the tailings pore fluids at the processing sites.

- o Sampling the tailings and groundwater at both processing sites for EPA Appendix IX organics.

All field and laboratory procedures, data analyses, and calculations were performed according to the standard operating procedures developed for the UMTRA Project (DOE, 1991). Figure D.7.1 depicts the typical construction details for the monitor wells installed by the DOE at the Rifle tailings sites and alternate disposal site. Figures D.7.2 through D.7.6 show the locations of all of the monitor wells at both mill processing sites and the proposed Estes Gulch disposal site.

D.7.4 HYDROGEOLOGIC CHARACTERIZATION--RIFLE PROCESSING SITES

D.7.4.1 Geology and hydrostratigraphy

The Rifle UMTRA Project sites are located on the southeastern flank of the asymmetric Piceance Creek Basin, a structural and sedimentary downwarp containing relatively horizontal sedimentary and volcanic rocks. The Old and New Rifle tailings sites rest on the Colorado River floodplain alluvium (Figure D.7.7), which is comprised of silts, sands, gravels, and cobbles. The Colorado River valley is incised into the Wasatch Formation and is bordered on the north by the Book Cliffs and the Grand Hogback monocline and on the south by the Roan Cliffs.

The Wasatch Formation at Rifle consists of a series of interbedded shales and lenticular sandstone units dipping five to ten degrees to the west-southwest. The formation contains the Shire, Molina, and Atwell

Gulch Members. The upper Shire Member is 1600 feet thick near Rifle and consists of variegated claystones, siltstones, and some lenticular sandstones. The middle Molina Member is 500 feet thick and consists primarily of sandstone with thin, interbedded claystones and siltstones. The lower Atwell Gulch Member is approximately 600 feet thick and contains a series of shales and sandstones with thin, discontinuous interbeds of lignite and carboniferous shale.

The Estes Gulch alternate disposal site, six miles north of Rifle, lies on the southwestern flank of the Grand Hogback monocline and is underlain by the Shire Member of the Wasatch Formation. Beneath the site, the bedding planes of the Wasatch Formation are near vertical, dipping from 65 to 75 degrees toward the south-southwest. Detailed descriptions of the geology at the Rifle UMTRA Project sites are provided in Section D.3 of Appendix D.

Regional groundwater flow in the Piceance Creek Basin occurs primarily in the Parachute Creek Member of the Green River Formation that overlies the Wasatch Formation (Weeks, 1974). However, in the vicinity of the Rifle UMTRA Project sites, the Green River Formation has been eroded away, leaving the Wasatch Formation exposed.

The variegated claystones, siltstones, and sandstones of the Wasatch Formation do not yield significant quantities of groundwater to wells (Wright Water Engineers,1979). Groundwater in the Wasatch Formation is localized, and no regional groundwater flow systems are described in the literature. The limited groundwater that occurs is generally found in fractured or weathered zones and is poor in quality. Coffin et al (1968 and 1971) state that the clay and shale beds of the Wasatch Formation are relatively impermeable, while the sandstone beds (of the Molina Member) are "poorly permeable". These reports also state that the Wasatch Formation is not known to yield water to wells.

The floodplain alluvium and the Wasatch Formation are two water-bearing units beneath the Old and New Rifle tailings sites. The tailings at both sites rest on the Colorado River alluvium, which is one mile wide, 20 to 40 feet deep, and bounded on the north and south by the Wasatch Formation (Figure D.7.7). The alluvium is recharged by precipitation, return irrigation flow, and the Colorado River. Beneath the alluvium, groundwater flow in the interlayered sandstone, siltstone, and claystone beds of the Wasatch Formation is semi-confined. The Wasatch Formation has lower hydraulic conductivities than the alluvium.

In general, groundwater flow in the alluvium and Wasatch Formation at the Rifle tailings sites is toward the west, paralleling the Colorado River. Seasonal fluctuations in the Colorado River control flow in the alluvium. During the summer when the Colorado River is high, the river recharges the alluvium. During the fall and winter when the river is low, groundwater in the alluvium discharges to the river. Similarly, the alluvium may also recharge the Wasatch Formation during periods of high flow, and the Wasatch Formation may recharge the alluvium during periods of low flow.

The Estes Gulch site is underlain by the Shire Member of the Wasatch Formation. Beneath the site, groundwater probably flows along the strike of the steeply dipping beds towards the southeast.

D.7.4.2 Groundwater flow and hydraulic characteristics

Old Rifle site

The alluvium at the Old Rifle site is approximately 20 feet thick, with depths to groundwater ranging from two to 22 feet below the land surface. Groundwater levels in the alluvium (wells 581 through 604) fluctuate more than seven feet during the year (Table D.7.2) (wells 581 through 604) depending on the stage height of the Colorado River. Figures D.7.8 and D.7.9 depict the potentiometric surfaces in the alluvium at the Old Rifle site during summer and winter, respectively.

The sources of recharge to the alluvium include bank infiltration from the Colorado River, precipitation, surface and subsurface irrigation return flow, and discharge from the Wasatch Formation in areas with upward, vertical potentiometric gradients (Figure D.7.10). There was also recharge from a closed basin north of U.S. Highway 6; groundwater seepage from the hillside was diverted through an underground culvert that previously discharged onto the Old Rifle site northeast of the tailings pile (Figures D.7.8 and D.7.9). This discharge percolated through the alluvium, creating a groundwater mound which extended into the tailings pile. However, the culvert has since been diverted to the Colorado River during Phase I construction of the remedial action on the Old Rifle tailings pile. The groundwater gradient in the Old Rifle alluvium is 0.003 (Calculation No. RFL-11-84-14-02-00).

Approximately 500 feet downgradient of the tailings pile, flow in the alluvium is deflected into the Colorado River by an outcrop of weathered Wasatch Formation claystone. Some groundwater continues to flow west in a 50-foot-wide strip of alluvium between the outcrop and the river. It is not known to what extent groundwater flows through the weathered claystone west of the site. Groundwater at the tailings site does not flow across the Colorado River in the alluvium because the river is a groundwater flow line.

Aquifer pumping tests conducted on five monitor wells in the alluvium at the Old Rifle site yielded an average hydraulic conductivity of 200 ft/day (7.0×10^{-2} cm/s)(Table D.7.3). The average linear groundwater velocity in the alluvium at the Old Rifle site was calculated to be 840 ft/yr (256 m/yr) using Darcy's Law, a hydraulic conductivity of 200 ft/day (7.0×10^{-2} cm/s), an effective porosity of 0.27, and a hydraulic gradient of 0.003 (Calculation No. RFL 02-89-16-01-000).

The Wasatch Formation beneath the Old Rifle site consists of interbedded layers of sandy siltstones and shales. Although these layers are regionally discontinuous, the Wasatch Formation is semi-confined. The potentiometric surface within the formation (Figure D.7.11) ranges from two to 30 feet below the ground surface with groundwater flow toward the west. Table D.7.2 contains water level data for the Wasatch Formation (wells 620 through 645).

Recharge to and discharge from the Wasatch Formation is dependent on vertical potentiometric gradients between the Wasatch Formation and the alluvium. Based on water level differences for nested monitor wells, vertical gradients at the Old Rifle site are generally upward (Figure D.7.10), with the Wasatch Formation discharging into the alluvium. However, groundwater mounding due to the culvert that discharged northeast of the tailings created a downward potentiometric gradient near Wasatch Formation monitor wells 623 and 624, and the alluvium recharged the Wasatch Formation. Thus, some contaminants within the alluvium migrated into the Wasatch Formation.

Falling head slug injection tests, performed on three monitor wells in the Wasatch Formation at the Old Rifle site, yielded an average hydraulic conductivity of 0.027 ft/day (9.6×10^{-6} cm/s)(Table D.7.4). The average horizontal linear groundwater velocity was calculated to be 0.3 ft/yr (0.09 m/yr) using Darcy's Law, a hydraulic conductivity of 0.03 ft/day (1.1×10^{-5} cm/s), an effective porosity of 0.10, and a hydraulic gradient of 0.003.

New Rifle site

Groundwater flow and hydraulic parameters

The alluvium at the New Rifle site is 25 to 30 feet thick, and depths to groundwater range from two to 57 feet. Groundwater levels in the alluvium fluctuate approximately five feet during the year (wells 581 through 610 and 615 through 619) (Table D.7.5), depending on the stage of the Colorado River. The alluvial potentiometric surface (Figures D.7.12 and D.7.13) does not extend into the tailings pile during high river stage, as it does at the Old Rifle site, but remains two to three feet below the pile.

Groundwater flow in the alluvium at the New Rifle site is toward the west and southwest under a hydraulic gradient ranging from 0.002 to 0.006. The alluvium is recharged by the Colorado River east of the site, and groundwater flow generally parallels the river channel to eventually discharge into the river downgradient of the site. Seasonal flow in Pioneer Ditch north of the site (Figure D.7.12) may also recharge the alluvium, adding the slight southwesterly component of flow. There are downward potentiometric gradients between the alluvium and the Wasatch Formation (Figure D.7.14), and groundwater in the alluvium discharges to the Wasatch Formation.

Aquifer pumping tests performed by the DOE on ten alluvial monitor wells at the New Rifle site during 1983 and 1985 indicate that the hydraulic conductivity in the alluvium averages 70 ft/day (2.5×10^{-2} cm/s)(Table D.7.6). The average linear groundwater velocity was calculated to be 280 ft/yr (85 m/yr) using Darcy's Law, an average hydraulic conductivity of 70 ft/day, an effective porosity of 0.27, and an average hydraulic gradient of 0.003 (Calculation No. RFL 02-89-16-01-000).

Groundwater flow in the Wasatch Formation at the New Rifle site is to the southwest (Figure D.7.15), paralleling flow in the alluvium. Groundwater levels in monitor wells completed in the Wasatch Formation (wells 611 through 614 and wells 621 through 651) are included in Table D.7.5. The Wasatch Formation is hydraulically connected to the alluvium although potentiometric levels are lower than in the alluvium (Figure D.7.14); consequently, groundwater from the alluvium recharges the Wasatch Formation.

The Wasatch Formation at the New Rifle site contains more sandstone interbeds than at the Old River site and is therefore more transmissive to groundwater flow. Slug injection tests on 12 monitor wells in the Wasatch Formation at the New Rifle site yielded an average hydraulic conductivity of 0.46 ft/day (1.6×10^{-4} cm/s) (Table D.7.7). This is an order of magnitude greater than the average hydraulic conductivity measured at the Old Rifle site. The average linear groundwater velocity was calculated for the Wasatch Formation using Darcy's Law. Based on a mean hydraulic conductivity of 0.46 ft/day, (1.6×10^{-4} cm/s) an effective porosity of 0.15, and a hydraulic gradient of 0.003, the average linear velocity was calculated to be three ft/yr.

D.7.4.3 Tailings and millings process characterization

Old Rifle site

The Old Rifle tailings pile is 13 acres in area and contains an estimated 333,000 cubic yards of tailings. The tailings consist of fine sands with a moderate amount of clay, and are up to 20 feet thick. Although the tailings are generally above the water table, the lower portions of the tailings become saturated during high stage periods of the Colorado River (DOE, 1983). The DOE has observed inundation of the lower 5.5 feet of tailings near monitor wells 581, 582, and 583 (Figure D.7.2) during high flow periods.

The Old Rifle mill was built in 1924 to recover vanadium from roscoelite ores. Extraction processes used included salt roasting, water leaching, and precipitation of sodium hexavanadate with sulfuric acid (Merritt, 1971). The processes were modified in 1946 to extract uranium by acid leaching and subsequent processing. Sulfuric and hydrochloric acids were used with ammonia to precipitate a "green-sludge" product.

This was purified by redissolving it in sulfuric acid and sodium chlorite, and then adding sodium carbonate. Finally, yellow cake was obtained from the purified solution by acidifying and boiling, and then adding ammonia gas (Merritt, 1971).

The contaminant source concentrations at the Old Rifle site were estimated by averaging the concentrations from lysimeters completed in the Old Rifle tailings. Although the five lysimeters were recently installed in the tailings pile, only two lysimeters produced enough sample for analysis. The lysimeters were sampled in December 1988 and April 1989, and the analytical results, representing contaminant source concentrations at the Old Rifle site, are presented in Table D.7.8. The table indicates that hazardous constituents exceeding laboratory detection limits in tailings at the Old Rifle site are arsenic, cadmium, chromium, mercury, molybdenum, nitrate, selenium, silver, uranium, Ra-226 and -228 combined, net gross alpha activity, antimony, beryllium, copper, fluoride, strontium, tin, vanadium, and zinc.

Three Old Rifle tailings samples were analyzed for Appendix IX organic constituents. Benzo [a] anthracene was found at a concentration of 770 parts per billion, approximately 2.5 times the detection limit. The source of this organic constituent is unknown. Benzo [a] anthracene is commonly found in wood preservatives. Other organic constituents detected in tailings extracts at concentrations greater than method detection limits at the Old Rifle site include benzo [a] pyrene, chrysene, diethyl phthalate, fluoranthene, indeno (1,2,3-cd) pyrene, and pyrene (see Calculation No. RFL-06-91-15-01).

The seepage flux of tailings leachate into groundwater at the Old Rifle site was estimated using Darcy's Law (Freeze and Cherry, 1979). Under saturated conditions in a perched groundwater system, the lowest saturated hydraulic conductivity in a horizontally stratified geologic system controls vertical seepage flux. The saturated hydraulic conductivities for the Old Rifle tailings ranged from 0.02 cm/s to 1.7×10^{-6} cm/s (DOE, 1987a), and average (geometric mean) 3.7×10^{-4} cm/s. These values are not low enough to create a distinct piezometric surface within the tailings, and precipitation infiltrates rapidly through the tailings into groundwater. Therefore, seepage through the tailings is equal to the net infiltration rate. Based on annual precipitation of 11 inches per year and assuming 20 percent net infiltration, the total annual seepage through the pile from precipitation averages 2130 gallons per day (1.5 gpm). A 20 percent net infiltration rate was selected to be conservative; actual infiltration may be considerably lower.

<u>New Rifle site</u>

Major sources of contamination at the New Rifle site are seepage from the tailings pile and from the vanadium ponds east of the tailings (Figure D.7.4). The vanadium ponds cover an area of six acres and are currently dry, although surface runoff may accumulate in them during the spring. The tailings pile at the New Rifle site is 33 acres in area and contains an estimated 2,415,000 cubic yards of tailings. The tailings are a mixture of sands and slimes and consist of the processed ore material and the chemicals used in the milling processes.

The milling processes used at the New Rifle site included the separation and purification of the uranium products with solvent extraction (Merritt, 1971). Ores containing uranium and low vanadium contents were separated by direct acid leaching, while ores with higher vanadium contents were initially salt roasted. The ores were then water- and acid-leached to remove the sodium vanadate and to dissolve the uranium. Solvent extraction using di (2-ethylhexyl) phosphoric acid (EHPA) was conducted to recover the uranium and vanadium. The vanadium was precipitated with sodium chlorite and sodium carbonate, and by heating and the addition of sulfuric acid. Finally, the precipitates were purified by redissolving them in ammoniacal solution and crystallizing ammonium metavanadate by adding ammonium chloride (Merritt, 1971).

The chemical characteristics of the contaminant source at the New Rifle site were evaluated from analyses of groundwater beneath the tailings and analyses of water extracts from the tailings (Markos and Bush, 1983). The average contaminant concentrations in groundwater from monitor wells 584, 586, 587, and 588, screened in the alluvium beneath the tailings are presented in Table D.7.9.

Five lysimeters were installed in the New Rifle tailings and in a vanadium pond in October 1988; however, all but one lysimeter were dry. The one lysimeter yielded only a few milliliters of sample. Two samples of tailings and one sample of sludge from a vanadium pond have been analyzed for Appendix IX (40 CFR 264) organics. The herbicides 2,4-D and 2,4,5-TP were found in the vanadium pond sludge at concentrations of 410 parts per billion (ppb) and 62 ppb, respectively (see Calculation No. RFL-06-91-15-01).

The seepage flux of tailings leachate into groundwater may be estimated using the Darcy equation. The lowest saturated hydraulic conductivity in a stratified geologic system controls the seepage flux perpendicular to the strata under saturated conditions. Based on triaxial permeability tests, the saturated hydraulic conductivity of the tailings at the New Rifle site range from 0.01 cm/s to 7.2×10^{-7} cm/s (DOE, 1987a), and the average (geometric mean) is 1.7×10^{-4} cm/s. Although the New Rifle tailings contain considerably more slimes than the Old Rifle tailings, the slimes are discontinuous throughout the pile and the average hydraulic conductivity is relatively high. For this reason, infiltration is still controlled by precipitation. Based on the average precipitation of 11 inches per year and assuming a conservative 20 percent net infiltration, the total annual seepage through the New Rifle tailings pile from precipitation averages 5400 gallons per day (3.8 gpm). This does not include infiltration due to irrigation for dust control purposes, and actual infiltration may be somewhat greater when the tailings are being irrigated.

Tailings seepage has affected groundwater quality beneath the pile. Average water quality analyses of groundwater samples from monitor wells 584, 586, 587, and 588 completed in the alluvium, are presented in Table D.7.9. Concentrations of arsenic, cadmium, chromium, lead, molybdenum, nitrate, selenium, silver, and uranium, and activities of net gross alpha in groundwater onsite and downgradient of the tailings exceeded the MCL and statistical maximum background concentrations. In addition, concentrations of antimony, cobalt, fluoride, strontium, thallium, tin, vanadium, and zinc are elevated above statistical maximum or maximum observed background concentrations (see Calculation No. RFL-06-91-15-01).

D.7.4.4 Background water quality

Old Rifle site

Background water quality is defined as the quality of water that would be present had uranium processing activities not occurred. This was determined by conducting statistical analyses on constituent concentrations in upgradient and crossgradient monitor wells not affected by uranium milling activities. 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 Old Rifle alluvium, which includes the minimum, mean, median, maximum, percentage of nondetects, the 99 percent confidence interval, and other important statistical parameters is provided in Table D.7.10. 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 lognormal. 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. Because the natural variation in background water quality is large and industrial activities may have affected groundwater quality between the Old and the New Rifle sites, background water quality was defined separately for each site.

The background quality of groundwater in the alluvium at the Old Rifle site was determined from chemical analyses of samples from upgradient monitor wells 597 and 598 and from crossgradient monitor wells 601 and 602 (Figure D.7.2). Monitor wells 597 and 598 are located approximately 0.5 mile upgradient of the site, and monitor wells 601 and 602 are located across the Colorado River from the site. Because of their locations relative to the processing site, none of these wells has been affected by uranium milling activities. However, monitor wells 597 and 598 are located downgradient of a gravel pit, which may have affected water quality in the vicinity. Nevertheless, these wells were used as background wells because they are upgradient of the Old Rifle site. Because monitor well 584 (Figure D.7.2) is located on the site in the contaminated ore-loading area, it was excluded as a background monitor well.

Tables D.7.10 and D.7.11 contain a summary of background and downgradient groundwater quality statistics in the alluvium at the Old Rifle site. Statistical maximums for each constituent are also presented in these tables. The statistical maximum may be represented as the 99 percent confidence maximum for normal or log normal distributions, or as a non-parametric confidence interval if the distribution is neither normal or lognormal.

Background concentrations for several hazardous constituents in the alluvium at the Old Rifle site exceed the proposed EPA MCLs. These constituents include molybdenum, selenium, and net gross alpha activity (Table D.7.12). Groundwater from background monitor wells in the alluvium is a calcium sulfate type (Figure D.7.16).

The background quality of groundwater in the Wasatch Formation at the Old Rifle site was determined from chemical analyses of samples from upgradient monitor wells 620, 621, and 622 and crossgradient monitor wells 625, 626, and 641 (Figure D.7.3). Monitor well 620 is located approximately 0.5 mile upgradient of the processing site, and although groundwater from this well contains relatively high concentrations of sulfate, uranium, and selenium, the well is not contaminated from activities at the Old Rifle processing site and reflects base flow in the Wasatch Formation. Hence, monitor well 620 was used to define background water quality in spite of the relatively high concentrations of constituents within samples from the well. Monitor wells 629 and 640 are contaminated with the cement grout used to construct the wells, and were excluded from use in defining background water quality. Monitor well 630 was excluded as a background well because it is a considerable distance from the site. Monitor wells 623 and 624 are located on the site, and do not represent background water quality in the Wasatch Formation. Monitor wells 644 and 645 are located downgradient of the site, and were excluded as background wells.

Background and downgradient water quality for the Wasatch Formation at the Old Rifle site is summarized in Tables D.7.13 and D.7.14.

Background concentrations of several hazardous constituents in the Wasatch Formation at the Old Rifle site exceed the proposed EPA groundwater protection MCLs (Table D.7.15). These constituents include molybdenum, selenium, uranium, and net gross alpha activity. Groundwater from background monitor wells in the Wasatch Formation is a sodium sulfate type (Figure D.7.17).

New Rifle site

Background water quality in the alluvium at the New Rifle site was defined using samples from New Rifle monitor wells 591 and 592 and RFO 603 and 604 (Figures D.7.2 and D.7.4). Background water quality statistics in the alluvium at the New Rifle site is summarized in Table D.7.16 and complete water quality analyses for all monitor wells at the New Rifle site (alluvium and Wasatch Formation) are available at the DOE UMTRA Project Office, Albuquerque, New Mexico. Background concentrations of chromium, molybdenum, selenium, uranium, and net gross alpha activity exceed the proposed EPA MCLs (Table D.7.17). Background water quality in the alluvium at the New Rifle site is a calcium sulfate type (Figure D.7.18).

Background water quality in the Wasatch Formation at the New Rifle site was determined using water quality analyses from monitor wells 640, 641, 644, 645, 646, and 647. Monitor wells 640 and 641 are north of U.S. Highway 6, crossgradient to the site. Monitor wells 644 and 645 are across the Colorado River southeast of (crossgradient to) the site, and monitor wells 646 and 647 are located 0.5 mile east (upgradient) of the site.

Background water quality statistics from the Wasatch Formation at the New Rifle site is summarized in Table D.7.18. In general, groundwater from the Wasatch Formation contains relatively high concentrations of sodium and TDS with considerable natural variability in constituent concentrations. Background concentrations of barium, molybdenum, selenium, and activities of radium-226 and -228 combined exceed the proposed EPA MCLs (Table D.7.19). Uncontaminated groundwater from the Wasatch Formation is a sodium sulfate type (Figure D.7.19).

D.7.4.5 Extent of contamination

Old Rifle site

Alluvium

Seepage of tailings fluids has contaminated groundwater in the entire 20-foot thickness of the alluvium beneath the Old Rifle site. Most contaminated groundwater occurs in the mill area and directly below and downgradient (west) of the tailings (Figures D.7.20 through D.7.24). The contamination extends westward to a distance of approximately 200 feet, where weathered Wasatch Formation claystone pinches out much of the alluvium, diverting contaminated groundwater into the Colorado River and considerably reducing the contamination downgradient from that point. The lateral extent of contamination in the alluvium is limited by the Wasatch Formation claystone to the north and the Colorado River to the south.

Background and downgradient water quality for the alluvial monitor wells at the Old Rifle site are summarized in Tables D.7.10 and D.7.11. Tailings seepage has caused degradation of groundwater quality, and maximum concentrations of several constituents in the alluvium exceed statistical maximum background concentrations and the proposed EPA MCLs (Table D.7.20). Concentrations of arsenic, chromium, molybdenum, selenium, uranium and activities of net gross alpha and radium-226 and -228 combined exceed the proposed EPA MCLs. Tailings seepage has also resulted in concentrations of the Appendix I constituents, antimony, fluoride, strontium, vanadium, and zinc that are elevated above statistical maximum or maximum observed background in the alluvium at the Old Rifle site (see Calculation No. RFL-06-91-15-01).

Uranium concentrations in groundwater within the alluvium exceed the proposed EPA groundwater MCLs by more than an order of magnitude, and provide a good indication of the extent and magnitude of contamination. Figure D.7.20 shows the distribution of the uranium concentrations in the alluvial groundwater at the Old Rifle site. Other contaminant concentrations tend to be more variable and less extensive than uranium concentrations but several were contoured. These contaminants include selenium, vanadium, arsenic and activity of radium-226 and -228 combined (Figures D.7.21 through D.7.24).

The degree of contamination in alluvial monitor wells at the Old Rifle site is shown on the bivariate plot of calcium and sulfate in alluvial groundwater samples (Figure D.7.25). In general, groundwater from the contaminated wells contained higher concentrations of calcium and sulfate than groundwater from the background monitor wells. A trilinear diagram of alluvial groundwater samples (Figure D.7.16) indicates that higher percentages of sulfate occur in contaminated alluvial groundwater and that higher percentages of carbonate and bicarbonate occur in uncontaminated alluvial groundwater.

Wasatch Formation

Groundwater quality in the Wasatch Formation at the Old Rifle site has also been affected by the uranium milling activities. Contamination occurs to a depth of at least 100 feet. The lateral extent of the contamination is less than in the alluvium due to the lower hydraulic conductivity of the formation and the upward potentiometric gradients which occur in the vicinity of the site. However, past seasonal drainage from a culvert north of the tailings pile generated a localized groundwater mound, creating a vertical hydraulic potential for contaminants in the alluvium to migrate into the Wasatch Formation. This contamination is limited to areas where the overlying alluvium is contaminated and where downward potentiometric gradients occurred.

Groundwater quality in on-site and downgradient wells completed in the Wasatch Formation at the Old Rifle site is summarized in Table D.7.14. Water quality for the groundwater within the Wasatch Formation at the Old Rifle site is summarized in Tables D.7.17 and D.7.18. Maximum concentrations of several constituents in the Wasatch Formation down-gradient of the tailings exceed statistical maximum background concentrations and the proposed EPA groundwater protection standards (Table D.7.21). Downgradient concentrations of barium, cadmium, chromium, lead, molybdenum, and selenium and activities of net gross alpha and radium-226 and -228 combined exceed the proposed EPA groundwater protection standards and downgradient concentrations antimony, strontium, vanadium, and zinc are elevated above statistical maximum background concentrations in the Wasatch Formation.

On-site monitor wells 623 and 624 are contaminated, as indicated by the bivariate plot of sulfate and uranium for groundwater samples from the Wasatch Formation (Figure D.7.26). Background monitor well 620 also contains elevated concentrations of sulfate and uranium, and does not plot near the other background wells on Figure D.7.26. These elevated concentrations in monitor well 620 may reflect geochemical processes occurring due to activities at the upgradient gravel pit. Monitor well 644, located 2000 feet west of the Old Rifle tailings across the Colorado River, contains concentrations of barium, cadmium, chromium, lead, selenium, uranium, chromium, lead, selenium, uranium, and activities of radium-226 and -228 exceeding the proposed EPA groundwater MCLs (Table D.7.21). However, this well is not contaminated, as groundwater samples from this monitor well are shown on the bivariate plot of Figure D.7.26 to plot within the range of background wells. The high concentrations of these constituents in this monitor well reflect the naturally poor quality of groundwater from the Wasatch Formation. Although monitor well 644 is not contaminated, it was not used as a background well because it is downgradient from the tailings.

The lateral extent of contamination in the Wasatch Formation is less than in the alluvium due to the lower hydraulic conductivity of the Wasatch Formation. However, the true extent of contamination in the Wasatch Formation at the Old Rifle site cannot be ascertained due to the limited number of monitor wells completed in the bedrock downgradient of the tailings. Consequently, no contaminant isopleths have been developed for the Wasatch Formation at the Old Rifle site.

Aquifer flushing

Alluvium

Preliminary calculations were conducted to estimate the natural flushing period for geochemically conservative contaminants (such as nitrate and sulfate) in the alluvium at the Old Rifle site. The length of time required to flush one pore volume from the upgradient edge of the tailings to the discharge zone along the Colorado River (the maximum flowpath distance) was calculated using the following simple relationship between average linear groundwater velocity in the alluvium and the flowpath distance:

$$Tf = L / V$$

where

Tf = flushing time for one pore volume (years).

L = the maximum flowpath distance from the upgradient edge of the tailings to the discharge zone along the Colorado River.

V = the average linear groundwater velocity (ft/yr).

This simple relationship is based on the assumptions that the contaminants are geochemically conservative (such as sulfate and nitrate), that the source of contaminants is removed instantaneously, and that dispersion is negligible.

The natural flushing period for geochemically conservative species in groundwater within the alluvium at the Old Rifle site was estimated to be less than 10 years. Thus, it is reasonable to conclude that conservative contaminant species in the alluvium will flush to background concentrations within 10 years after the tailings have been removed, and certainly within 100 years after the tailings have been removed.

The length of time for natural flushing to remove geochemically non-conservative species (such as metals) cannot presently be determined. The information required to estimate the time for these species to disperse to background concentrations or to MCLs includes an additional detailed geochemical characterization. This information would be obtained during the separate characterization process that addresses Subpart B of 40 CFR 192. However, it is reasonable to assume that the required flushing times for geochemically less conservative species in the alluvium at the Old Rifle site may be considerably greater than 10 years.

Wasatch Formation

Because the hydraulic conductivity of the Wasatch Formation is significantly lower than that of the alluvium, natural flushing of contaminants in the Wasatch Formation would be negligible compared to natural flushing in the alluvium. Therefore, little or no natural flushing is predicted to occur in the Wasatch Formation within 100 years at the Old Rifle site.

Appendix IX organic contaminants in groundwater

Limited groundwater sampling for organic contaminants has been done at the Old Rifle site. Analyses for EPA priority pollutant organics were conducted on samples from on-site monitor wells 581 and 586 in 1986, and analyses for EPA Appendix IX organic constituents were conducted on samples from on-site monitor wells 581 and 583 and from background well 601 in 1988.

The solvent toluene was detected in monitor well 586 at a concentration of 0.009 mg/l. The compound alpha-BHC was detected in monitor well 581 at 0.00023 mg/l. Although these chemicals were not used in the actual milling process at the Old Rifle site, they may have been used on the site while the mill was in operation.

New Rifle site

Alluvium

The seepage of tailings and vanadium pond fluids has significantly affected groundwater quality in the alluvium at the New Rifle site. The areal extent of contamination (Figures D.7.27 through D.7.33) is much greater than at the Old Rifle site, and the concentrations of contaminants exceed the EPA MCLs by a greater margin.

The contaminant plume in the alluvium extends over an area of more than 400 acres at the New Rifle site. Groundwater in the entire depth of alluvium has been contaminated, with the highest concentrations of contaminants occurring immediately beneath and downgradient of the tailings pile and vanadium ponds. Most the of contamination occurs within 4000 feet downgradient of the New Rifle tailings pile as shown by sulfate and uranium isopleth maps (Figures D.7.27 and D.7.28), although concentrations of sulfate, TDS, and chloride may be elevated up to 8000 feet downgradient as indicated by samples from monitor well 608. Contaminated groundwater in the alluvium discharges into the Colorado River southwest of the pile but does not affect the river water quality (Section D.8, Surface Water Hydrology).

Table D.7.22 summarizes the downgradient groundwater quality statistics in the alluvium at the New Rifle site. Tailings seepage has significantly affected groundwater quality in the alluvium and resulted in concentrations of a number of constituents exceeding the proposed EPA groundwater protection standards. Maximum concentrations of arsenic, cadmium, chromium, molybdenum, nitrate, selenium, uranium, and net gross alpha activity exceed statistical maximum background concentrations and the proposed EPA groundwater protection standards in groundwater from monitor wells completed in the alluvium downgradient of the site (Table D.7.23). In addition, downgradient concentrations of antimony, cobalt, fluoride, strontium, thallium, tin, vanadium, and zinc are elevated above statistical maximum background concentrations in the alluvium at the New Rifle site.

The contaminant isopleths for molybdenum, nitrate, vanadium and selenium (Figures D.7.29 through D.7.32) show a less defined and less extensive area of contamination than do the sulfate and uranium isopleths.

Groundwater samples from alluvial monitor wells at the New Rifle site are shown in a trilinear diagram on Figure D.7.18. Background samples are a calcium sulfate type of water while groundwater samples commingled with tailings fluids are a sodium sulfate type of water. A distinct mixing zone is apparent, with samples from monitor wells further downgradient from the tailings pile representing the water quality of background samples.

A bivariate plot (Figure D.7.33) of alkalinity and sulfate concentrations in the alluvial monitor wells provides additional evidence of the degrees of mixing of the groundwater and tailings fluids. The concentrations of alkalinity and sulfate are high in monitor wells near the tailings pile and vanadium ponds, and decrease downgradient and toward the lateral edges of the contamination.

Wasatch Formation

Downward movement of contamination from the alluvium has affected groundwater quality in the Wasatch Formation at the New Rifle site, but the areal extent of contamination is less than in the alluvium. Figures D.7.34 through D.7.36 present sulfate, uranium, and molybdenum isopleths in the Wasatch Formation. Groundwater in the Wasatch Formation bedrock is contaminated to a depth of at least 90 feet at a distance of up to 3500 feet downgradient (west) of the tailings. No contamination has been observed in monitor wells completed in the Wasatch Formation south of the Colorado River. Furthermore, no contamination is expected to occur in the Wasatch Formation across the Colorado River, as the formation dips between four and ten degrees to the northwest (see Section D.3.4, Site Geology).

Tables D.7.18 and D.7.24 are statistical summaries of upgradient and downgradient groundwater quality in the Wasatch Formation at the New Rifle site. Maximum concentrations of arsenic, barium, lead, molybdenum, selenium, uranium, and activities of radium-226 and -228 combined and net gross alpha exceed the proposed EPA groundwater protection standards in the Wasatch Formation downgradient of the New Rifle tailings (Table D.7.25). Tailings seepage has also resulted in elevated concentrations of antimony, fluoride, strontium, sulfide, vanadium, and zinc above the statistical maximum background concentrations in groundwater (Table D.7.18 and D.7.24).

Background and contaminated samples of groundwater from the Wasatch Formation are a sodium sulfate type of water (Figure D.7.19). However, the contaminated samples differ from background samples because the sulfates comprise a greater percentage of the total anions. Contaminated samples are also distinguished on a bivariate plot of alkalinity and sulfate concentrations because they contain higher concentrations of alkalinity and sulfate than background samples (Figure D.7.37).

Aquifer flushing

Alluvium

Preliminary calculations were performed to estimate the natural flushing periods of geochemically-conservative contaminants (such as nitrate and sulfate) in the alluvium at the New Rifle site. The length of time required to flush one pore volume was calculated using the relationships described in Section D.7.4.5. The flushing period for the nitrate and sulfate to migrate from the upgradient edge of the vanadium ponds to the point where nitrate concentrations are estimated to be at the MCL and where sulfate concentrations are approximately at background was estimated to be 50 years after the tailings have been removed (Calculation No. Rifle 02-89-16-01-000). Thus, it is reasonable to conclude that conservative contaminant species in the alluvium at the New Rifle site would flush to background concentrations within 50 years after the tailings have been removed, and certainly within 100 years after the tailings have been removed. The length of time for natural flushing to remove geochemically nonconservative species (such as metals) cannot be determined at this time. The information required to estimate the time for these species to disperse to background concentrations or to MCLs includes an additional and very detailed geochemical characterization. This additional information would be obtained during the separate characterization process that addresses Subpart B of 40 CFR 192. However, it is reasonable to assume that the required flushing time for geochemically nonconservative species in the alluvium at the New Rifle site may be considerably greater than 50 years.

Wasatch Formation

Because the hydraulic conductivity of the Wasatch Formation is significantly lower than that of the alluvium, natural flushing of contaminants in the Wasatch Formation will be negligible compared to natural flushing in the alluvium. Therefore, little or no natural flushing is predicted to occur in the Wasatch Formation within 100 years at the New Rifle site.

Appendix IX organic contaminants in groundwater

Limited groundwater sampling for organic contaminants has been done at the New Rifle site. Analyses for EPA priority pollutant organics were conducted in 1986 on monitor wells 619 and 643. Low concentrations of the solvent toluene (0.0069 and 0.0054 mg/l, respectively) were detected in monitor wells 619 and 643.

In December 1988, the DOE sampled on-site monitor wells 581, 584, and 587 and upgradient monitor well 592 for Appendix IX organic constituents. The solvent toluene was detected in monitor well 581 and 587 at concentrations of 0.018 mg/l and 0.008 mg/l, respectively. The solvent acetone and the herbicide 2,4,5-TP were detected in monitor well 584 at concentrations of 0.017 and 0.005 mg/l, respectively. This concentration of 2,4,5-TP is less than the MCL (0.010 mg/l).

Toluene may have been used on the site, although it was not used in the actual solvent extraction milling process. The solvent may have been used for cleaning equipment and machinery in the mill. The herbicide 2,4,5-TP is also believed to have been used on the site for weed control.

Southwest Hazard Control, Inc. conducted an environmental survey of the New Rifle processing site and identified several organic hazardous wastes on site. These include several halogenated solvents, di(2-ethylhexyl) phosphoric acid (EHPA), PCBs, and herbicides containing 2,4-D and 2,4,5-TP.

D.7.5 HYDROGEOLOGICAL CHARACTERIZATION–ESTES GULCH DISPOSAL SITE

D.7.5.1 Geology and hydrostratigraphy

The Estes Gulch alternate disposal site is six miles north of Rifle on the southwestern flank of the Grand Hogback monocline. The Wasatch Formation underlies the site and consists of at least 3800 feet of variegated claystones, siltstones, shales, and fine grained sandstones. The Mesaverde Group (Ohio Creek and Williams Fork Formations) underlies the Wasatch Formation, and is the uppermost aquifer beneath the disposal cell. The Williams Fork Formation of the Mesaverde Group is approximately 4500 feet thick, and consists of light-brown to white sandstones, grey to black shale, and coal beds (Tweto et al, 1978). The massive resistant sandstone beds of this formation comprise the Grand Hogback north of the disposal site. The thin Ohio Creek Formation is considered by some authors to be the uppermost unit of the Mesaverde Group (and Williams Fork Formation). However, the Rifle site is approximately 60 miles northwest of the area described in the literature. The kaolinitic conglomeratic Ohio Creek unit is less than 100 feet thick near Estes Gulch and is not known to be a regional aquifer in the area. The Ohio Creek near the Estes Gulch site contains a high percentage of clay and appears to be quite impermeable.

Beneath the site, bedding planes dip in the Wasatch Formation approximately 65 to 75 degrees to the southwest. This dip decreases abruptly to 10 to 20 degrees 500 to 800 feet downslope of the proposed toe of the pile. This abrupt change in the dip occurs along a fault which parallels the Grand Hogback. The fault is filled with clay gouge and does not appear to be a significant groundwater transport pathway. Further discussion of this fault is included in section D.3.

Exploratory drilling encountered other minor faults paralleling the bedding planes and occurring randomly in the steeply dipping strata beneath the site. These faults occur as smooth planes with thin clay gouge fillings. Often, closely spaced fractures occur near these minor faults, becoming widely spaced within a few feet of the faults.

Further investigation of the Estes Gulch site conducted in 1991 by MK indicated the shallow bedrock under the disposal cell may be classified into three groups.

Group I - The Group I zone consists of a series of interbedded siltstones, sandstones, and shales, located approximately along the southern boundary of the disposal site (see Figures 6 and 7, MK Calculations Vol. IX). The percentage distribution of the rock types is as follows:

Siltstone:	40 percent
Sandstone:	30 percent
Shale:	30 percent

The relative permeability of the Group I zone is considered low to moderate (conservatively averaging 6.5×10^{-7} cm/s on an area basis) with a potential area for water transmission covering at least 30 percent, which is equivalent to the areal extent of the sandstone.

Group II - The Group II zone consists of alternating siltstone and sandstone beds. Group II covers the south central portion of the disposal cell site (see Figures 6 and 7, MK Calculations Vol. IX). The following rock type percentages were recorded:

Siltstone:	49 percent
Sandstone:	46 percent
Shale:	5 percent

The Group II zone has been classified as one of relatively moderate permeability (conservatively 1.0×10^{-6} cm/s [sandstone] to 3.4×10^{-8} cm/s [siltstone/weathered shale], both on an area basis). Due to this relatively moderate permeability, this group is considered a key zone of the disposal cell foundation to reduce or relieve the potential for the buildup of a saturated zone of tailings water.

Group III - The Group III zone consists primarily of siltstone, shale, and claystone, and a small percentage of sandstone (10 percent). The rock type distribution is as follows:

Siltstone:	60 percent
Sandstone:	10 percent
Shale/claystone:	30 percent

This group of rocks occupies approximately two-thirds of the area of the disposal cell site. Group III has been identified as a zone of very low permeability (conservatively averaging 1.5×10^{-7} cm/s).

In 1993, MK conducted further testing to define the saturated vertical permeability of sandstones at the low portion of the disposal cell and the saturated vertical permeability of siltstone in the cell foundation. The geometric mean of the low portion of the disposal cell was found to be 4×10^{-7} cm/s. The permeability of the siltstone was determined to range from 7×10^{-8} cm/s to 3×10^{-5} cm/s.

D.7.5.2 Groundwater flow and hydraulic characteristics

Wasatch Formation

The Wasatch Formation is an aquitard, and does not contain significant quantities of groundwater (Wright Water Engineers, 1979; Giles, 1980: Coffin et al, 1968; and Coffin et al, 1971). The limited groundwater in the Wasatch Formation beneath the site flows through fractures and joints along the strike of the beds. Localized recharge to the bedrock occurs through weathered zones and fractures, and in areas where vertical sandstone beds intercept the ground surface. Recharge percolates down to limited zones of saturation, and groundwater then slowly flows along strike of the nearly vertical beds. Because groundwater saturation is localized, the potentiometric gradient cannot be defined in the vicinity of the disposal cell. The potentiometric surface was not defined for the Wasatch because it is an aquitard. Anisotropy within the shales and claystones of the Wasatch Formation is significant, with the principal component of the hydraulic conductivity following the strike of the beds.

South of the fault zone, where bedding planes dip 10 to 15 degrees towards the southwest, groundwater probably flows towards the southwest along the dip of the beds. The fault itself is not believed to be a significant groundwater recharge zone, as monitor well 702 is completed in the fault zone and recovered very slowly during a bailer recovery test. Analysis of well recovery data in monitor well 702 yields a hydraulic conductivity of 1 x 10^{-9} cm/s within the fault zone (Calculation No. RFL 09-89-14-02a). Therefore, the fault is not a significant zone of groundwater recharge, because there is little enhancement of hydraulic conductivity in the fault zone. Considerably more recharge to the near horizontal beds of the Wasatch Formation probably occurs along Government Creek.

Groundwater discharge from the Wasatch Formation near Government Creek occurs as underflow to the southeast. The Colorado River is a regional point of groundwater discharge for the Wasatch Formation.

In 1986, the DOE installed ten monitor wells at the Estes Gulch site (monitor wells 952 through 969 in Figure D.7.6 and Table D.7.26) ranging in depths from 60 to 301 feet. Nine of the wells are dry. Water was encountered in the deepest well (well 963) at a depth of 270 feet below ground surface, and has slowly risen to a depth of 163 feet below the ground surface. Unfortunately, samples from well 963 appear to be cement grout contaminated from the well construction, with pH values ranging from 11.6 through 12.1.

In July 1988, the DOE installed three additional monitor wells (well numbers 701, 702 and 703) completed to depths of 500 to 545 feet (Figure D.7.6 and Table D.7.26). Monitor well 701 is located south of the fault (mentioned above) in the nearly horizontal beds. Monitor well 702 is located in the fault zone, while monitor well 703 is located in the near-vertical beds north of the fault. All three wells showed little or no water at completion, and water levels were below 490 feet several days after completion. In March 1989, water levels in the three wells ranged from 339 to 470 feet below ground surface, but hydrostatic equilibrium in the wells may not have been reached (Table D.7.18).

Several laboratory and field tests were performed from 1988 to 1993 to characterize the lower and upper Wasatch Formation at the Estes Gulch disposal site.

The vertical saturated hydraulic conductivity of the Wasatch Formation at the Estes Gulch site ranges from 0.004 to 2 X 10^{-5} ft/day (1 x 10^{-6} to 7 x 10^{-9} cm/s) based on laboratory triaxial permeability tests on four rock core samples from beneath the site (Table D.7.20) (Calculation No. RFL 08-89-13-02). These values are the hydraulic conductivities of rock matrix and do not reflect secondary hydraulic conductivity due to fracturing.

Packer tests conducted in 1988 at the site indicate that the hydraulic conductivity in the upper 20 feet of weathered bedrock ranges from less than 3×10^{-4} to 6×10^{-1} ft/day (1×10^{-7} to 2×10^{-4} cm/s) as shown in Table D.7.27 (Calculation No. RFL 09-89-14-036). The geometric mean hydraulic conductivity was 3×10^{-6} cm/s, with a lower 90 percent confidence interval of 3×10^{-7} cm/s (TAC Calculation No. RFL 03-91-01-04-00). Packer tests below the weathered bedrock indicate that the fractures close with depth and are relatively impermeable. This may be due to the confining pressure of the overlying bedrock and the clay gouge fill encountered in the fractures.

The average hydraulic conductivity of the Wasatch Formation decreases several orders of magnitude below the weathered zone, to 6×10^{-5} ft/day (2×10^{-8} cm/s), based on constant head permeability tests conducted in 1988 on four monitor wells at Estes Gulch (Table D.7.28) (Calculation No. RFL 08-89-14-03-00). The four monitor wells were completed at depths of 100 to 250 feet below ground surface. This hydraulic conductivity is more representative of the formation as a whole, and reflects both matrix permeability and the fracture permeability of the bedrock in which the wells are screened. Monitor well 965 was screened in the fault zone south of the proposed disposal cell, yet shows no significantly higher hydraulic conductivity due to fracturing. Thus, the fault is a significant groundwater flow route.

<u>Williams Fork Formation</u>

The Williams Fork Formation of the Mesaverde Group underlies the Wasatch Formation, and is the uppermost aquifer beneath the Estes Gulch disposal cell. No monitor wells were installed in the Williams Fork Formation because it is projected to be more than 3800 feet below ground surface (Calculation No. RFL 06-90-13-04-00). However, limited information on the regional groundwater flow and hydraulic characteristics of the Mesaverde Group is available in the geologic literature.

Groundwater recharge to the Williams Fork Formation of the Mesaverde Group occurs at the Grand Hogback, 3800 feet north of the Estes Gulch disposal site. The Williams Fork Formation is confined beneath the Wasatch, and flow is structurally controlled. Groundwater flows downdip to the southwest, away from the Grand Hogback towards the axis of the Piceance Creek Basin. Upward potentiometric gradients occur between the Williams Fork Formation and the Wasatch Formation because the Wasatch Formation is an aquitard confining the Williams Fork Formation.

The Mesaverde Group does not outcrop in the center of the Piceance Creek Basin, and groundwater discharge from the Mesaverde Group occurs as leakage to adjacent geologic formations and through more permeable fault zones which intercept the ground surface (Giles, 1980).

D.7.5.3 Background water quality

Wasatch Formation

Groundwater from the Wasatch Formation is a sodium sulfate or sodium chloride type, based on samples from monitor wells 701, 702, and 703. Table D.7.29 contains water quality analyses of groundwater samples from these monitor wells and from three low-yield domestic wells located 0.75 mile west of (crossgradient to) the site. The locations of the on-site monitor wells are presented in Figure D.7.6 and the vicinity domestic well locations are presented in Figure D.7.38. Figure D.7.39 is a trilinear diagram of groundwater samples from the wells completed in the Wasatch Formation at Estes Gulch, and Figure D.7.40 is a Stiff diagram of the samples. The predominance of sulfate and chloride in the groundwater and the slow groundwater velocity of the Wasatch Formation (Section D.7.5.2) indicate that groundwater has a long residence time in the bedrock (Freeze and Cherry, 1979) and recharge from precipitation is low. Additional discussion of infiltration at Estes Gulch is presented in Section E.2.1.1 of Appendix E.

Based on the trilinear diagram (Figure D.7.39) and the Stiff diagram (Figure D.7.40), monitor well 963 is grout contaminated, as shown by its high pH values (11.6 to 12.1) and its relatively high alkalinity. Groundwater from monitor wells 702 and 703 also contains high pH values (11.6 and 11.7, respectively), but these wells were probably not grout contaminated during construction. Both the trilinear diagram and the Stiff diagram indicate that samples from these wells, unlike samples from monitor well 963, plot within the background range for the Wasatch Formation. These high pH values reflect background water quality because relatively high pH (10 to 11) values were also measured in the slurries of drilling cuttings from these wells.

Groundwater in the Wasatch Formation beneath the site is limited use (Class III) groundwater (40 CFR 192.11(e)). Limited use groundwater is groundwater that is not a current or potential source of drinking water because (1) the concentration of total dissolved solids is in excess of 10,000 mg/l, (2) widespread, ambient contamination unrelated to activities involving residual radioactive materials from a designated processing site exists that cannot be cleaned up using treatment methods reasonably employed in public water-supply systems, or (3) the quantity of water available is less than 150 gallons per day (gpd) (40 CFR 192.11(e)). Groundwater in the Wasatch Formation at Estes Gulch satisfies the second and third criteria, and may satisfy the first criteria.

Groundwater in the Wasatch Formation beneath the disposal cell is of extremely poor quality, with TDS concentrations ranging from 8,260 to 25,100 mg/l, and it also contains high concentrations of naturally occurring contaminants (Table D.7.19). Selenium concentrations in the groundwater range from 0.022 to 0.975 mg/l, and the average selenium concentration was 15 times the proposed EPA MCL average. Molybdenum concentrations are five times greater than the proposed EPA MCL. Barium, cadmium, chromium, lead, net gross alpha, and radium-226 and -228 combined also exceed the proposed EPA MCLs.

The classification of limited use groundwater at the Estes Gulch site may be based on the criteria that the groundwater contains widespread ambient contamination, and that this contamination cannot be cleaned up using methods reasonably employed by public water supply systems. The EPA has provided guidance in their draft guidelines for groundwater classification on the treatability of groundwater (EPA, 1984). The primary constituent of concern in groundwater in the Wasatch Formation at the Estes Gulch site is selenium, since background concentrations are substantially above Federal drinking water standards. Selenium can be removed by several types of treatment approaches, the majority of which are too inefficient to remove enough selenium from the groundwater at the Estes Gulch site to make the water potable. However, three treatment technologies--desalination, ion exchange, and ozonation--remove 97, 98, and 99 percent selenium, respectively (EPA, 1986). The EPA's groundwater classification guidelines provide information by EPA region on the number of public water-supply systems using various treatment technologies. None of the three treatment technologies discussed are used on a widespread basis. The EPA has found all three technologies applied in some region of the country. For EPA Region VIII (the region which includes Colorado), one public water-supply system uses desalination, two use ion exchange, and none use ozonation. Desalination has high capital, operation, and maintenance costs, as does the ion exchange process. Given the infrequency of use of these treatment technologies (e.g., not reasonably employed), the high capital and operational costs, the low yield aquifer, and the low population density, the Wasatch Formation could be classified as limited use groundwater due to widespread ambient contamination that cannot be cleaned up using methods reasonably employed by public water supply systems.

The three domestic wells completed in the Wasatch Formation 0.75 mile west of the site are not within the same hydrostratigraphic unit of the Wasatch Formation as the disposal site. These wells are located cross-gradient to the disposal site and across the fault. The beds in which the domestic wells are completed are nearly horizontal, whereas beneath the disposal site the beds of the Wasatch Formation are steeply inclined. The domestic wells are near Government Creek in an area of the Wasatch Formation which is recharged by the creek. On the other hand, recharge is relatively minimal to groundwater beneath the disposal site and groundwater is in contact with the bedrock for a considerably longer period of time. The differing sources for groundwater in the Wasatch Formation are reflected in the pH values of groundwater from the wells; monitor wells completed south of the fault contain pH values less than 9.0, while groundwater from wells north of the fault typically contains high pH values (Figure D.7.40).

A drilling log for one of the domestic wells indicates that the wells are completed in a portion of the stratigraphic section where considerably more sandstone occurs than was encountered at the Estes Gulch site. This would explain why the yield of the Wasatch Formation is high enough to support domestic use near Government Creek, while yield is considerably lower beneath the Estes Gulch disposal site, and supports the hypothesis that the domestic wells are not within the same hydrostratigraphic unit of the Wasatch Formation or the disposal site.

The Wasatch Formation beneath the Estes Gulch disposal site cannot yield 150 gpd to a well, based on preliminary calculations using the Theis Equation, and groundwater beneath the site may also be designated as limited use based on this limited yield (Calculation No. RFL 09-89-14-036). The Theis calculations assumed a six-inch well, 200 feet of available drawdown, and a hydraulic conductivity of 10^{-4} ft/day. If the Wasatch Formation is pumped at an average rate of 150 gpd, the calculated drawdown within 30 days is greater than 200 feet. This drawdown exceeds the available drawdown in a typical well which might be completed in the Wasatch Formation, and demonstrates that the formation cannot support a pumping rate of 150 gpd.

Williams Fork Formation

Site-specific groundwater quality data are not available on the Williams Fork Formation. There are no existing wells, in the vicinity of Estes Gulch, screened in the Williams Fork Formation. Therefore, regional studies were reviewed to obtain information. Although regional water quality in the Williams Fork Formation may differ to some degree from site-specific conditions, the USGS data are the best available. It is reasonable to expect some similarity of water quality within one formation.

The Williams Fork Formation is in the Mesaverde Group, which is one of the more important aquifers of western Colorado (Pearl, 1980). Groundwater quality from this aquifer is generally good. Table D.7.30 contains water quality analyses of groundwater samples from the Mesaverde group, and Figure D.7.41 is a trilinear diagram of groundwater samples from these regionally located wells. Based on this trilinear diagram, groundwater in the Williams Fork Formation (Mesaverde Group) is a calcium magnesium bicarbonate type.

In general, groundwater quality in the Williams Fork Formation is considerably better than groundwater quality in the Wasatch Formation aquitard, based on regional groundwater quality data from the Mesaverde Group (Giles, 1980). TDS concentrations in the Mesaverde Group range from 41 to 235 mg/l. Groundwater from the Mesaverde Group also contains low concentrations of selenium, sodium and chloride (Table D.7.23), while groundwater in the Wasatch Formation contains much higher levels of these constituents (Table D.7.19).

D.7.6 GROUNDWATER USE, VALUE, AND ALTERNATE SUPPLIES

The Colorado River is the primary source of domestic water in the Rifle area. The city of Rifle obtains all of its water for municipal use from the Colorado River approximately 0.5 mile upgradient of the Old Rifle tailings site, and all water users within the municipal boundaries are connected to the municipal water system. The city also supplies water to users outside the city limits (Mintum, 1986). Most residents living outside the municipal boundaries obtain their water from private wells (Figure D.7.42).

Sixty-three wells have been identified in the vicinity of the Rifle processing sites and the Estes Gulch disposal site (Figure D.7.42). Most of the wells are completed in the Colorado River and Rifle Creek alluvium, although some wells are completed in the Wasatch Formation and in the landslide and alluvial deposits on the Taughenbaugh Mesa.

Forty-seven wells are within two miles of the Old Rifle site, thirty-six wells are within two miles of the New Rifle site, and nine wells are within two miles of the Estes Gulch site. Three of the wells near Estes Gulch are screened in the Wasatch Formation approximately 0.75 miles west of the site, but are not currently being used. Although located at a lower elevation than the Estes Gulch site, these wells are south of the fault near the disposal site, and are not in hydrologic connection with the limited groundwater beneath the disposal site. The other wells in the Rifle area are used primarily for irrigation and livestock watering. There is no groundwater use in the Williams Fork Formation of the Mesaverde Group near the Rifle sites because of the great depth to this aquifer.

Natural groundwater quality in the Colorado River alluvium and in the underlying Wasatch Formation is poor, with high sulfate and TDS concentrations (Wright Water Engineers, 1979). Consequently, the water from wells in the area is not very potable. Most of the residents with wells consider the water quality too poor to drink, but use their water for toilets and for cooking and watering gardens and livestock.

Several domestic wells were identified during the period of September 1990 to September 1991 which are downgradient or crossgradient of the New and Old Rifle tailings and which have total concentrations of uranium, selenium, or net gross alpha that are greater than the EPA MCLs (Table D.7.31). Analytical results of these domestic well samples were sent to well owners in July 1991.

Domestic wells downgradient or crossgradient of the New and Old Rifle tailings which have total concentrations of hazardous constituents that exceed EPA MCLs include the Highway 6 and 24 trailer park wells, the Blackmoore Spring well, the All Seasons Propane well, the Northwest Pipeline office well, and the Ideal Cement Company well (Table D.7.31). The All Seasons Propane well, the Highway 6 and 24 trailer park well and the Blackmoore Spring well are located about 0.25 to 0.50 miles north of the tailings areas. The Northwest Pipeline office, which is located about one mile downgradient of the New Rifle site, is presently being connected to the Rifle municipal water supply and use of their well will be discontinued. The Ideal Cement Company is located approximately two miles downgradient of the New Rifle tailings pile.

Further information and a risk assessment are needed to evaluate the potential health impacts in domestic wells downgradient of the Rifle sites. The scheduled risk assessment for the Rifle sites has been initiated. The risk assessment, which will take several months to complete, will include a detailed evaluation of current and potential uses of affected groundwater, institutional controls, and risks associated with nondrinking uses of the groundwater. More specifically, the assessment will include an evaluation of the following:

- o Background groundwater quality.
- o Risks associated with potentially affected domestic wells.
- o Risks associated with consuming fish caught from the Old Rifle pond.
- o Potential future use of groundwater.
- o Assessment of data needs.
- o Costs for corrective action, if needed.

The risk assessment will be prepared in accordance with EPA methodology for Superfund. The preliminary determination of whether corrective action is needed will be based on EPA's Interim Guidance on Removal Action Levels at Contaminated Drinking Water Sites (EPA, 1987).

The value of groundwater use in the Rifle area can be estimated by multiplying the quantity presently used by current water rates. The total groundwater use from sixty-three wells is estimated to be 2.7 million gallons per month, assuming that each well pumps at an average rate of one gallon per minute. Based on current water supply rates for the area (Abel, 1986), the total value of groundwater use per well would be $30 dollars per month. For the sixty-three wells, the value of existing groundwater use is estimated to be $22,700 per year.

Groundwater development in the Rifle area should not increase appreciably for the next 50 years because future population growth in Garfield County is expected to be only one to two percent per year (Section 2.1 of Appendix J, Land Use and Socioeconomics). The use of groundwater for livestock watering is not expected to increase significantly. High TDS concentrations in groundwater in the alluvium and the Wasatch Formation restrict the use of groundwater for irrigation, and background water quality within the two formations is too poor to allow development for a large-scale potable water supply. Readily available water exists in the Colorado River and in colluvium and basalt flows overlying the Wasatch Formation on the Taughenbaugh and Grass Mesas south of Rifle. These aquifers are topographically higher than the contaminated alluvium and Wasatch Formation at the Rifle tailings sites and cannot be affected by the existing groundwater contamination.

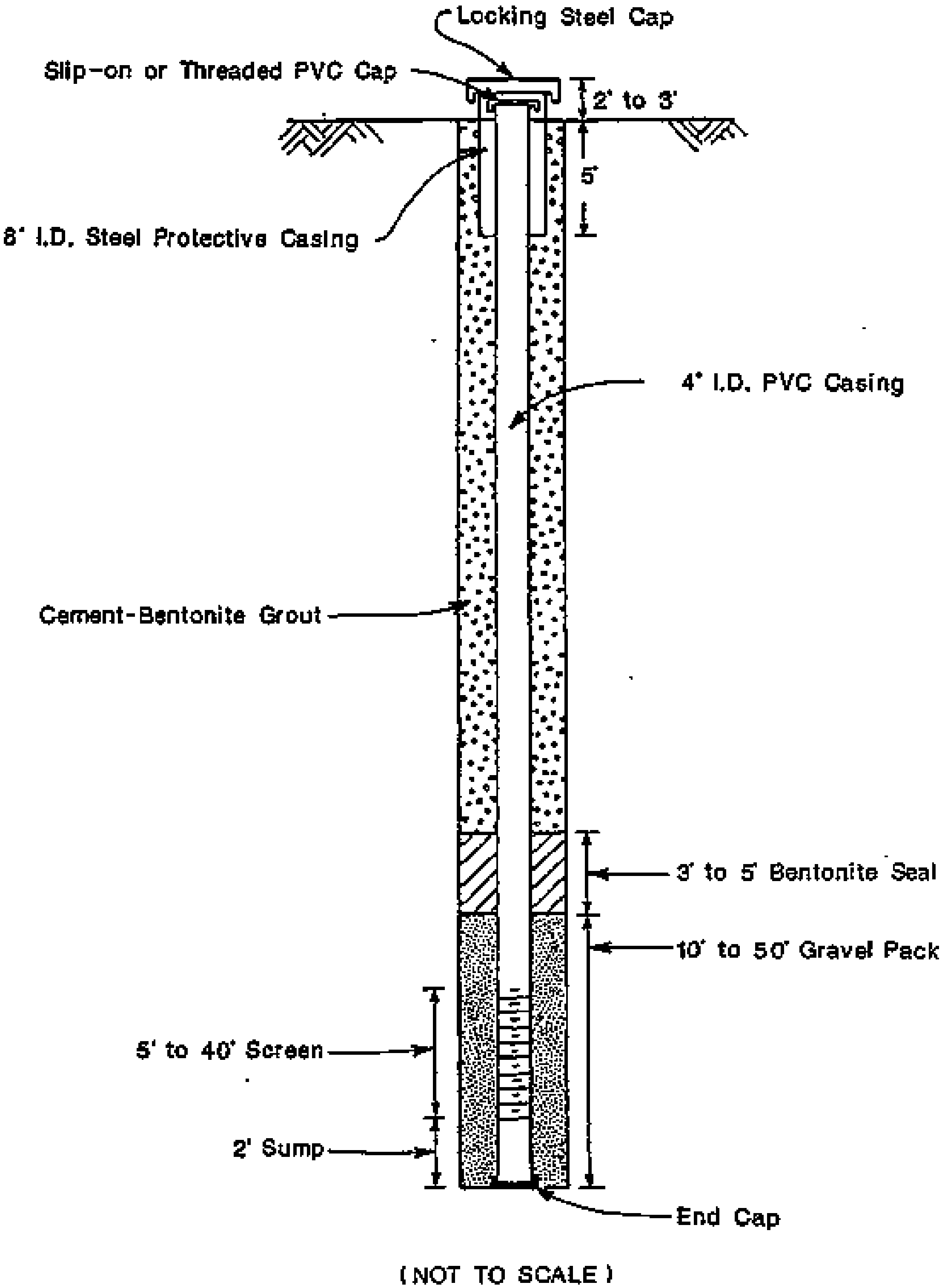


FIGURE D.7.1
TYPICAL MONITOR WELL INSTALLATION

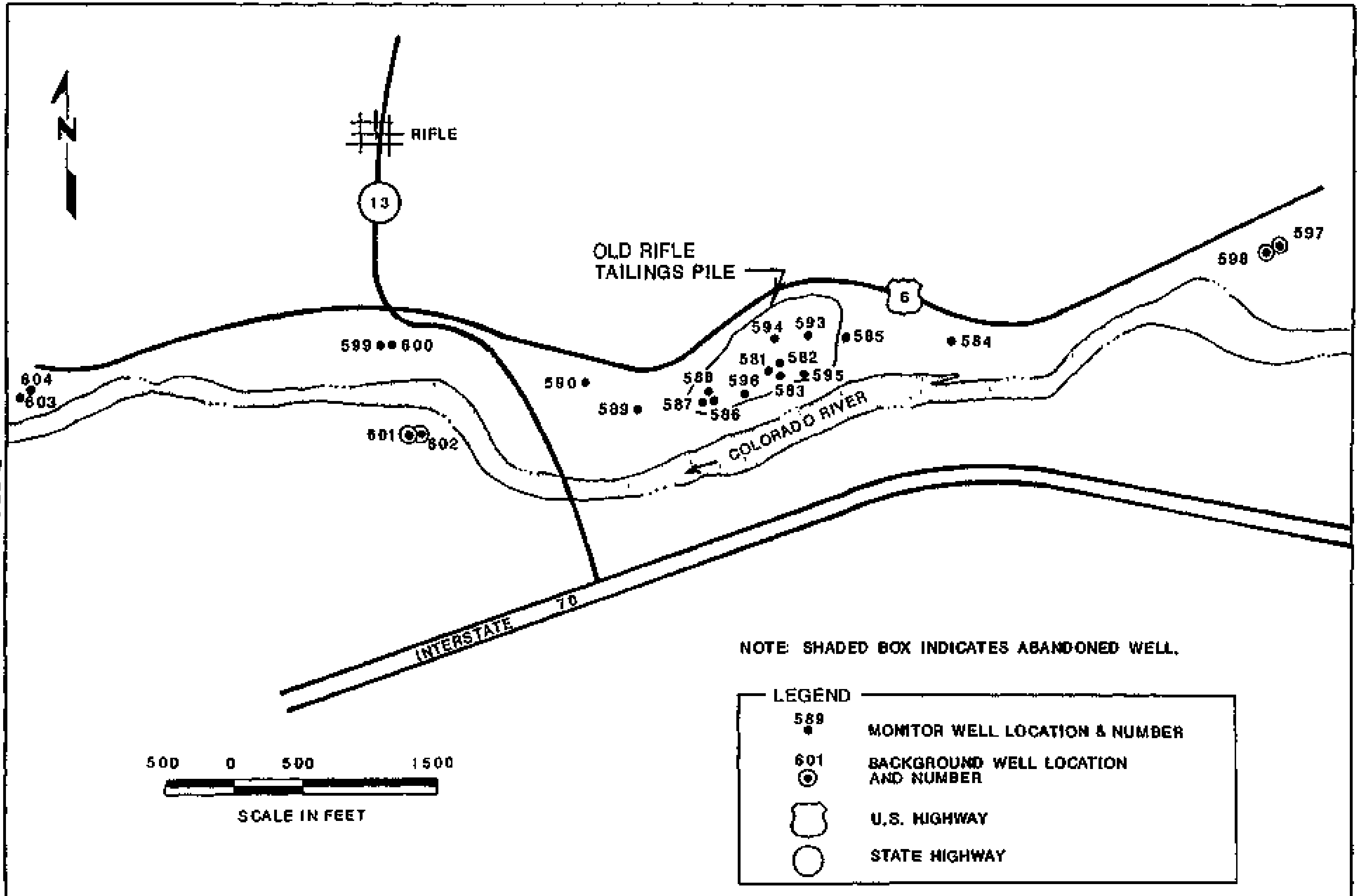


FIGURE D.7.2
LOCATIONS OF ALLUVIAL MONITOR WELLS, OLD RIFLE SITE

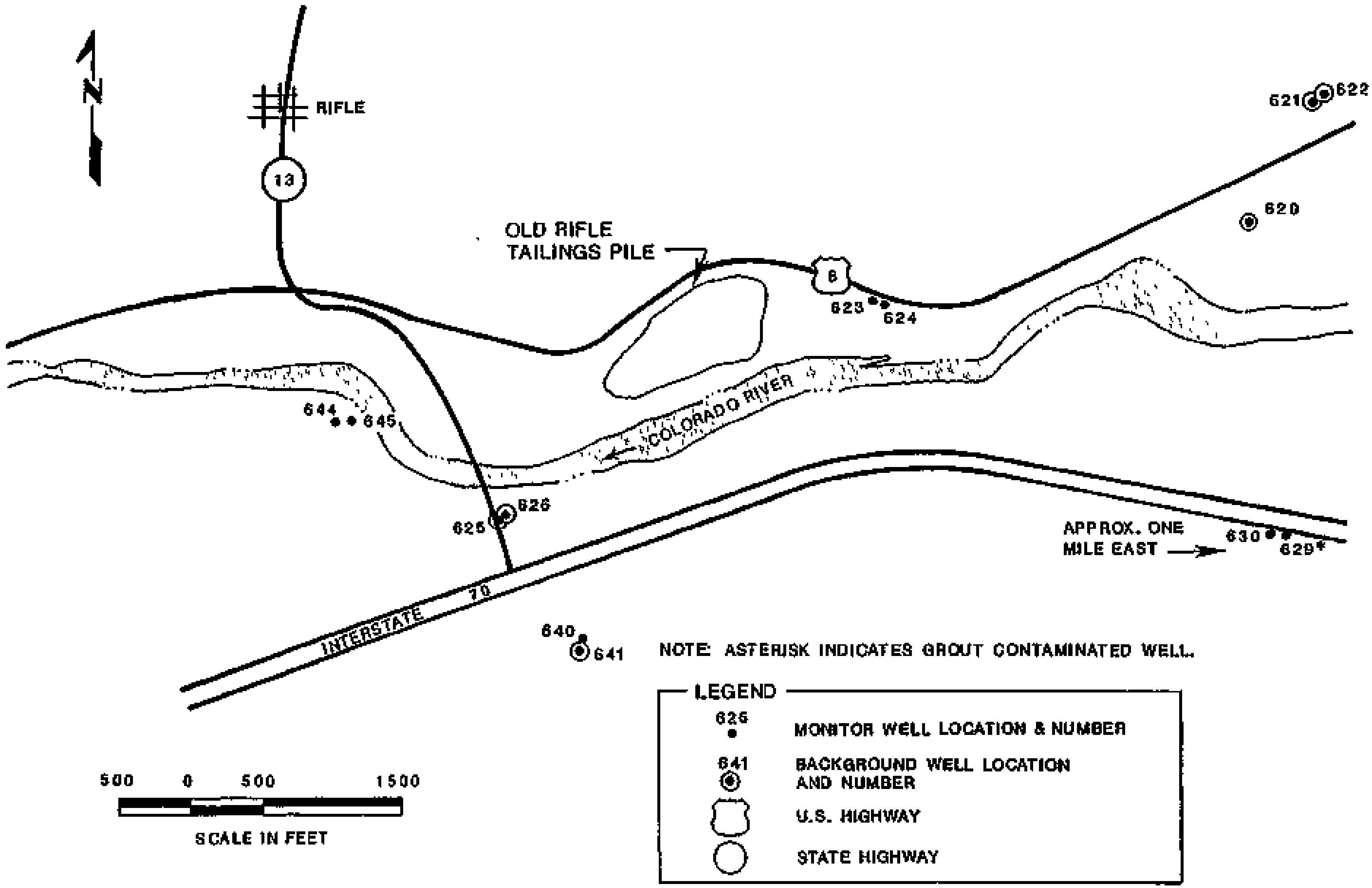


FIGURE D.7.3
LOCATIONS OF WASATCH FORMATION MONITOR WELLS, OLD RIFLE SITE

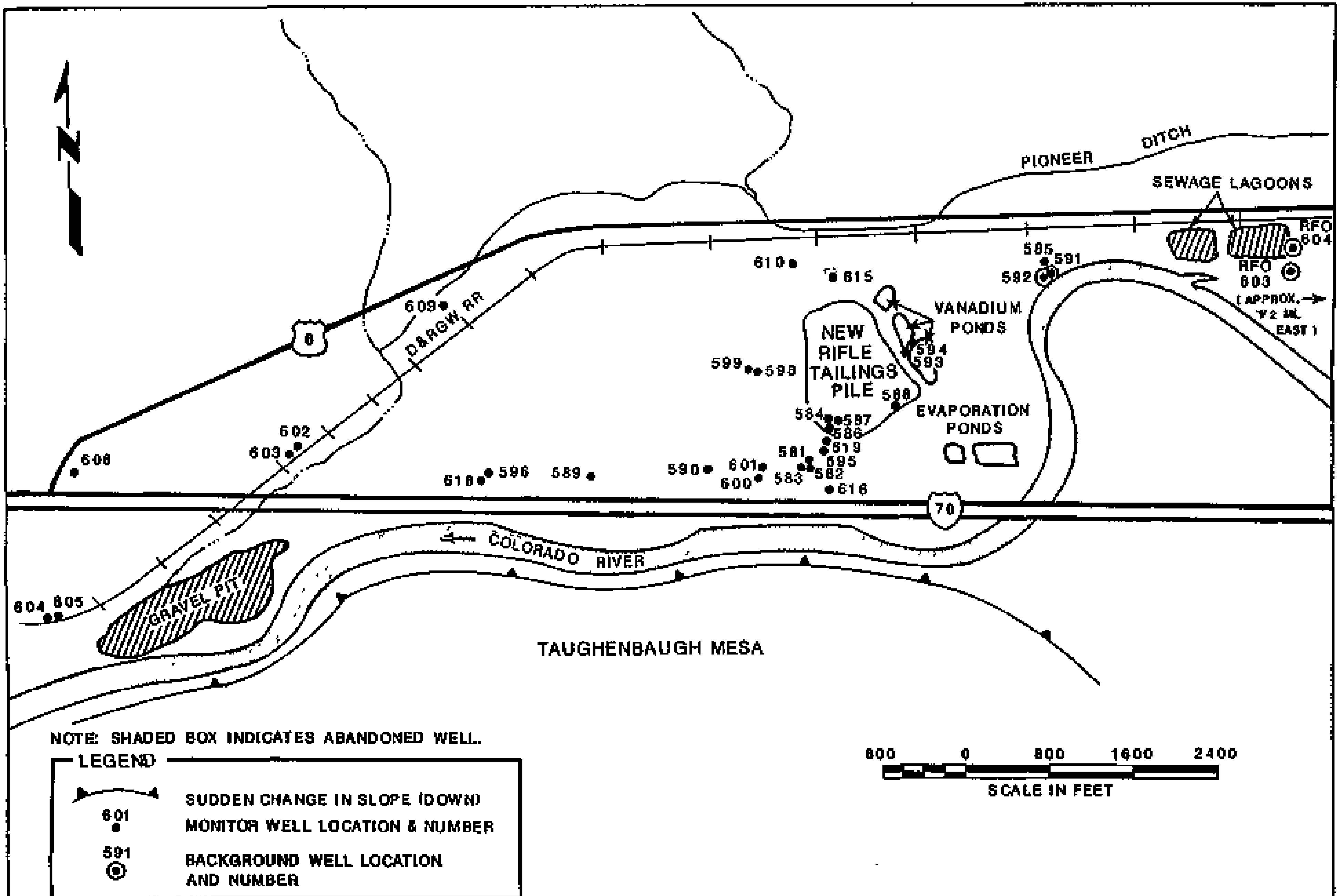


FIGURE D.7.4
LOCATIONS OF ALLUVIAL MONITOR WELLS, NEW RIFLE SITE

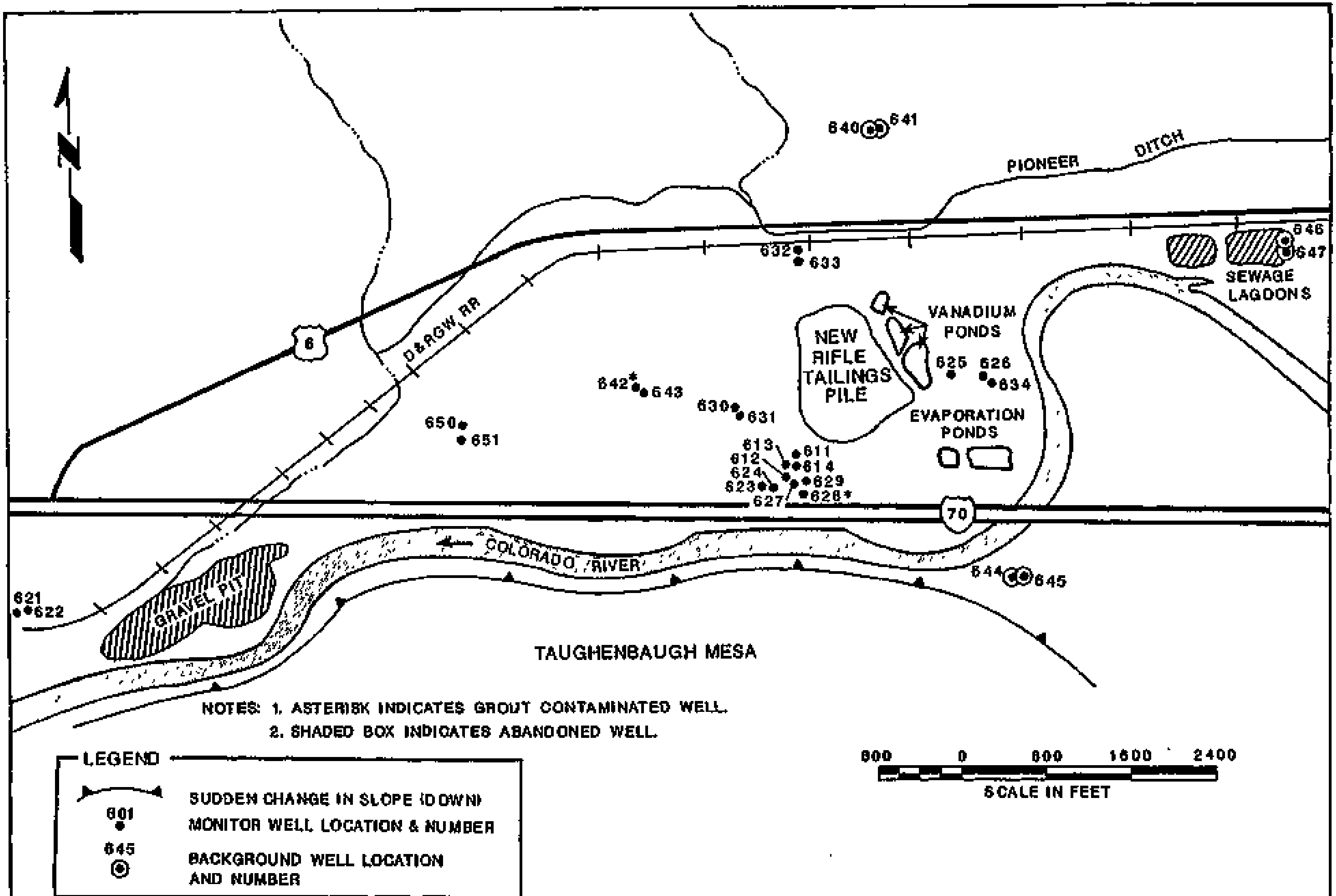


FIGURE D.7.5
LOCATIONS OF WASATCH FORMATION MONITOR WELLS, NEW RIFLE SITE

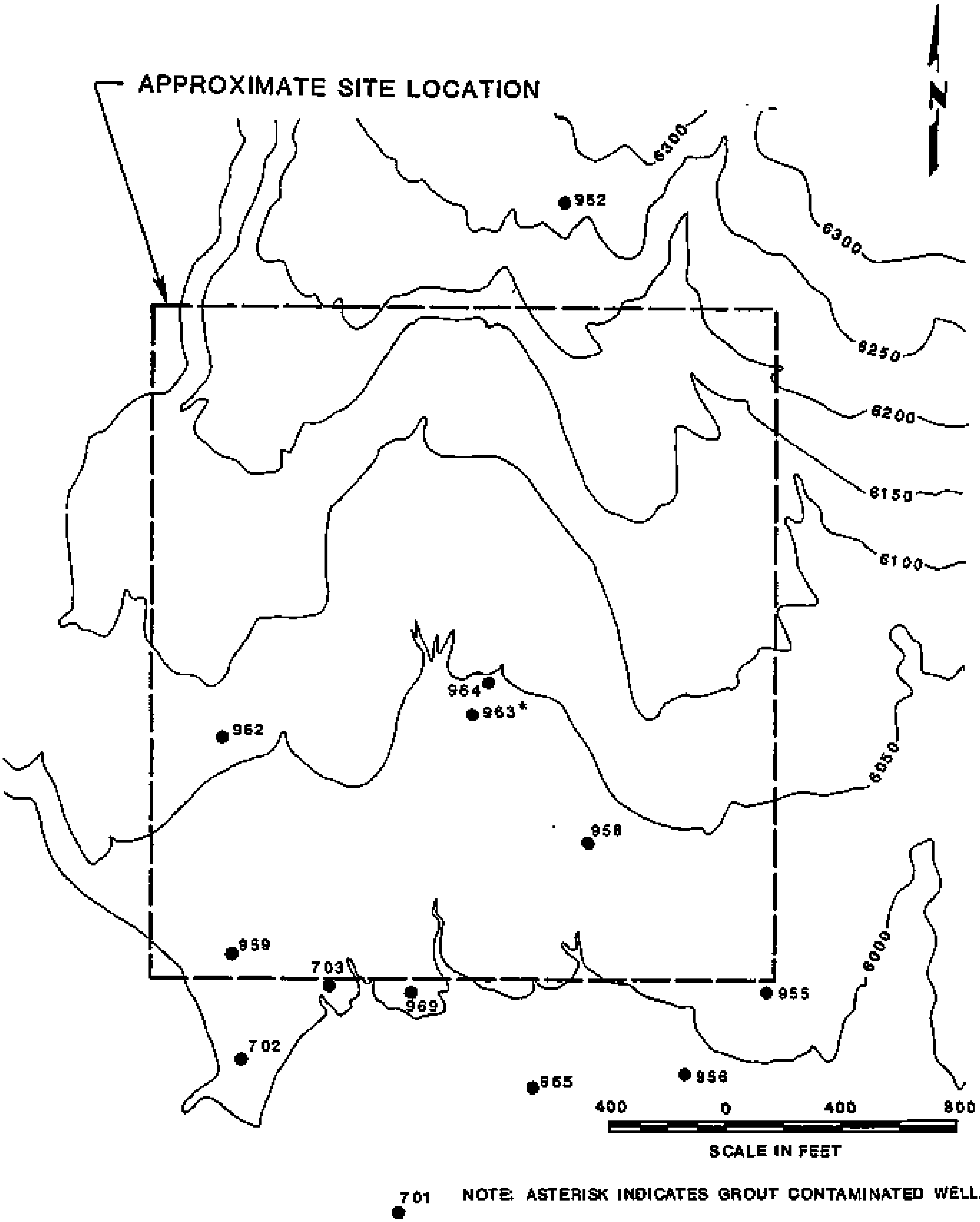


FIGURE D.7.6
MONITOR WELL LOCATIONS, ESTES GULCH SITE

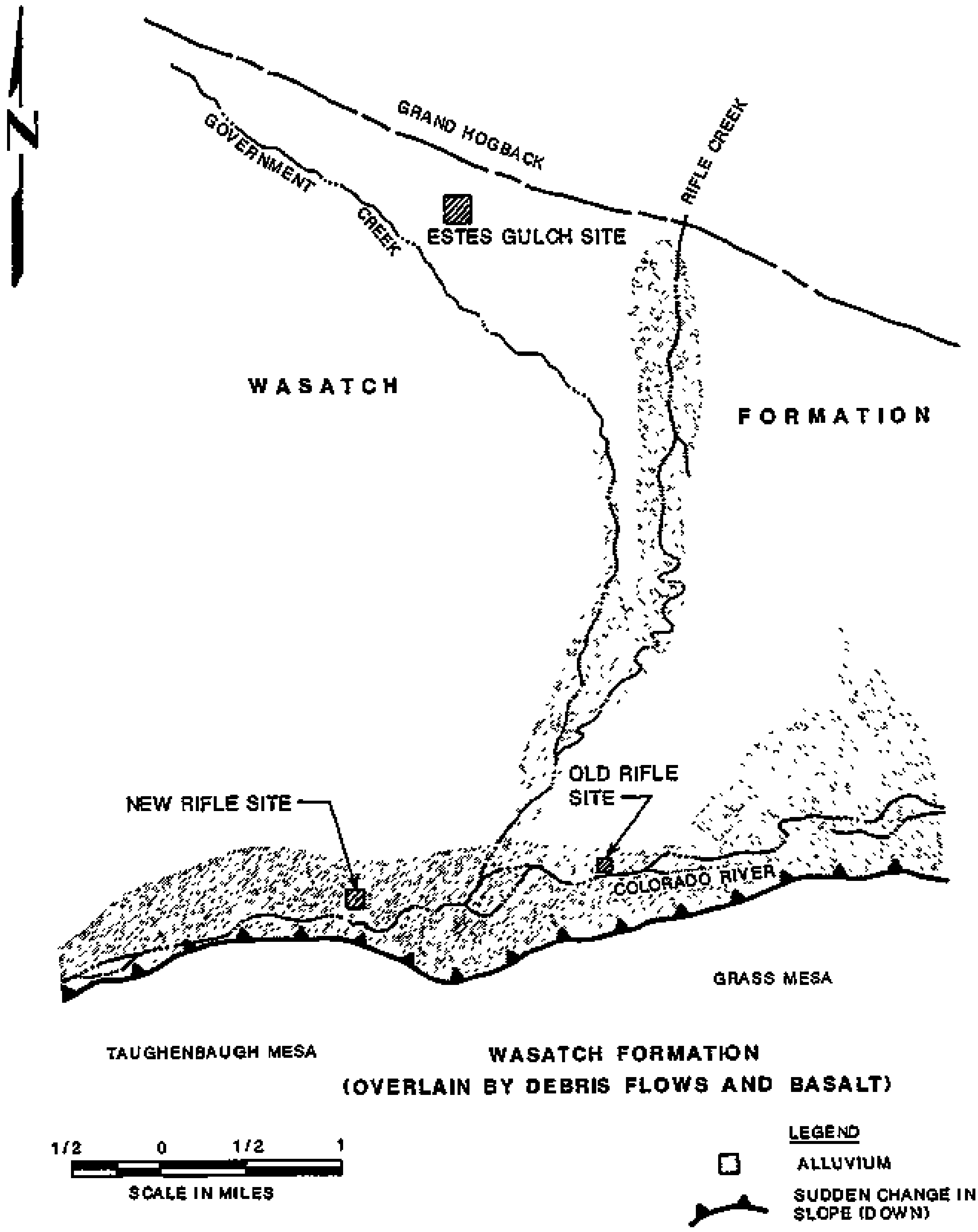


FIGURE D.7.7
SCHEMATIC REPRESENTATION OF PRINCIPAL GEOLOGIC UNITS IN THE RIFLE AREA

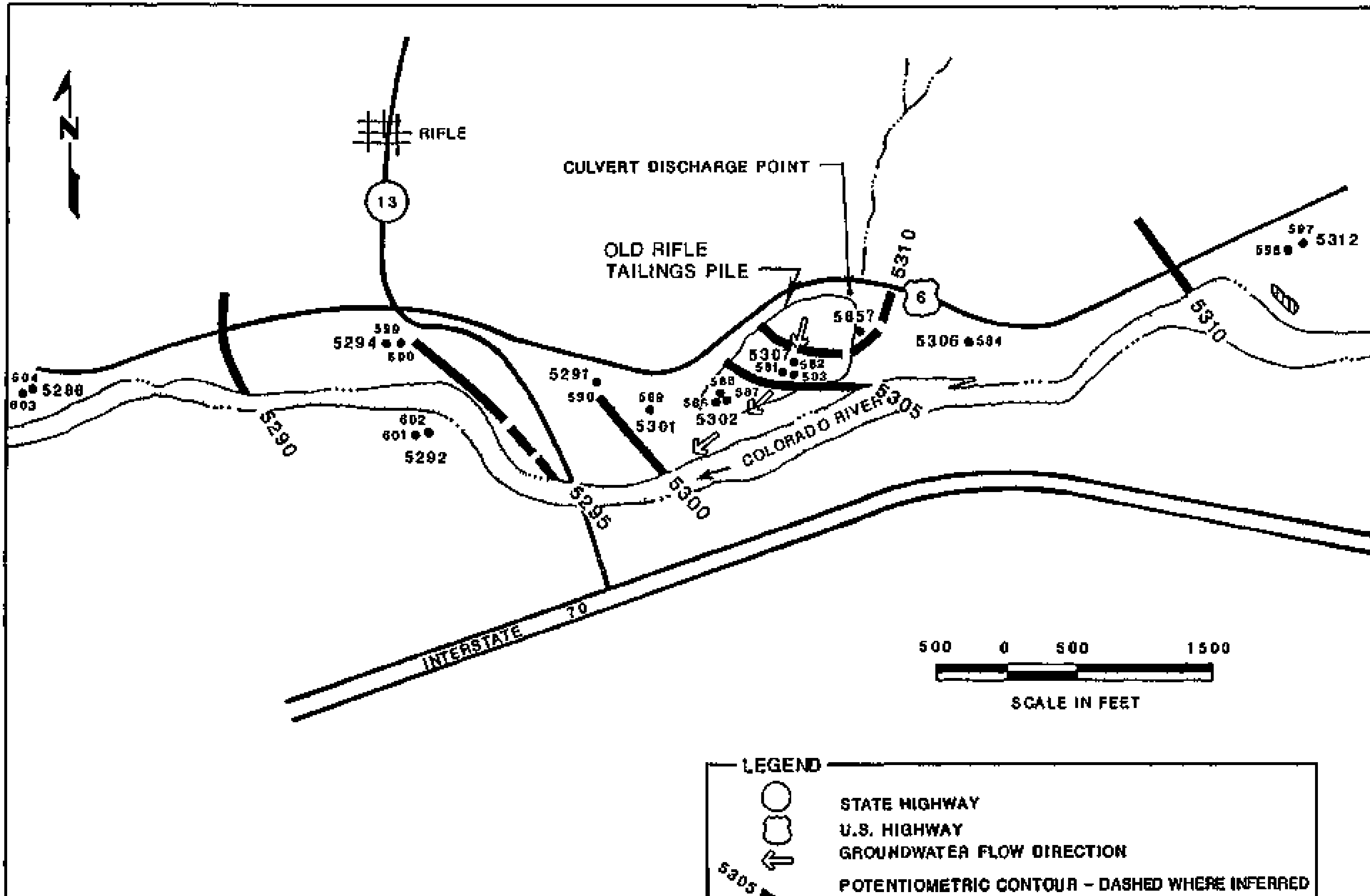


FIGURE D.7.8
ALLUVIAL POTENTIOMETRIC SURFACE, OLD RIFLE SITE, JUNE 1985

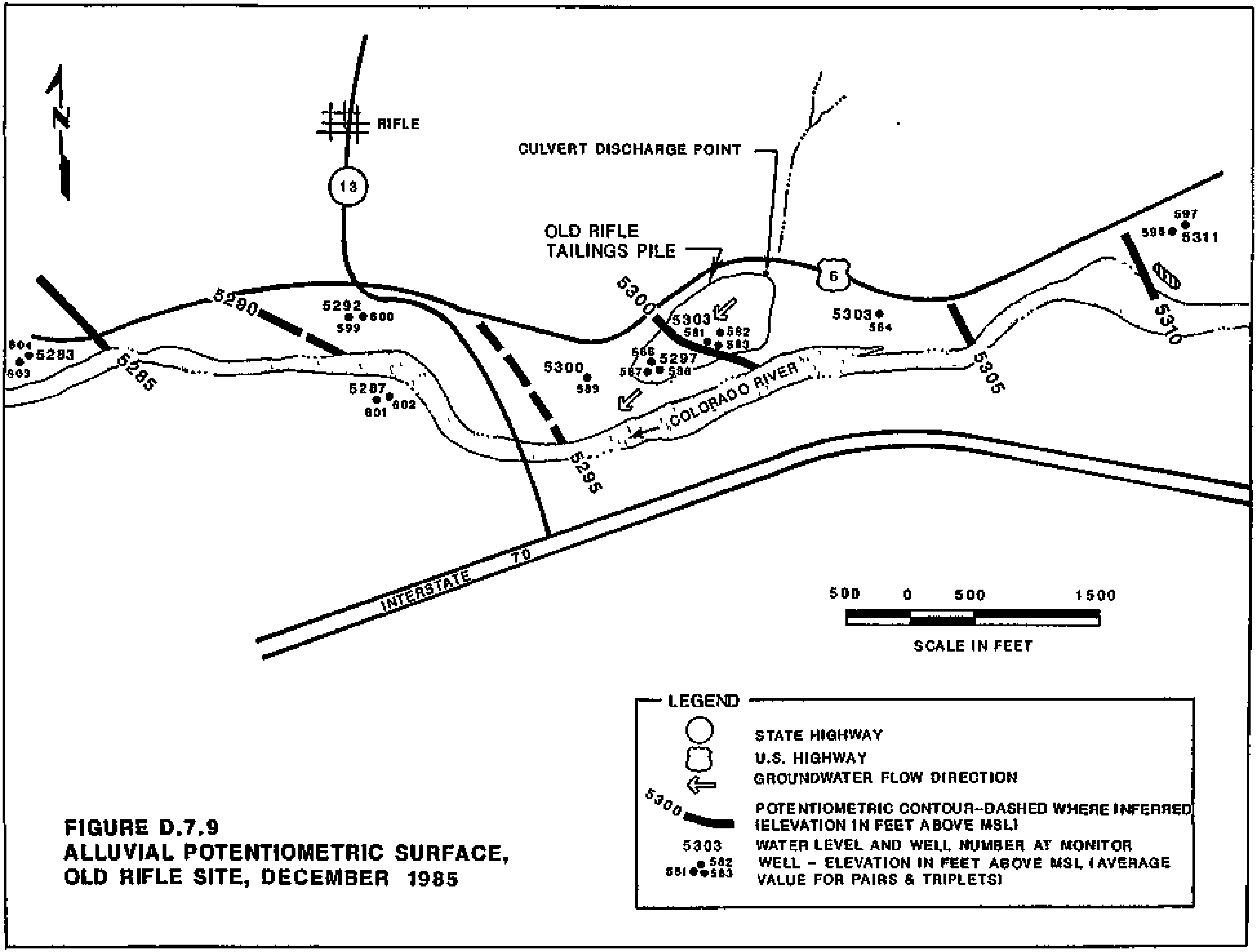


FIGURE D.7.9
ALLUVIAL POTENTIOMETRIC SURFACE, OLD RIFLE SITE, DECEMBER 1985

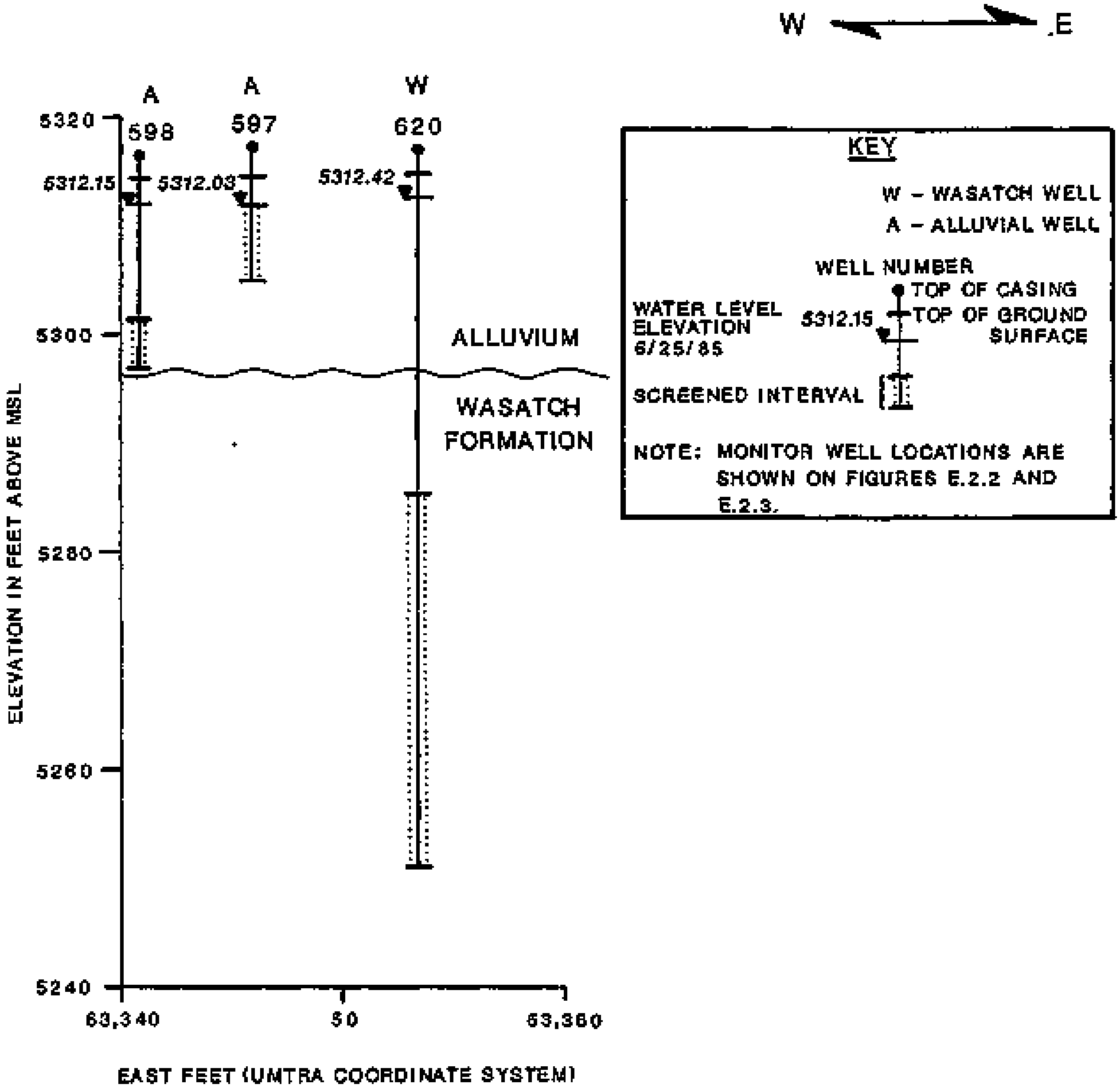


FIGURE D.7.10
WATER LEVEL DIFFERENCES
BETWEEN ALLUVIUM AND WASATCH FORMATION, OLD RIFLE SITE

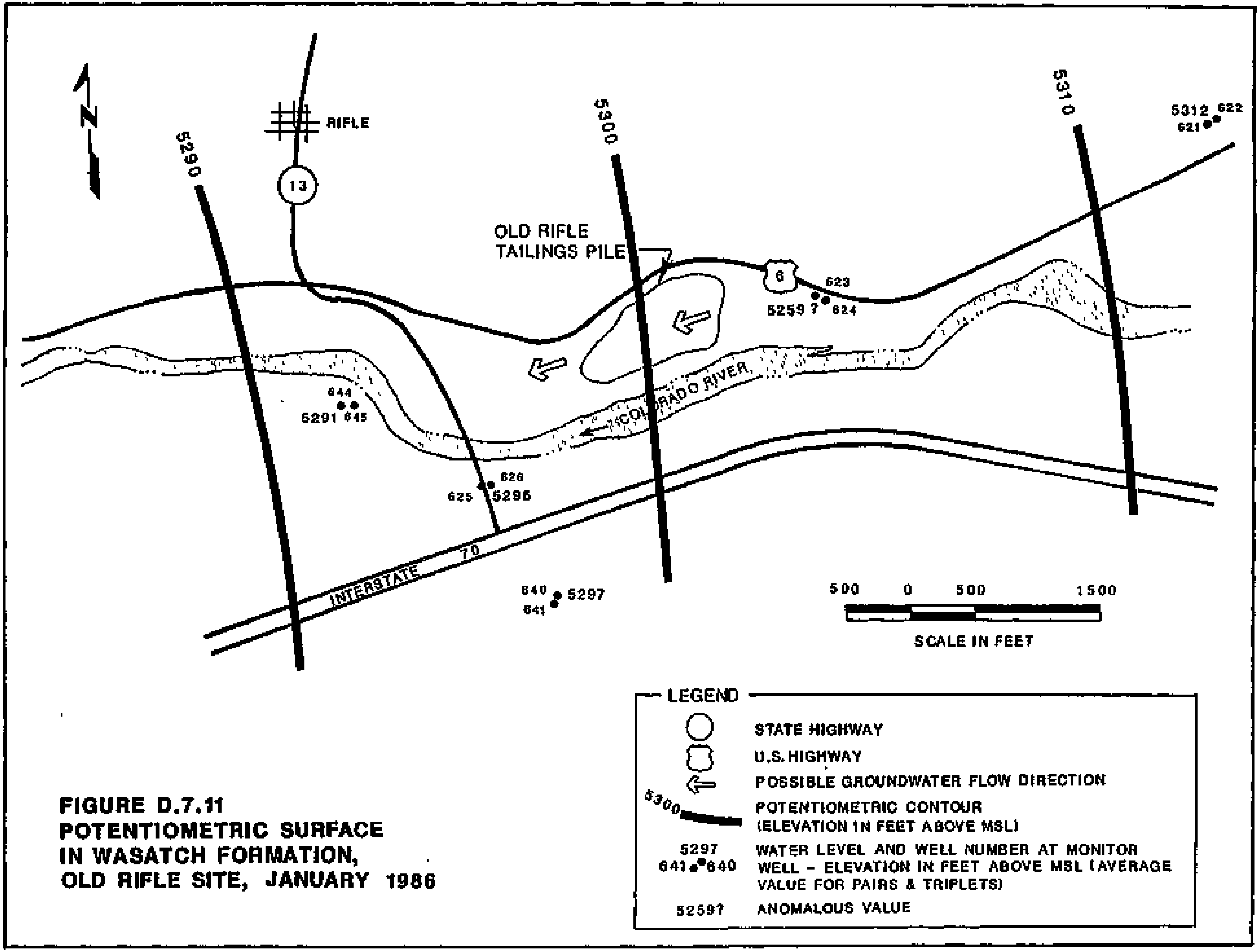


FIGURE D.7.11
POTENTIOMETRIC SURFACE IN WASATCH FORMATION, OLD RIFLE SITE, JANUARY 1986

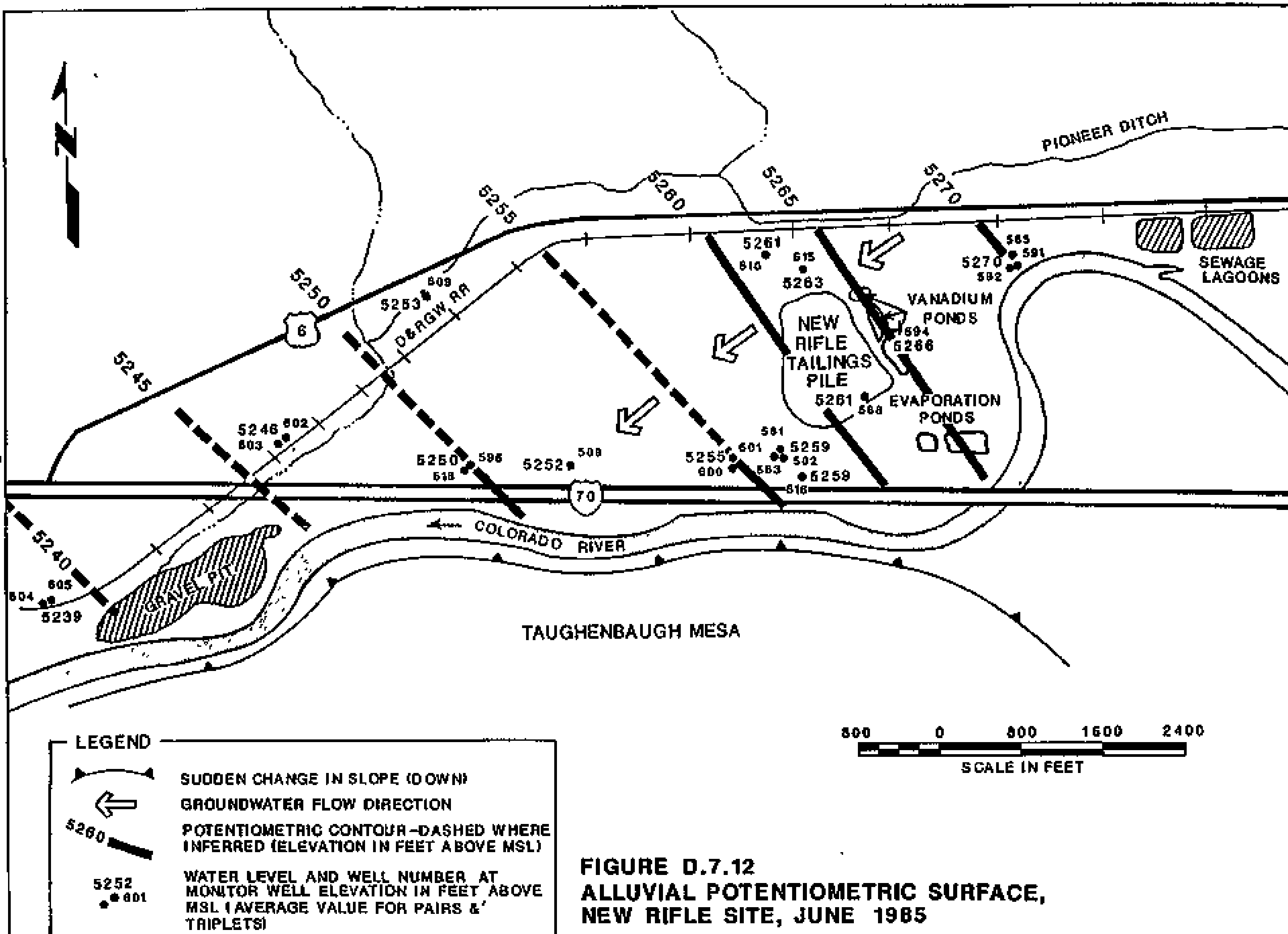


FIGURE D.7.12
ALLUVIAL POTENTIOMETRIC SURFACE, NEW RIFLE SITE, JUNE 1985

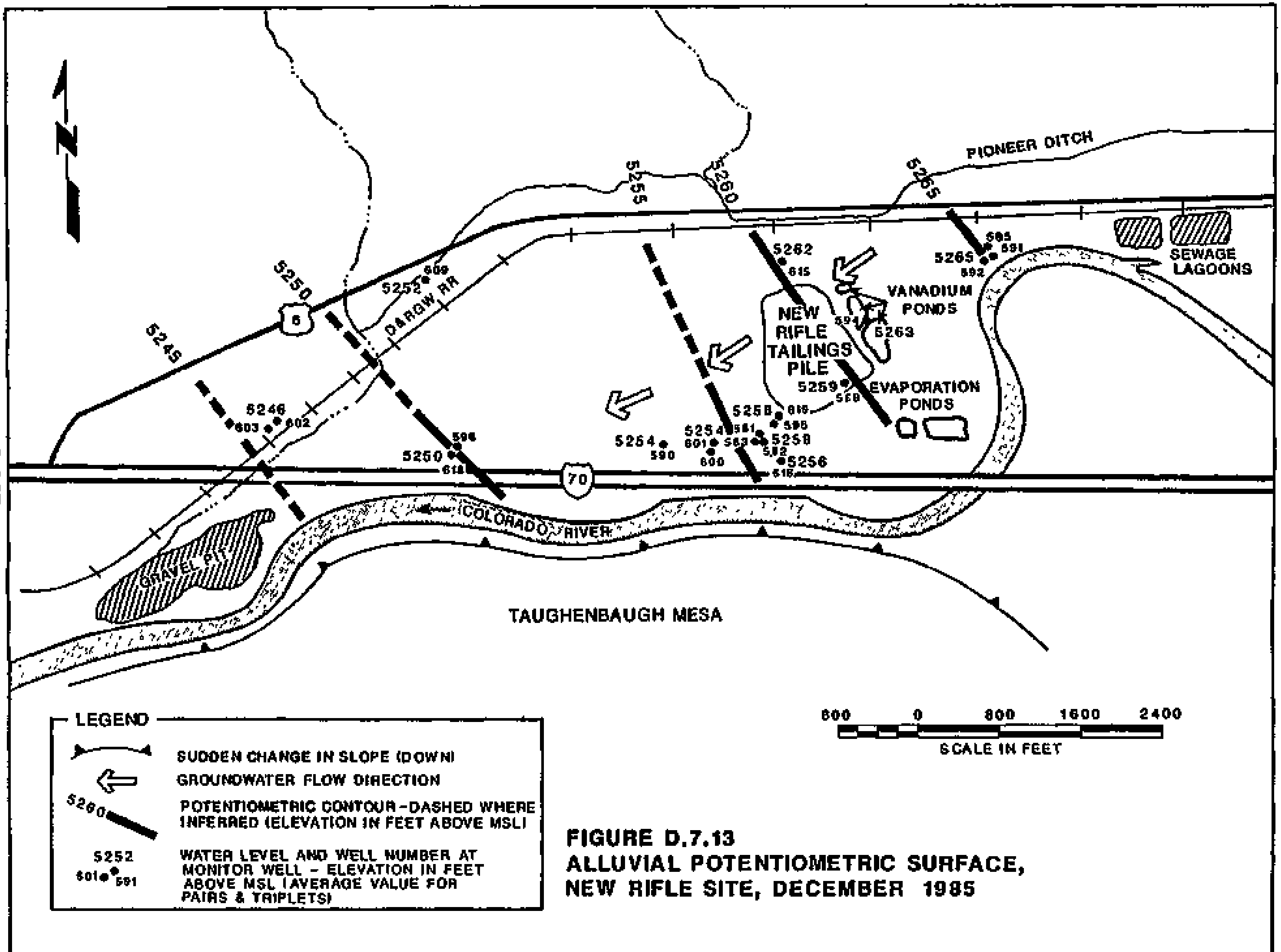


FIGURE D.7.13
ALLUVIAL POTENTIOMETRIC SURFACE, NEW RIFLE SITE, DECEMBER 1985

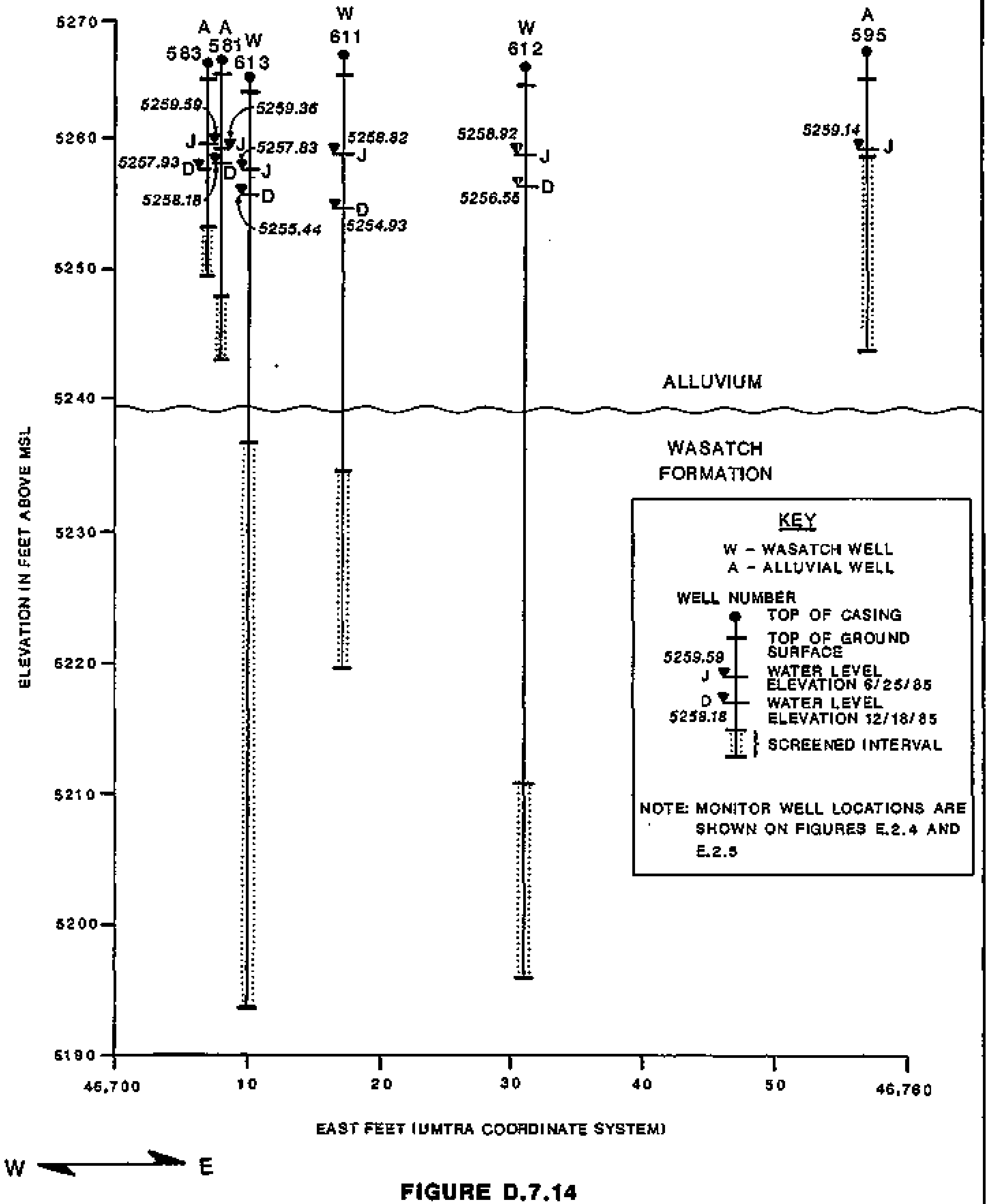


FIGURE D.7.14
WATER LEVEL DIFFERENCES
BETWEEN ALLUVIUM AND WASATCH FORMATION, NEW RIFLE SITE

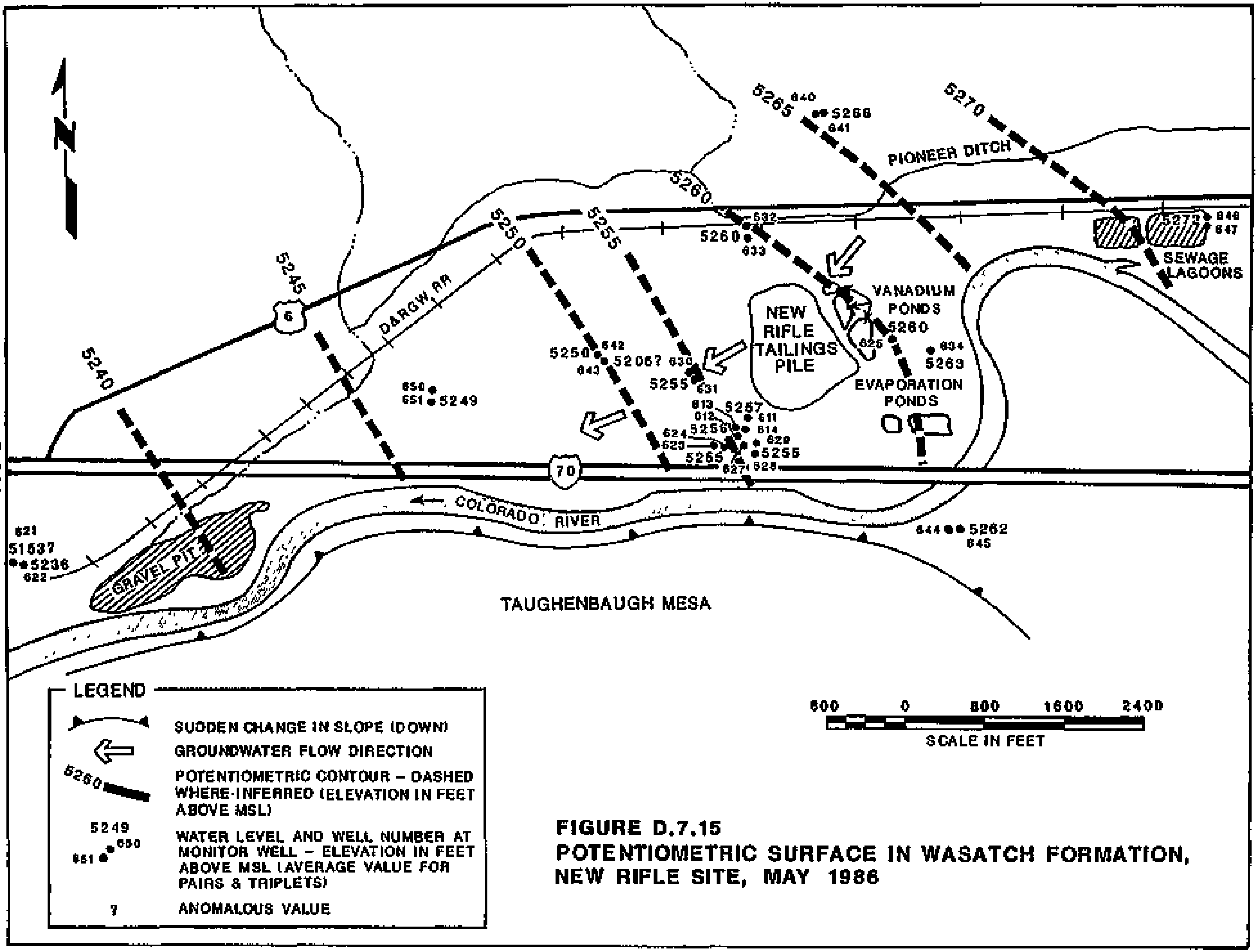


FIGURE D.7.15
POTENTIOMETRIC SURFACE IN WASATCH FORMATION, NEW RIFLE SITE, MAY 1986

LEGEND

- △ BACKGROUND WELL
- ○ ONSITE WELL
- □ LYSIMETER COMPLETED IN THE TAILINGS
- • DOWNGRADIENT OR CROSSGRADIENT WELL

(TRILINEAR SCALES ARE PERCENTAGES OF EQUIVALENTS PER LITER OF MAJOR IONS.)

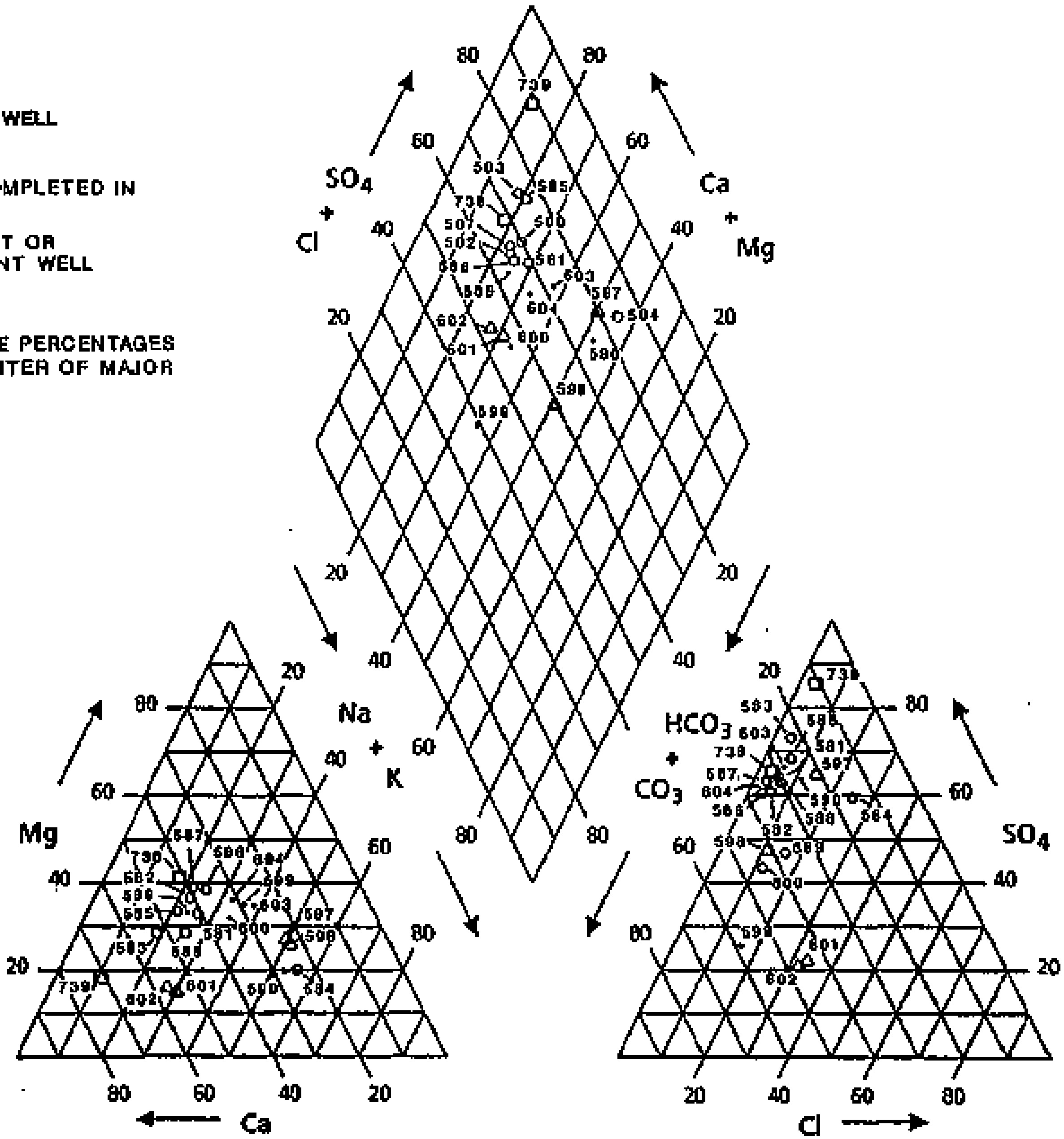


FIGURE D.7.16
TRILINEAR DIAGRAM OF ALLUVIAL GROUNDWATER
OLD RIFLE SITE

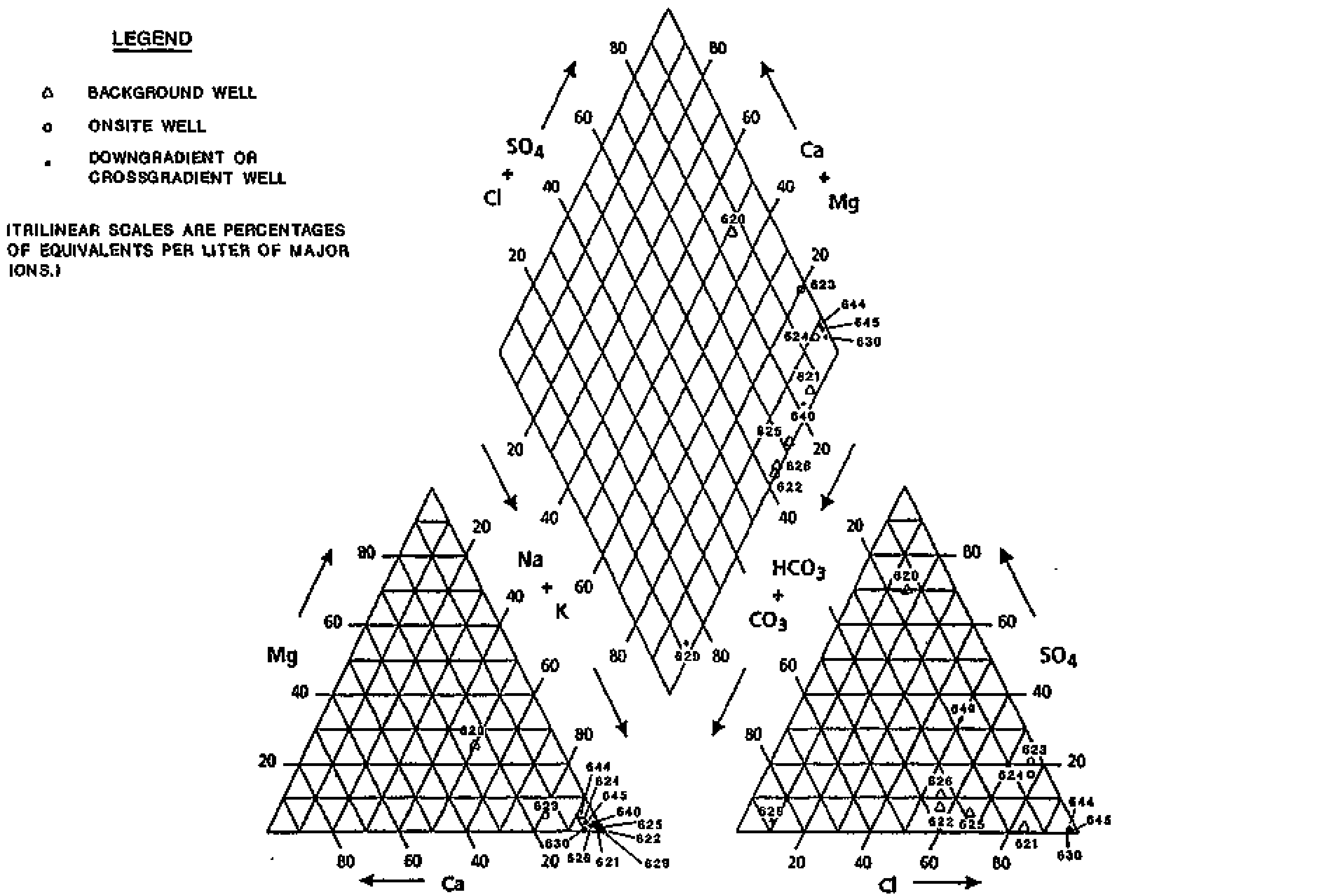


FIGURE D.7.17
TRILINEAR DIAGRAM OF WASATCH FORMATION GROUNDWATER
OLD RIFLE SITE

LEGEND

△ BACKGROUND WELL

○ WELL COMPLETED THROUGH THE TAILINGS

• DOWNGRADIENT OR CROSSGRADIENT WELL

(TRILINEAR SCALES ARE PERCENTAGES OF EQUIVALENTS PER LITER OF MAJOR IONS.)

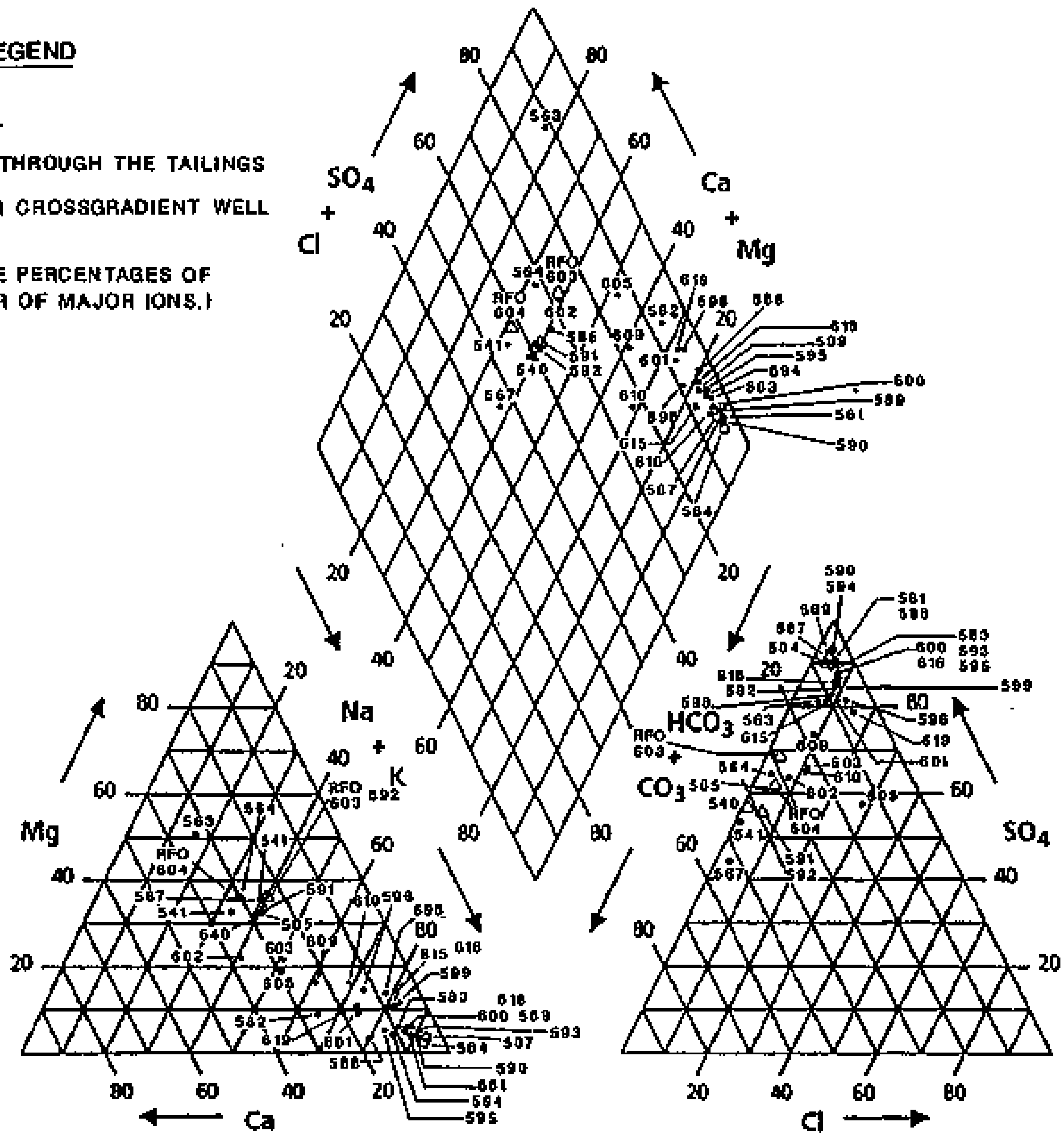


FIGURE D.7.18
TRILINEAR DIAGRAM OF ALLUVIAL GROUNDWATER
NEW RIFLE SITE

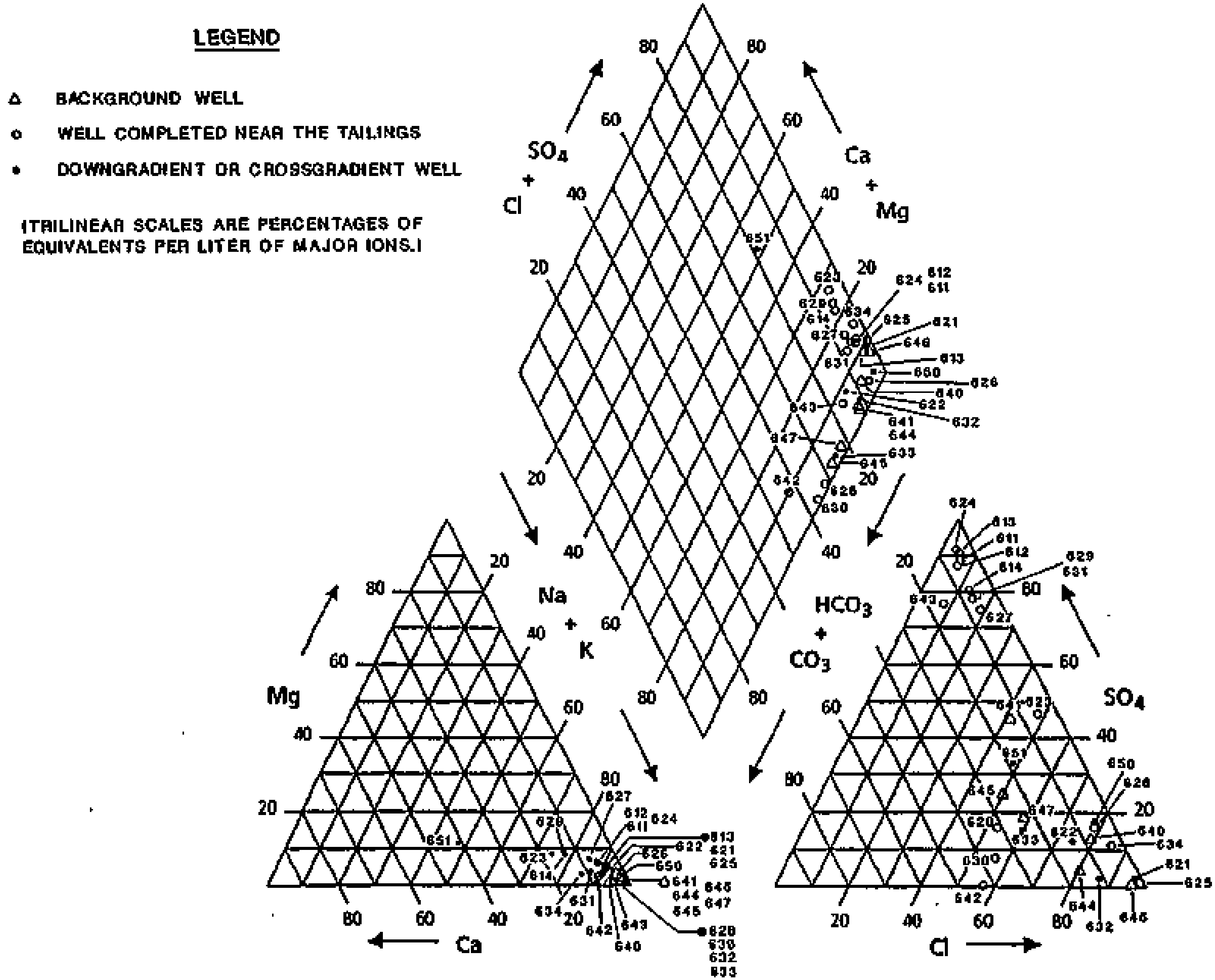


FIGURE D.7.19
TRILINEAR DIAGRAM OF WASATCH FORMATION GROUNDWATER
NEW RIFLE SITE

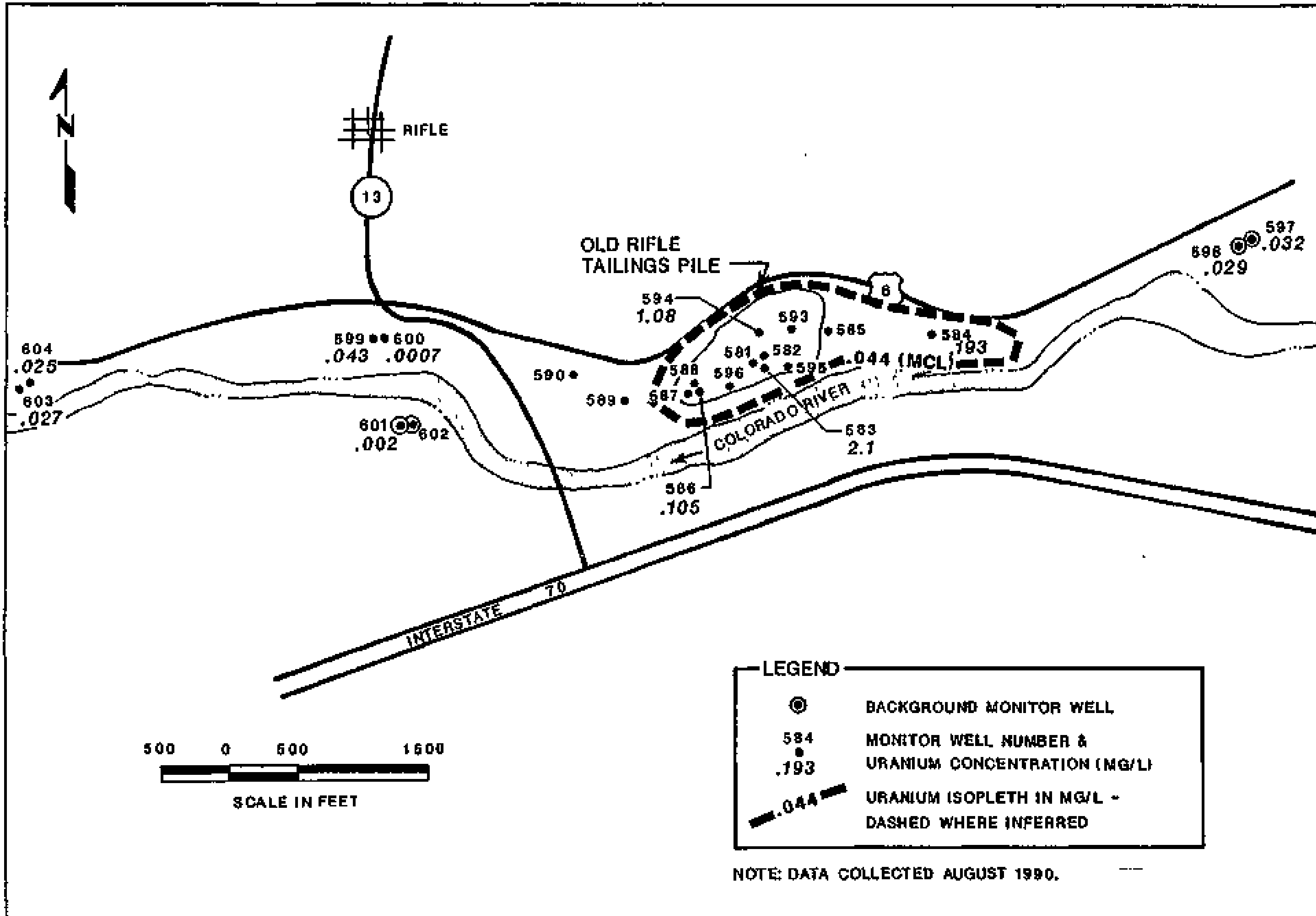


FIGURE D.7.20
URANIUM CONCENTRATIONS IN ALLUVIAL GROUNDWATER, OLD RIFLE SITE

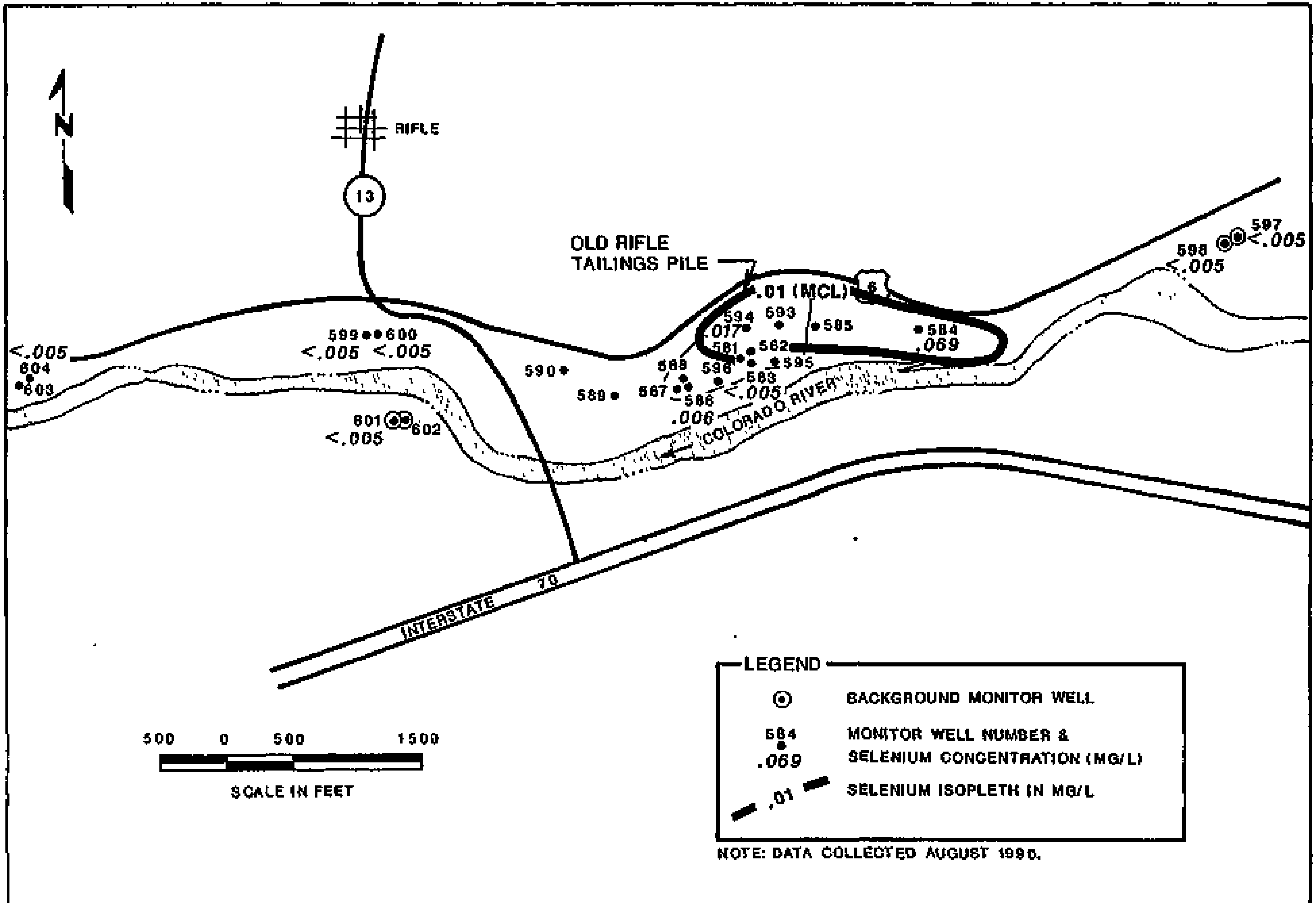
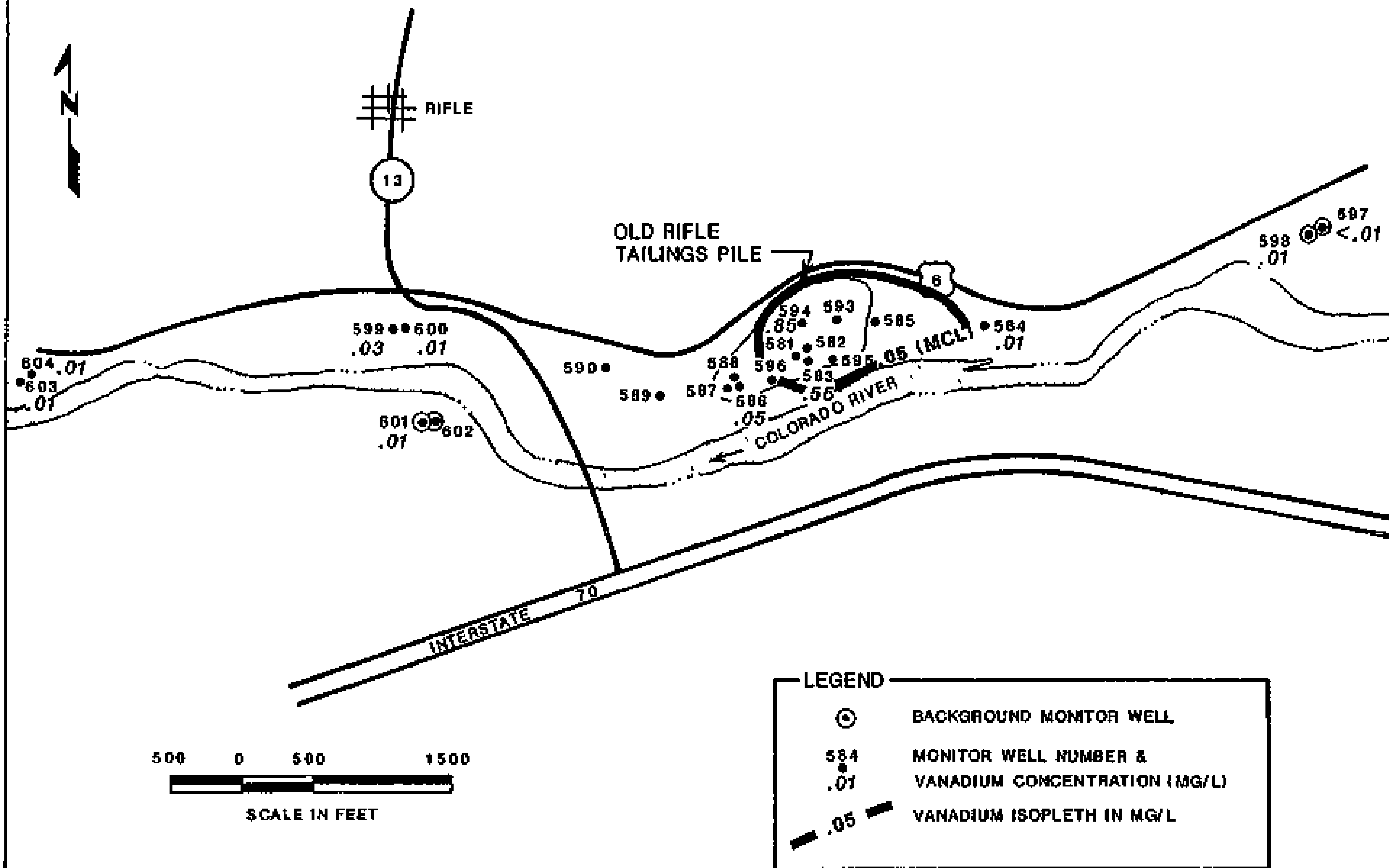


FIGURE D.7.21
SELENIUM CONCENTRATIONS IN ALLUVIAL GROUNDWATER, OLD RIFLE SITE



NOTE: DATA COLLECTED AUGUST 1990.

FIGURE D.7.22
VANADIUM CONCENTRATIONS IN ALLUVIAL GROUNDWATER, OLD RIFLE SITE

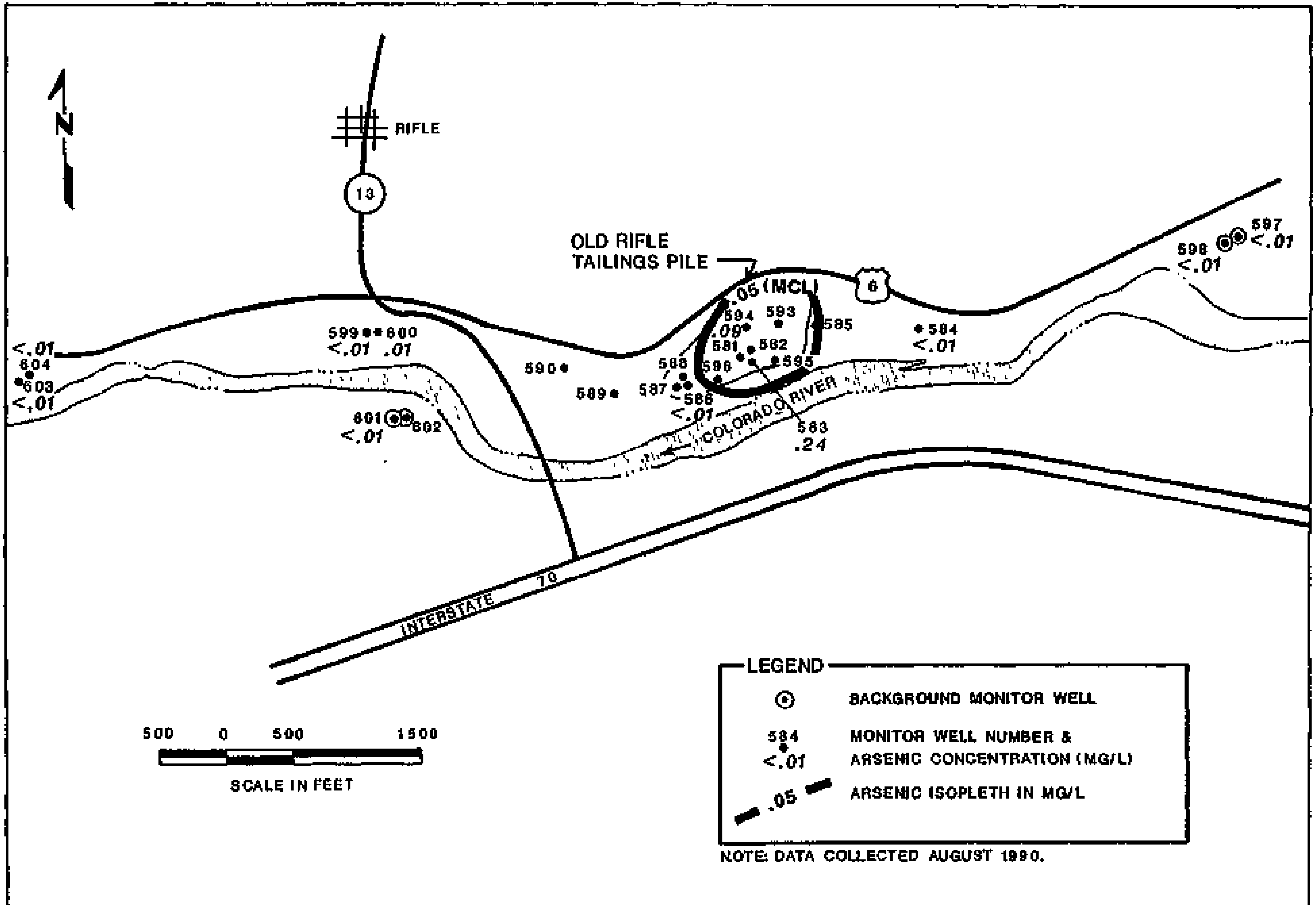


FIGURE D.7.23
ARSENIC CONCENTRATIONS IN ALLUVIAL GROUNDWATER, OLD RIFLE SITE

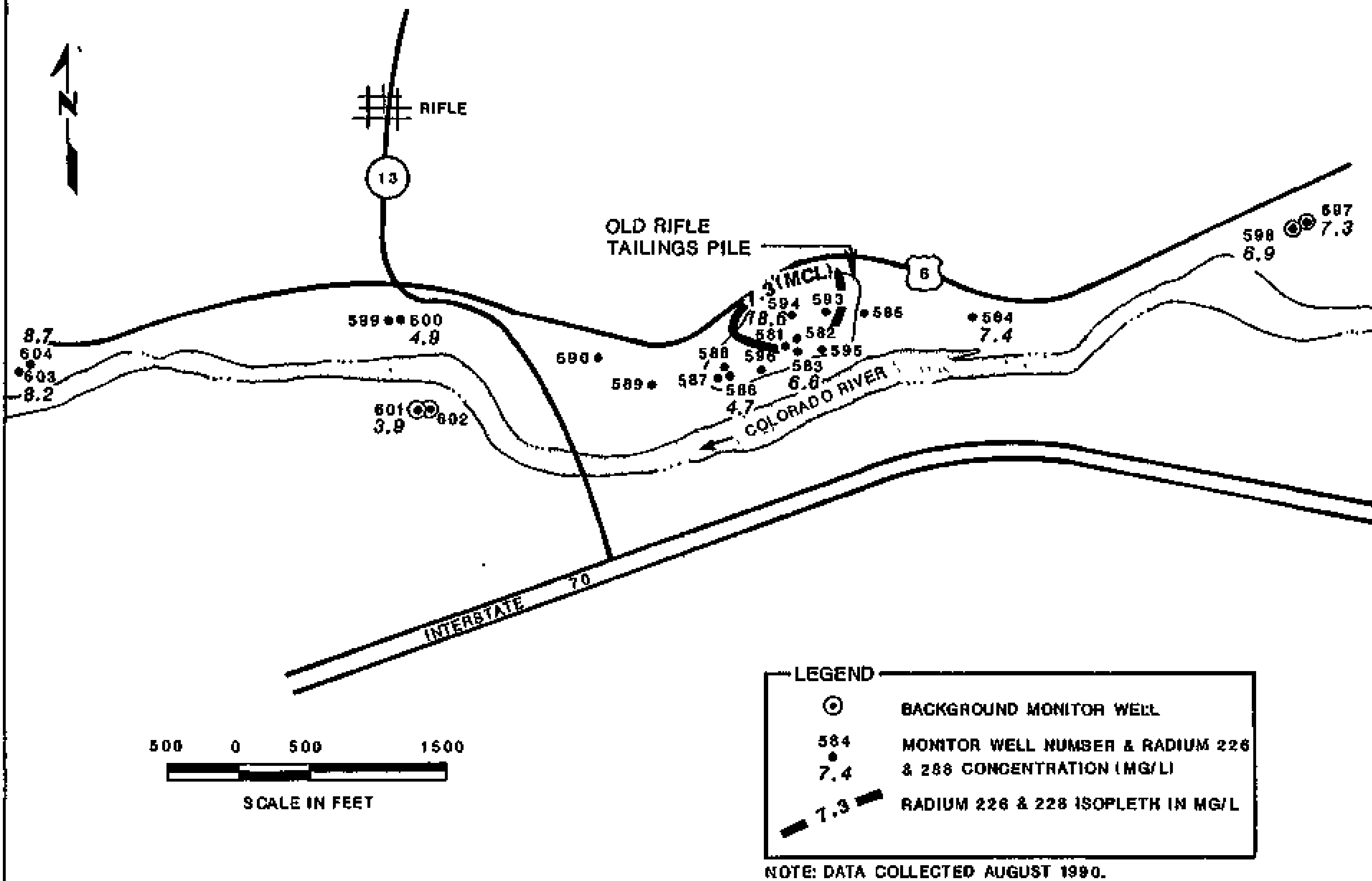


FIGURE D.7.24
RADIUM 226 & 228 CONCENTRATIONS IN ALLUVIAL GROUNDWATER, OLD RIFLE SITE

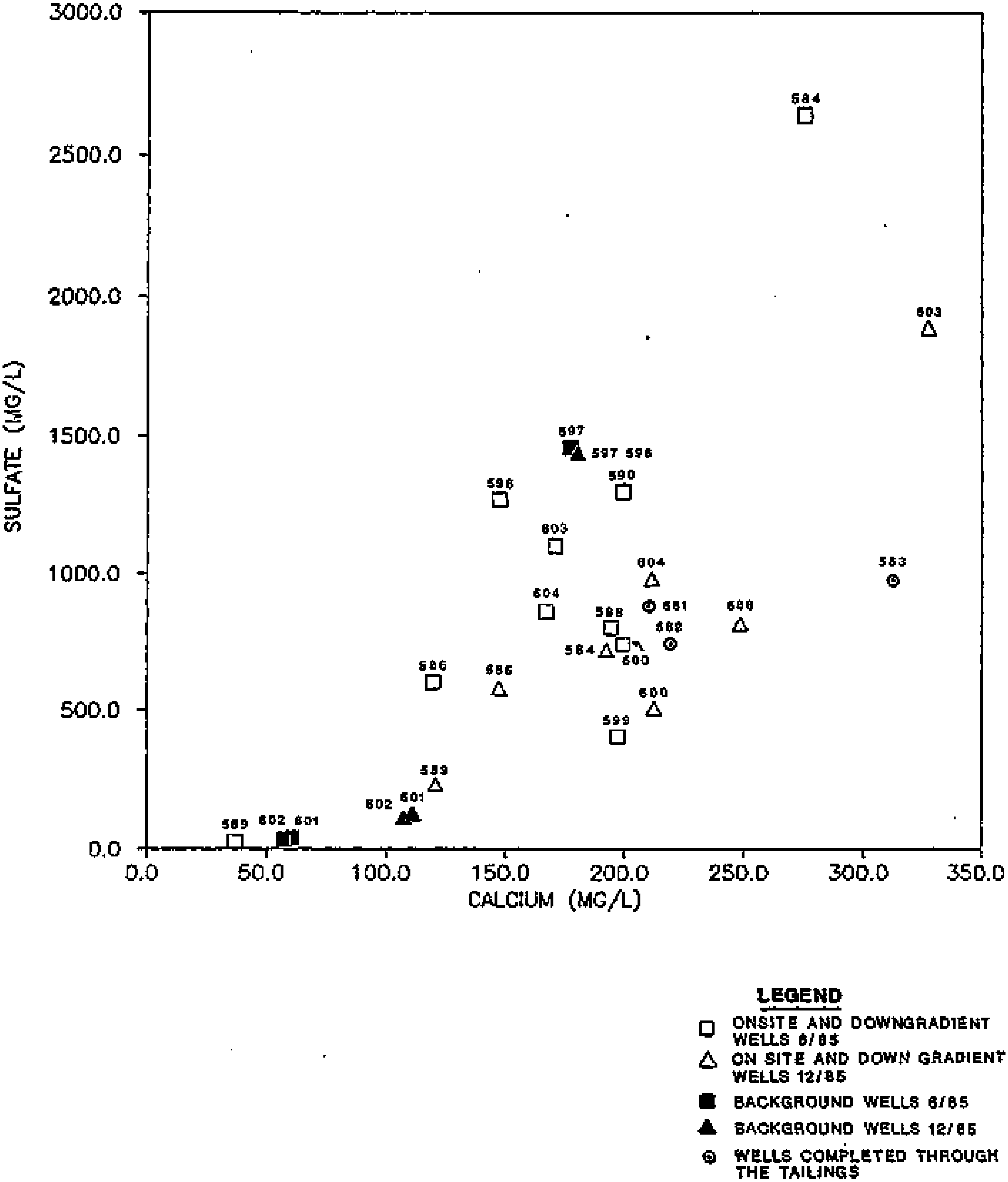


FIGURE D.7.25
BIVARIATE PLOT OF CALCIUM AND SULFATE CONCENTRATIONS IN ALLUVIAL GROUNDWATER, OLD RIFLE SITE

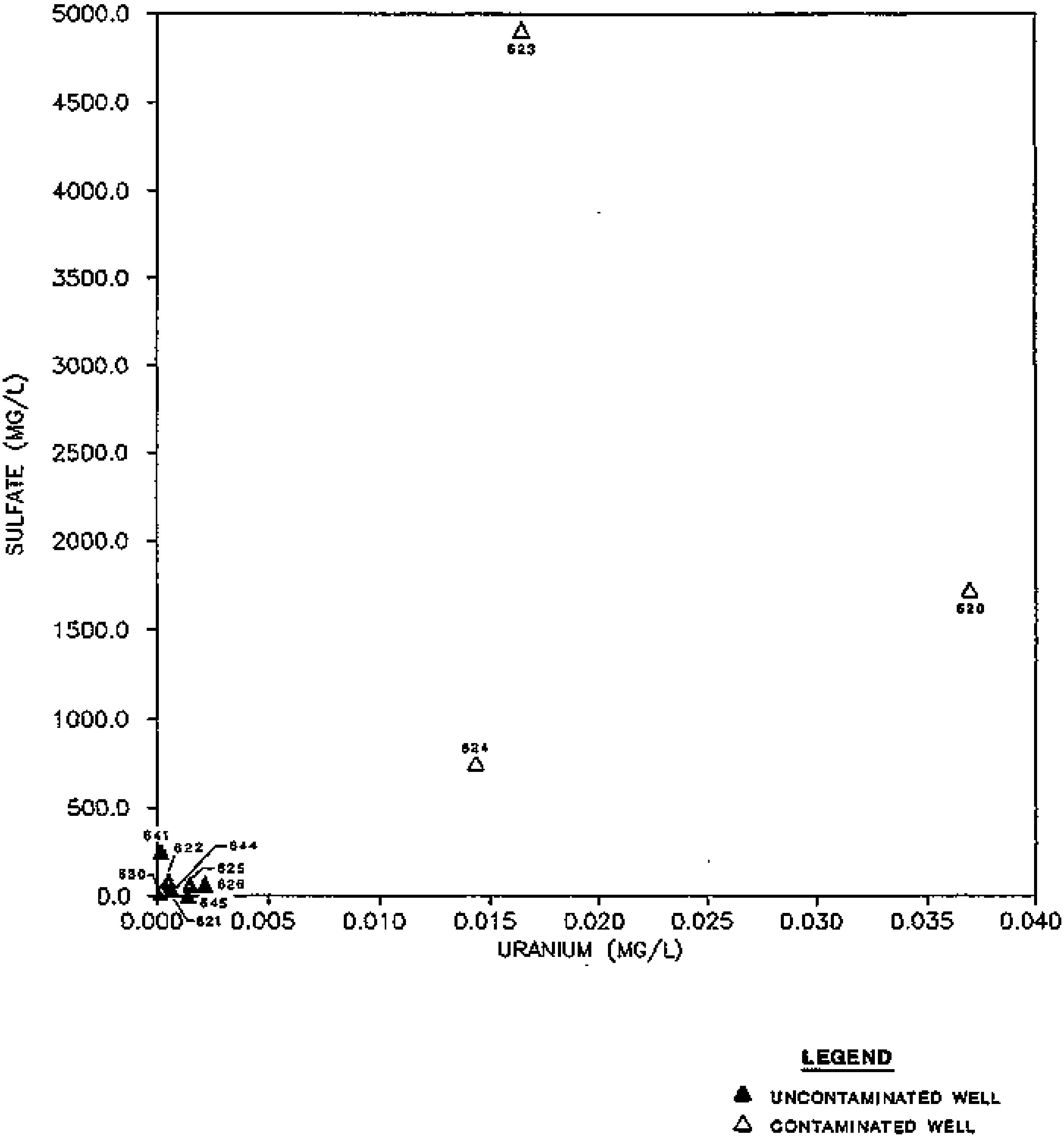


FIGURE D.7.26
BIVARIATE PLOT OF SULFATE AND URANIUM CONCENTRATIONS IN WASATCH FORMATION GROUNDWATER, OLD RIFLE SITE

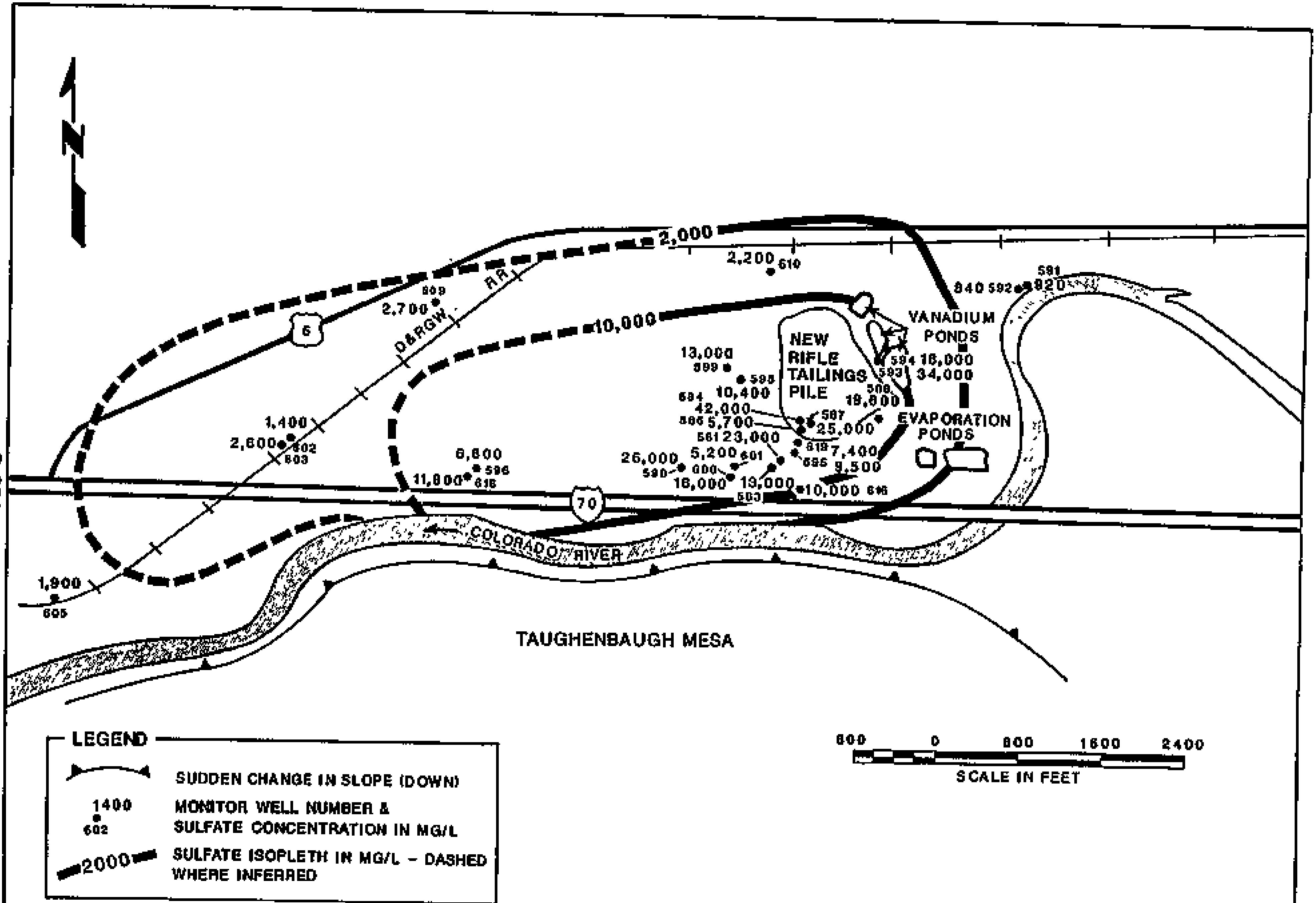
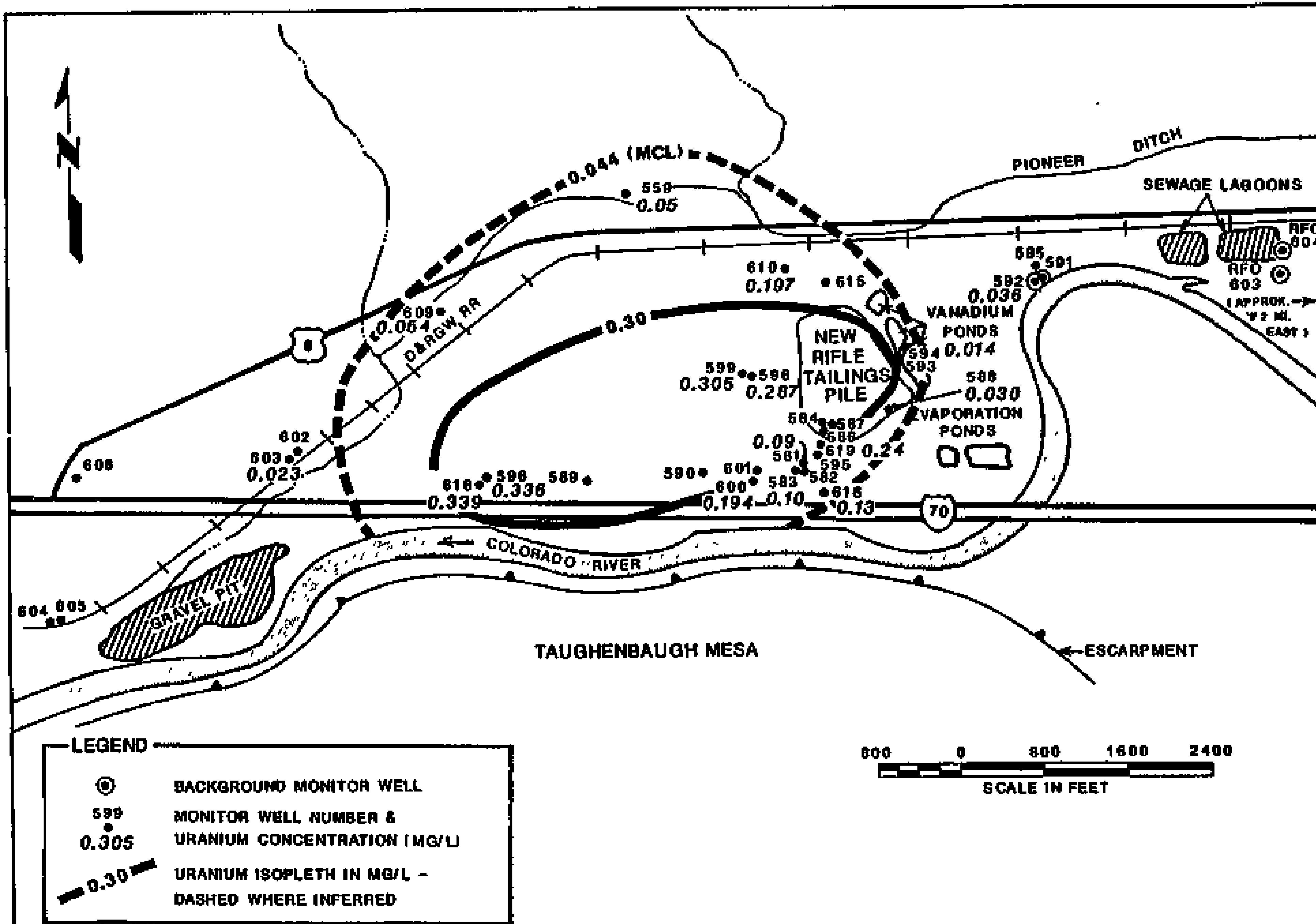


FIGURE D.7.27
SULFATE CONCENTRATIONS IN ALLUVIAL GROUNDWATER, NEW RIFLE SITE



NOTE: DATA COLLECTED AUGUST 1990.

FIGURE D.7.28
URANIUM CONCENTRATIONS IN ALLUVIAL GROUNDWATER, NEW RIFLE SITE

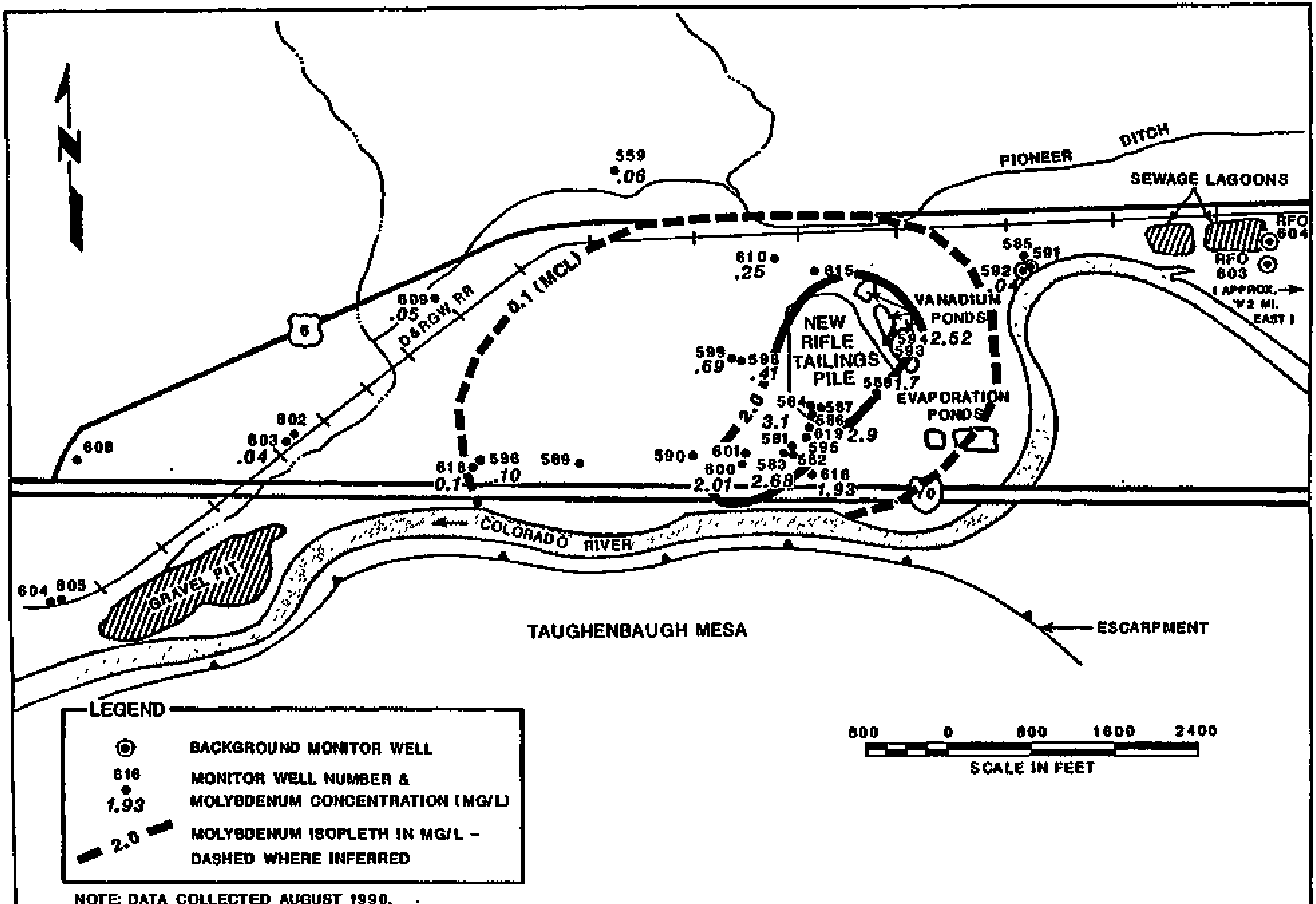
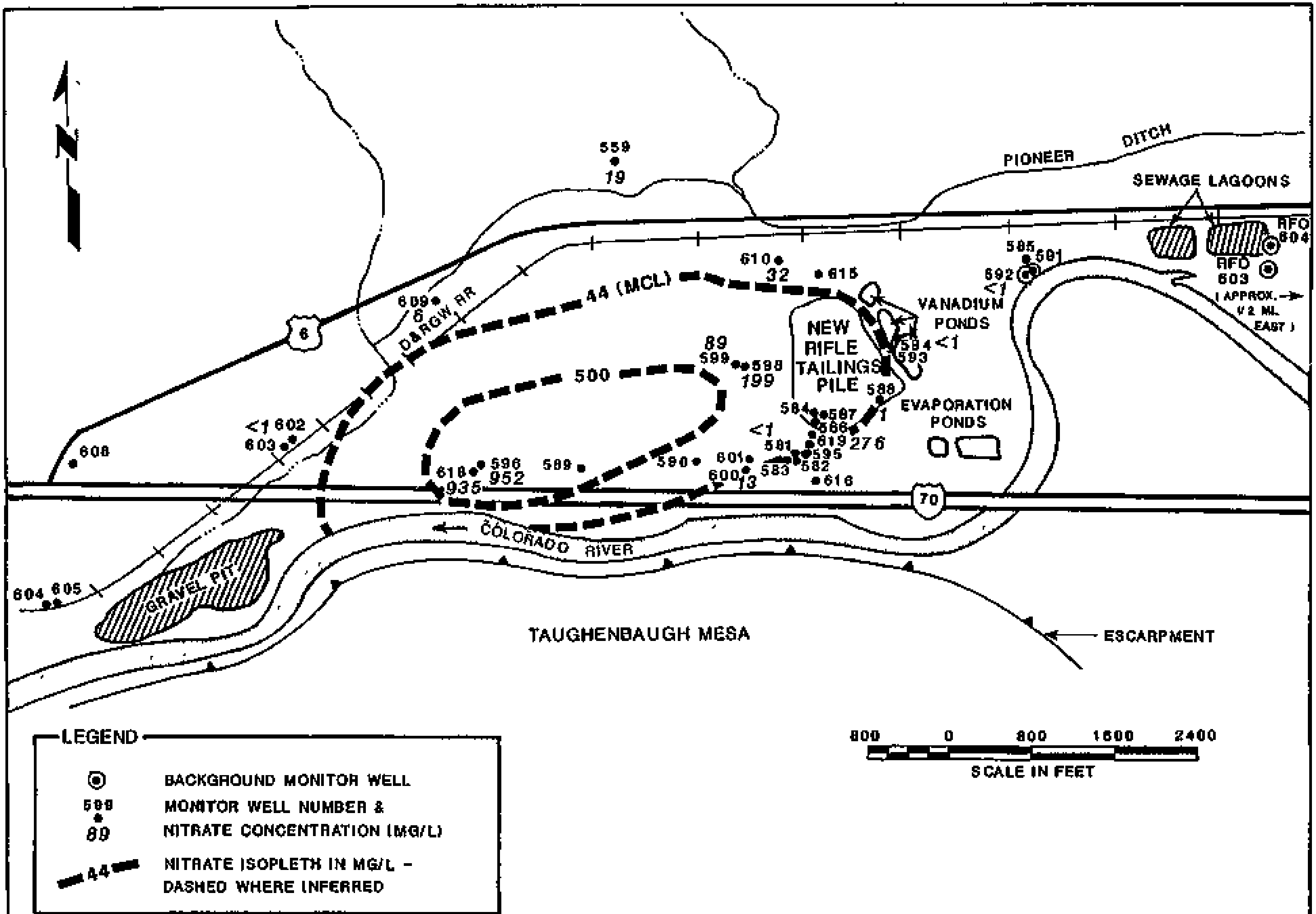
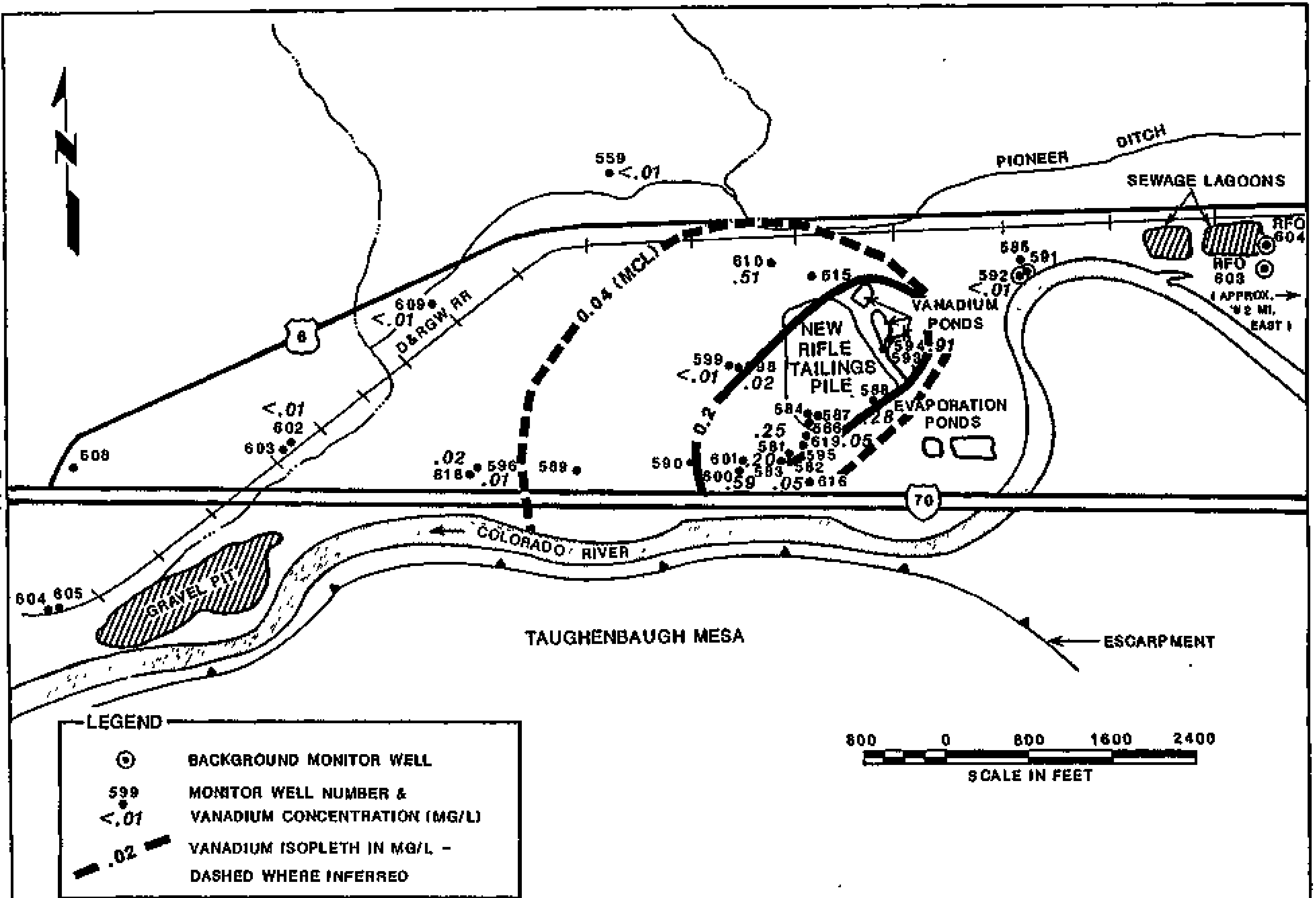


FIGURE D.7.29
MOLYBDENUM CONCENTRATIONS IN ALLUVIAL GROUNDWATER, NEW RIFLE SITE



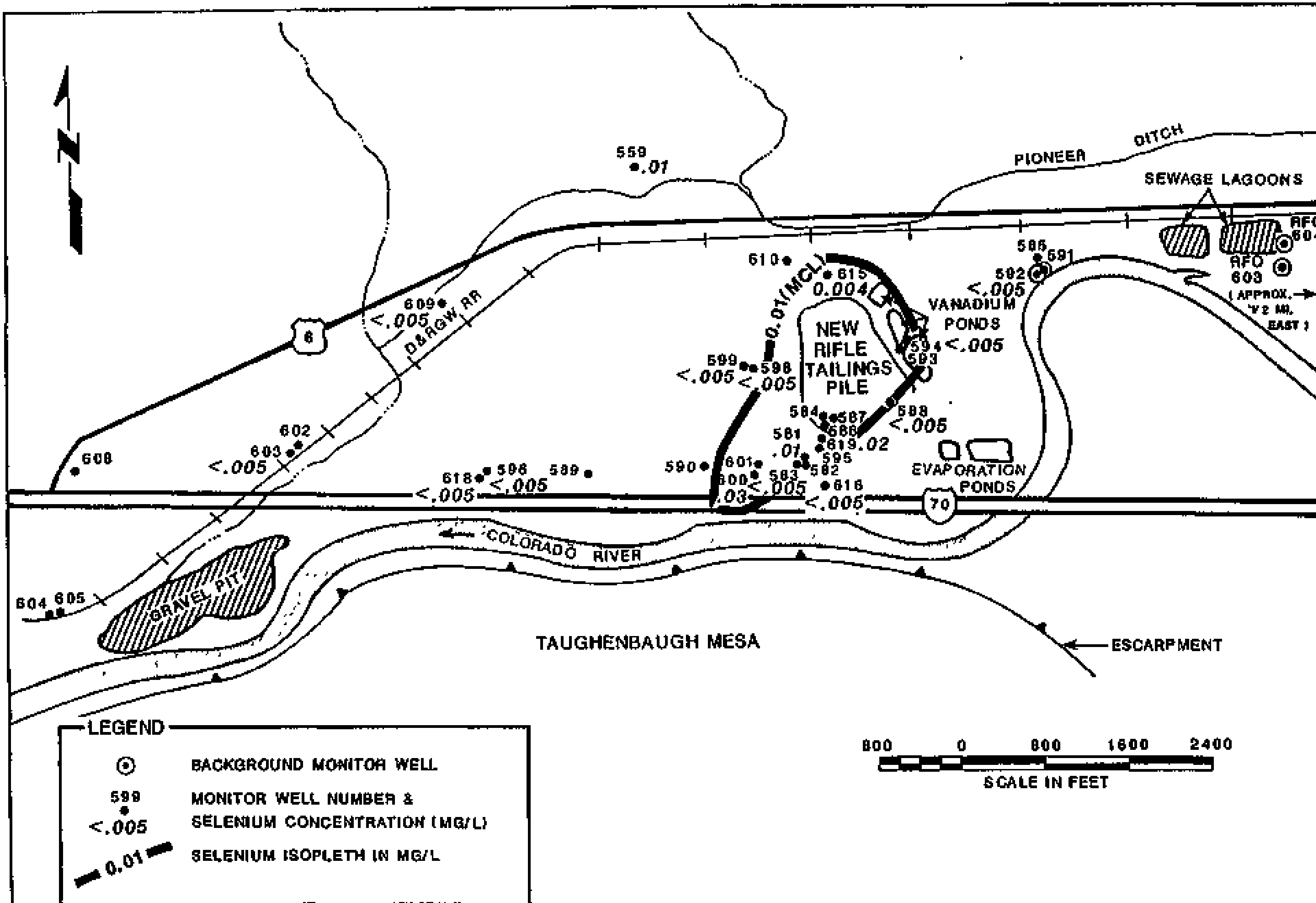
NOTE: DATA COLLECTED AUGUST 1990.

FIGURE D.7.30
NITRATE CONCENTRATIONS IN ALLUVIAL GROUNDWATER, NEW RIFLE SITE



NOTE: DATA COLLECTED AUGUST 1990.

FIGURE D.7.31
VANADIUM CONCENTRATIONS IN ALLUVIAL GROUNDWATER, NEW RIFLE SITE



NOTE: DATA COLLECTED AUGUST 1990.

FIGURE D.7.32
SELENIUM CONCENTRATIONS IN ALLUVIAL GROUNDWATER, NEW RIFLE SITE

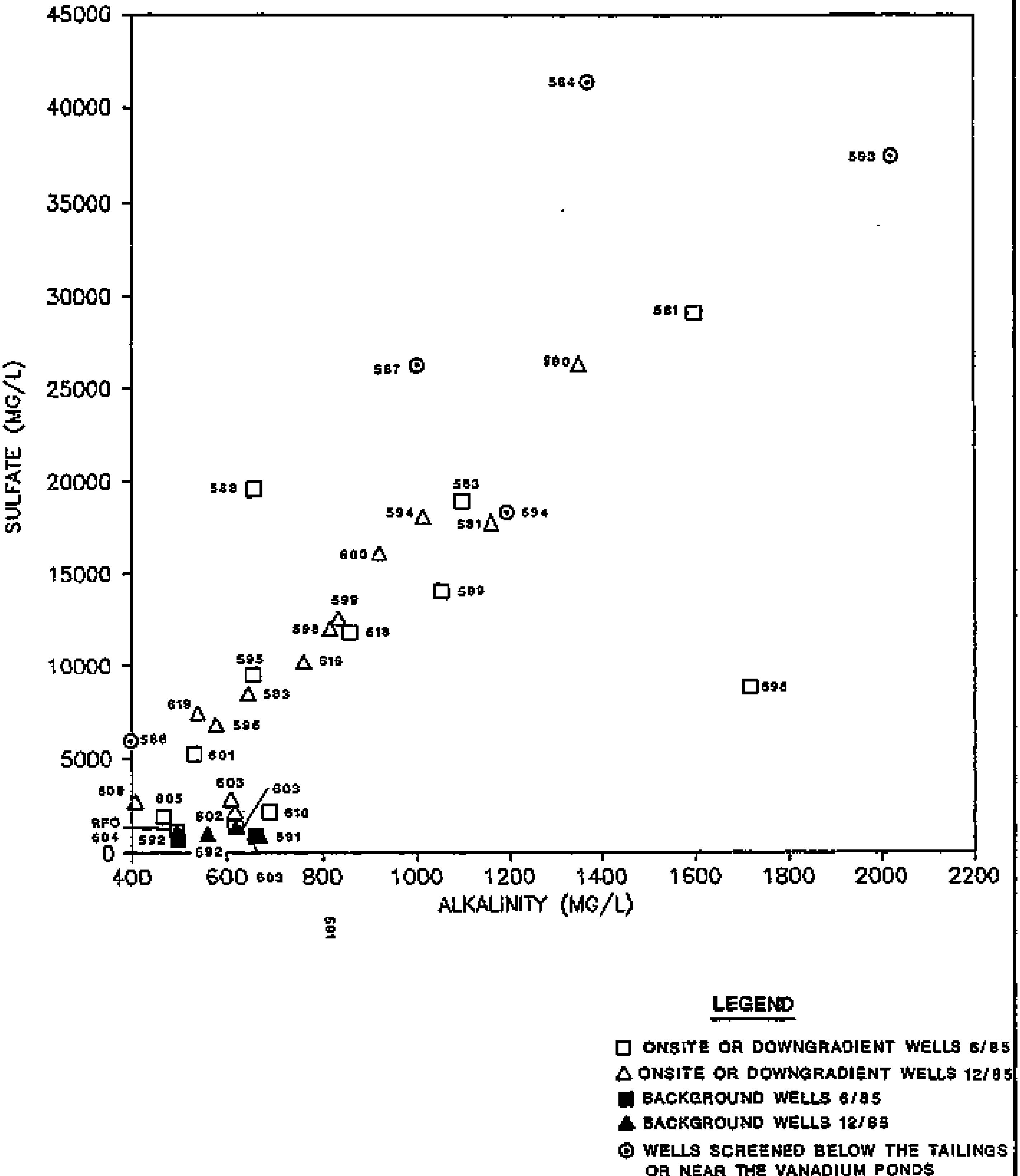


FIGURE D.7.33
BIVARIATE PLOT OF ALKALINITY AND SULFATE CONCENTRATIONS IN ALLUVIAL GROUNDWATER, NEW RIFLE SITE

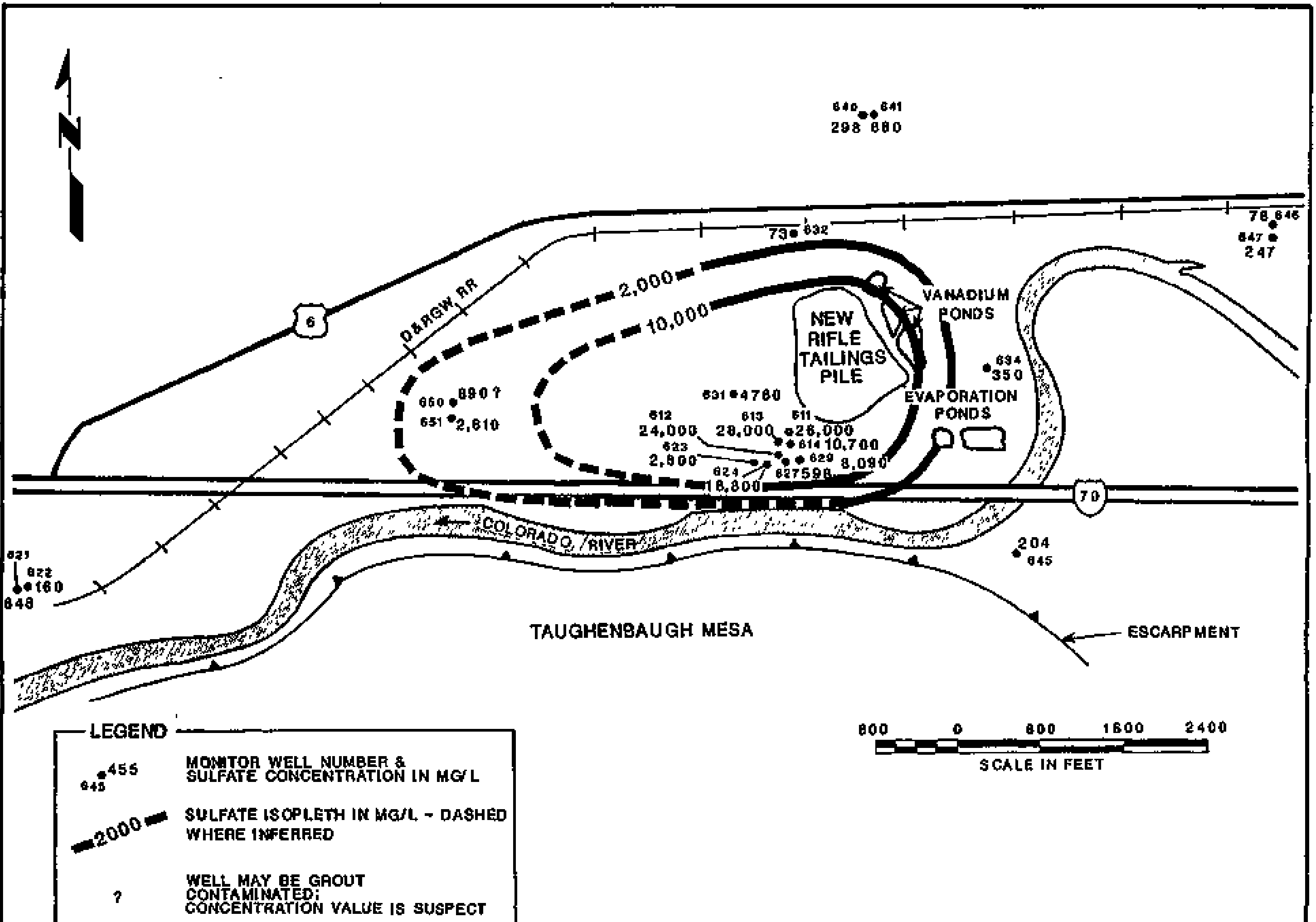
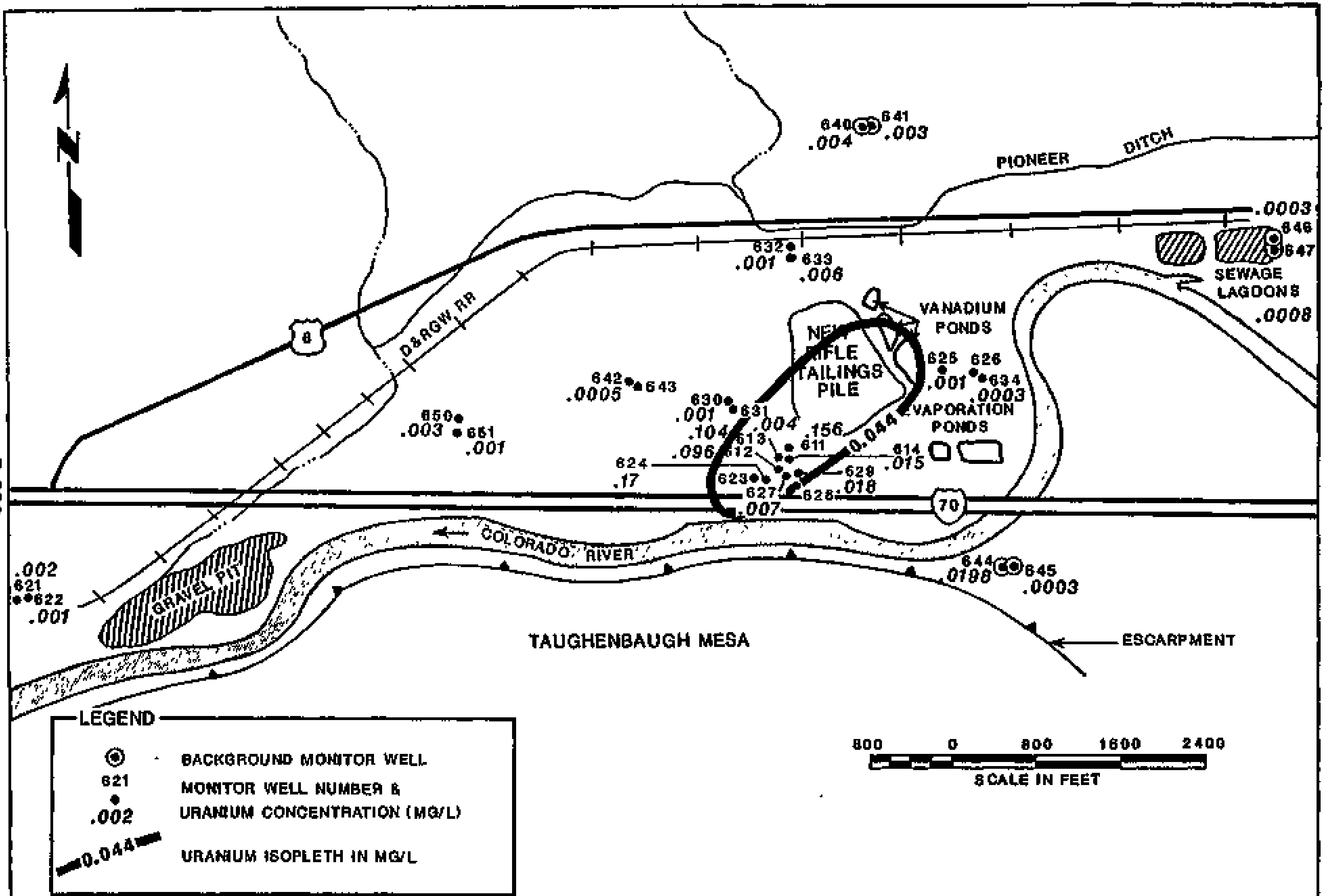
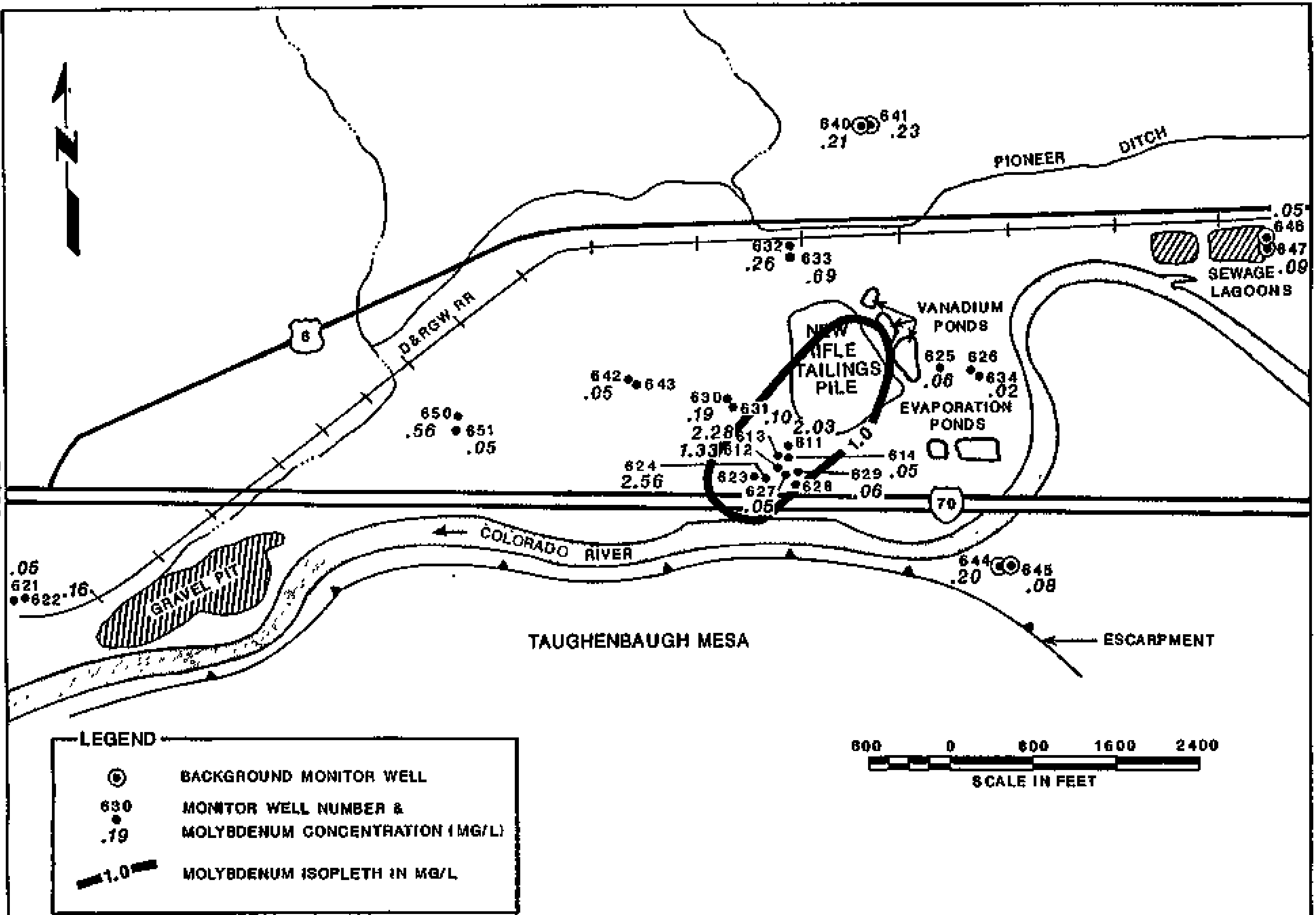


FIGURE D.7.34
SULFATE CONCENTRATIONS IN THE WASATCH FORMATION, NEW RIFLE SITE



NOTE: DATA COLLECTED AUGUST 1990

FIGURE D.7.35
URANIUM CONCENTRATIONS IN THE WASATCH FORMATION, NEW RIFLE SITE



NOTE: DATA COLLECTED AUGUST 1990.

FIGURE D.7.36
MOLYBDENUM CONCENTRATIONS IN THE WASATCH FORMATION, NEW RIFLE SITE

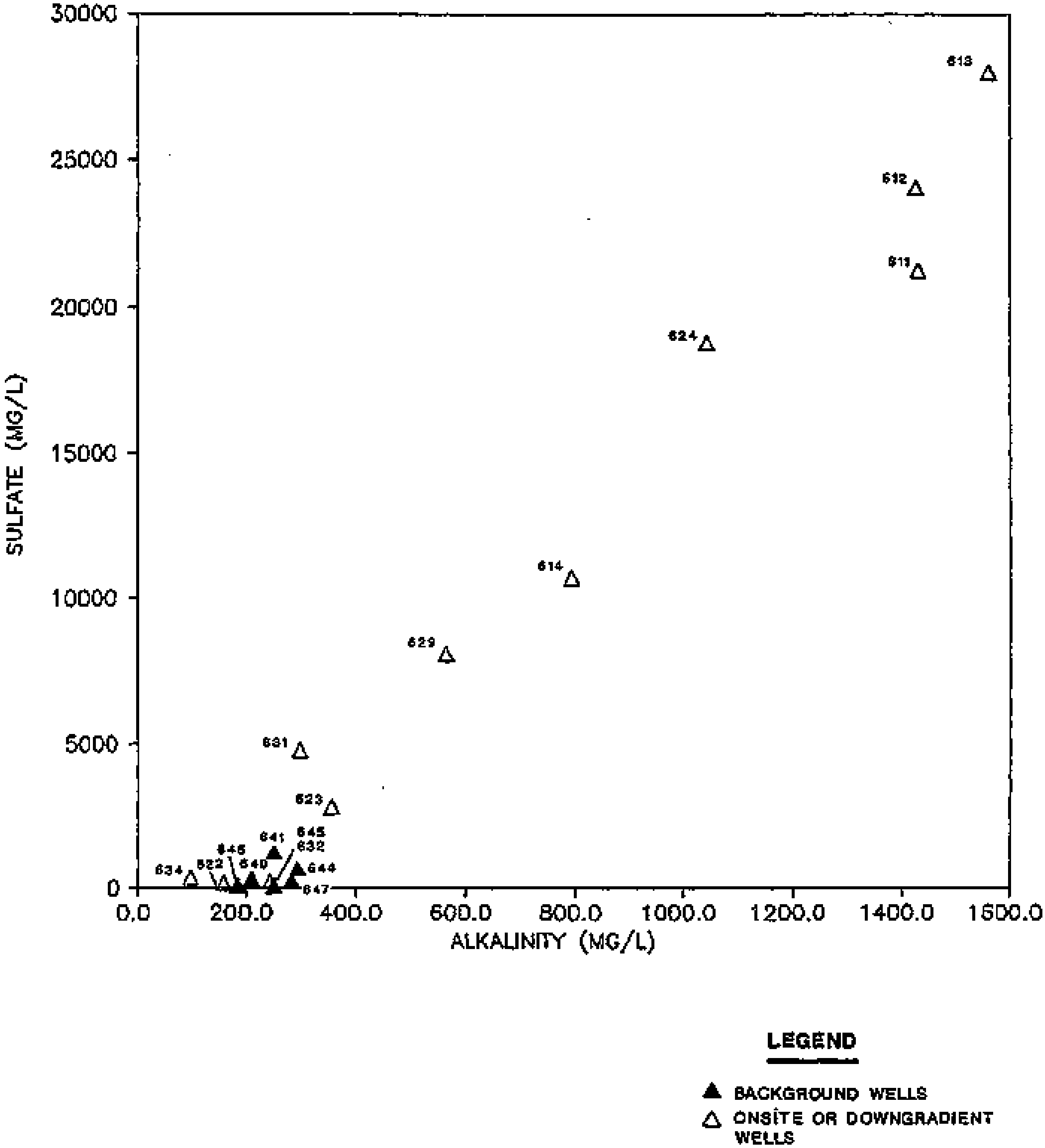


FIGURE D.7.37
BIVARIATE PLOT OF ALKALINITY AND SULFATE CONCENTRATIONS IN WASATCH FORMATION GROUNDWATER, NEW RIFLE SITE

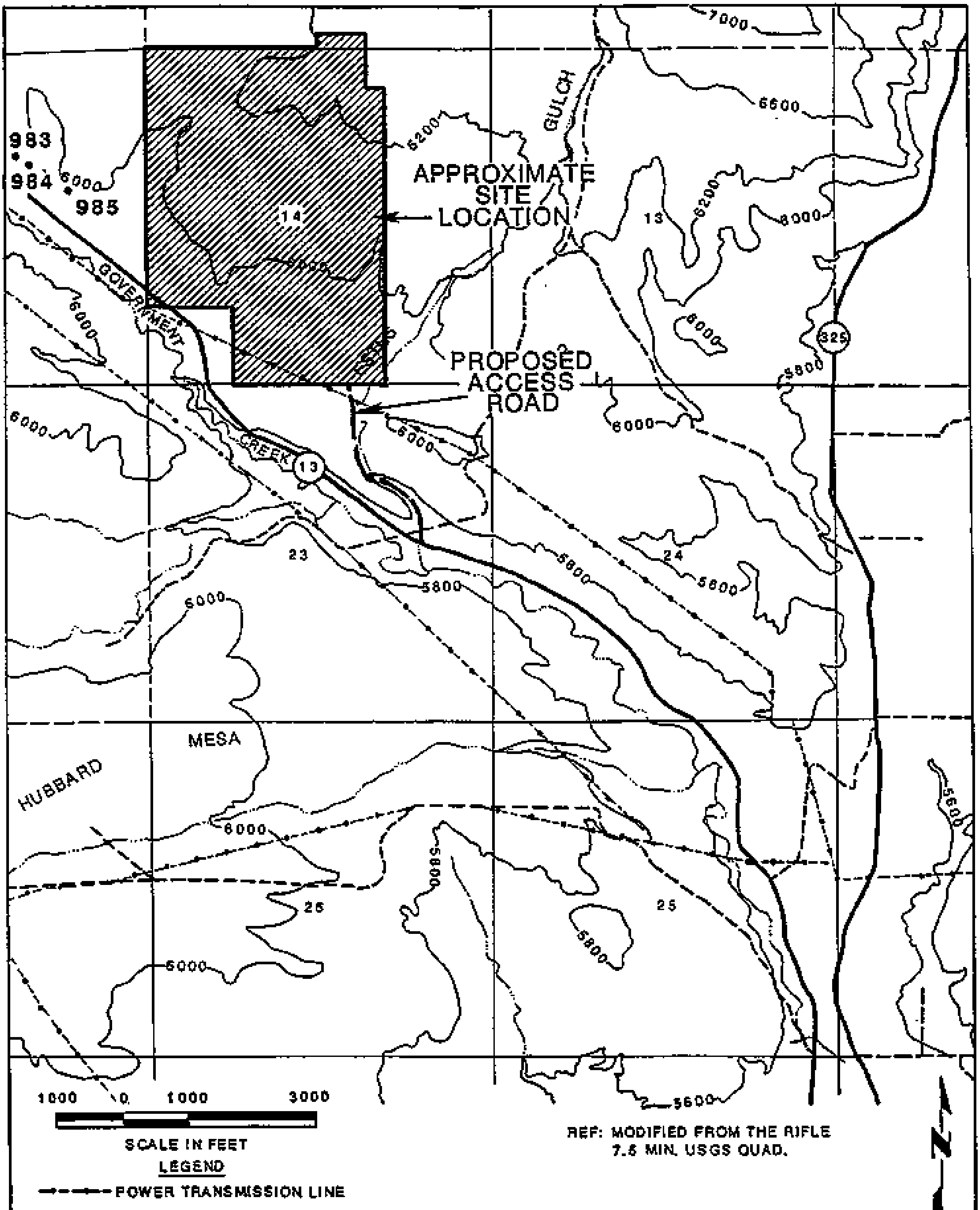
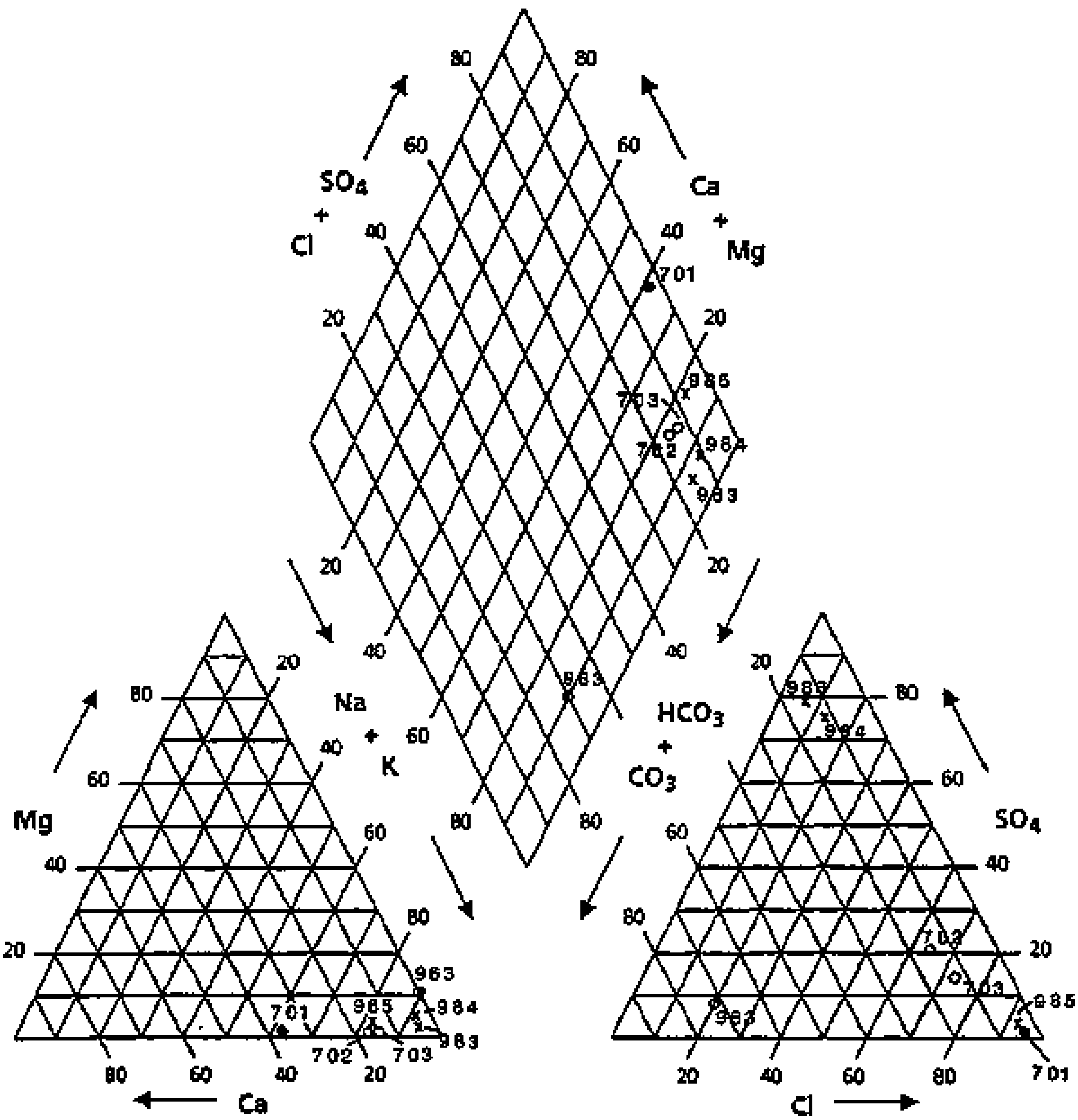


FIGURE D.7.38
DOMESTIC WELLS NEAR THE ESTES GULCH SITE



LEGEND

x OFF SITE DOMESTIC WELL (pH ~ 8)

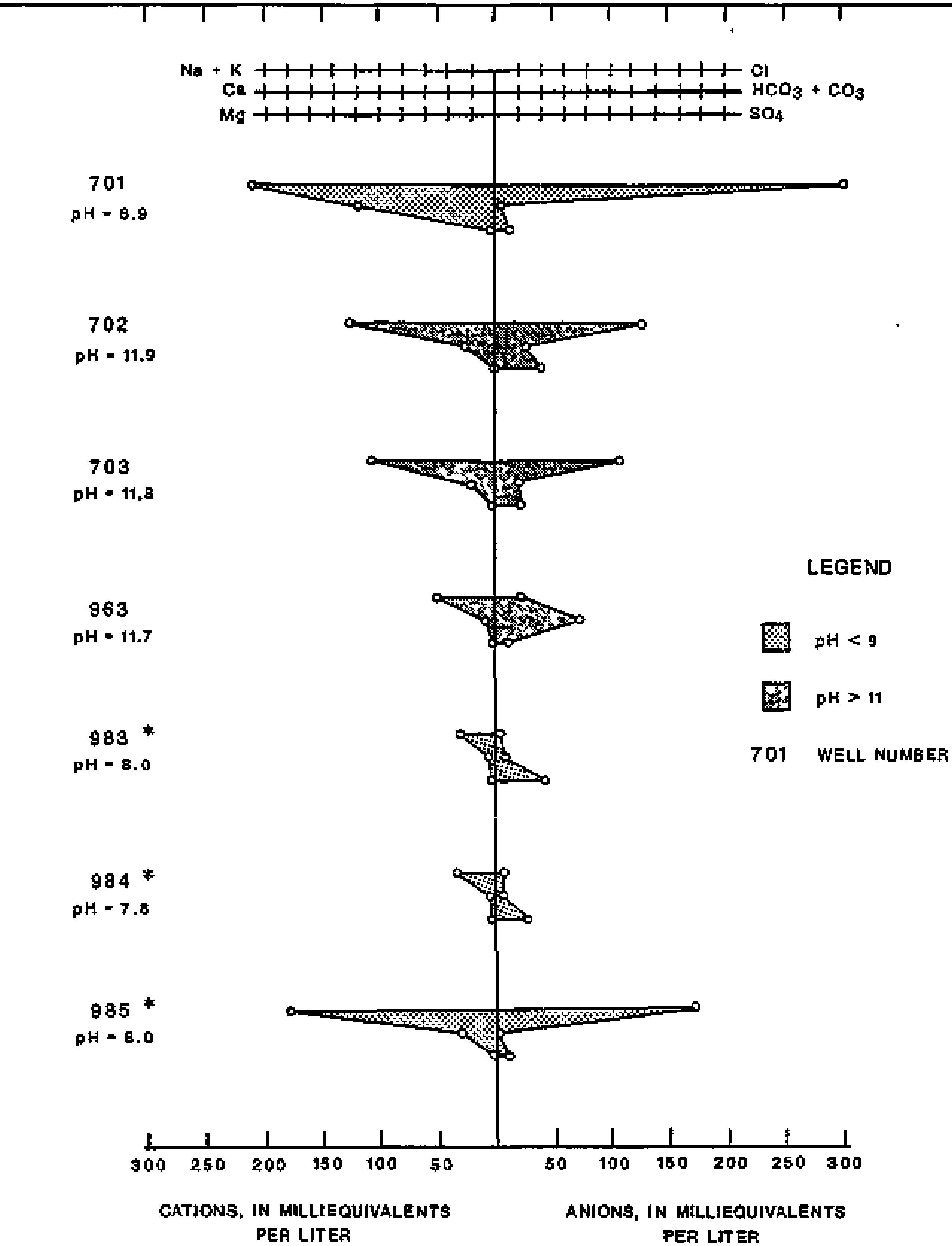
o HIGH pH (> 11) MONITOR WELL

• LOW pH (< 9) MONITOR WELL

(TRILINEAR SCALES ARE PERCENTAGES OF EQUIVALENTS PER LITER OF MAJOR IONS)

FIGURE D.7.39

TRILINEAR DIAGRAM OF WASATCH FORMATION GROUNDWATER, VICINITY OF ESTES GULCH SITE



* OFFSITE DOMESTIC WELL

FIGURE D.7.40
STIFF DIAGRAM OF WASATCH FORMATION GROUNDWATER VICINITY OF ESTES GULCH SITE

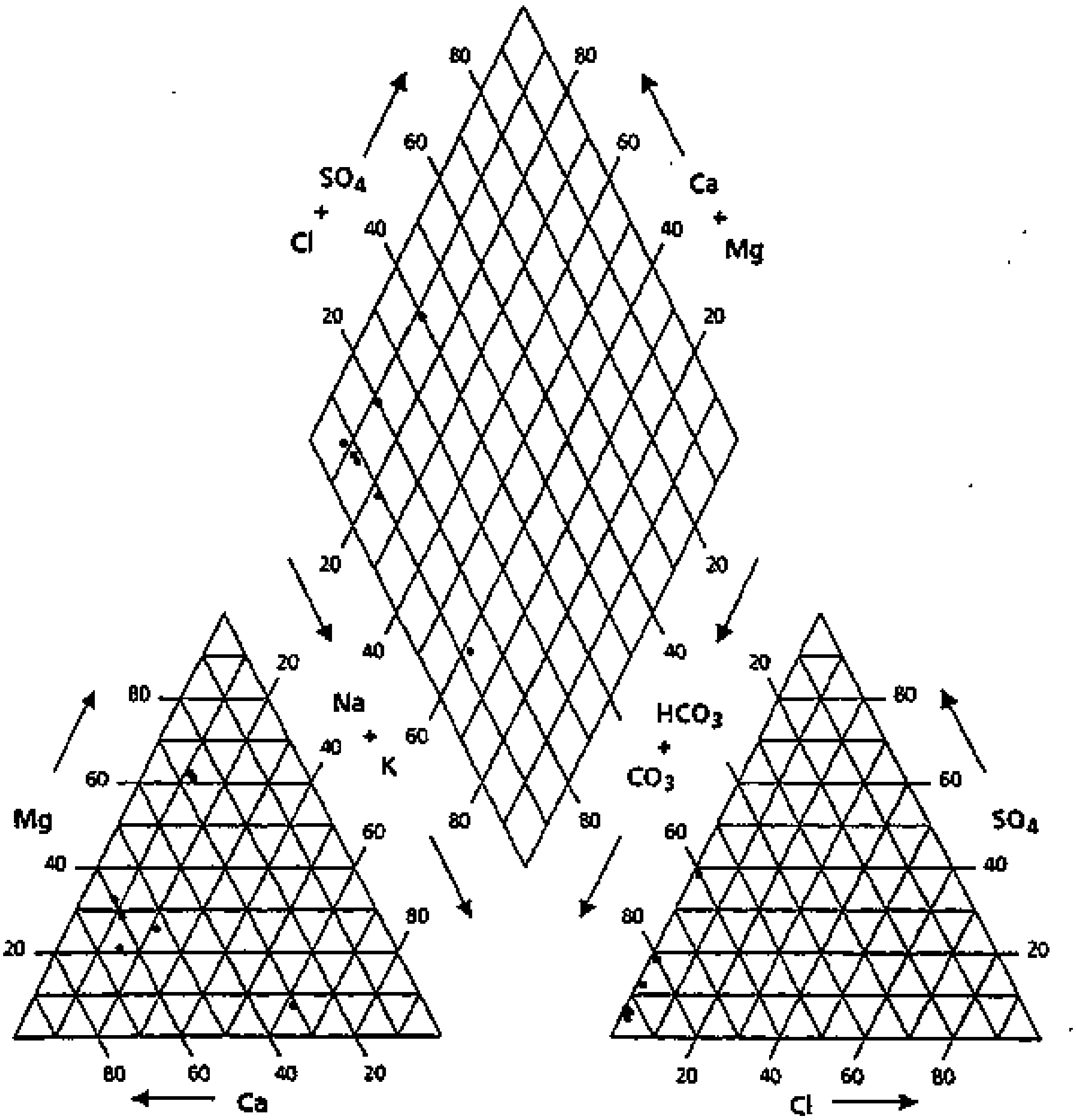


FIGURE D.7. 41
TRILINEAR DIAGRAM OF GROUNDWATER SAMPLES FROM THE MESA VERDE GROUP (GILES, 1980)

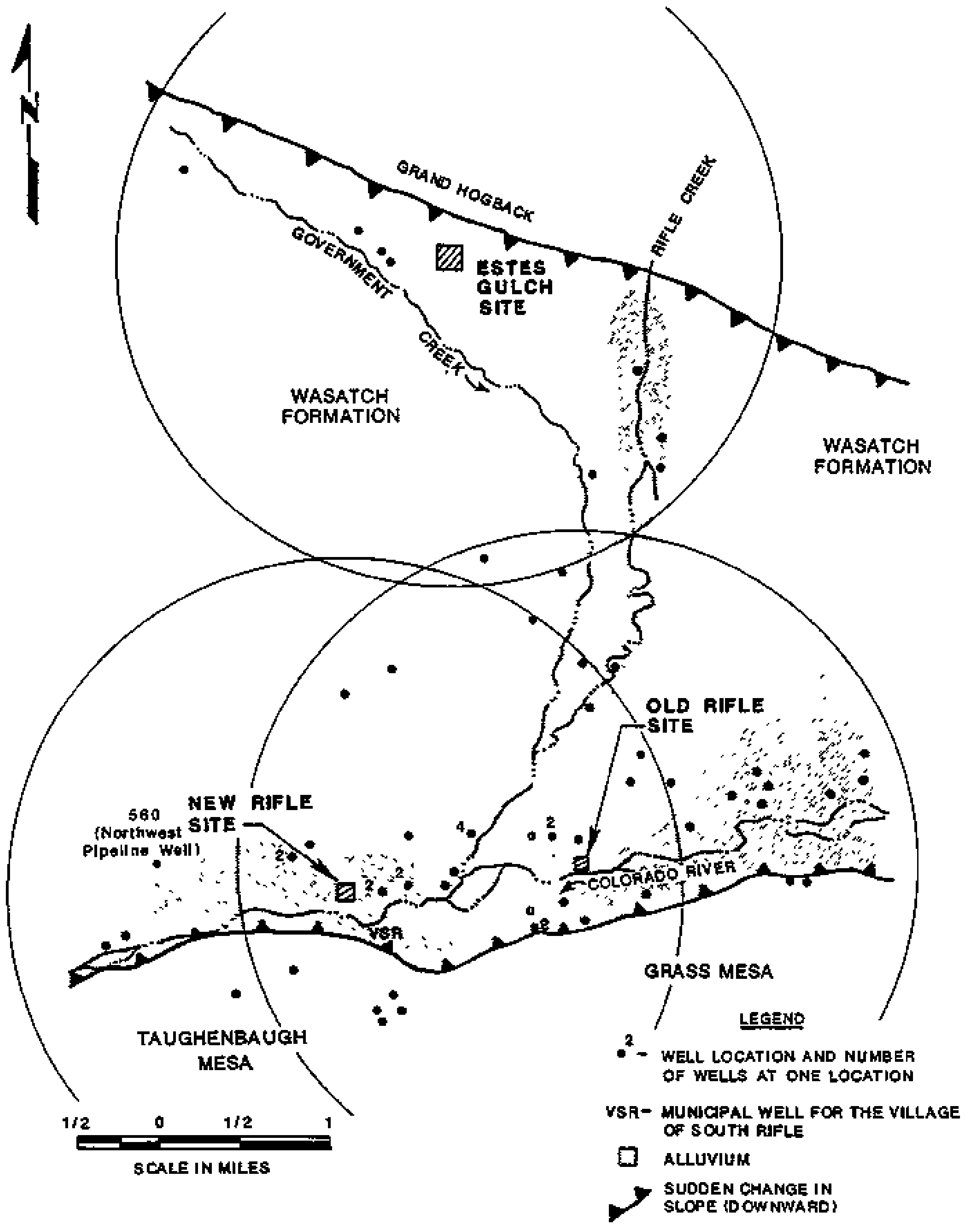


FIGURE D.7.42
EXISTING WATER WELLS WITHIN A TWO-MILE RADIUS OF THE OLD RIFLE, NEW RIFLE, AND ESTES GULCH SITES

Table D.7.1 Maximum concentration of constituents for groundwater protection[a,b]

Constituent	Maximum concentration[c] (40 CFR 192)
Arsenic	0.05
Barium	1.00
Cadmium	0.01
Chromium	0.05
Lead	0.05
Mercury	0.002
Selenium	0.01
Silver	0.05
Endrin (1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a, 5,6,7,8,8a-octahydro-1,4-endo,endo-5,8-dimethanonapthalene)	0.0002
Lindane (1,2,3,4,5,6-hexachlorocyclohexane, gamma isomer)	0.004
Methoxychlor (1,1,1-Trichloro-2,2'-bis (p-methoxyphenylethane))	0.10
Toxaphene ($C_{10}H_{10}Cl_6$, Technical chlorinated camphene, 67-69 percent chlorine)	0.005
2,4-D (2,4-Dichlorophenoxyacetic acid)	0.10
2,4,5-TP Silvex (2,4,5-Trichlorophenoxypropionic acid)	0.01
Benzene (Cyclohexatriene)	0.005
Vinyl chloride (Ethene, chloro-)	0.002
Tetrachloromethane (Carbon tetrachloride)	0.005
1,2-Dichloroethane (Ethylene dichloride)	0.005
Trichloroethene (Trichloroethylene)	0.005
1,1,1-Dichloroethylene (Ethene, 1, 1-dichloro-)	0.007
1,1-Trichloroethane (Methyl chloroform)	0.20
p-Dichlorobenzene (Benzene, 1,4-dichloro-)	0.075
Nitrate (as N)	10
Molybdenum	0.10
Combined radium-226 and radium-228	5 pCi/l
Combined uranium-234 and uranium-238	30 pCi/l
Gross alpha-particle activity (excluding radon and uranium)	15 pCi/l

[a]Appendix IX (40 CFR 264) elemental inorganic and organic constituents are analyzed in tailings fluids and groundwater to characterize the site with regards to hazardous constituents listed in Appendix I (40 CFR 192).
[b]Modified after EPA, 1991.
[c]Milligrams per liter unless stated otherwise.

Table D.7.2 Static groundwater levels in monitor wells, Old Rifle Site
SITE: RFO01 RIFLE (OLD)
REPORT DATE: 07/11/91

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	FORMATION OF COMPLETION	FLOW CODE	CASING ELEVATION (FT MSL)	GROUND ELEVATION (FT MSL)	LOG DATE	LOG TIME	DEPTH FROM TOP OF CASING (FT)	DEPTH FROM GROUND (FT)	GROUNDWATER ELEVATION (FT MSL)
0581	25859.7	59739.0	AL	O	5323.05	5321.30	01/30/83	08:00	22.50	20.75	5300.55
							02/17/83	21:49	22.50	20.75	5300.55
							02/23/83	16:11	22.50	20.75	5300.55
							06/06/83	14:47	19.20	17.45	5303.85
							06/21/83	07:22	18.10	16.35	5304.95
							09/19/83	16:38	21.40	19.65	5301.65
							10/01/83	08:02	21.60	19.85	5301.45
							01/10/84	14:56	21.50	19.75	5301.55
							01/23/84	08:19	21.60	19.85	5301.45
							06/24/85	16:30	17.90	16.15	5305.15
							12/08/85	13:31	21.23	19.48	5301.82
							10/22/87	13:00	22.19	20.44	5300.86
							04/21/89	14:54	22.72	20.97	5300.33
							09/20/89	13:50	23.30	21.55	5299.75
							02/22/90	15:07	23.82	22.07	5299.23
0582	25865.7	59749.6	AL	O	5323.41	5321.21	01/23/83	11:02	19.50	17.30	5303.91
							02/17/83	12:42	19.20	17.00	5304.21
							02/23/83	16:13	19.20	17.00	5304.21
							06/06/83	14:48	18.60	16.40	5304.81
							06/21/83	19:24	18.20	16.00	5305.21
							09/19/83	16:48	18.70	16.50	5304.71
							10/01/83	20:04	18.70	16.50	5304.71
							01/10/84	14:58	18.70	16.50	5304.71
							01/23/84	08:21	18.70	16.50	5304.71
							06/24/85	16:15	14.03	11.83	5309.38
							12/09/85	10:46	18.01	15.81	5305.40
							10/22/87	15:00	18.83	16.63	5304.58
							04/21/89	14:56	18.92	16.72	5304.49
							09/20/89	13:48	18.91	16.71	5304.50
							02/22/90	15:05	19.17	16.97	5304.24
0583	25653.5	59749.1	AL	O	5323.08	5321.58	01/23/82	11:07	22.60	21.10	5300.48
							01/24/83	20:00	22.50	21.00	5300.58
							02/17/83	23:11	22.60	21.10	5300.48
							02/23/83	16:15	22.50	21.00	5300.58
							06/06/83	14:46	19.30	17.80	5303.78
							06/21/83	07:23	18.20	16.70	5304.88
							09/19/83	16:37	21.50	20.00	5301.58
							10/01/83	08:03	21.60	20.10	5301.48
							01/10/84	14:57	21.60	20.10	5301.48
							01/23/84	08:20	21.70	20.20	5301.38
							04/21/89	14:59	22.77	21.27	5300.31

FORMATION OF COMPLETION CODE:
AL - ALLUVIUM

FLOW RELATIONSHIP CODE:
O - ON-SITE

Table D.7.2 Static groundwater levels in monitor wells, Old Rifle Site
SITE: RFO01 RIFLE (OLD)
REPORT DATE: 07/11/91

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	FORMATION OF COMPLETION	FLOW CODE	CASING ELEVATION (FT MSL)	GROUND ELEVATION (FT MSL)	LOG DATE	LOG TIME	DEPTH FROM TOP OF CASING (FT)	DEPTH FROM GROUND (FT)	GROUNDWATER ELEVATION (FT MSL)
0583	25653.5	59749.1	AL	0	5323.08	5321.58	02/22/90	15:40	DRY	DRY	-
							08/22/90	10:00	23.47	21.97	5299.61
0584	25854.6	61016.4	AL	0	5312.91	5311.61	01/22/83	15:45	12.60	11.30	5300.31
							02/16/83	11:46	12.60	11.30	5300.31
							02/23/83	14:02	12.70	11.40	5300.21
							06/06/83	14:46	7.10	5.80	5305.81
							06/10/83	14:02	6.70	5.40	5306.21
							06/21/83	14:39	5.80	4.50	5307.11
							09/19/83	16:13	11.10	9.80	5301.81
							09/30/83	15:40	11.20	9.90	5301.71
							10/01/83	15:14	11.20	9.90	5301.71
							01/10/84	13:53	11.20	9.90	5301.71
							01/19/84	16:05	11.20	9.90	5301.71
							01/23/84	15:42	11.20	9.90	5301.71
							06/25/85	08:06	7.13	5.83	5305.78
							12/08/85	09:05	9.93	8.63	5302.98
							10/22/87	09:30	11.39	10.09	5301.52
							04/21/89	16:10	11.12	9.82	5301.79
							09/20/89	13:30	11.80	10.50	5301.11
							02/21/90	13:50	12.12	10.82	5300.79
							08/23/90	09:10	11.82	10.52	5301.09
0585	25834.2	60509.5	AL	0	5313.71	5312.11	01/22/83	15:25	12.90	11.30	5300.81
							01/23/83	08:15	12.90	11.30	5300.81
							02/16/83	13:21	12.80	11.20	5300.91
							02/23/83	14:13	12.80	11.20	5300.91
							06/06/83	16:31	9.20	7.60	5304.51
							06/10/83	15:30	8.10	6.50	5305.61
							06/21/83	14:39	7.50	5.90	5306.21
							09/19/83	16:10	11.70	10.10	5302.01
							10/01/83	13:41	11.90	10.30	5301.81
							01/10/84	13:59	12.00	10.40	5301.71
							01/20/84	11:33	12.10	10.50	5301.61
							01/23/84	15:35	12.10	10.50	5301.61
							10/22/87	10:40	11.20	9.60	5302.51
0586	25399.9	59233.8	AL	0	5308.35	5306.84	02/09/83	08:00	10.80	9.29	5297.55
							02/23/83	15:46	10.80	9.29	5297.55
							06/06/83	15:11	6.70	5.19	5301.65
							06/20/83	07:43	4.90	3.39	5303.45
							06/21/83	15:26	4.40	2.89	5303.95
							09/19/83	16:56	9.90	8.39	5298.45

FORMATION OF COMPLETION CODE:
AL - ALLUVIUM

FLOW RELATIONSHIP CODE:
0 - ON-SITE

Table D.7.2 Static groundwater levels in monitor wells, Old Rifle Site
SITE: RFO01 RIFLE (OLD)
REPORT DATE: 07/11/91

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	FORMATION OF COMPLETION	FLOW CODE	CASING ELEVATION (FT MSL)	GROUND ELEVATION (FT MSL)	LOG DATE	LOG TIME	DEPTH FROM TOP OF CASING (FT)	DEPTH FROM GROUND (FT)	GROUNDWATER ELEVATION (FT MSL)
0586	25399.9	59235.8	AL	O	5308.35	5306.84	09/30/83	08:26	9.90	8.39	5298.45
							10/01/83	15:47	9.90	8.39	5298.45
							01/10/84	15:21	9.90	8.39	5298.45
							01/20/84	11:58	10.00	8.49	5298.35
							01/23/84	15:12	10.00	8.49	5298.35
							06/25/85	08:25	7.15	5.64	5301.20
							12/08/85	16:15	11.28	9.77	5297.07
							10/23/87	08:00	11.20	9.69	5297.15
							04/21/89	15:02	10.05	8.54	5298.30
							02/22/90	15:20	11.93	10.42	5296.42
							08/23/90	10:10	11.25	9.74	5297.10
0587	25400.8	59221.5	AL	O	5308.13	5306.83	02/09/83	15:30	10.40	9.10	5297.73
							02/23/83	15:40	10.70	9.40	5297.43
							06/06/83	15:11	6.60	5.30	5301.53
							06/20/83	07:42	4.80	3.50	5303.33
							06/21/83	15:25	4.30	3.00	5303.83
							09/19/83	16:55	9.80	8.50	5298.33
							09/30/83	08:25	9.90	8.60	5298.23
							10/01/83	15:40	9.90	8.60	5298.23
							01/10/84	15:22	9.90	8.60	5298.23
							01/19/84	11:59	10.00	8.70	5298.13
							01/23/84	15:10	10.00	8.70	5298.13
							04/21/89	15:04	10.03	8.73	5298.10
							02/22/90	15:22	11.82	10.52	5296.31
0588	25400.8	59209.6	AL	O	5308.41	5307.01	02/09/83	16:45	10.90	9.50	5297.51
							02/23/83	15:50	10.90	9.50	5297.51
							06/06/83	15:12	6.80	5.40	5301.61
							06/20/83	07:41	4.80	3.40	5303.61
							06/21/83	15:26	4.30	2.90	5304.11
							09/19/83	16:53	10.00	8.60	5298.41
							09/30/83	08:26	10.00	8.60	5298.41
							10/01/83	15:49	10.00	8.60	5298.41
							01/10/84	15:23	10.00	8.60	5298.41
							01/19/84	12:00	10.10	8.70	5298.31
							01/23/84	15:09	10.10	8.70	5298.31
							06/25/85	10:00	6.61	5.21	5301.80
							12/10/85	16:38	10.67	9.27	5297.74
							10/23/87	09:00	11.48	10.08	5296.93
							04/21/89	15:05	10.24	8.84	5298.17
							02/22/90	15:23	12.11	10.71	5296.30
0589	25219.8	58351.0	AL	D	5307.16	5306.00	01/23/83	15:42	7.90	6.74	5299.26

FORMATION OF COMPLETION CODE:
AL - ALLUVIUM

FLOW RELATIONSHIP CODE:
O - ON-SITE
D - DOWN GRADIENT

Table D.7.2 Static groundwater levels in monitor wells, Old Rifle Site
SITE: RFO01 RIFLE (OLD)
REPORT DATE: 07/11/91

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	FORMATION OF COMPLETION	FLOW CODE	CASING ELEVATION (FT MSL)	GROUND ELEVATION (FT MSL)	LOG DATE	LOG TIME	DEPTH FROM TOP OF CASING (FT)	DEPTH FROM GROUND (FT)	GROUNDWATER ELEVATION (FT MSL)
0589	25219.0	58351.0	AL	D	5307.16	5306.00	02/16/83	07:02	7.90	6.74	5299.26
							02/23/83	15:30	7.80	6.64	5299.36
							06/06/83	15:18	5.80	4.64	5301.36
							06/10/83	07:45	5.30	4.14	5301.86
							06/21/83	15:49	0.30	-0.86	5306.86
							09/19/83	17:06	7.40	6.24	5299.76
							09/29/83	15:25	7.50	6.34	5299.66
							10/01/83	15:57	7.50	6.34	5299.66
							01/10/84	15:33	7.60	6.44	5299.56
							01/20/84	15:48	7.60	6.44	5299.56
							01/23/84	15:17	7.60	6.44	5299.56
							06/25/85	11:00	6.11	4.95	5301.05
							12/18/85	09:38	6.98	5.82	5300.18
0590	25552.2	58651.7	AL	D	5301.68	5300.00	02/15/83	16:27	13.80	12.12	5287.88
							02/23/83	15:20	13.90	12.22	5287.78
							06/06/83	15:25	12.20	10.52	5289.48
							06/10/83	09:42	11.60	9.92	5290.08
							06/21/83	15:34	6.40	4.72	5295.28
							09/19/83	17:02	13.20	11.52	5288.48
							09/29/83	16:33	13.40	11.72	5288.28
							10/01/83	15:55	13.50	11.82	5288.18
							01/10/84	15:28	13.60	11.92	5288.08
							01/20/84	14:12	13.60	11.92	5288.08
							01/23/84	15:21	13.60	11.92	5288.08
							06/25/85	08:35	10.44	8.76	5291.24
							10/23/87	11:25	13.93	12.25	5287.75
							06/21/89	17:10	7.20	5.52	5294.48
0593	26107.3	59951.9	AL	O	5322.50	5320.20	02/23/83	14:39	20.80	18.50	5301.70
							06/06/83	14:53	18.60	16.30	5303.90
							06/21/83	14:44	16.90	14.60	5305.60
							09/19/83	16:25	19.60	17.30	5302.90
							10/01/83	15:21	19.80	17.50	5302.70
							01/10/84	15:56	19.80	17.50	5302.70
							01/23/84	14:36	19.90	17.60	5302.60
							02/22/90	15:45	DRY	DRY	-
0594	26866.7	59686.1	AL	O	5325.10	5323.30	02/23/83	15:01	23.20	21.40	5301.90
							06/06/83	14:53	20.50	18.70	5304.60
							06/21/83	15:10	19.20	17.40	5305.90
							09/19/83	17:17	22.30	20.50	5302.80

FORMATION OF COMPLETION CODE:
AL - ALLUVIUM

FLOW RELATIONSHIP CODE:
D - DOWN GRADIENT
O - ON-SITE

Table D.7.2 Static groundwater levels in monitor wells, Old Rifle Site
SITE: RFO01 RIFLE (OLD)
REPORT DATE: 07/11/91

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	FORMATION OF COMPLETION	FLOW CODE	CASING ELEVATION (FT MSL)	GROUND ELEVATION (FT MSL)	LOG DATE	LOG TIME	DEPTH FROM TOP OF CASING (FT)	DEPTH FROM GROUND (FT)	GROUNDWATER ELEVATION (FT MSL)
0594	26866.7	59686.1	AL	O	5325.10	5323.30	10/01/83	15:30	22.40	20.60	5302.70
							01/10/84	15:08	22.30	20.50	5302.80
							01/23/84	14:53	22.40	20.60	5302.70
							02/22/90	15:50	24.06	22.26	5301.04
							08/22/90	11:45	18.20	16.40	5306.90
0595	25798.8	59948.9	AL	O	5323.22	-	02/22/90	15:55	DRY	DRY	-
0596	25613.6	59506.5	AL	O	5324.26	-	02/22/90	16:00	DRY	DRY	-
							08/22/90	11:30	DRY	DRY	-
0597	26560.5	63346.1	AL	U	5317.20	5319.40	06/24/85	10:13	5.25	7.37	5312.05
							12/09/85	10:55	6.22	8.34	5311.06
							10/21/87	14:45	7.14	9.26	5310.14
							10/04/89	12:01	7.21	9.33	5310.07
							02/21/90	13:17	7.54	9.66	5309.74
							08/24/90	11:30	7.16	9.28	5310.12
0598	26551.7	63341.1	AL	U	5316.95	5314.60	06/24/85	10:10	4.80	2.45	5312.15
							12/09/85	13:30	5.97	3.62	5310.98
							10/21/87	16:00	6.90	4.55	5310.05
							10/04/89	12:03	6.87	4.52	5310.08
							02/21/90	13:19	7.27	4.92	5309.68
							08/24/90	12:10	6.91	4.56	5310.04
0599	25880.9	56777.7	AL	O	5303.33	5300.60	06/24/85	12:20	9.00	6.27	5294.33
							04/21/89	15:29	12.48	9.75	5290.85
							09/20/89	09:55	12.92	10.19	5290.41
							02/21/90	15:47	13.38	10.65	5289.95
							08/24/90	15:53	11.82	9.09	5291.51
0600	25790.1	56788.1	AL	O	5302.86	5301.10	06/24/85	12:05	8.49	6.73	5294.37
							12/10/85	10:30	11.12	9.36	5291.74
							10/23/87	13:00	12.55	10.79	5290.31
							04/21/89	15:30	11.99	10.23	5290.87
							09/20/89	09:55	12.50	10.74	5290.36
							02/21/90	15:45	13.08	11.32	5289.78
							08/24/90	15:40	9.62	7.86	5293.24
0601	25156.2	57007.9	AL	O	5297.21	5296.10	06/24/85	10:45	4.50	3.39	5292.71
							12/07/85	11:32	12.00	10.89	5285.21

FORMATION OF COMPLETION CODE:
AL - ALLUVIUM

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

Table D.7.2 Static groundwater levels in monitor wells, Old Rifle Site
SITE: RF001 RIFLE (OLD)
REPORT DATE: 07/11/91

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	FORMATION OF COMPLETION	FLOW CODE	CASING ELEVATION (FT MSL)	GROUND ELEVATION (FT MSL)	LOG DATE	LOG TIME	DEPTH FROM TOP OF CASING (FT)	DEPTH FROM GROUND (FT)	GROUNDWATER ELEVATION (FT MSL)
0601	25156.2	57007.9	AL	D	5297.21	5296.10	10/23/87	16:45	8.07	6.96	5289.14
							04/21/89	15:17	7.17	6.06	5290.04
							09/20/89	10:27	8.75	7.64	5288.46
							02/21/90	15:05	8.79	7.68	5288.42
							08/24/90	09:45	8.48	7.37	5288.73
0602	25151.3	57017.5	AL	D	5297.84	5295.80	06/24/85	12:20	6.60	4.56	5291.24
							12/08/85	09:23	8.19	6.15	5289.65
							04/21/89	15:18	7.85	5.81	5289.99
							09/20/89	10:28	DRY	DRY	-
							02/21/90	15:07	9.41	7.37	5288.43
							08/24/90	09:30	9.00	6.96	5288.84
0603	25418.7	54103.4	AL	D	5291.98	5290.30	06/24/85	14:20	6.05	4.37	5285.93
							12/09/85	14:59	9.14	7.46	5282.84
							10/23/87	14:10	6.35	4.67	5285.63
							09/20/89	11:40	9.80	8.12	5282.18
							08/24/90	14:00	9.25	7.57	5282.73
0604	25422.8	54113.3	AL	D	5292.11	5291.30	06/24/85	15:30	6.15	5.34	5285.96
							12/09/85	16:30	9.02	8.21	5283.09
							10/23/87	15:00	9.51	8.70	5282.60
							09/20/89	11:41	9.90	9.09	5282.21
							08/24/90	14:00	9.79	8.98	5282.32
0620	26971.5	63332.5	WS	U	5316.84	5341.80	06/24/85	12:00	4.42	29.38	5312.42
							10/26/87	09:20	6.50	31.46	5310.34
							10/04/89	12:00	6.56	31.52	5310.28
							02/21/90	13:15	6.93	31.89	5309.91
							08/27/90	07:20	6.60	31.56	5310.24
0621	27430.7	63843.5	WS	U	5316.00	5315.60	01/15/86	14:41	3.87	3.47	5312.13
							04/21/89	15:39	3.98	3.58	5312.02
							09/20/89	11:12	4.75	4.35	5311.25
							02/21/90	13:23	4.16	3.76	5311.84
							08/25/90	09:26	4.90	4.50	5311.10
0622	27415.7	63810.1	WS	U	5317.21	5315.80	01/15/86	11:21	4.45	3.04	5312.76
							10/24/87	09:25	4.50	3.09	5312.71
							04/21/89	15:41	4.73	3.32	5312.48
							09/20/89	11:14	5.35	3.94	5311.86
							02/21/90	13:25	4.80	3.39	5312.41

FORMATION OF COMPLETION CODE:
AL - ALLUVIUM
WS - WASATCH FORMATION - UNDIFFERENTIATED

FLOW RELATIONSHIP CODE:
D - DOWN GRADIENT
U - UPGRADIENT

Table D.7.2 Static groundwater levels in monitor wells, Old Rifle Site
SITE: RFO01 RIFLE (OLD)
REPORT DATE: 07/11/91

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	FORMATION OF COMPLETION	FLOW CODE	CASING ELEVATION (FT MSL)	GROUND ELEVATION (FT MSL)	LOG DATE	LOG TIME	DEPTH FROM TOP OF CASING (FT)	DEPTH FROM GROUND (FT)	GROUNDWATER ELEVATION (FT MSL)
0622	27415.7	63810.1	WS	U	5317.21	5315.80	08/25/90	10:32	5.77	4.36	5311.44
0623	26007.5	60810.0	WS	O	5313.91	5312.00	01/13/86	10:40	76.89	74.98	5237.02
							10/26/87	08:05	17.40	15.49	5296.51
							04/21/89	16:14	16.40	14.49	5297.51
							09/20/89	13:23	13.33	11.42	5300.58
							02/21/90	13:39	12.41	10.50	5301.50
							08/22/90	14:30	12.08	10.17	5301.83
0624	26020.7	60783.6	WS	O	5314.84	5313.60	01/13/86	12:45	53.79	54.55	5259.05
							10/26/87	07:20	69.70	68.46	5245.14
							04/21/89	16:15	73.40	72.16	5241.44
							09/20/89	13:21	73.00	71.76	5241.84
							02/21/90	13:41	12.41	11.17	5302.43
0625	24520.2	58149.2	WS	O	5304.95	5303.29	01/12/86	07:30	9.21	7.55	5295.74
							10/25/87	10:00	9.44	7.78	5295.51
							04/21/89	15:22	9.87	8.21	5295.08
							09/20/89	10:15	9.91	8.25	5295.04
							02/21/90	14:50	10.44	8.78	5294.51
							08/26/90	15:00	9.90	8.24	5295.05
0626	24513.3	58124.9	WS	D	5306.39	5304.64	01/12/86	07:42	12.58	10.83	5293.81
							10/25/87	13:50	12.34	10.59	5294.05
							04/21/89	15:21	12.12	10.37	5294.27
							09/20/89	10:16	12.52	10.77	5293.87
							02/21/90	14:45	13.39	11.64	5293.00
							08/23/90	16:53	12.58	10.83	5293.81
0629	25130.7	60069.1	WS	C	5362.26	5361.00	01/16/86	16:30	158.43	157.17	5203.83
							04/21/89	16:45	87.02	85.76	5275.24
							02/21/90	15:25	75.15	73.89	5287.11
0630	25118.0	60037.9	WS	C	5362.39	5360.90	01/16/86	09:25	20.00	18.51	5342.39
							04/21/89	16:47	11.13	9.64	5351.26
							02/21/90	15:35	10.91	9.42	5351.48
							08/25/90	14:32	10.50	9.01	5351.89
0640	23664.2	58713.2	WS	C	5302.66	5303.70	01/14/86	16:17	5.27	6.31	5297.39
							04/21/89	16:56	5.99	7.03	5296.67

FORMATION OF COMPLETION CODE:
WS - WASATCH FORMATION - UNDIFFERENTIATED

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

Table D.7.2 Static groundwater levels in monitor wells, Old Rifle Site
SITE: RF001 RIFLE (OLD)
REPORT DATE: 07/11/91

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	FORMATION OF COMPLETION	FLOW CODE	CASING ELEVATION (FT MSL)	GROUND ELEVATION (FT MSL)	LOG DATE	LOG TIME	DEPTH FROM TOP OF CASING (FT)	DEPTH FROM GROUND (FT)	GROUNDWATER ELEVATION (FT MSL)
0640	23664.2	58713.2	WS	C	5302.66	5303.70	09/20/89	10:44	3.95	4.99	5298.71
							02/21/90	14:37	6.58	7.62	5296.08
							08/26/90	09:06	3.75	4.79	5298.91
0641	23632.6	58712.2	WS	C	5302.08	5300.20	01/14/86	14:42	6.05	4.17	5296.03
							10/24/87	16:10	3.91	2.03	5298.17
							04/21/89	16:55	6.33	4.45	5295.75
							09/20/89	10:45	4.42	2.54	5297.66
							02/21/90	14:35	7.02	5.14	5295.06
							08/26/90	12:10	4.04	2.16	5298.04
0644	25173.8	57025.3	WS	D	5298.64	5297.27	01/12/86	13:00	6.75	5.38	5291.89
							10/25/87	14:00	6.42	5.05	5292.22
							04/21/89	15:16	5.38	4.01	5293.26
							09/20/89	10:34	6.00	4.63	5292.64
							02/21/90	15:00	6.09	4.72	5292.55
							08/23/90	13:00	5.92	4.55	5292.72
0645	25178.6	57003.9	WS	D	5298.50	5297.08	01/12/86	11:15	9.13	7.71	5289.37
							10/25/87	16:30	8.79	7.37	5289.71
							04/21/89	15:15	8.30	6.88	5290.20
							09/20/89	10:33	10.25	8.83	5288.25
							02/21/90	15:02	9.58	8.16	5288.92
							08/23/90	16:05	8.46	7.04	5290.04

FORMATION OF COMPLETION CODE:
WS - WASATCH FORMATION - UNDIFFERENTIATED

FLOW RELATIONSHIP CODE:
C - CROSS GRADIENT
D - DOWN GRADIENT

DATA FILE: M:\DART\RF001\GWL10002.DAT

FIELDS DISPLAYED WITH A DASH INDICATE THE DATA IS UNAVAILABLE

Table D.7.3 Hydraulic conductivity for the alluvial aquifer, Old Rifle site

Monitor well number[a]	Hydraulic conductivity (ft/day)[b]
581	340
584	59.5
586	765
589	820
590	28.3
	Geometric mean = 200 ft/day

[a]Monitor well locations are shown on Figure D.7.2.
[b]Ref. DOE, 1983. Hydraulic conductivities are based on aquifer tests conducted by the DOE in 1983.

Table D.7.4 Hydraulic conductivity for the Wasatch Formation, Old Rifle site

Monitor well number[a]	Hydraulic conductivity[b] (ft/day)
621	0.010
622	0.025
	Geometric mean = 0.016 ft/day

[a]Monitor well locations are shown on Figure D.7.3.
[b]Hydraulic conductivities were determined using the Skibitzke method (Skibitzke, 1963).

Table D.7.5 Static groundwater levels in monitor wells, New Rifle Site
SITE: RFN01 RIFLE (NEW)
REPORT DATE: 07/11/91

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	FORMATION OF COMPLETION	FLOW CODE	CASING ELEVATION (FT MSL)	GROUND ELEVATION (FT MSL)	LOG DATE	LOG TIME	DEPTH FROM TOP OF CASING (FT)	DEPTH FROM GROUND (FT)	GROUNDWATER ELEVATION (FT MSL)
0559	-	-	AL	D	-	-	09/13/90	08:25	35.10	-	-
0581	23390.0	46708.2	AL	O	5265.90	5264.70	11/09/82	07:54	10.50	9.30	5255.40
							02/10/83	13:15	9.20	8.00	5256.70
							02/23/83	12:17	9.20	8.00	5256.70
							04/06/83	12:59	7.80	6.60	5258.10
							06/14/83	08:24	7.20	6.00	5258.70
							06/21/83	17:14	7.10	5.90	5258.80
							09/19/83	15:05	8.10	6.90	5257.80
							09/26/83	08:36	8.20	7.00	5257.70
							10/01/83	14:40	8.20	7.00	5257.70
							01/16/84	10:02	8.60	7.40	5257.30
							01/17/84	08:33	8.60	7.40	5257.30
							01/24/84	09:52	8.70	7.50	5257.20
							06/25/85	14:30	6.54	5.34	5259.36
							12/17/85	16:00	7.72	6.52	5258.18
							10/27/87	09:55	10.00	8.80	5255.90
							04/21/89	09:57	9.40	8.20	5256.50
							09/22/89	09:50	10.25	9.05	5255.65
							02/22/90	09:10	10.47	9.27	5255.43
							09/14/90	12:03	10.40	9.20	5255.50
0582	23308.9	46716.5	AL	O	5265.72	5264.50	01/12/83	14:00	9.10	7.88	5256.62
							02/15/83	13:27	8.90	7.68	5256.82
							02/23/83	12:18	9.00	7.78	5256.72
							04/06/83	13:01	7.60	6.38	5258.12
							06/14/83	08:22	7.00	5.78	5258.72
							06/21/83	17:13	6.80	5.58	5258.92
							09/19/83	15:06	7.80	6.58	5257.92
							09/26/83	08:37	7.90	6.68	5257.82
							10/01/83	16:47	7.90	6.68	5257.82
							01/16/84	10:03	8.30	7.08	5257.42
							01/17/84	08:35	8.30	7.08	5257.42
							01/24/84	09:50	8.40	7.18	5257.32
							04/21/89	09:58	9.17	7.95	5256.55
							09/22/89	09:48	10.03	8.81	5255.69
							02/22/90	09:47	10.27	9.05	5255.45
0583	23373.7	46706.8	AL	O	5265.80	5264.40	01/11/83	11:38	9.10	7.70	5256.70
							02/10/83	15:00	9.30	7.90	5256.50
							02/23/83	12:20	9.30	7.90	5256.50
							04/06/83	12:54	7.90	6.50	5257.90

FORMATION OF COMPLETION CODE:
AL - ALLUVIUM

FLOW RELATIONSHIP CODE:
D - DOWN GRADIENT
O - ON-SITE

Table D.7.3 Static groundwater levels in monitor wells, New Rifle Site
SITE: RFN01 RIFLE (NEW)
REPORT DATE: 07/11/91

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	FORMATION OF COMPLETION	FLOW CODE	CASING ELEVATION (FT MSL)	GROUND ELEVATION (FT MSL)	LOG DATE	LOG TIME	DEPTH FROM TOP OF CASING (FT)	DEPTH FROM GROUND (FT)	GROUNDWATER ELEVATION (FT MSL)
0583	23373.7	46706.8	AL	O	5265.80	5264.40	06/14/83	08:23	7.30	5.90	5258.50
							06/21/83	17:11	7.10	5.70	5258.70
							09/19/83	15:06	8.20	6.80	5257.60
							09/23/83	08:38	8.30	6.90	5257.50
							10/01/83	16:46	8.30	6.90	5257.50
							01/16/84	10:01	8.60	7.20	5257.20
							01/17/84	08:34	8.60	7.20	5257.20
							01/24/84	09:53	8.70	7.30	5257.10
							06/25/85	13:03	6.21	4.81	5259.59
							12/18/85	10:25	7.87	6.47	5257.93
							04/21/89	09:19	9.51	8.11	5256.29
							09/22/89	09:54	10.35	8.95	5255.45
							02/22/90	09:45	10.63	9.23	5255.17
							09/16/90	13:10	10.65	9.25	5255.15
0584	23647.5	46912.6	AL	O	5316.61	5314.90	02/14/83	10:00	59.60	57.89	5257.01
							02/23/83	12:43	59.30	57.59	5257.31
							06/06/83	13:17	58.10	56.39	5258.51
							06/16/83	08:02	57.70	55.99	5258.91
							06/21/83	17:38	57.50	55.79	5259.11
							09/19/83	15:22	57.90	56.19	5258.71
							09/20/83	08:34	58.00	56.29	5258.61
							09/29/83	08:02	58.10	56.39	5258.51
							10/01/83	17:02	58.10	56.39	5258.51
							01/16/84	16:15	58.50	56.79	5258.11
							01/18/84	08:54	58.60	56.89	5258.01
							01/24/84	09:33	58.80	57.09	5257.81
							04/21/89	10:25	59.40	57.69	5257.21
0585	25310.7	49003.6	AL	C	5275.39	5275.40	01/21/83	15:30	8.80	8.81	5266.59
							02/15/83	09:33	9.20	9.21	5266.19
							02/23/83	13:37	8.80	8.81	5266.59
							06/06/83	12:11	5.90	5.91	5269.49
							06/15/83	07:48	5.10	5.11	5270.29
							06/21/83	16:46	4.70	4.71	5270.69
							09/19/83	14:39	7.80	7.81	5267.59
							09/27/83	14:13	7.80	7.81	5267.59
							10/01/83	16:22	8.00	8.01	5267.39
							01/17/84	15:29	8.20	8.21	5267.19
							01/20/84	08:17	8.20	8.21	5267.19
							01/24/84	08:38	8.20	8.21	5267.19
							10/26/87	12:50	9.30	9.31	5266.09

FORMATION OF COMPLETION CODE:
AL - ALLUVIUM

FLOW RELATIONSHIP CODE:
O - ON-SITE
C - CROSS GRADIENT

Table D.7.5 Static groundwater levels in monitor wells, New Rifle Site
SITE: RFN01 RIFLE (NEW)
REPORT DATE: 07/11/91

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	FORMATION OF COMPLETION	FLOW CODE	CASING ELEVATION (FT MSL)	GROUND ELEVATION (FT MSL)	LOG DATE	LOG TIME	DEPTH FROM TOP OF CASING (FT)	DEPTH FROM GROUND (FT)	GROUNDWATER ELEVATION (FT MSL)
0585	25310.7	49003.6	AL	C	5275.39	5275.40	04/21/89	13:50	9.12	9.13	5266.27
0586	23612.1	46916.6	AL	O	5316.61	5315.10	02/22/83	09:08	59.10	57.59	5257.51
							02/23/83	12:48	59.10	57.59	5257.51
							06/06/83	13:22	57.80	56.29	5258.81
							06/16/83	07:58	57.20	55.69	5259.41
							06/21/83	17:32	57.10	55.59	5259.51
							09/19/83	15:25	57.80	56.29	5258.81
							09/28/83	08:36	57.90	56.39	5258.71
							10/01/83	16:58	57.90	56.39	5258.71
							01/16/84	14:13	58.40	56.89	5258.21
							01/18/84	08:51	58.50	56.99	5258.11
							01/24/84	09:28	58.50	56.99	5258.11
							04/21/89	10:23	59.42	57.91	5257.19
0587	23632.4	46918.3	AL	O	5315.94	5315.04	02/14/83	14:15	55.00	54.10	5260.94
							02/23/83	12:45	58.50	57.60	5257.44
							06/06/83	13:19	57.30	56.40	5258.64
							06/16/83	08:08	56.70	55.80	5259.24
							06/21/83	17:35	56.50	55.60	5259.44
							09/19/83	15:23	57.20	56.30	5258.74
							09/28/83	08:55	57.30	56.40	5258.64
							10/01/83	17:01	57.30	56.40	5258.64
							01/16/84	16:28	57.80	56.90	5258.14
							01/18/84	08:57	57.90	57.00	5258.04
							01/24/84	09:31	57.90	57.00	5258.04
							04/21/89	10:24	58.78	57.88	5257.16
0588	23879.2	47867.8	AL	O	5265.73	5265.70	01/21/83	08:25	6.90	6.87	5258.83
							02/15/83	11:35	7.10	7.07	5258.63
							02/23/83	13:12	7.10	7.07	5258.63
							06/06/83	13:37	4.60	4.57	5261.13
							06/17/83	10:55	4.30	4.27	5261.43
							06/21/83	17:51	4.10	4.07	5261.63
							09/19/83	15:45	6.20	6.17	5259.53
							09/29/83	13:26	6.30	6.27	5259.43
							10/01/83	17:16	6.40	6.37	5259.33
							01/17/84	13:47	6.70	6.67	5259.03
							01/24/84	10:05	6.90	6.87	5258.83
							06/26/85	13:50	4.75	4.72	5260.98
							12/16/85	09:38	6.52	6.49	5259.21
							10/27/87	08:45	8.00	7.97	5257.73

FORMATION OF COMPLETION CODE:
AL - ALLUVIUM

FLOW RELATIONSHIP CODE:
C - CROSS GRADIENT
O - ON-SITE

Table D.7.3 Static groundwater levels in monitor wells, New Rifle Site
SITE: RFN01 RIFLE (NEW)
REPORT DATE: 07/11/91

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	FORMATION OF COMPLETION	FLOW CODE	CASING ELEVATION (FT MSL)	GROUND ELEVATION (FT MSL)	LOG DATE	LOG TIME	DEPTH FROM TOP OF CASING (FT)	DEPTH FROM GROUND (FT)	GROUNDWATER ELEVATION (FT MSL)
0588	25879.2	47867.8	AL	O	5265.73	5265.70	09/17/90	12:00	8.48	8.45	5257.25
0589	23426.8	44646.4	AL	D	5258.07	5256.40	01/10/83	14:00	9.90	8.23	5248.17
							02/10/83	10:00	9.80	8.13	5248.27
							02/23/83	11:41	9.70	8.03	5248.37
							06/06/83	12:43	8.00	6.33	5250.07
							06/17/83	17:02	7.80	6.13	5250.27
							06/21/83	10:11	7.70	6.03	5250.37
							09/19/83	16:00	9.20	7.53	5248.87
							09/27/83	10:44	9.50	7.83	5248.57
							10/01/83	16:34	9.70	8.03	5248.37
							01/16/84	14:05	9.30	7.63	5248.77
							01/24/84	09:06	9.40	7.73	5248.67
							06/25/85	11:00	6.11	4.44	5251.96
							10/27/87	15:10	10.38	8.71	5247.69
							04/21/89	09:21	8.97	7.30	5249.10
0590	23415.9	45779.3	AL	D	5259.47	5258.10	01/21/83	13:36	7.80	6.43	5251.67
							02/10/83	10:00	7.80	6.43	5251.67
							06/06/83	12:33	6.50	5.13	5252.97
							06/17/83	15:00	6.00	4.63	5253.47
							06/21/83	10:18	5.80	4.43	5253.67
							09/19/83	15:57	6.60	5.23	5252.87
							09/27/83	08:36	6.80	5.43	5252.67
							10/01/83	16:30	6.80	5.43	5252.67
							01/16/84	09:45	7.20	5.83	5252.27
							01/24/84	08:57	7.20	5.83	5252.27
							12/18/85	14:25	5.93	4.56	5253.54
							10/27/87	14:15	8.15	6.78	5251.32
							04/21/89	09:44	7.35	5.98	5252.12
0591	25105.9	49085.8	AL	U	5275.01	5272.80	06/25/85	15:05	5.32	3.11	5269.69
							12/12/85	10:05	10.12	7.91	5264.89
							10/26/87	13:50	10.75	8.54	5264.26
							04/21/89	13:36	10.58	8.37	5264.43
0592	25099.6	49076.9	AL	U	5275.15	5272.60	06/25/85	16:40	5.52	2.97	5269.63
							12/16/85	11:00	10.06	7.51	5265.09
							10/26/87	11:30	10.95	8.40	5264.20
							04/21/89	13:38	9.80	7.25	5265.35
							09/20/89	15:05	11.10	8.55	5264.05

FORMATION OF COMPLETION CODE:
AL - ALLUVIUM

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

Table D.7.5 Static groundwater levels in monitor wells, New Rifle Site
SITE: RFN01 RIFLE (NEW)
REPORT DATE: 07/11/91

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	FORMATION OF COMPLETION	FLOW CODE	CASING ELEVATION (FT MSL)	GROUND ELEVATION (FT MSL)	LOG DATE	LOG TIME	DEPTH FROM TOP OF CASING (FT)	DEPTH FROM GROUND (FT)	GROUNDWATER ELEVATION (FT MSL)
0592	25099.6	49076.9	AL	U	5275.15	5272.60	08/29/90	11:06	11.20	8.65	5263.95
0593	24431.3	47775.0	AL	O	5278.18	5276.60	06/25/85	16:04	12.40	10.82	5265.78
							12/14/85	10:40	14.05	12.47	5264.13
							04/21/89	08:19	17.03	15.45	5261.15
							09/20/89	15:34	17.25	15.67	5260.93
							09/17/90	15:08	17.83	16.25	5260.35
0594	24439.0	47782.4	AL	O	5278.13	5276.40	06/25/85	07:01	13.76	12.03	5264.37
							12/14/85	08:35	15.03	13.30	5263.10
							10/26/87	14:30	16.60	14.87	5261.53
							04/21/89	08:20	17.17	15.44	5260.96
							09/20/89	15:32	17.34	15.61	5260.79
							09/17/90	16:00	17.80	16.07	5260.33
0595	23341.8	46757.9	AL	D	5266.77	5264.70	06/26/85	13:34	7.63	5.56	5259.14
							10/27/87	10:55	11.58	9.51	5255.19
							04/21/89	10:00	10.97	8.90	5255.80
0596	23247.9	43631.5	AL	D	5257.01	5254.90	06/26/85	09:30	6.92	4.81	5250.09
							12/17/85	14:40	7.35	5.24	5249.66
							09/22/89	10:42	11.40	9.29	5245.61
							02/22/90	11:35	11.27	9.16	5245.74
							08/29/90	16:31	11.65	9.54	5245.36
0598	24494.4	44977.5	AL	O	5257.30	5255.20	06/26/85	11:45	3.81	1.71	5253.49
							12/16/85	15:00	3.69	1.59	5253.61
							04/21/89	08:59	5.69	3.59	5251.61
							09/22/89	10:19	6.85	4.75	5250.45
							02/22/90	11:30	5.77	3.67	5251.53
							08/29/90	15:38	6.90	4.80	5250.40
0599	24496.2	44967.5	AL	O	5257.45	5255.50	06/26/85	16:30	3.93	1.98	5253.52
							12/13/85	11:10	3.89	1.94	5253.56
							10/28/87	09:15	6.80	4.85	5250.65
							04/21/89	09:00	5.84	3.89	5251.61
							09/22/89	10:20	6.98	5.03	5250.47
							02/22/90	11:53	5.89	3.94	5251.56
							09/17/90	17:45	7.23	5.28	5250.22
0600	23172.4	46209.7	AL	O	5263.26	5260.60	06/26/85	08:50	7.84	5.18	5255.42

FORMATION OF COMPLETION CODE:
AL - ALLUVIUM

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

Table D.7.3 Static groundwater levels in monitor wells, New Rifle Site
SITE: RFN01 RIFLE (NEW)
REPORT DATE: 07/11/91

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	FORMATION OF COMPLETION	FLOW CODE	CASING ELEVATION (FT MSL)	GROUND ELEVATION (FT MSL)	LOG DATE	LOG TIME	DEPTH FROM TOP OF CASING (FT)	DEPTH FROM GROUND (FT)	GROUNDWATER ELEVATION (FT MSL)
0600	23172.4	46209.7	AL	D	5263.26	5260.60	12/17/85	11:30	9.98	7.32	5253.28
							10/27/87	12:45	11.70	9.04	5251.56
							04/21/89	09:50	10.97	8.31	5252.29
							09/22/89	10:06	11.73	9.07	5251.53
							02/22/90	10:42	12.18	9.52	5251.08
							09/16/90	11:00	11.90	9.24	5251.36
0601	23184.3	46216.6	AL	D	5263.02	5260.70	06/26/85	10:15	7.52	5.20	5255.50
							04/21/89	09:49	10.65	8.33	5252.37
							09/22/89	10:08	11.00	8.68	5252.02
							02/22/90	10:40	11.11	8.79	5251.91
							09/16/90	15:20	11.10	8.78	5251.92
0602	23606.1	41783.3	AL	D	5253.57	5250.90	06/26/85	08:50	7.58	4.91	5245.99
							12/11/85	10:10	7.89	5.22	5245.68
							04/21/89	11:41	10.15	7.48	5243.42
							09/22/89	13:28	10.05	7.38	5243.52
							02/21/90	17:04	10.65	7.98	5242.92
							08/25/90	13:40	10.80	8.13	5242.77
0603	23390.7	41789.2	AL	D	5253.82	5251.00	06/26/85	10:24	8.00	5.18	5245.82
							12/11/85	13:40	8.17	5.35	5245.65
							10/28/87	13:15	11.00	8.18	5242.82
							04/21/89	11:39	10.41	7.59	5243.41
							09/22/89	13:38	10.34	7.52	5243.48
							02/21/90	17:00	10.92	8.10	5242.90
							08/25/90	14:30	11.09	8.27	5242.73
0604	21999.2	39432.9	AL	O	5261.59	5259.80	04/21/89	11:59	DRY	DRY	-
							09/22/89	13:55	DRY	DRY	-
							02/21/90	16:30	DRY	DRY	-
0605	21998.9	39443.7	AL	D	5261.77	5259.80	06/25/85	17:10	22.54	20.57	5239.23
							04/21/89	12:00	25.98	24.01	5235.79
							09/22/89	13:56	26.25	24.28	5235.52
							02/21/90	16:33	26.96	24.99	5234.81
							08/29/90	19:16	25.40	23.43	5236.37
0608	23541.3	39685.6	AL	D	5301.97	5300.60	04/21/89	11:54	DRY	DRY	-
							09/20/89	09:25	DRY	DRY	-
							02/21/90	16:50	DRY	DRY	-
							08/25/90	12:05	DRY	DRY	-

FORMATION OF COMPLETION CODE:
AL - ALLUVIUM

FLOW RELATIONSHIP CODE:
O - ON-SITE
D - DOWN GRADIENT

Table D.7.5 Static groundwater levels in monitor wells, New Rifle Site
SITE: RFN01 RIFLE (NEW)
REPORT DATE: 07/11/91

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	FORMATION OF COMPLETION	FLOW CODE	CASING ELEVATION (FT MSL)	GROUND ELEVATION (FT MSL)	LOG DATE	LOG TIME	DEPTH FROM TOP OF CASING (FT)	DEPTH FROM GROUND (FT)	GROUNDWATER ELEVATION (FT MSL)
0609	25804.8	43476.2	AL	D	5260.24	5257.90	06/27/85	11:30	7.57	5.23	5252.67
							12/10/85	11:45	8.15	5.81	5252.09
							10/28/87	11:55	11.80	9.46	5248.44
							04/21/89	11:27	11.17	8.83	5249.07
							09/22/89	11:37	10.97	8.63	5249.27
							02/22/90	09:00	10.30	7.96	5249.94
							08/25/90	10:00	10.50	8.16	5249.74
0610	25420.4	46583.7	AL	O	5280.29	5278.50	06/27/85	09:00	18.83	17.04	5261.46
							10/20/87	09:35	21.46	19.67	5258.83
							09/22/89	09:38	21.75	19.96	5258.54
							02/22/90	13:20	26.62	24.83	5253.67
							08/29/90	12:45	21.70	19.91	5258.59
0611	23399.4	46717.0	WS	O	5266.39	5264.80	06/27/85	11:51	7.57	5.98	5258.82
							12/17/85	10:45	11.46	9.87	5254.93
							05/21/86	16:20	9.07	7.48	5257.32
							11/02/87	12:35	11.00	9.41	5255.39
							04/21/89	10:00	10.70	9.11	5255.69
							09/22/89	09:45	11.50	9.91	5254.89
							02/22/90	09:05	10.59	9.00	5255.80
							09/11/90	08:55	10.65	9.06	5255.74
0612	23332.1	46732.5	WS	O	5265.61	5264.00	06/26/85	16:37	6.69	5.08	5258.92
							12/14/85	17:00	9.06	7.45	5256.55
							05/22/86	09:07	9.70	8.09	5255.91
							11/02/87	14:50	10.80	9.19	5254.81
							04/21/89	10:06	10.40	8.79	5255.21
							09/22/89	09:56	11.13	9.52	5254.48
							02/22/90	10:12	11.50	9.89	5254.11
							09/13/90	16:41	11.15	9.54	5254.46
0613	23320.5	46710.2	WS	O	5264.71	5263.40	06/27/85	08:30	6.88	5.57	5257.83
							12/10/85	14:20	8.77	7.46	5255.94
							05/22/86	09:30	10.77	9.46	5253.94
							10/29/87	14:45	10.33	9.02	5254.38
							04/21/89	10:03	9.73	8.42	5254.98
							09/22/89	09:59	10.50	9.19	5254.21
							02/22/90	10:14	10.68	9.37	5254.03
							09/13/90	13:13	10.65	9.34	5254.06
0614	23340.6	46725.9	WS	O	5265.03	5263.60	06/27/85	14:25	10.00	8.57	5255.03

FORMATION OF COMPLETION CODE:
AL - ALLUVIUM
WS - WASATCH FORMATION - UNDIFFERENTIATED

FLOW RELATIONSHIP CODE:
D - DOWN GRADIENT
O - ON-SITE

Table D.7.3 Static groundwater levels in monitor wells, New Rifle Site
SITE: RFN01 RIFLE (NEW)
REPORT DATE: 07/11/91

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	FORMATION OF COMPLETION	FLOW CODE	CASING ELEVATION (FT MSL)	GROUND ELEVATION (FT MSL)	LOG DATE	LOG TIME	DEPTH FROM TOP OF CASING (FT)	DEPTH FROM GROUND (FT)	GROUNDWATER ELEVATION (FT MSL)
0614	23340.6	46725.9	WS	D	5265.03	5263.60	05/23/86	09:10	8.70	7.27	5256.33
							04/21/89	10:04	10.85	9.42	5254.18
							09/22/89	09:55	11.60	10.17	5253.43
							02/22/90	10:10	11.72	10.29	5253.31
							09/11/90	12:24	11.65	10.22	5253.38
0615	25249.2	47148.5	AL	O	5278.62	5277.20	06/26/85	13:50	15.63	14.21	5262.99
							12/13/85	09:38	16.55	15.13	5262.07
							10/26/87	16:10	18.40	16.98	5260.22
0616	23095.6	46995.4	AL	O	5266.01	5264.70	06/26/85	17:01	6.64	5.33	5259.37
							12/12/85	16:00	9.36	8.05	5256.65
							10/27/87	12:38	11.00	9.69	5255.01
							04/21/89	10:17	10.76	9.45	5255.25
							09/20/89	16:02	11.41	10.10	5254.60
							02/22/90	14:20	11.93	10.62	5254.08
							09/11/90	10:25	11.63	10.32	5254.38
0618	23250.0	43631.5	AL	O	5256.95	5254.70	06/26/85	10:50	6.91	4.66	5250.04
							10/28/87	11:30	12.88	10.63	5244.07
							04/21/89	09:30	10.77	8.52	5246.18
							09/22/89	10:43	11.39	9.14	5245.56
							02/22/90	11:40	11.25	9.00	5245.70
							08/29/90	10:00	11.60	9.35	5245.35
0619	23385.0	46690.7	AL	O	5265.84	5263.60	06/27/85	09:15	6.94	4.70	5258.90
							04/21/89	10:01	10.05	7.81	5255.79
							09/22/89	09:53	10.87	8.63	5254.97
							02/22/90	09:13	11.14	8.90	5254.70
							09/16/90	08:30	11.15	8.91	5254.69
0621	22086.4	39361.7	WS	D	5259.56	5257.53	05/13/86	09:00	106.80	104.77	5152.76
							11/03/87	07:00	77.40	75.37	5182.16
							04/21/89	12:01	76.82	74.79	5182.74
							09/22/89	13:45	67.75	65.72	5191.81
							02/21/90	16:20	60.82	58.79	5198.74
							09/15/90	09:15	52.60	50.57	5206.96
0622	22029.1	39364.2	WS	D	5260.31	5258.45	01/16/86	09:30	25.55	23.69	5234.76
							05/13/86	10:19	24.65	22.79	5235.66
							11/03/87	10:45	25.15	23.29	5235.16
							04/21/89	12:02	23.44	21.58	5236.87

FORMATION OF COMPLETION CODE:
WS - WASATCH FORMATION - UNDIFFERENTIATED
AL - ALLUVIUM

FLOW RELATIONSHIP CODE:
O - ON-SITE
D - DOWN GRADIENT

Table D.7.5 Static groundwater levels in monitor wells, New Rifle Site
SITE: RFN01 RIFLE (NEW)
REPORT DATE: 07/11/91

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	FORMATION OF COMPLETION	FLOW CODE	CASING ELEVATION (FT MSL)	GROUND ELEVATION (FT MSL)	LOG DATE	LOG TIME	DEPTH FROM TOP OF CASING (FT)	DEPTH FROM GROUND (FT)	GROUNDWATER ELEVATION (FT MSL)
0622	22029.1	39564.2	WS	D	5260.31	5258.45	09/22/89	13:47	24.95	23.09	5235.36
							02/21/90	16:22	23.53	21.67	5236.78
							09/15/90	09:15	25.29	23.43	5235.02
0623	23133.9	46470.3	WS	O	5262.92	5261.44	11/19/85	10:01	11.62	10.14	5251.30
							05/19/86	14:40	8.00	6.52	5254.92
							11/02/87	15:00	10.40	8.92	5252.52
0624	23134.6	46530.2	WS	O	5262.66	5260.98	11/20/85	16:10	8.30	6.62	5254.36
							05/19/86	15:44	8.22	6.54	5254.44
							11/03/87	07:45	9.60	7.92	5253.06
							04/21/89	09:53	8.89	7.21	5253.77
							09/22/89	10:03	9.68	8.00	5252.98
							02/22/90	10:30	10.28	8.60	5252.38
							09/12/90	16:45	9.90	8.22	5252.76
0625	24163.5	46503.6	WS	O	5266.79	5265.45	11/21/85	11:15	50.60	49.26	5216.19
							05/22/86	10:45	7.00	5.66	5259.79
							11/04/87	06:55	5.50	4.16	5261.29
							04/21/89	08:03	6.23	4.89	5260.56
							09/20/89	15:15	5.56	4.22	5261.23
							02/22/90	14:34	6.01	4.67	5260.78
							08/27/90	12:29	5.67	4.33	5261.12
0626	24147.0	46556.3	WS	C	5267.42	5266.07	04/21/89	08:06	74.32	72.97	5193.10
							09/20/89	15:19	73.83	72.48	5193.59
							02/22/90	14:50	74.54	73.19	5192.88
							08/27/90	16:36	73.12	71.77	5194.30
0627	23156.1	46746.8	WS	O	5263.26	5261.52	11/20/85	09:05	10.31	8.57	5252.95
							05/21/86	13:15	8.20	6.46	5255.06
							11/02/87	08:15	10.75	9.01	5252.51
							04/21/89	10:12	10.81	8.87	5252.45
							09/20/89	15:53	11.45	9.71	5251.81
							02/22/90	14:00	12.05	10.31	5251.21
							09/12/90	08:47	11.50	9.76	5251.76
0628	23097.0	46849.7	WS	D	5265.50	5263.66	12/06/85	13:28	12.23	10.39	5253.27
							05/21/86	13:13	11.54	9.70	5253.96
							04/21/89	10:14	12.87	11.03	5252.63
							09/20/89	15:59	13.50	11.66	5252.00

FORMATION OF COMPLETION CODE:
WS - WASATCH FORMATION - UNDIFFERENTIATED

FLOW RELATIONSHIP CODE:
D - DOWN GRADIENT
O - ON-SITE
C - CROSS GRADIENT

Table D.7.5 Static groundwater levels in monitor wells, New Rifle Site
SITE: RFN01 RIFLE (NEW)
REPORT DATE: 07/11/91

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	FORMATION OF COMPLETION	FLOW CODE	CASING ELEVATION (FT MSL)	GROUND ELEVATION (FT MSL)	LOG DATE	LOG TIME	DEPTH FROM TOP OF CASING (FT)	DEPTH FROM GROUND (FT)	GROUNDWATER ELEVATION (FT MSL)
0628	23097.8	44849.7	WS	O	5265.50	5263.66	02/22/90	14:06	14.18	12.34	5251.32
0629	23190.7	46817.0	WS	O	5263.83	5262.25	12/07/85	10:30	8.91	7.33	5254.92
							05/23/86	08:37	8.15	6.57	5255.68
							11/02/87	08:20	10.60	9.02	5253.23
							04/21/89	10:11	10.08	8.50	5253.75
							09/28/89	15:57	10.83	9.25	5253.00
							02/22/90	14:03	11.41	9.83	5252.42
							09/12/90	14:12	11.05	9.47	5252.78
0630	23036.8	46203.7	WS	O	5263.09	5261.64	01/10/86	09:26	8.37	6.92	5254.72
							05/19/86	11:30	8.76	7.31	5254.33
							11/03/87	09:45	9.80	8.35	5253.29
							04/21/89	08:44	9.14	7.69	5253.95
							09/22/89	10:12	10.10	8.65	5252.99
							02/22/90	13:11	9.82	8.37	5253.27
							08/27/90	13:15	10.13	8.68	5252.96
0631	23066.3	46204.4	WS	O	5263.50	5261.90	01/11/86	09:01	7.07	5.47	5256.43
							05/19/86	12:10	7.84	6.24	5255.66
							11/04/87	13:45	9.60	8.00	5253.90
							04/21/89	08:46	8.65	7.05	5254.85
							09/22/89	10:14	9.62	8.02	5253.88
							02/22/90	13:13	9.36	7.76	5254.14
							08/28/90	15:57	9.90	8.30	5253.60
0632	25287.7	46760.2	WS	C	5278.87	5276.99	01/13/86	16:00	19.16	17.28	5259.71
							05/23/86	11:25	19.37	17.49	5259.50
							11/06/87	16:20	20.79	18.91	5258.08
							04/21/89	08:35	21.14	19.26	5257.73
							09/22/89	09:35	21.33	19.45	5257.54
							02/22/90	13:42	12.12	10.24	5266.75
							08/30/90	08:30	21.35	19.47	5257.52
0633	25233.7	46763.9	WS	C	5278.63	5276.86	01/13/86	10:08	18.10	16.33	5260.53
							05/27/86	15:48	18.30	16.53	5260.33
							04/21/89	08:33	20.00	18.23	5258.63
							09/22/89	09:30	20.15	18.38	5258.48
							02/22/90	13:40	19.08	17.31	5259.55
							08/30/90	12:30	20.10	18.33	5258.53
0634	24193.9	48515.8	WS	C	5267.35	5265.71	01/13/86	15:22	5.59	3.95	5261.76

FORMATION OF COMPLETION CODE:
WS - WASATCH FORMATION - UNDIFFERENTIATED

FLOW RELATIONSHIP CODE:
O - ON-SITE
C - CROSS GRADIENT

Table D.7.5 Static groundwater levels in monitor wells, New Rifle Site
SITE: RFN01 RIFLE (NEW)
REPORT DATE: 07/11/91

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	FORMATION OF COMPLETION	FLOW CODE	CASING ELEVATION (FT MSL)	GROUND ELEVATION (FT MSL)	LOG DATE	LOG TIME	DEPTH FROM TOP OF CASING (FT)	DEPTH FROM GROUND (FT)	GROUNDWATER ELEVATION (FT MSL)
0636	24193.9	48515.8	WS	C	5267.35	5265.71	05/21/86	10:36	4.34	2.70	5263.01
							10/29/87	07:20	6.40	4.76	5260.95
							04/21/89	08:00	6.16	4.52	5261.19
							09/20/89	15:13	6.83	5.19	5260.52
							02/22/90	14:40	7.44	5.80	5259.91
							08/27/90	11:20	6.75	5.11	5260.60
0640	26448.0	47479.5	WS	C	5335.90	5335.02	01/16/86	13:55	93.28	92.40	5242.62
							05/12/86	10:40	72.40	71.52	5263.50
							10/30/87	09:05	73.27	72.39	5262.63
							09/15/90	16:00	73.80	72.92	5262.10
0641	26415.5	47479.2	WS	C	5334.63	5333.75	05/12/86	10:00	64.86	63.98	5269.77
							10/29/87	09:05	61.00	60.12	5273.63
							09/15/90	15:53	60.00	59.12	5274.63
0642	24029.2	45297.9	WS	D	5258.97	5257.09	01/15/86	08:30	20.88	19.00	5238.09
							05/21/86	07:30	9.00	7.12	5249.97
							11/04/87	14:30	8.70	6.82	5250.27
							04/21/89	08:51	9.18	7.30	5249.79
							09/22/89	10:25	9.64	7.76	5249.33
							02/22/90	10:50	8.10	6.22	5250.87
							08/28/90	08:50	9.40	7.52	5249.57
0643	24049.0	45268.5	WS	D	5258.18	5256.36	01/15/86	12:15	59.40	57.58	5198.78
							05/22/86	07:35	52.20	50.38	5205.98
							04/21/89	08:53	52.70	50.88	5205.48
							09/22/89	10:26	51.29	49.47	5206.89
							02/22/90	10:52	50.07	48.25	5208.11
							08/28/90	12:03	48.55	46.73	5209.63
0644	22330.1	48022.6	WS	C	5269.85	5268.35	01/11/86	15:00	7.88	6.38	5261.97
							05/13/86	12:45	7.94	6.44	5261.91
							04/21/89	12:27	7.73	6.23	5262.12
							09/20/89	17:39	8.33	6.83	5261.52
							02/22/90	08:33	8.38	6.88	5261.47
							09/14/90	07:51	8.60	7.10	5261.25
0645	22354.4	48064.2	WS	C	5270.70	5268.78	01/11/86	15:08	8.89	6.97	5261.81
							05/13/86	12:40	7.85	5.93	5262.85
							11/04/87	13:50	8.83	6.91	5261.87
							04/21/89	12:26	8.46	6.54	5262.24

FORMATION OF COMPLETION CODE:
WS - WASATCH FORMATION - UNDIFFERENTIATED

FLOW RELATIONSHIP CODE:
C - CROSS GRADIENT
D - DOWN GRADIENT

Table D.7.5 Static groundwater levels in monitor wells, New Rifle Site
SITE: RFN01 RIFLE (NEW)
REPORT DATE: 07/11/91

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	FORMATION OF COMPLETION	FLOW CODE	CASING ELEVATION (FT MSL)	GROUND ELEVATION (FT MSL)	LOG DATE	LOG TIME	DEPTH FROM TOP OF CASING (FT)	DEPTH FROM GROUND (FT)	GROUNDWATER ELEVATION (FT MSL)
0645	22354.4	48884.2	WS	C	5270.70	5268.78	09/20/89	17:42	9.17	7.25	5261.53
							02/22/90	08:30	9.31	7.39	5261.39
							09/13/90	14:50	9.35	7.43	5261.35
0646	25409.6	51316.7	WS	U	5279.96	5278.18	01/14/86	12:10	9.31	7.53	5270.65
							05/15/86	13:40	9.42	7.64	5270.54
							10/28/87	14:45	10.77	8.99	5269.19
							04/21/89	13:29	10.46	8.68	5269.50
							09/20/89	11:25	10.09	8.31	5269.87
							02/21/90	16:00	10.64	8.86	5269.32
							09/14/90	13:25	10.20	8.42	5269.76
0647	25367.9	51315.9	WS	U	5279.44	5277.94	01/14/86	09:00	6.60	5.10	5272.84
							05/15/86	14:15	5.55	4.05	5273.89
							10/28/87	14:45	7.90	6.40	5271.54
							04/21/89	13:26	7.90	6.40	5271.54
							09/20/89	11:27	6.25	4.75	5273.19
							02/21/90	16:01	8.54	7.04	5270.90
							09/15/90	13:30	6.03	4.53	5273.41
0650	23626.9	43590.2	WS	D	5254.10	5252.59	01/14/86	16:00	11.19	9.68	5242.91
							05/23/86	13:36	6.14	4.63	5247.96
							04/21/89	09:12	8.87	7.36	5245.23
							09/22/89	10:38	9.41	7.90	5244.69
							02/22/90	11:10	8.88	7.37	5245.22
							09/13/90	13:00	9.65	8.14	5244.45
0651	23672.4	43589.3	WS	D	5254.49	5253.01	01/15/86	09:26	11.07	9.59	5243.42
							05/23/86	14:54	4.00	2.52	5250.49
							11/03/87	14:35	11.50	10.02	5242.99
							04/21/89	09:09	8.56	7.08	5245.93
							09/22/89	10:37	8.82	7.34	5245.67
							02/22/90	11:13	8.40	6.92	5246.09
							08/29/90	15:15	9.40	7.92	5245.09

FORMATION OF COMPLETION CODE:
WS - WASATCH FORMATION - UNDIFFERENTIATED

FLOW RELATIONSHIP CODE:
C - CROSS GRADIENT
U - UPGRADIENT
D - DOWN GRADIENT

DATA FILE: M:\DART\RFN01\GWL10003.DAT

FIELDS DISPLAYED WITH A DASH INDICATE THE DATA IS UNAVAILABLE

Table D.7.6 Hydraulic conductivity for the alluvial aquifer, New Rifle site

Monitor well number[a]	Hydraulic conductivity[b] (ft/day)
581	102[b]
582	85[c]
583	70.9[b]
583	139[c]
584	82.2[b]
585	14.5[b]
587	19.8[b]
588	70.9[b]
589	150[b]
590	145[b]
	Geometric mean = 70 ft/day

[a]Monitor well locations are shown on Figure D.7.4.
[b]Ref. DOE, 1983. Hydraulic conductivities are based on aquifer tests conducted by the DOE in 1983.
[c]Ref. Davis and DeWeist, 1966. Hydraulic conductivities are based on aquifer tests conducted by the DOE in 1985.

Table D.7.7 Hydraulic conductivity for the Wasatch Formation, New Rifle site

Monitor well number[a]	Hydraulic conductivity[b] (ft/day)
611	2.26[c]
612	0.32
623	0.56
627	0.34
632	0.28
644	0.012
645	0.19
646	0.08
647	0.41
	Geometric mean = 0.088 ft/day

[a]Monitor well locations are shown on Figure D.7.5.
[b]Hydraulic conductivities were determined using the Skibitzke method (Skibitzke, 1963).
[c]Hydraulic conductivity is based on a slug injection test conducted by the DOE January 12, 1986.

Table D.7.8 Contaminant source concentrations from lysimeter samples,
Old Rifle Site
SITE: RFO01 RIFLE (OLD)
LOCATION: 0738
NORTH COORDINATE: UNKNOWN
EAST COORDINATE: UNKNOWN
12/10/88 TO 04/21/89
REPORT DATE: 07/11/91

FORMATION OF COMPLETION: URANIUM MILL TAILINGS (TA)
HYDRAULIC FLOW RELATIONSHIP: ON-SITE (O)

PARAMETER NAME	LOG DATE	SAMPLE ID	UNITS OF MEASURE	PVI	PARAMETER VALUE	FLAGS	PARAMETER UNCERTAINTY
ALKALINITY	12/10/88	0001	MG/L CACO3		312.		-
	04/21/89	0001			304.		-
ALUMINUM	12/10/88	0001	MG/L		0.4		-
	04/21/89	0001		<	0.1		-
AMMONIUM	12/10/88	0001	MG/L	<	0.1		-
	04/21/89	0001		<	0.1		-
ANTIMONY	12/10/88	0001	MG/L		0.009		-
	04/21/89	0001			0.004		-
ARSENIC	12/10/88	0001	MG/L		1.56		-
	04/21/89	0001			2.30		-
BARIUM	12/10/88	0001	MG/L	<	0.01		-
	04/21/89	0001		<	0.1		-
BERYLLIUM	12/10/88	0001	MG/L		0.08		-
	04/21/89	0001		<	0.01		-
BORON	12/10/88	0001	MG/L		0.2		-
	04/21/89	0001			0.29		-
BROMIDE	04/21/89	0001	MG/L	<	0.1		-
CADMIUM	12/10/88	0001	MG/L		0.007		-
	04/21/89	0001		<	0.001		-
CALCIUM	12/10/88	0001	MG/L		163.		-
	04/21/89	0001			127.		-
CHLORIDE	12/10/88	0001	MG/L		42.		-
	04/21/89	0001			30.		-
CHROMIUM	12/10/88	0001	MG/L		0.10		-
	04/21/89	0001		<	0.01		-
COBALT	12/10/88	0001	MG/L	<	0.05		-

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

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

Table D.7.8 Contaminant source concentrations from lysimeter samples, Old Rifle Site
SITE: RFO01 RIFLE (OLD)
LOCATION: 0738
NORTH COORDINATE: UNKNOWN
EAST COORDINATE: UNKNOWN
12/10/88 TO 04/21/89
REPORT DATE: 07/11/91

FORMATION OF COMPLETION: URANIUM MILL TAILINGS (TA)
HYDRAULIC FLOW RELATIONSHIP: ON-SITE (O)

PARAMETER NAME	LOG DATE	SAMPLE ID	UNITS OF MEASURE	PVI	PARAMETER VALUE	FLAGS	PARAMETER UNCERTAINTY
COBALT	04/21/89	0001	MG/L	<	0.05		-
COPPER	12/10/88	0001	MG/L	<	0.02		-
	04/21/89	0001			0.03		-
CYANIDE	04/21/89	0001	MG/L		0.	c	-
FLUORIDE	12/10/88	0001	MG/L		1.1		-
	04/21/89	0001			0.	c	-
GROSS ALPHA	04/21/89	0001	PCI/L		640.		30.
GROSS BETA	04/21/89	0001	PCI/L		460.		10.
IRON	12/10/88	0001	MG/L		0.07		-
	04/21/89	0001			0.07		-
LEAD	12/10/88	0001	MG/L	<	0.01		-
	04/21/89	0001		<	0.01		-
MAGNESIUM	12/10/88	0001	MG/L		96.2		-
	04/21/89	0001			90.2		-
MANGANESE	12/10/88	0001	MG/L		0.04		-
	04/21/89	0001			0.02		-
MERCURY	12/10/88	0001	MG/L	<	0.0002		-
	04/21/89	0001			0.0007		-
MOLYBDENUM	12/10/88	0001	MG/L		0.09		-
	04/21/89	0001			0.12		-
NET GROSS ALPHA *	04/21/89	0001	PCI/L		-37.77		-
NICKEL	12/10/88	0001	MG/L	<	0.04		-

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

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

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

OTHER PARAMETER VALUE FLAGS:
c - CHANGED DETECTION LIMIT

Table D.7.8 Contaminant source concentrations from lysimeter samples,
Old Rifle Site
SITE: RF001 RIFLE (OLD)
LOCATION: 0738
NORTH COORDINATE: UNKNOWN
EAST COORDINATE: UNKNOWN
12/10/88 TO 04/21/89
REPORT DATE: 07/11/91

FORMATION OF COMPLETION: URANIUM MILL TAILINGS (TA)
HYDRAULIC FLOW RELATIONSHIP: ON-SITE (O)

PARAMETER NAME	LOG DATE	SAMPLE ID	UNITS OF MEASURE	PVI	PARAMETER VALUE	FLAGS	PARAMETER UNCERTAINTY
NICKEL	04/21/89	0001	MG/L	<	0.04		-
NITRATE	12/10/88	0001	MG/L		2.9		-
	04/21/89	0001			29.		-
PH	12/10/88	0001	SU		7.53		-
	04/21/89	0001			7.51		-
PHOSPHATE	12/10/88	0001	MG/L		4.0		-
	04/21/89	0001			1.8		-
POTASSIUM	12/10/88	0001	MG/L		4.0		-
	04/21/89	0001			9.1		-
RADIUM-226	12/10/88	0001	PCI/L		2.0		2.1
	04/21/89	0001			1.9		1.1
SELENIUM	12/10/88	0001	MG/L		0.191		-
	04/21/89	0001			0.171		-
SILICA - SIO2	12/10/88	0001	MG/L		61.		-
	04/21/89	0001			69.4		-
SILVER	12/10/88	0001	MG/L		0.02		-
	04/21/89	0001		<	0.01		-
SODIUM	12/10/88	0001	MG/L		82.9		-
	04/21/89	0001			79.0		-
SPECIFIC CONDUCTANCE	12/10/88	0001	UMHO/CM		420.		-
	04/21/89	0001			1100.		-
STRONTIUM	12/10/88	0001	MG/L		1.2		-
	04/21/89	0001			0.4		-
SULFATE	12/10/88	0001	MG/L		638.		-
	04/21/89	0001			520.		-
SULFIDE	04/21/89	0001	MG/L		0.	C	-

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

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

OTHER PARAMETER VALUE FLAGS:
C - CHANGED DETECTION LIMIT

Table D.7.8 Contaminant source concentrations from lysimeter samples, Old Rifle Site
SITE: RFO01 RIFLE (OLD)
LOCATION: 0738
NORTH COORDINATE: UNKNOWN
EAST COORDINATE: UNKNOWN
12/10/88 TO 04/21/89
REPORT DATE: 07/11/91

FORMATION OF COMPLETION: URANIUM MILL TAILINGS (TA)
HYDRAULIC FLOW RELATIONSHIP: ON-SITE (O)

PARAMETER NAME	LOG DATE	SAMPLE ID	UNITS OF MEASURE	PVI	PARAMETER VALUE	FLAGS	PARAMETER UNCERTAINTY
TEMPERATURE	12/10/88	0001	C - DEGREE		7.0		-
THALLIUM	12/10/88	0001	MG/L	<	0.01		-
	04/21/89	0001		<	0.01		-
THORIUM-230	04/21/89	0001	PCI/L		2.4		1.5
TIN	12/10/88	0001	MG/L		0.011		-
	04/21/89	0001		<	0.005		-
TOTAL DISSOLVED SOLIDS	12/10/88	0001	MG/L		1170.		-
	04/21/89	0001			1230.		-
TOTAL ORGANIC CARBON	04/21/89	0001	MG/L		3.1		-
URANIUM	12/10/88	0001	MG/L		1.39		-
	04/21/89	0001			0.980		-
VANADIUM	12/10/88	0001	MG/L		9.17		-
	04/21/89	0001			9.79		-
ZINC	12/10/88	0001	MG/L		0.022		-
	04/21/89	0001			0.018		-

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

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

Table D.7.8 Contaminant source concentrations from lysimeter samples, Old Rifle Site
SITE: RFO01 RIFLE (OLD)
LOCATION: 0739
NORTH COORDINATE: UNKNOWN
EAST COORDINATE: UNKNOWN
12/10/88 TO 04/21/89
REPORT DATE: 07/11/91

FORMATION OF COMPLETION: URANIUM MILL TAILINGS (TA)
HYDRAULIC FLOW RELATIONSHIP: ON-SITE (O)

PARAMETER NAME	LOG DATE	SAMPLE ID	UNITS OF MEASURE	PVI	PARAMETER VALUE	FLAGS	PARAMETER UNCERTAINTY
ALKALINITY	12/10/88 04/21/89	0001 0001	MG/L CACO3		204. 79.		- -
ALUMINUM	12/10/88 04/21/89	0001 0001	MG/L	 <	1.0 0.1		- -
AMMONIUM	12/10/88 04/21/89	0001 0001	MG/L	< <	0.1 0.1		- -
ANTIMONY	12/10/88 04/21/89	0001 0001	MG/L		0.012 0.003		- -
ARSENIC	12/10/88 04/21/89	0001 0001	MG/L	<	0.01 5.55		- -
BARIUM	12/10/88 04/21/89	0001 0001	MG/L	< <	0.01 0.1		- -
BERYLLIUM	12/10/88 04/21/89	0001 0001	MG/L	 <	0.27 0.01		- -
BORON	12/10/88 04/21/89	0001 0001	MG/L	 <	0.2 0.1		- -
BROMIDE	04/21/89	0001	MG/L		0.7		-
CADMIUM	12/10/88 04/21/89	0001 0001	MG/L		0.013 0.002		- -
CALCIUM	12/10/88 04/21/89	0001 0001	MG/L		511. 526.		- -
CHLORIDE	12/10/88 04/21/89	0001 0001	MG/L		42. 3.3		- -
CHROMIUM	12/10/88 04/21/89	0001 0001	MG/L		0.17 0.01		- -
COBALT	12/10/88	0001	MG/L	<	0.05		-

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

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

Table 8.7.8 Contaminant source concentrations from lysimeter samples, Old Rifle Site
SITE: RFO01 RIFLE (OLD)
LOCATION: 0739
NORTH COORDINATE: UNKNOWN
EAST COORDINATE: UNKNOWN
12/10/88 TO 04/21/89
REPORT DATE: 07/11/91

FORMATION OF COMPLETION: URANIUM MILL TAILINGS (TA)
HYDRAULIC FLOW RELATIONSHIP: ON-SITE (O)

PARAMETER NAME	LOG DATE	SAMPLE ID	UNITS OF MEASURE	PVI	PARAMETER VALUE	FLAGS	PARAMETER UNCERTAINTY
COBALT	04/21/89	0001	MG/L	<	0.05		-
COPPER	12/10/88	0001	MG/L		0.03		-
	04/21/89	0001			0.03		-
CYANIDE	12/10/88	0001	MG/L	<	0.01		-
	04/21/89	0001		<	0.01		-
FLUORIDE	12/10/88	0001	MG/L		2.0		-
	04/21/89	0001			1.1		-
GROSS ALPHA	12/10/88	0001	PCI/L		250.		40.
	04/21/89	0001			78.		23.
GROSS BETA	12/10/88	0001	PCI/L		140.		10.
	04/21/89	0001			96.		15.
IRON	12/10/88	0001	MG/L		0.11		-
	04/21/89	0001			0.09		-
LEAD	12/10/88	0001	MG/L	<	0.01		-
	04/21/89	0001		<	0.01		-
MAGNESIUM	12/10/88	0001	MG/L		80.6		-
	04/21/89	0001			46.2		-
MANGANESE	12/10/88	0001	MG/L		0.14		-
	04/21/89	0001			0.02		-
MERCURY	12/10/88	0001	MG/L	<	0.0002		-
	04/21/89	0001			0.0004		-
MOLYBDENUM	12/10/88	0001	MG/L		0.44		-
	04/21/89	0001			0.77		-
NET GROSS ALPHA *	12/10/88	0001	PCI/L		171.11		-

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

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

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

Table D.7.8 Contaminant source concentrations from lysimeter samples,
Old Rifle Site
SITE: RF001 RIFLE (OLD)
LOCATION: 0739
NORTH COORDINATE: UNKNOWN
EAST COORDINATE: UNKNOWN
12/10/88 TO 04/21/89
REPORT DATE: 07/11/91

FORMATION OF COMPLETION: URANIUM MILL TAILINGS (TA)
HYDRAULIC FLOW RELATIONSHIP: ON-SITE (O)

PARAMETER NAME	LOG DATE	SAMPLE ID	UNITS OF MEASURE	PVI	PARAMETER VALUE	FLAGS	PARAMETER UNCERTAINTY
NET GROSS ALPHA *	04/21/89	0001	PCI/L		76.01		-
NICKEL	12/10/88	0001	MG/L	<	0.04		-
	04/21/89	0001		<	0.04		-
NITRATE	12/10/88	0001	MG/L		3.4		-
	04/21/89	0001			27.		-
PH	12/10/88	0001	SU		7.43		-
	04/21/89	0001			7.32		-
PHOSPHATE	12/10/88	0001	MG/L		3.4		-
	04/21/89	0001			3.0		-
POTASSIUM	12/10/88	0001	MG/L		5.22		-
	04/21/89	0001			4.0		-
RADIUM-226	12/10/88	0001	PCI/L		46.		5.
	04/21/89	0001			36.		4.
RADIUM-226 + RADIUM-228	12/10/88	0001	PCI/L		64.00		-
RADIUM-228	12/10/88	0001	PCI/L		18.		18.
SELENIUM	12/10/88	0001	MG/L		2.05		-
	04/21/89	0001			1.76		-
SILICA - SIO2	12/10/88	0001	MG/L		56.		-
	04/21/89	0001			52.1		-
SILVER	12/10/88	0001	MG/L		0.04		-
	04/21/89	0001		<	0.01		-
SODIUM	12/10/88	0001	MG/L		93.8		-
	04/21/89	0001			69.7		-
SPECIFIC CONDUCTANCE	12/10/88	0001	UMHO/CM		950.		-

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

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

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

Table D.7.8 Contaminant source concentrations from lysimeter samples, Old Rifle Site
SITE: RFO01 RIFLE (OLD)
LOCATION: 0739
NORTH COORDINATE: UNKNOWN
EAST COORDINATE: UNKNOWN
12/10/88 TO 04/21/89
REPORT DATE: 07/11/91

FORMATION OF COMPLETION: URANIUM MILL TAILINGS (TA)
HYDRAULIC FLOW RELATIONSHIP: ON-SITE (O)

PARAMETER NAME	LOG DATE	SAMPLE ID	UNITS OF MEASURE	PVI	PARAMETER VALUE	FLAGS	PARAMETER UNCERTAINTY
SPECIFIC CONDUCTANCE	04/21/89	0001	UMHO/CM		1950.		-
STRONTIUM	12/10/88	0001	MG/L		1.0		-
	04/21/89	0001			0.4		-
SULFATE	12/10/88	0001	MG/L		1480.		-
	04/21/89	0001			1610.		-
SULFIDE	12/10/88	0001	MG/L	<	0.1		-
	04/21/89	0001		<	0.1		-
TEMPERATURE	12/10/88	0001	C - DEGREE		7.0		-
THALLIUM	12/10/88	0001	MG/L	<	0.01		-
	04/21/89	0001		<	0.01		-
THORIUM-230	12/10/88	0001	PCI/L		1.0		1.2
	04/21/89	0001			1.3		1.3
TIN	12/10/88	0001	MG/L		0.026		-
	04/21/89	0001		<	0.005		-
TOTAL DISSOLVED SOLIDS	12/10/88	0001	MG/L		2600.		-
	04/21/89	0001			2520.		-
TOTAL ORGANIC CARBON	12/10/88	0001	MG/L		5.0		-
	04/21/89	0001			6.0		-
URANIUM	12/10/88	0001	MG/L		0.115		-
	04/21/89	0001			0.0029	c	-
VANADIUM	12/10/88	0001	MG/L		29.2		-
	04/21/89	0001			41.2		-
ZINC	12/10/88	0001	MG/L		0.040		-
	04/21/89	0001			0.031		-

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\RFO01\GWQ10014.DAT

Table D.7.9 Water quality statistics for the alluvium beneath tailings,
New Rifle Site
SITE: RFN01 RIFLE (NEW)
05/08/91 TO 05/11/91
REPORT DATE: 07/11/91

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
ANTIMONY			MG/L								
14	0.0015	0.0150	0.0100	NA	NA	NA	92.9	0.0015	0.0150	NONPARAMETRIC	2
ARSENIC			MG/L								
14	0.0150	0.0500	0.0150	NA	NA	NA	100.0	0.0150	0.0500	NONPARAMETRIC	2
BROMIDE			MG/L								
14	0.1000	8.2000	0.6500	0.6720	3.0655	NA	7.1	0.3040	1.4857	LOGNORMAL	7,8
CADMIUM			MG/L								
14	0.0005	0.0340	0.0015	NA	NA	NA	85.7	0.0005	0.0050	NONPARAMETRIC	2
LEAD			MG/L								
14	0.0025	0.0500	0.0150	NA	NA	NA	100.0	0.0025	0.0500	NONPARAMETRIC	2
SELENIUM			MG/L								
14	0.0150	0.0500	0.0200	NA	NA	NA	92.9	0.0150	0.0500	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.

INPUT DATA FILENAME: M:\DART\RFN01\GWQ10020.DAT

Table D.7.10 Background water quality statistics in the alluvium, Old Rifle Site
SITE: RFO01 RIFLE (OLD)
10/22/87 TO 08/27/90
REPORT DATE: 01/24/92

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	162.0000	489.0000	+ 472.5000	382.8333	151.2553	0.3951	0.0	175.0455	590.6211	NORMAL	
ALUMINUM			MG/L								
6	** 0.1000	0.2500	+ 0.1000	NA	NA	NA	50.0	** 0.1000	0.2500	NONPARAMETRIC	2,6
AMMONIUM			MG/L								
6	** 0.1000	0.4000	** 0.1000	NA	NA	NA	66.7	** 0.1000	0.4000	NONPARAMETRIC	2,6
ANTIMONY			MG/L								
3	** 0.0030	** 0.0030	** 0.0030	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
ARSENIC			MG/L								
6	0.0020	0.0050	+ 0.0045	NA	NA	NA	50.0	0.0020	0.0050	NONPARAMETRIC	2,6
BARIUM			MG/L								
6	0.0400	0.1500	+ 0.0550	NA	NA	NA	33.3	0.0400	0.1500	NONPARAMETRIC	2,6
BROMIDE			MG/L								
6	** 0.1000	** 0.1000	** 0.1000	NA	NA	NA	100.0	** 0.1000	** 0.1000	NONPARAMETRIC	2,6
CADMIUM			MG/L								
6	** 0.0010	0.0025	+ 0.0015	NA	NA	NA	100.0	** 0.0010	0.0025	NONPARAMETRIC	2,6
CALCIUM			MG/L								
6	62.6000	264.0000	+ 164.0000	161.9000	78.5719	0.4853	0.0	53.9614	269.8386	NORMAL	
CHLORIDE			MG/L								
6	62.0000	130.0000	+ 78.3500	85.6167	26.0314	0.3040	0.0	49.8559	121.3774	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, 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.
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 D.7.10 Background water quality statistics in the alluvium,
Old Rifle Site
SITE: RF001 RIFLE (OLD)
10/22/87 To 08/27/90
REPORT DATE: 01/24/92

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 95% CONFIDENCE INTERVAL MINIMUM	STATISTICAL RANGE 95% CONFIDENCE INTERVAL MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
CHROMIUM	MG/L	6	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	** 0.0100	** 0.0100	NONPARAMETRIC	2,6
FLUORIDE	MG/L	6	0.4000	0.5000	+ 0.4150	0.4250	0.0378	0.0890	0.0	0.3731	0.4769	NORMAL	
GROSS ALPHA	PCI/L	3	** 1.0000	56.0000	11.0000	NA	NA	NA	33.3	NA	NA	UNKNOWN	1
GROSS BETA	PCI/L	3	3.1000	21.0000	21.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
IRON	MG/L	6	0.0300	1.4100	+ 0.7850	0.7583	0.5970	0.7873	0.0	** 0.0300	1.5785	NORMAL	
LEAD	MG/L	6	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	** 0.0100	** 0.0100	NONPARAMETRIC	2,6
MAGNESIUM	MG/L	6	10.8000	190.0000	+ 119.5000	103.2167	75.6225	0.7327	0.0	** 0.0010	207.1035	NORMAL	
MANGANESE	MG/L	6	0.4300	4.5100	+ 2.7650	2.4600	1.5917	0.6470	0.0	0.2734	4.6466	NORMAL	
MOLYBDENUM	MG/L	6	0.0200	0.1900	+ 0.0400	0.0833	0.0792	0.9499	0.0	** 0.0100	0.1921	NORMAL	
NET GROSS ALPHA ***	PCI/L	3	-8.8900	34.0500	-0.8700	NA	NA	NA	0.0	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.
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 D.7.10 Background water quality statistics in the alluvium,
Old Rifle Site
SITE: RF001 RIFLE (OLD)
10/22/87 TO 08/27/90
REPORT DATE: 01/24/92

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
NITRATE			MG/L								
6	** 1.0000	** 1.0000	** 1.0000	NA	NA	NA	100.0	** 1.0000	** 1.0000	NONPARAMETRIC	2,6
NITRITE			MG/L								
3	** 0.1000	** 0.1000	** 0.1000	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
PH			SU								
6	7.1900	7.3500	+ 7.2471	NA	NA	NA	0.0	NA	NA	UNKNOWN	
PHOSPHATE			MG/L								
6	** 0.1000	1.1000	** 0.1000	NA	NA	NA	83.3	** 0.1000	1.1000	NONPARAMETRIC	2,6
POTASSIUM			MG/L								
6	3.1100	8.1100	+ 7.1000	6.1050	2.1008	0.3441	0.0	3.2191	8.9909	NORMAL	
RADIUM-226			PCI/L								
6	** 0.1000	0.6000	+ 0.1250	NA	NA	NA	50.0	** 0.1000	0.6000	NONPARAMETRIC	2,6
RADIUM-226 + RADIUM-228			PCI/L								
6	0.7000	1.8000	+ 1.2500	1.2417	0.4974	0.4006	0.0	0.5583	1.9250	NORMAL	
RADIUM-228			PCI/L								
6	** 1.0000	1.7000	+ 1.1000	1.0500	0.4848	0.4617	0.0	** 1.0000	1.7160	NORMAL	
SELENIUM			MG/L								
6	** 0.0050	0.0360	** 0.0050	NA	NA	NA	50.0	** 0.0050	0.0360	NONPARAMETRIC	2,6
SILICA - SIO2			MG/L								
6	13.7000	19.0000	+ 17.1500	16.6667	1.9694	0.1182	0.0	13.9611	19.3722	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 D.7.10 Background water quality statistics in the alluvium,
Old Rifle Site
SITE: RF001 RIFLE (OLD)
10/22/87 TO 08/27/90
REPORT DATE: 01/26/92

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								
3	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
SODIUM			MG/L								
6	78.1000	345.0000	+ 216.0000	212.8500	108.6074	0.5103	0.0	63.6499	362.0501	NORMAL	
SPECIFIC CONDUCTANCE			UMHO/CM								
6	692.0000	2430.0000	+ 1675.0000	1592.0000	599.4464	0.3765	0.0	768.5072	2415.4928	NORMAL	
STRONTIUM			MG/L								
3	0.4500	1.9400	1.8900	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
SULFATE			MG/L								
6	52.0000	1420.0000	+ 873.0000	755.0000	569.3133	0.7541	0.0	** 0.1000	1537.0972	NORMAL	
SULFIDE			MG/L								
3	** 0.1000	** 0.1000	** 0.1000	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
TEMPERATURE			C - DEGREE								
6	13.0000	16.5000	+ 14.2500	14.5167	1.1923	0.0821	0.0	12.8787	16.1546	NORMAL	
TOTAL DISSOLVED SOLIDS			MG/L								
6	478.0000	3210.0000	+ 1720.0000	1742.3333	1131.1576	0.6492	0.0	188.3994	3296.2672	NORMAL	
TOTAL ORGANIC CARBON			MG/L								
3	2.0000	6.0000	5.6000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
URANIUM			MG/L								
6	0.0020	0.0320	+ 0.0290	0.0210	0.0146	0.6925	0.0	** 0.0020	0.0410	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.

Table D.7.10 Background water quality statistics in the alluvium,
Old Rifle Site
SITE: RF001 RIFLE (OLD)
10/22/87 TO 08/27/90
REPORT DATE: 01/24/92

PARAMETER NAME / # OF SAMP	MINIMUM	MAXIMUM	UNITS / MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 95% CONFIDENCE INTERVAL MINIMUM	STATISTICAL RANGE 95% CONFIDENCE INTERVAL MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
VANADIUM			MG/L								
6	** 0.0100	0.0600	+ 0.0200	NA	NA	NA	16.7	** 0.0100	0.0600	NONPARAMETRIC	2,6
ZINC			MG/L								
6	** 0.0050	0.0110	** 0.0050	NA	NA	NA	50.0	** 0.0050	0.0110	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, $\alpha = 0.01$
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\RF001\GW010027.DAT

Table D.7.11 Downgradient water quality statistics in the alluvium,
Old Rifle Site
SITE: RFO01 RIFLE (OLD)
10/22/87 TO 08/27/90
REPORT DATE: 01/23/92

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
ALKALINITY			MG/L CACO3								
19	253.0000	717.0000	376.0000	408.0000	114.9348	0.2817	0.0	340.7093	475.2907	NORMAL	
ALUMINUM			MG/L								
19	** 0.1000	0.3800	0.1700	NA	NA	NA	42.1	** 0.1000	0.2100	NONPARAMETRIC	2
AMMONIUM			MG/L								
17	** 0.1000	1.3000	** 0.1000	NA	NA	NA	76.5	** 0.1000	0.4000	NONPARAMETRIC	2
ANTIMONY			MG/L								
9	** 0.0030	0.0060	** 0.0030	NA	NA	NA	77.8	** 0.0030	0.0060	NONPARAMETRIC	2
ARSENIC			MG/L								
19	0.0010	1.1400	0.0050	NA	NA	NA	31.6	0.0040	0.0400	NONPARAMETRIC	2
BARIUM			MG/L								
19	0.0200	0.1400	0.0500	NA	NA	NA	42.1	0.0200	0.0500	NONPARAMETRIC	2
BERYLLIUM			MG/L								
1	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
BROMIDE			MG/L								
18	0.0500	1.0000	+ 0.0500	NA	NA	NA	72.2	0.0500	0.1000	NONPARAMETRIC	2
CADMIUM			MG/L								
19	** 0.0010	0.0080	0.0025	NA	NA	NA	89.5	** 0.0010	0.0025	NONPARAMETRIC	2
CALCIUM			MG/L								
19	69.8000	318.0000	148.0000	170.9368	65.5436	0.3834	0.0	132.5631	209.3106	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 D.7.11 Downgradient water quality statistics in the alluvium,
Old Rifle Site
SITE: RFO01 RIFLE (OLD)
10/22/87 TO 08/27/90
REPORT DATE: 01/23/92

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								
19	26.0000	218.0000	48.0000		73.9263	56.2138	0.7604	0.0	41.0149	106.8378	NORMAL	
CHROMIUM				MG/L								
19	** 0.0100	0.0800	** 0.0100		NA	NA	NA	94.7	** 0.0100	** 0.0100	NONPARAMETRIC	2
COBALT				MG/L								
1	** 0.0500	** 0.0500	** 0.0500		NA	NA	NA	100.0	NA	NA	UNKNOWN	1
COPPER				MG/L								
1	** 0.0200	** 0.0200	** 0.0200		NA	NA	NA	100.0	NA	NA	UNKNOWN	1
CYANIDE				MG/L								
1	** 0.0100	** 0.0100	** 0.0100		NA	NA	NA	100.0	NA	NA	UNKNOWN	1
FLUORIDE				MG/L								
18	0.4000	1.2000	+ 0.6800		0.6950	0.1926	0.2771	0.0	0.5785	0.8115	NORMAL	
GROSS ALPHA				PCI/L								
6	6.5000	1300.0000	+ 62.0000		58.2261	6.6993	NA	0.0	4.2693	794.1162	LOGNORMAL	7,8
GROSS BETA				PCI/L								
6	16.0000	460.0000	+ 41.5000		49.3532	3.3275	NA	0.0	9.4634	257.3852	LOGNORMAL	7,8
IRON				MG/L								
19	0.0500	7.9900	0.0700		0.1611	5.4281	NA	0.0	0.0598	0.4337	LOGNORMAL	7,8

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* 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.
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 D.7.11 Downgradient water quality statistics in the alluvium,
Old Rifle Site
SITE: RFO01 RIFLE (OLD)
10/22/87 TO 08/27/90
REPORT DATE: 01/23/92

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	19	** 0.0100	0.0200	** 0.0100	NA	NA	NA	94.7	** 0.0100	** 0.0100	NONPARAMETRIC	2
MAGNESIUM	MG/L	19	41.0000	143.0000	92.0000	91.1474	23.5996	0.2589	0.0	77.3305	104.9642	NORMAL	
MANGANESE	MG/L	19	0.0300	1.0500	0.3200	0.4737	0.2950	0.6227	0.0	0.3010	0.6464	NORMAL	
MERCURY	MG/L	1	** 0.0002	** 0.0002	** 0.0002	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
MOLYBDENUM	MG/L	19	0.0200	0.1700	0.1200	0.0963	0.0550	0.5710	0.0	0.0641	0.1285	NORMAL	
NET GROSS ALPHA ***	PCI/L	6	-140.6000	43.8500	+ -8.7750	NA	NA	NA	0.0	-140.6000	43.8500	NONPARAMETRIC	9,6
NICKEL	MG/L	1	** 0.0400	** 0.0400	** 0.0400	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
NITRATE	MG/L	17	** 1.0000	6.6000	** 1.0000	NA	NA	NA	58.8	** 1.0000	2.0000	NONPARAMETRIC	2
NITRITE	MG/L	10	** 0.1000	** 0.1000	** 0.1000	NA	NA	NA	100.0	** 0.1000	** 0.1000	NONPARAMETRIC	2

*** 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, a = 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 D.7.11 Downgradient water quality statistics in the alluvium, Old Rifle Site
SITE: RFO01 RIFLE (OLD)
10/22/87 TO 08/27/90
REPORT DATE: 01/23/92

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
PH			SU								
19	6.5500	7.3700	7.1000	NA	NA	NA	0.0	NA	NA	UNKNOWN	
PHOSPHATE			MG/L								
18	** 0.1000	5.1000	** 0.1000	NA	NA	NA	66.7	** 0.1000	3.0000	NONPARAMETRIC	2
POTASSIUM			MG/L								
19	2.6000	10.0000	6.2300	5.9537	1.8614	0.3127	0.0	4.8639	7.0435	NORMAL	
RADIUM-226			PCI/L								
17	** 0.1000	16.0000	0.1000	NA	NA	NA	35.3	** 0.1000	0.7000	NONPARAMETRIC	2
RADIUM-226 + RADIUM-228			PCI/L								
16	0.3500	5.0000	+ 1.0250	1.3062	1.1612	0.8889	0.0	0.5509	2.0616	NORMAL	
RADIUM-228			PCI/L								
16	** 1.0000	2.0000	** 1.0000	** 1.0000	0.5119	0.6605	0.0	** 1.0000	1.1080	NORMAL	
SELENIUM			MG/L								
19	** 0.0050	0.1170	0.0140	NA	NA	NA	26.3	** 0.0050	0.0210	NONPARAMETRIC	2
SILICA - SIO2			MG/L								
18	9.0000	51.8000	+ 20.2000	23.0389	10.8626	0.4715	5.6	16.4665	29.6113	NORMAL	
SILVER			MG/L								
9	** 0.0100	0.0100	** 0.0100	NA	NA	NA	88.9	** 0.0100	0.0100	NONPARAMETRIC	2
SODIUM			MG/L								
19	56.0000	500.0000	141.0000	185.2895	117.7844	0.6357	0.0	116.3304	254.2486	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, a = 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 D.7.11 Downgradient water quality statistics in the alluvium,
Old Rifle Site
SITE: RF001 RIFLE (OLD)
10/22/87 TO 08/27/90
REPORT DATE: 01/23/92

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
SPECIFIC CONDUCTANCE			UMHO/CM								
19	490.0000	2500.0000	1375.0000	1414.3684	547.1885	0.3869	0.0	1094.0066	1734.7303	NORMAL	
STRONTIUM			MG/L								
9	1.1400	4.3800	2.4600	2.4722	0.8843	0.3577	0.0	1.6186	3.3258	NORMAL	
SULFATE			MG/L								
19	160.0000	1530.0000	601.0000	689.8947	356.2730	0.5164	0.0	481.3080	898.4815	NORMAL	
SULFIDE			MG/L								
10	** 0.1000	** 0.1000	** 0.1000	NA	NA	NA	100.0	** 0.1000	** 0.1000	NONPARAMETRIC	2
TEMPERATURE			C - DEGREE								
19	10.5000	20.0000	14.0000	14.0947	2.0266	0.1438	0.0	12.9082	15.2813	NORMAL	
THALLIUM			MG/L								
1	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
TIN			MG/L								
1	0.0120	0.0120	0.0120	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
TOTAL DISSOLVED SOLIDS			MG/L								
18	740.0000	2970.0000	+ 1460.0000	1558.0000	596.1220	0.3826	0.0	1197.3178	1918.6822	NORMAL	
TOTAL ORGANIC CARBON			MG/L								
4	63.0000	116.0000	+ 88.0000	88.7500	24.4864	0.2759	0.0	33.1536	144.3464	NORMAL	
URANIUM			MG/L								
19	0.0007	2.1000	0.1080	0.0991	8.1643	NA	0.0	0.0290	0.3389	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, 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.
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 D.7.11 Downgradient water quality statistics in the alluvium,
Old Rifle Site
SITE: RFO01 RIFLE (OLD)
10/22/87 TO 08/27/90
REPORT DATE: 01/23/92

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								
19	0.0100	6.6100	0.0500	0.0775	5.8963	NA	0.0	0.0274	0.2190	LOGNORMAL	7,8
ZINC			MG/L								
19	** 0.0050	0.0350	** 0.0050	NA	NA	NA	52.6	** 0.0050	0.0090	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, α = 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.

INPUT DATA FILENAME: M:\UART\RFO01\GWQ10013.DAT

Table D.7.12 Groundwater quality measurements exceeding maximum concentration limits in background alluvial monitor wells, Old Rifle Site
SITE: RF001 RIFLE (OLD)
10/22/87 TO 08/27/90
REPORT DATE: 01/23/92

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	6	MG/L	0.0500	-	-	-	-	-	-	-	-
ARSENIC (TOTAL)	0	MG/L	0.0500	-	-	-	-	-	-	-	-
BARIUM	6	MG/L	1.0000	-	-	-	-	-	-	-	-
BARIUM (TOTAL)	0	MG/L	1.0000	-	-	-	-	-	-	-	-
CADMIUM	6	MG/L	0.0100	-	-	-	-	-	-	-	-
CADMIUM (TOTAL)	0	MG/L	0.0100	-	-	-	-	-	-	-	-
CHROMIUM	6	MG/L	0.0500	-	-	-	-	-	-	-	-
CHROMIUM (TOTAL)	0	MG/L	0.0500	-	-	-	-	-	-	-	-
GROSS ALPHA	3	PCI/L	15.0000	0597	08/27/90	0001	AL	U	56.	1.0	21.
GROSS ALPHA (TOTAL)	0	PCI/L	15.0000	-	-	-	-	-	-	-	-
LEAD	6	MG/L	0.0500	-	-	-	-	-	-	-	-
LEAD (TOTAL)	0	MG/L	0.0500	-	-	-	-	-	-	-	-
MERCURY	0	MG/L	0.0020	-	-	-	-	-	-	-	-
MERCURY (TOTAL)	0	MG/L	0.0020	-	-	-	-	-	-	-	-
MOLYBDENUM	6	MG/L	0.1000	0597 0598	10/22/87 10/22/87	0001 0001	AL AL	U U	0.19 0.18	0.01 0.01	- -
MOLYBDENUM (TOTAL)	0	MG/L	0.1000	-	-	-	-	-	-	-	-
NET GROSS ALPHA *	3	PCI/L	15.0000	0597	08/27/90	0001	AL	U	34.0	-	-
NET GROSS ALPHA (TOTAL) **	0	PCI/L	15.0000	-	-	-	-	-	-	-	-

* 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

FLOW RELATIONSHIP CODE:
U - UPGRADIENT

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

Table D.7.12 Groundwater quality measurements exceeding maximum concentration limits in background alluvial monitor wells, Old Rifle Site
SITE: RFO01 RIFLE (OLD)
10/22/87 TO 08/27/90
REPORT DATE: 01/23/92

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.
NITRATE	6	MG/L	44.0000	-	-	-	-	-	-		-	-
NITRATE (TOTAL)	0	MG/L	44.0000	-	-	-	-	-	-		-	-
RA-226 & RA-228	6	PCI/L	5.0000	-	-	-	-	-	-		-	-
RA-226 & RA-228 (TOTAL)	0	PCI/L	5.0000	-	-	-	-	-	-		-	-
SELENIUM	6	MG/L	0.0100	0597	10/22/87	0001	AL	U	0.036		0.005	-
				0598	10/22/87	0001	AL	U	0.034		0.005	-
SELENIUM (TOTAL)	0	MG/L	0.0100	-	-	-	-	-	-		-	-
SILVER	3	MG/L	0.0500	-	-	-	-	-	-		-	-
SILVER (TOTAL)	0	MG/L	0.0500	-	-	-	-	-	-		-	-
URANIUM	5	MG/L	0.0440	-	-	-	-	-	-		-	-
URANIUM (TOTAL)	0	MG/L	0.0440	-	-	-	-	-	-		-	-

FORMATION OF COMPLETION CODE:
AL - ALLUVIUM

FLOW RELATIONSHIP CODE:
U - UPGRADIENT

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

DATA FILE NAME: M:\DART\RFO01\GW010021.DAT

Table D.7.13 Background water quality statistics in the Wasatch Formation, Old Rifle Site
SITE: RFO01 RIFLE (OLD)
05/14/86 TO 08/27/90
REPORT DATE: 01/27/92

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
ALKALINITY			MG/L CACO3								
17	208.0000	425.0000	307.0000	308.1765	72.7824	0.2362	0.0	262.5805	353.7724	NORMAL	
ALUMINUM			MG/L								
13	** 0.0600	0.2600	** 0.0600	NA	NA	NA	61.5	** 0.0600	0.1700	NONPARAMETRIC	2
AMMONIUM			MG/L								
17	** 0.1000	0.7000	0.3000	NA	NA	NA	23.5	** 0.1000	0.4000	NONPARAMETRIC	2
ANTIMONY			MG/L								
6	** 0.0030	** 0.0030	** 0.0030	NA	NA	NA	100.0	** 0.0030	** 0.0030	NONPARAMETRIC	2,6
ARSENIC			MG/L								
17	0.0030	0.0070	0.0050	NA	NA	NA	70.6	0.0050	0.0050	NONPARAMETRIC	2
BARIUM			MG/L								
13	0.0300	0.3000	0.0500	NA	NA	NA	38.5	0.0400	0.1300	NONPARAMETRIC	2
BROMIDE			MG/L								
11	0.0500	3.8000	0.1000	NA	NA	NA	18.2	0.0500	0.4000	NONPARAMETRIC	2
CADMIUM			MG/L								
17	** 0.0010	0.0025	** 0.0010	NA	NA	NA	100.0	** 0.0010	0.0025	NONPARAMETRIC	2
CALCIUM			MG/L								
17	3.5900	324.0000	5.4300	13.5855	4.7996	NA	0.0	5.0853	36.2936	LOGNORMAL	7,8
CHLORIDE			MG/L								
17	196.0000	1700.0000	437.0000	564.0000	365.5332	0.6481	0.0	335.0046	792.9954	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.
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 D.7.13 Background water quality statistics in the Wasatch Formation, Old Rifle Site
SITE: RF001 RIFLE (OLD)
05/14/86 TO 08/27/90
REPORT DATE: 01/27/92

PARAMETER NAME / # OF SAMP	MINIMUM	MAXIMUM	UNITS / MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 95% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
CHROMIUM			MG/L								
11	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	** 0.0100	** 0.0100	NONPARAMETRIC	2
COBALT			MG/L								
2	** 0.0500	** 0.0500	** 0.0500	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
COPPER			MG/L								
2	** 0.0200	** 0.0200	** 0.0200	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
FLUORIDE			MG/L								
13	0.1900	3.9700	2.8200	2.3231	1.3540	0.5828	0.0	1.3163	3.3299	NORMAL	
GROSS ALPHA			PCI/L								
8	** 0.2000	71.0000	+ 10.5000	NA	NA	NA	37.5	** 0.2000	71.0000	NONPARAMETRIC	2
GROSS BETA			PCI/L								
8	0.5000	49.0000	+ 8.7000	NA	NA	NA	25.0	0.5000	49.0000	NONPARAMETRIC	2
IRON			MG/L								
17	** 0.0200	0.2400	** 0.0200	NA	NA	NA	58.8	** 0.0200	0.0400	NONPARAMETRIC	2
LEAD			MG/L								
13	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	** 0.0100	** 0.0100	NONPARAMETRIC	2
LEAD-210			PCI/L								
2	** 1.5000	** 1.5000	** 1.5000	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
MAGNESIUM			MG/L								
17	0.7100	137.0000	1.1400	3.6923	6.3325	NA	0.0	1.1618	11.7343	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.
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 D.7.13 Background water quality statistics in the Wasatch Formation,
Old Rifle Site
SITE: RFO01 RIFLE (OLD)
05/14/86 TO 08/27/90
REPORT DATE: 01/27/92

PARAMETER NAME / # OF SAMP	MINIMUM	MAXIMUM	UNITS / MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 95% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
MANGANESE			MG/L								
17	** 0.0100	1.4500	0.0170	NA	NA	NA	23.5	** 0.0100	0.0300	NONPARAMETRIC	2
MOLYBDENUM			MG/L								
17	** 0.0100	0.3100	0.1900	0.1656	0.1118	0.6749	11.8	0.0956	0.2356	NORMAL	
NET GROSS ALPHA ***			PCI/L								
8	-2.0400	55.9100	+ 9.0600	NA	NA	NA	0.0	-2.0400	55.9100	NONPARAMETRIC	9
NICKEL			MG/L								
2	** 0.0400	** 0.0400	** 0.0400	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
NITRATE			MG/L								
13	** 1.0000	4.0000	** 1.0000	NA	NA	NA	84.6	** 1.0000	1.0000	NONPARAMETRIC	2
NITRITE			MG/L								
5	** 0.1000	** 0.1000	** 0.1000	NA	NA	NA	100.0	** 0.1000	** 0.1000	NONPARAMETRIC	2,5
PH			SU								
17	7.0000	9.1000	8.3000	NA	NA	NA	0.0	NA	NA	UNKNOWN	
PHOSPHATE			MG/L								
11	** 0.1000	6.2000	** 0.1000	NA	NA	NA	54.5	** 0.1000	0.9000	NONPARAMETRIC	2
POLONIUM-210			PCI/L								
2	** 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, 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.
9) The nonparametic distribution was used because the data failed the normal distribution test and includes values ≤0.

Table D.7.13 Background water quality statistics in the Wasatch Formation, Old Rifle Site
SITE: RFO01 RIFLE (OLD)
05/14/86 TO 08/27/90
REPORT DATE: 01/27/92

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
POTASSIUM	MG/L	17	1.2800	6.8400	2.8000	3.2765	1.7843	0.5446	0.0	2.1586	4.3943	NORMAL	
RADIUM-226	PCI/L	13	** 0.1000	0.6000	0.2000	NA	NA	NA	23.1	0.1000	0.5000	NONPARAMETRIC	2
RADIUM-226 + RADIUM-228	PCI/L	13	0.4000	2.1000	1.0000	0.9808	0.4250	0.4334	0.0	0.6647	1.2968	NORMAL	
RADIUM-228	PCI/L	13	** 1.0000	1.5000	** 1.0000	NA	NA	NA	38.5	** 1.0000	1.2000	NONPARAMETRIC	2
SELENIUM	MG/L	17	0.0010	0.0280	0.0025	NA	NA	NA	70.6	0.0025	0.0025	NONPARAMETRIC	2
SILICA - SIO2	MG/L	13	6.0000	13.0000	7.0000	7.6400	2.0081	0.2628	0.0	6.1468	9.1332	NORMAL	
SILVER	MG/L	6	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	** 0.0100	** 0.0100	NONPARAMETRIC	2,6
SODIUM	MG/L	17	288.0000	1140.0000	571.0000	563.7647	203.0291	0.3601	0.0	436.5732	690.9563	NORMAL	
SPECIFIC CONDUCTANCE	UMHO/CM	17	1000.0000	3250.0000	2020.0000	2006.6471	684.3070	0.3410	0.0	1577.9495	2435.3446	NORMAL	
STRONTIUM	MG/L	8	0.1000	3.0000	+ 0.3245	0.3863	3.0946	NA	0.0	0.1166	1.2791	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, α = 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 D.7.13 Background water quality statistics in the Wasatch Formation, Old Rifle Site
SITE: RFO01 RIFLE (OLD)
05/14/86 TO 08/27/90
REPORT DATE: 01/27/92

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
SULFATE			MG/L								
17	15.6000	1920.0000	81.0000	135.2442	3.9150	NA	0.0	57.5160	318.0158	LOGNORMAL	7,8
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								
17	9.5000	17.5000	11.5000	11.7412	1.8537	0.1579	0.0	10.5799	12.9025	NORMAL	
THORIUM-230			PCI/L								
2	** 1.0000	** 1.0000	** 1.0000	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
TIN			MG/L								
2	** 0.0050	** 0.0050	** 0.0050	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
TOTAL DISSOLVED SOLIDS			MG/L								
17	810.0000	3690.0000	1550.0000	1816.0000	867.1231	0.4775	0.0	1272.7738	2359.2262	NORMAL	
TOTAL ORGANIC CARBON			MG/L								
6	3.0000	100.0000	+ 71.5000	64.0000	35.2363	0.5506	0.0	15.5939	112.4061	NORMAL	
URANIUM			MG/L								
17	0.0006	0.0470	0.0015	NA	NA	NA	41.2	0.0015	0.0037	NONPARAMETRIC	2
VANADIUM			MG/L								
13	** 0.0100	0.0500	0.0300	NA	NA	NA	15.4	** 0.0100	0.0400	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.
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 D.7.13 Background water quality statistics in the Wasatch Formation,
Old Rifle Site
SITE: RF001 RIFLE (OLD)
05/14/86 TO 08/27/90
REPORT DATE: 01/27/92

PARAMETER NAME			UNITS					STATISTICAL RANGE 95% CONFIDENCE INTERVAL			
# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
ZINC			MG/L								
13	** 0.0050	0.0210	0.0070	NA	NA	NA	30.8	** 0.0050	0.0180	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, a = 0.01
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.

INPUT DATA FILENAME: N:\DART\RF001\GWQ10031.DAT

Table D.7.14 Downgradient water quality statistics in the Wasatch Formation,
Old Rifle Site
SITE: RF001 RIFLE (OLD)
05/16/86 TO 08/24/90
REPORT DATE: 07/11/91

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	11	48.0000	175.0000	98.0000	105.0909	31.8825	0.3034	0.0	78.5208	131.6610	NORMAL	
ALUMINUM	MG/L	12	0.0500	0.2600	0.1000	NA	NA	NA	41.7	0.0500	0.2400	NONPARAMETRIC	2
ALUMINUM (TOTAL)	MG/L	1	784.0000	784.0000	784.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
AMMONIUM	MG/L	10	0.0500	3.5000	2.2500	2.1350	1.1131	0.5213	10.0	1.1421	3.1279	NORMAL	
AMMONIUM (TOTAL)	MG/L	1	8.6000	8.6000	8.6000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
ANTIMONY	MG/L	4	0.0015	0.0330	0.0083	NA	NA	NA	50.0	0.0015	0.0330	NONPARAMETRIC	2,4
ANTIMONY (TOTAL)	MG/L	1	0.0015	0.0015	0.0015	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
ARSENIC	MG/L	12	0.0010	0.0300	0.0050	NA	NA	NA	50.0	0.0020	0.0050	NONPARAMETRIC	2
ARSENIC (TOTAL)	MG/L	1	0.0200	0.0200	0.0200	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
BARIUM	MG/L	12	0.0300	8.6300	4.0200	4.1692	2.9250	0.7016	8.3	1.8741	6.4642	NORMAL	

* The statistical maximum is the 99 percent one sided confidence interval, a = 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.

Table D.7.14 Downgradient water quality statistics in the Wasatch Formation,
Old Rifle Site
SITE: RFO01 RIFLE (OLD)
05/16/86 TO 08/24/90
REPORT DATE: 07/11/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
BARIUM (TOTAL)	MG/L	1	45.4000	45.4000	45.4000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
BERYLLIUM	MG/L	2	0.0050	0.0050	0.0050	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
BROMIDE	MG/L	5	1.0000	5.4000	1.6000	2.3800	1.7612	0.7400	0.0	-0.5713	5.3313	NORMAL	
CADMIUM	MG/L	12	0.0005	0.0700	0.0015	NA	NA	NA	66.7	0.0005	0.0630	NONPARAMETRIC	2
CADMIUM (TOTAL)	MG/L	1	0.0440	0.0440	0.0440	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
CALCIUM	MG/L	12	66.0000	328.0000	254.0000	239.7500	82.4226	0.3438	0.0	175.0797	304.4203	NORMAL	
CALCIUM (TOTAL)	MG/L	1	697.0000	697.0000	697.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
CHLORIDE	MG/L	12	1170.0000	8290.0000	6970.0000	5959.1667	2463.5948	0.4134	0.0	4026.1833	7892.1500	NORMAL	
CHLORIDE (TOTAL)	MG/L	1	8040.0000	8040.0000	8040.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
CHROMIUM	MG/L	8	0.0050	0.0900	0.0050	NA	NA	NA	75.0	0.0050	0.0900	NONPARAMETRIC	2

* 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 D.7.14 Downgradient water quality statistics in the Wasatch Formation,
Old Rifle Site
SITE: RFO01 RIFLE (OLD)
05/16/86 TO 08/24/90
REPORT DATE: 07/11/91

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 (TOTAL)	MG/L	1	0.8200	0.8200	0.8200	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
COBALT	MG/L	6	0.0250	0.0250	0.0250	NA	NA	NA	100.0	0.0250	0.0250	NONPARAMETRIC	2,6
COPPER	MG/L	6	0.0100	0.0240	0.0100	NA	NA	NA	66.7	0.0100	0.0240	NONPARAMETRIC	2,6
CYANIDE	MG/L	2	0.0050	0.0050	0.0050	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
FLUORIDE	MG/L	10	0.5000	1.3000	0.5850	0.6750	0.2503	0.3707	0.0	0.4518	0.8982	NORMAL	
FLUORIDE (TOTAL)	MG/L	1	0.1000	0.1000	0.1000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
GROSS ALPHA	PCI/L	6	0.1000	60.0000	0.1000	NA	NA	NA	83.3	0.1000	60.0000	NONPARAMETRIC	2,6
GROSS ALPHA (TOTAL)	PCI/L	1	220.0000	220.0000	220.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
GROSS BETA	PCI/L	6	0.5000	48.0000	0.5000	NA	NA	NA	66.7	0.5000	48.0000	NONPARAMETRIC	2,6
GROSS BETA (TOTAL)	PCI/L	1	230.0000	230.0000	230.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1

* The statistical maximum is the 99 percent one sided confidence interval, a = 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 inc.

Table D.7.14 Downgradient water quality statistics in the Wasatch Formation,
Old Rifle Site
SITE: RFO01 RIFLE (OLD)
05/16/86 TO 08/24/90
REPORT DATE: 07/11/91

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
IRON			MG/L								
12	0.0150	0.3000	0.0600	NA	NA	NA	25.0	0.0150	0.1300	NONPARAMETRIC	2
IRON (TOTAL)			MG/L								
1	930.0000	930.0000	930.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
LEAD			MG/L								
12	0.0050	0.0500	0.0125	NA	NA	NA	50.0	0.0050	0.0500	NONPARAMETRIC	2
LEAD (TOTAL)			MG/L								
1	1.4300	1.4300	1.4300	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
LEAD-210			PCI/L								
4	0.7500	0.7500	0.7500	NA	NA	NA	100.0	0.7500	0.7500	NONPARAMETRIC	2,4
MAGNESIUM			MG/L								
12	12.4000	63.9000	48.5000	45.1750	16.8216	0.3724	0.0	31.9765	58.3735	NORMAL	
MAGNESIUM (TOTAL)			MG/L								
1	282.0000	282.0000	282.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
MANGANESE			MG/L								
12	0.0410	0.3600	0.2400	0.2181	0.0918	0.4212	0.0	0.1460	0.2901	NORMAL	
MANGANESE (TOTAL)			MG/L								
1	13.0000	13.0000	13.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
MERCURY			MG/L								
2	0.0001	0.0001	0.0001	NA	NA	NA	100.0	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.
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 D.7.14 Downgradient water quality statistics in the Wasatch Formation,
Old Rifle Site
SITE: RFO01 RIFLE (OLD)
05/16/86 TO 08/24/90
REPORT DATE: 07/11/91

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
MOLYBDENUM			MG/L								
12	0.0050	0.1200	0.0350	NA	NA	NA	25.0	0.0050	0.0800	NONPARAMETRIC	2
MOLYBDENUM (TOTAL)			MG/L								
1	0.2100	0.2100	0.2100	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
NET GROSS ALPHA ***			PCI/L								
6	-16.3600	59.5900	-0.9300	NA	NA	NA	0.0	-16.3600	59.5900	NONPARAMETRIC	9,6
NET GROSS ALPHA (TOTAL) ****			PCI/L								
1	97.8900	97.8900	97.8900	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
NITRATE			MG/L								
9	0.5000	42.1000	0.5000	NA	NA	NA	88.9	0.5000	42.1000	NONPARAMETRIC	2
NITRATE (TOTAL)			MG/L								
1	0.5000	0.5000	0.5000	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
NITRITE			MG/L								
4	0.0500	0.0500	0.0500	NA	NA	NA	100.0	0.0500	0.0500	NONPARAMETRIC	2,4
PHOSPHATE			MG/L								
6	0.0500	3.7000	1.9500	NA	NA	NA	33.3	0.0500	3.7000	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.
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 nonparametric distribution was used because the data failed the normal distribution test and includes values ≤0.

Table D.7.24 Downgradient water quality statistics in the Wasatch Formation, Old Rifle Site
SITE: RFO01 RIFLE (OLD)
05/16/86 TO 08/24/90
REPORT DATE: 07/11/91

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
PHOSPHATE (TOTAL)			MG/L								
1	0.0500	0.0500	0.0500	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
POLONIUM-210			PCI/L								
4	0.5000	0.5000	0.5000	NA	NA	NA	100.0	0.5000	0.5000	NONPARAMETRIC	2,4
POTASSIUM			MG/L								
12	8.5600	43.2000	21.9500	21.8225	11.3970	0.5223	0.0	12.8802	30.7648	NORMAL	
POTASSIUM (TOTAL)			MG/L								
1	100.0000	100.0000	100.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
RADIUM-226			PCI/L								
10	0.0500	6.6000	1.2000	NA	NA	NA	20.0	0.5000	6.6000	NONPARAMETRIC	2
RADIUM-226 (TOTAL)			PCI/L								
1	90.0000	90.0000	90.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
RADIUM-226 + RADIUM-228			PCI/L								
9	1.0000	12.4000	6.4000	6.2889	3.7029	0.5888	0.0	2.7144	9.8634	NORMAL	
RADIUM-226 + RADIUM-228 (TOTAL)			PCI/L								
1	260.0000	260.0000	260.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
RADIUM-228			PCI/L								
9	0.5000	10.0000	3.5000	NA	NA	NA	44.4	0.5000	10.0000	NONPARAMETRIC	2
RADIUM-228 (TOTAL)			PCI/L								
1	170.0000	170.0000	170.0000	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.
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 D.7.14 Downgradient water quality statistics in the Wasatch Formation, Old Rifle Site
SITE: RFO01 RIFLE (OLD)
05/16/86 TO 08/24/90
REPORT DATE: 07/11/91

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
SELENIUM			MG/L								
12	0.0025	0.1700	0.0025	NA	NA	NA	58.3	0.0025	0.1380	NONPARAMETRIC	2
SELENIUM (TOTAL)			MG/L								
1	0.0025	0.0025	0.0025	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
SILICA - SIO2			MG/L								
10	6.3100	8.7000	7.0400	7.2740	0.7947	0.1093	0.0	6.5650	7.9830	NORMAL	
SILICA - SIO2 (TOTAL)			MG/L								
1	102.0000	102.0000	102.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
SILVER			MG/L								
4	0.0050	0.0200	0.0125	NA	NA	NA	50.0	0.0050	0.0200	NONPARAMETRIC	2,4
SILVER (TOTAL)			MG/L								
1	0.0800	0.0800	0.0800	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
SODIUM			MG/L								
12	1880.0000	4560.0000	4050.0000	3803.3333	925.8051	0.2434	0.0	3076.9290	4529.7377	NORMAL	
SODIUM (TOTAL)			MG/L								
1	3460.0000	3460.0000	3460.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
SPECIFIC CONDUCTANCE			UMHO/CM								
13	7000.0000	16000.0000	12900.0000	12514.6154	2861.8369	0.2287	0.0	10386.6233	14642.6075	NORMAL	
STRONTIUM			MG/L								
8	2.5100	15.6000	12.8000	11.9350	4.3405	0.3637	0.0	7.3343	16.5357	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.

Table D.7.14 Downgradient water quality statistics in the Wasatch Formation, Old Rifle Site
SITE: RFO01 RIFLE (OLD)
05/16/86 TO 08/24/90
REPORT DATE: 07/11/91

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
STRONTIUM (TOTAL)			MG/L								
1	24.3000	24.3000	24.3000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
SULFATE			MG/L								
12	0.0500	850.0000	6.4500	10.4876	12.7196	NA	8.3	1.4259	77.1379	LOGNORMAL	7,8
SULFATE (TOTAL)			MG/L								
1	9.9000	9.9000	9.9000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
SULFIDE			MG/L								
4	0.0500	0.0500	0.0500	NA	NA	NA	100.0	0.0500	0.0500	NONPARAMETRIC	2,4
TEMPERATURE			C - DEGREE								
13	9.5000	14.0000	12.0000	11.8615	1.6480	0.1389	0.0	10.6361	13.0869	NORMAL	
THALLIUM			MG/L								
2	0.0100	0.0100	0.0100	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
THORIUM-230			PCI/L								
4	0.5000	1.0000	0.5000	NA	NA	NA	75.0	0.5000	1.0000	NONPARAMETRIC	2,4
TIN			MG/L								
6	0.0025	0.2600	0.0025	NA	NA	NA	66.7	0.0025	0.2600	NONPARAMETRIC	2,6
TOTAL DISSOLVED SOLIDS			MG/L								
10	5240.0000	13700.0000	12200.0000	11241.0000	3035.1952	0.2700	0.0	8533.3676	13948.6324	NORMAL	

* 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.
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.

Table D.7.14 Downgradient water quality statistics in the Wasatch Formation,
Old Rifle Site
SITE: RFO01 RIFLE (OLD)
05/16/86 TO 08/24/90
REPORT DATE: 07/11/91

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
TOTAL DISSOLVED SOLIDS (TOTAL)			MG/L								
1	13200.0000	13200.0000	13200.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
TOTAL ORGANIC CARBON			MG/L								
2	24.0000	29.0000	26.5000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
TOTAL ORGANIC CARBON (TOTAL)			MG/L								
1	102.0000	102.0000	102.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
URANIUM			MG/L								
12	0.0004	0.0240	0.0015	NA	NA	NA	33.3	0.0006	0.0096	NONPARAMETRIC	2
URANIUM (TOTAL)			MG/L								
1	0.1780	0.1780	0.1780	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
VANADIUM			MG/L								
12	0.0050	0.0700	0.0250	NA	NA	NA	33.3	0.0050	0.0500	NONPARAMETRIC	2
VANADIUM (TOTAL)			MG/L								
1	1.3400	1.3400	1.3400	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
ZINC			MG/L								
12	0.0025	0.1700	0.0070	NA	NA	NA	25.0	0.0025	0.0290	NONPARAMETRIC	2
ZINC (TOTAL)			MG/L								
1	5.9800	5.9800	5.9800	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.

INPUT DATA FILENAME: N:\DART\RFO01\GWQ10009.DAT

Table D.7.15 Groundwater quality measurements exceeding maximum concentration limits in background Wasatch Formation wells, Old Rifle Site
SITE: RF001 RIFLE (OLD)
05/14/86 TO 08/27/90
REPORT DATE: 01/27/92

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	17	MG/L	0.0500	-	-	-	-	-	-		-	-
ARSENIC (TOTAL)	0	MG/L	0.0500	-	-	-	-	-	-		-	-
BARIUM	13	MG/L	1.0000	-	-	-	-	-	-		-	-
BARIUM (TOTAL)	0	MG/L	1.0000	-	-	-	-	-	-		-	-
CADMIUM	17	MG/L	0.0100	-	-	-	-	-	-		-	-
CADMIUM (TOTAL)	0	MG/L	0.0100	-	-	-	-	-	-		-	-
CHROMIUM	11	MG/L	0.0500	-	-	-	-	-	-		-	-
CHROMIUM (TOTAL)	0	MG/L	0.0500	-	-	-	-	-	-		-	-
GROSS ALPHA	8	PCI/L	15.0000	0620	08/27/90	0001	WS	U	71.		1.0	35.
				0621	05/14/86	0001	WS	U	< 61.	e	0.2	-
				0622	05/14/86	0001	WS	U	33.	e	0.2	-
				0622	08/27/90	0001	WS	U	17.		1.0	16.
GROSS ALPHA (TOTAL)	0	PCI/L	15.0000	-	-	-	-	-	-		-	-
LEAD	13	MG/L	0.0500	-	-	-	-	-	-		-	-
LEAD (TOTAL)	0	MG/L	0.0500	-	-	-	-	-	-		-	-
MERCURY	0	MG/L	0.0020	-	-	-	-	-	-		-	-
MERCURY (TOTAL)	0	MG/L	0.0020	-	-	-	-	-	-		-	-
MOLYBDENUM	17	MG/L	0.1000	0620	10/26/87	0001	WS	U	0.15		0.01	-
				0621	05/14/86	0001	WS	U	0.161		0.01	-
				0621	08/27/90	0001	WS	U	.12		0.01	-
				0622	05/14/86	0001	WS	U	0.254		0.01	-
				0622	10/25/87	0001	WS	U	0.31		0.01	-
				0622	08/27/90	0001	WS	U	.29		0.01	-

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

FORMATION OF COMPLETION CODE:
WS - WASATCH FORMATION - UNDIFFERENTIATED

FLOW RELATIONSHIP CODE:
U - UPGRADIENT

OTHER PARAMETER VALUE FLAGS:
e - NO UNCERTAINTY VALUE REPORTED

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

Table D.7.15 Groundwater quality measurements exceeding maximum concentration limits in background Wasatch Formation wells, Old Rifle Site
SITE: RFO01 RIFLE (OLD)
05/14/86 TO 08/27/90
REPORT DATE: 01/27/92

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.
MOLYBDENUM	17	MG/L	0.1000	0625	05/15/86	0001	WS	D	0.25	0.01	-
				0625	10/26/87	0001	WS	D	0.19	0.01	-
				0625	08/27/90	0001	WS	D	.19	0.01	-
				0626	05/15/86	0001	WS	D	0.23	0.01	-
				0626	10/25/87	0001	WS	D	0.30	0.01	-
				0626	08/27/90	0001	WS	D	.28	0.01	-
MOLYBDENUM (TOTAL)	0	MG/L	0.1000	-	-	-	-	-	-	-	-
NET GROSS ALPHA *	8	PCI/L	15.0000	0620	08/27/90	0001	WS	U	55.9	-	-
				0622	05/14/86	0001	WS	U	32.0	-	-
				0622	08/27/90	0001	WS	U	16.0	-	-
NET GROSS ALPHA (TOTAL) **	0	PCI/L	15.0000	-	-	-	-	-	-	-	-
NITRATE	13	MG/L	44.0000	-	-	-	-	-	-	-	-
NITRATE (TOTAL)	0	MG/L	44.0000	-	-	-	-	-	-	-	-
RA-226 & RA-228	13	PCI/L	5.0000	-	-	-	-	-	-	-	-
RA-226 & RA-228 (TOTAL)	0	PCI/L	5.0000	-	-	-	-	-	-	-	-
SELENIUM	17	MG/L	0.0100	0620	10/26/87	0001	WS	U	0.028	0.005	-
SELENIUM (TOTAL)	0	MG/L	0.0100	-	-	-	-	-	-	-	-
SILVER	6	MG/L	0.0500	-	-	-	-	-	-	-	-
SILVER (TOTAL)	0	MG/L	0.0500	-	-	-	-	-	-	-	-
URANIUM	17	MG/L	0.0440	0620	05/14/86	0001	WS	U	0.047	0.003	-
URANIUM (TOTAL)	0	MG/L	0.0440	-	-	-	-	-	-	-	-

* 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:
WS - WASATCH FORMATION - UNDIFFERENTIATED

FLOW RELATIONSHIP CODE:
D - DOWN GRADIENT
U - UPGRADIENT

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

DATA FILE NAME: M:\DART\RFO01\GWQ10032.DAT

Table D.7.16 Background water quality statistics in the alluvium,
New Rifle Site
SITE: RFN01 RIFLE (NEW)
10/25/87 TO 08/29/90
REPORT DATE: 01/23/92

PARAMETER NAME			UNITS					STATISTICAL RANGE			
# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	95% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
ALKALINITY			MG/L CACO3								
8	411.0000	877.0000	+ 519.5000	545.0000	144.3804	0.2649	0.0	391.9635	698.0365	NORMAL	
ALUMINUM			MG/L								
8	** 0.0900	0.1600	+ 0.0950	NA	NA	NA	37.5	** 0.0900	0.1800	NONPARAMETRIC	2
ALUMINUM (TOTAL)			MG/L								
1	** 0.1000	** 0.1000	** 0.1000	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
AMMONIUM			MG/L								
7	** 0.1000	** 0.1000	** 0.1000	NA	NA	NA	100.0	** 0.1000	** 0.1000	NONPARAMETRIC	2
ANTIMONY			MG/L								
4	** 0.0030	0.0220	** 0.0030	NA	NA	NA	75.0	** 0.0030	0.0220	NONPARAMETRIC	2,4
ANTIMONY (TOTAL)			MG/L								
1	** 0.0030	** 0.0030	** 0.0030	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
ARSENIC			MG/L								
8	0.0020	0.0050	+ 0.0050	NA	NA	NA	50.0	0.0020	0.0050	NONPARAMETRIC	2
ARSENIC (TOTAL)			MG/L								
1	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
BARIUM			MG/L								
8	0.0200	0.0600	+ 0.0500	NA	NA	NA	50.0	0.0200	0.0600	NONPARAMETRIC	2
BARIUM (TOTAL)			MG/L								
1	** 0.1000	** 0.1000	** 0.1000	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.
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 D.7.16 Background water quality statistics in the alluvium,
New Rifle Site
SITE: RFN01 RIFLE (NEW)
10/25/87 TO 08/29/90
REPORT DATE: 01/23/92

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
BERYLLIUM			MG/L								
1	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
BROMIDE			MG/L								
7	** 0.1000	** 0.1000	** 0.1000	NA	NA	NA	100.0	** 0.1000	** 0.1000	NONPARAMETRIC	2
BROMIDE (TOTAL)			MG/L								
1	** 0.1000	** 0.1000	** 0.1000	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
CADMIUM			MG/L								
8	** 0.0010	0.0090	+ 0.0025	NA	NA	NA	87.5	** 0.0010	0.0090	NONPARAMETRIC	2
CADMIUM (TOTAL)			MG/L								
1	** 0.0010	** 0.0010	** 0.0010	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
CALCIUM			MG/L								
8	127.0000	168.0000	+ 139.5000	144.7500	15.0309	0.1038	0.0	128.8179	160.6821	NORMAL	
CALCIUM (TOTAL)			MG/L								
1	125.0000	125.0000	125.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
CHLORIDE			MG/L								
8	30.0000	56.0000	+ 48.0000	46.2500	7.5923	0.1642	0.0	38.2025	54.2975	NORMAL	
CHLORIDE (TOTAL)			MG/L								
1	44.0000	44.0000	44.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
CHROMIUM			MG/L								
8	** 0.0100	0.0800	** 0.0100	NA	NA	NA	87.5	** 0.0100	0.0800	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, 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.

Table D.7.16 Background water quality statistics in the alluvium,
New Rifle Site
SITE: RFN01 RIFLE (NEW)
10/25/87 TO 08/29/90
REPORT DATE: 01/23/92

PARAMETER NAME / # OF SAMP	MINIMUM	MAXIMUM	UNITS / MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 95% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
CHROMIUM (TOTAL)			MG/L								
1	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
COBALT			MG/L								
1	** 0.0500	** 0.0500	** 0.0500	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
COPPER			MG/L								
1	0.0200	0.0200	0.0200	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
CYANIDE			MG/L								
1	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
FLUORIDE			MG/L								
7	0.6000	0.7900	0.7000	0.6843	0.0673	0.0983	0.0	0.6043	0.7642	NORMAL	
FLUORIDE (TOTAL)			MG/L								
1	0.7000	0.7000	0.7000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
GROSS ALPHA			PCI/L								
3	10.0000	61.0000	16.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
GROSS ALPHA (TOTAL)			PCI/L								
1	53.0000	53.0000	53.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
GROSS BETA			PCI/L								
3	16.0000	21.0000	17.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
GROSS BETA (TOTAL)			PCI/L								
1	18.0000	18.0000	18.0000	NA	NA	NA	0.0	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, α = 0.01
1) A minimum of 4 samples must be available for the statistical analysis.

Table D.7.16 Background water quality statistics in the alluvium, New Rifle Site
SITE: RFN01 RIFLE (NEW)
10/25/87 TO 08/29/90
REPORT DATE: 01/23/92

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
IRON			MG/L								
8	0.0500	1.1700	+ 0.1500	0.1925	3.6573	NA	0.0	0.0487	0.7608	LOGNORMAL	7,8
IRON (TOTAL)			MG/L								
1	1.6700	1.6700	1.6700	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
LEAD			MG/L								
8	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	** 0.0100	** 0.0100	NONPARAMETRIC	2
LEAD (TOTAL)			MG/L								
1	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
MAGNESIUM			MG/L								
8	79.0000	117.0000	+ 112.0000	107.7500	12.6124	0.1171	0.0	94.3815	121.1185	NORMAL	
MAGNESIUM (TOTAL)			MG/L								
1	112.0000	112.0000	112.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
MANGANESE			MG/L								
8	0.6300	0.8400	+ 0.7450	0.7375	0.0783	0.1062	0.0	0.6545	0.8205	NORMAL	
MANGANESE (TOTAL)			MG/L								
1	0.7600	0.7600	0.7600	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
MERCURY			MG/L								
1	** 0.0002	** 0.0002	** 0.0002	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, 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.
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 D.7.16 Background water quality statistics in the alluvium,
New Rifle Site
SITE: RFN01 RIFLE (NEW)
10/25/87 TO 08/29/90
REPORT DATE: 01/23/92

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
MOLYBDENUM			MG/L								
8	0.0300	0.1500	+ 0.1150	0.0950	0.0535	0.5627	0.0	0.0383	0.1517	NORMAL	
MOLYBDENUM (TOTAL)			MG/L								
1	0.0300	0.0300	0.0300	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
NET GROSS ALPHA ***			PCI/L								
3	-8.7000	43.8500	-8.5200	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
NET GROSS ALPHA (TOTAL) ****			PCI/L								
1	28.9900	28.9900	28.9900	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
NICKEL			MG/L								
1	0.0400	0.0400	0.0400	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
NITRATE			MG/L								
7	** 1.0000	1.8000	** 1.0000	NA	NA	NA	85.7	** 1.0000	1.8000	NONPARAMETRIC	2
NITRITE			MG/L								
4	** 0.1000	** 0.1000	** 0.1000	NA	NA	NA	100.0	** 0.1000	** 0.1000	NONPARAMETRIC	2,4
PH			SU								
8	7.0500	7.3200	+ 7.0950	NA	NA	NA	0.0	NA	NA	UNKNOWN	
PHOSPHATE			MG/L								
7	** 0.1000	5.5200	3.0000	NA	NA	NA	42.9	** 0.1000	5.5200	NONPARAMETRIC	2

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

Table D.7.16 Background water quality statistics in the alluvium, New Rifle Site
SITE: RFN01 RIFLE (NEW)
10/25/87 TO 08/29/90
REPORT DATE: 01/23/92

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
PHOSPHATE (TOTAL)			MG/L								
1	** 0.1000	** 0.1000	** 0.1000	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
POTASSIUM			MG/L								
8	3.8000	8.7000	+ 5.8300	5.9150	1.9064	0.3223	0.0	3.8943	7.9357	NORMAL	
POTASSIUM (TOTAL)			MG/L								
1	4.4000	4.4000	4.4000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
RADIUM-226			PCI/L								
7	** 0.1000	1.6000	0.2000	0.1811	2.9764	NA	14.3	** 0.1000	0.6618	LOGNORMAL	7,8
RADIUM-226 (TOTAL)			PCI/L								
1	** 0.6000	** 0.6000	** 0.6000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
RADIUM-226 + RADIUM-228			PCI/L								
7	0.3000	1.7000	1.1500	0.9071	0.5660	0.6239	0.0	0.2346	1.5795	NORMAL	
RADIUM-226 + RADIUM-228 (TOTAL)			PCI/L								
1	0.8000	0.8000	0.8000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
RADIUM-228			PCI/L								
7	** 1.0000	1.1000	** 1.0000	** 1.0000	0.4826	0.8661	0.0	** 1.0000	1.1304	NORMAL	
RADIUM-228 (TOTAL)			PCI/L								
1	** 1.0000	** 1.0000	** 1.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
SELENIUM			MG/L								
8	** 0.0050	0.0220	+ 0.0180	NA	NA	NA	37.5	** 0.0050	0.0220	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, 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.
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 D.7.16 Background water quality statistics in the alluvium,
New Rifle Site
SITE: RFN01 RIFLE (NEW)
10/25/87 TO 08/29/90
REPORT DATE: 01/23/92

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
SELENIUM (TOTAL)			MG/L								
1	** 0.0050	** 0.0050	** 0.0050	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
SILICA - SIO2			MG/L								
7	15.5000	19.0000	17.0000	17.2857	1.3409	0.0776	0.0	15.6928	18.8787	NORMAL	
SILICA - SIO2 (TOTAL)			MG/L								
1	19.0000	19.0000	19.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
SILVER			MG/L								
4	** 0.0100	0.0100	** 0.0100	NA	NA	NA	75.0	** 0.0100	0.0100	NONPARAMETRIC	2,4
SILVER (TOTAL)			MG/L								
1	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
SODIUM			MG/L								
8	180.0000	334.0000	+ 241.0000	240.6250	52.0108	0.2161	0.0	185.4960	295.7540	NORMAL	
SODIUM (TOTAL)			MG/L								
1	252.0000	252.0000	252.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
SPECIFIC CONDUCTANCE			UMHO/CM								
8	1200.0000	2250.0000	+ 1685.0000	1690.6250	296.0265	0.1751	0.0	1376.8508	2004.3992	NORMAL	
STRONTIUM			MG/L								
4	2.1000	2.7600	+ 2.4100	2.4200	0.3699	0.1528	0.0	1.5802	3.2598	NORMAL	
STRONTIUM (TOTAL)			MG/L								
1	2.1000	2.1000	2.1000	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.
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 D.7.16 Background water quality statistics in the alluvium,
New Rifle Site
SITE: RFN01 RIFLE (NEW)
10/25/87 TO 08/29/90
REPORT DATE: 01/23/92

PARAMETER NAME			UNITS								
# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 95% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
SULFATE			MG/L								
8	585.0000	884.0000	+ 835.5000	783.0000	114.4827	0.1462	0.0	661.6537	904.3463	NORMAL	
SULFATE (TOTAL)			MG/L								
1	680.0000	680.0000	680.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
SULFIDE			MG/L								
4	** 0.1000	** 0.1000	** 0.1000	NA	NA	NA	100.0	** 0.1000	** 0.1000	NONPARAMETRIC	2,4
TEMPERATURE			C - DEGREE								
8	10.0000	14.9000	+ 13.8500	13.1250	1.7597	0.1341	0.0	11.2598	14.9902	NORMAL	
THALLIUM			MG/L								
1	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
TIN			MG/L								
1	0.0090	0.0090	0.0090	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
TOTAL DISSOLVED SOLIDS			MG/L								
7	1280.0000	1910.0000	1640.0000	1660.0000	209.1252	0.1260	0.0	1411.5714	1908.4286	NORMAL	
TOTAL DISSOLVED SOLIDS (TOTAL)			MG/L								
1	1690.0000	1690.0000	1690.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
URANIUM			MG/L								
8	0.0197	0.0690	+ 0.0315	0.0375	0.0172	0.4572	0.0	0.0193	0.0557	NORMAL	
URANIUM (TOTAL)			MG/L								
1	0.0350	0.0350	0.0350	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.
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 D.7.16 Background water quality statistics in the alluvium, New Rifle Site
SITE: RFN01 RIFLE (NEW)
10/25/87 TO 08/29/90
REPORT DATE: 01/23/92

PARAMETER NAME / # OF SAMP	MINIMUM	MAXIMUM	UNITS / MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 95% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
VANADIUM			MG/L								
8	** 0.0100	0.0500	+ 0.0300	0.0256	0.0159	0.6209	12.5	** 0.0100	0.0425	NORMAL	
VANADIUM (TOTAL)			MG/L								
1	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
ZINC			MG/L								
8	** 0.0050	0.0180	** 0.0050	NA	NA	NA	75.0	** 0.0050	0.0180	NONPARAMETRIC	2
ZINC (TOTAL)			MG/L								
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 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.

INPUT DATA FILENAME: M:\DART\RFN01\GWD10042.DAT

Table D.7.17 Groundwater quality measurements exceeding maximum concentration limits in background alluvial wells, New Rifle Site
SITE: RFN01 RIFLE (NEW)
10/26/87 TO 08/29/90
REPORT DATE: 01/23/92

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	4	MG/L	0.0500	-	-	-	-	-	-		-	-
ARSENIC (TOTAL)	1	MG/L	0.0500	-	-	-	-	-	-		-	-
BARIUM	4	MG/L	1.0000	-	-	-	-	-	-		-	-
BARIUM (TOTAL)	1	MG/L	1.0000	-	-	-	-	-	-		-	-
CADMIUM	4	MG/L	0.0100	-	-	-	-	-	-		-	-
CADMIUM (TOTAL)	1	MG/L	0.0100	-	-	-	-	-	-		-	-
CHROMIUM	4	MG/L	0.0500	0592	12/10/88	0001	AL	U	0.08		0.01	-
CHROMIUM (TOTAL)	1	MG/L	0.0500	-	-	-	-	-	-		-	-
GROSS ALPHA	1	PCI/L	15.0000	0592	08/29/90	0001	AL	U	16.		1.0	17.
GROSS ALPHA (TOTAL)	1	PCI/L	15.0000	0592	08/29/90	N001	AL	U	53.		1.0	22.
LEAD	4	MG/L	0.0500	-	-	-	-	-	-		-	-
LEAD (TOTAL)	1	MG/L	0.0500	-	-	-	-	-	-		-	-
MERCURY	1	MG/L	0.0020	-	-	-	-	-	-		-	-
MERCURY (TOTAL)	0	MG/L	0.0020	-	-	-	-	-	-		-	-
MOLYBDENUM	4	MG/L	0.1000	0591	10/26/87	0001	AL	U	0.15		0.01	-
				0592	10/26/87	0001	AL	U	0.13		0.01	-
				0592	12/10/88	0001	AL	U	0.10		0.01	-
MOLYBDENUM (TOTAL)	1	MG/L	0.1000	-	-	-	-	-	-		-	-
NET GROSS ALPHA *	1	PCI/L	15.0000	-	-	-	-	-	-		-	-

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

FORMATION OF COMPLETION CODE:
AL - ALLUVIUM

FLOW RELATIONSHIP CODE:
U - UPGRADIENT

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

Table D.7.17 Groundwater quality measurements exceeding maximum concentration limits in background alluvial wells, New Rifle Site
SITE: RFN01 RIFLE (NEW)
10/26/87 TO 08/29/90
REPORT DATE: 01/23/92

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.
NET GROSS ALPHA (TOTAL) **	1	PCI/L	15.0000	0592	08/29/90	N001	AL	U	29.0	-	-
NITRATE	3	MG/L	44.0000	-	-	-	-	-	-	-	-
NITRATE (TOTAL)	0	MG/L	44.0000	-	-	-	-	-	-	-	-
RA-226 & RA-228	3	PCI/L	5.0000	-	-	-	-	-	-	-	-
RA-226 & RA-228 (TOTAL)	1	PCI/L	5.0000	-	-	-	-	-	-	-	-
SELENIUM	4	MG/L	0.0100	0591 0592 0592	10/26/87 10/26/87 12/10/88	0001 0001 0001	AL AL AL	U U U	0.018 0.019 0.022	0.005 0.005 0.005	- - -
SELENIUM (TOTAL)	1	MG/L	0.0100	-	-	-	-	-	-	-	-
SILVER	2	MG/L	0.0500	-	-	-	-	-	-	-	-
SILVER (TOTAL)	1	MG/L	0.0500	-	-	-	-	-	-	-	-
URANIUM	4	MG/L	0.0440	0591 0592	10/26/87 12/10/88	0001 0001	AL AL	U U	0.0546 0.0690	0.003 0.003	- -
URANIUM (TOTAL)	1	MG/L	0.0440	-	-	-	-	-	-	-	-

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

FORMATION OF COMPLETION CODE:
AL - ALLUVIUM

FLOW RELATIONSHIP CODE:
U - UPGRADIENT

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

DATA FILE NAME: M:\DART\RFN01\GW010016.DAT

Table D.7.17 Groundwater quality measurements exceeding maximum concentration limits in background alluvial wells, New Rifle Site
SITE: RFO01 RIFLE (OLD)
10/25/87 TO 08/27/90
REPORT DATE: 01/23/92

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	4	MG/L	0.0500	-	-	-	-	-	-	-	-
ARSENIC (TOTAL)	0	MG/L	0.0500	-	-	-	-	-	-	-	-
BARIUM	4	MG/L	1.0000	-	-	-	-	-	-	-	-
BARIUM (TOTAL)	0	MG/L	1.0000	-	-	-	-	-	-	-	-
CADMIUM	4	MG/L	0.0100	-	-	-	-	-	-	-	-
CADMIUM (TOTAL)	0	MG/L	0.0100	-	-	-	-	-	-	-	-
CHROMIUM	4	MG/L	0.0500	-	-	-	-	-	-	-	-
CHROMIUM (TOTAL)	0	MG/L	0.0500	-	-	-	-	-	-	-	-
GROSS ALPHA	2	PCI/L	15.0000	0604	08/27/90	0001	AL	D	61.	1.0	21.
GROSS ALPHA (TOTAL)	0	PCI/L	15.0000	-	-	-	-	-	-	-	-
LEAD	4	MG/L	0.0500	-	-	-	-	-	-	-	-
LEAD (TOTAL)	0	MG/L	0.0500	-	-	-	-	-	-	-	-
MERCURY	0	MG/L	0.0020	-	-	-	-	-	-	-	-
MERCURY (TOTAL)	0	MG/L	0.0020	-	-	-	-	-	-	-	-
MOLYBDENUM	4	MG/L	0.1000	0603 0604	10/25/87 10/25/87	0001 0001	AL AL	D D	0.15 0.13	0.01 0.01	- -
MOLYBDENUM (TOTAL)	0	MG/L	0.1000	-	-	-	-	-	-	-	-
NET GROSS ALPHA *	2	PCI/L	15.0000	0604	08/27/90	0001	AL	D	43.9	-	-
NET GROSS ALPHA (TOTAL) **	0	PCI/L	15.0000	-	-	-	-	-	-	-	-

* 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

FLOW RELATIONSHIP CODE:
D - DOWN GRADIENT

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

Table D.7.17 Groundwater quality measurements exceeding maximum concentration limits in background alluvial wells, New Rifle Site
SITE: RF001 RIFLE (OLD)
10/25/87 TO 08/27/90
REPORT DATE: 01/23/92

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.
NITRATE	4	MG/L	44.0000	-	-	-	-	-	-		-	-
NITRATE (TOTAL)	0	MG/L	44.0000	-	-	-	-	-	-		-	-
RA-226 & RA-228	4	PCI/L	5.0000	-	-	-	-	-	-		-	-
RA-226 & RA-228 (TOTAL)	0	PCI/L	5.0000	-	-	-	-	-	-		-	-
SELENIUM	4	MG/L	0.0100	0603	10/25/87	0001	AL	D	0.021		0.005	-
				0604	10/25/87	0001	AL	D	0.018		0.005	-
SELENIUM (TOTAL)	0	MG/L	0.0100	-	-	-	-	-	-		-	-
SILVER	2	MG/L	0.0500	-	-	-	-	-	-		-	-
SILVER (TOTAL)	0	MG/L	0.0500	-	-	-	-	-	-		-	-
URANIUM	4	MG/L	0.0440	-	-	-	-	-	-		-	-
URANIUM (TOTAL)	0	MG/L	0.0440	-	-	-	-	-	-		-	-

FORMATION OF COMPLETION CODE:
AL - ALLUVIUM

FLOW RELATIONSHIP CODE:
D - DOWN GRADIENT

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

DATA FILE NAME: M:\DART\RF001\GWQ10022.DAT

Table D.7.18 Background water quality statistics in the Wasatch Formation,
New Rifle Site
SITE: RFN01 RIFLE (NEW)
05/12/86 TO 09/19/90
REPORT DATE: 07/11/91

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								
15	131.0000	310.0000	270.0000	244.6000	57.4914	0.2350	0.0	205.6488	283.5512	NORMAL	
ALUMINUM			MG/L								
12	0.0300	0.1300	0.0500	NA	NA	NA	58.3	0.0500	0.1100	NONPARAMETRIC	2
AMMONIUM			MG/L								
15	0.2000	2.3000	0.4000	0.7600	0.6864	0.9032	0.0	0.2950	1.2250	NORMAL	
ANTIMONY			MG/L								
5	0.0015	0.0015	0.0015	NA	NA	NA	100.0	0.0015	0.0015	NONPARAMETRIC	2,5
ARSENIC			MG/L								
15	0.0040	0.0100	0.0050	NA	NA	NA	60.0	0.0050	0.0070	NONPARAMETRIC	2
BARIUM			MG/L								
12	0.0300	1.7000	0.0500	NA	NA	NA	50.0	0.0400	1.3000	NONPARAMETRIC	2
BROMIDE			MG/L								
10	0.5000	13.9000	1.3500	1.7998	2.8091	NA	0.0	0.7163	4.5226	LOGNORMAL	7,8
CADMIUM			MG/L								
15	0.0005	0.0030	0.0005	NA	NA	NA	93.3	0.0005	0.0025	NONPARAMETRIC	2
CALCIUM			MG/L								
15	3.9600	149.0000	12.8000	17.7699	3.6026	NA	0.0	7.4571	42.3446	LOGNORMAL	7,8
CHLORIDE			MG/L								
15	0.8000	5570.0000	622.0000	692.5977	8.1815	NA	0.0	166.7339	2876.9881	LOGNORMAL	7,8

* The statistical maximum is the 99 percent one sided confidence interval, a = 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.

Table D.7.18 Background water quality statistics in the Wasatch Formation,
New Rifle Site
SITE: RFN01 RIFLE (NEW)
05/12/86 TO 09/19/90
REPORT DATE: 07/11/91

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								
10	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2
COBALT			MG/L								
2	0.0250	0.0250	0.0250	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
COPPER			MG/L								
2	0.0100	0.0100	0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
FLUORIDE			MG/L								
12	0.7600	2.5000	1.6050	1.6742	0.6215	0.3712	0.0	1.1865	2.1618	NORMAL	
GROSS ALPHA			PCI/L								
7	0.1000	8.0000	0.5000	NA	NA	NA	85.7	0.1000	8.0000	NONPARAMETRIC	2
GROSS BETA			PCI/L								
7	0.5000	75.0000	6.9000	NA	NA	NA	28.6	0.5000	75.0000	NONPARAMETRIC	2
IRON			MG/L								
15	0.0100	0.2500	0.0150	NA	NA	NA	46.7	0.0150	0.0800	NONPARAMETRIC	2
LEAD			MG/L								
12	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2
LEAD-210			PCI/L								
2	0.7500	0.7500	0.7500	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
MAGNESIUM			MG/L								
15	1.2700	33.1000	4.3500	4.7094	3.4773	NA	0.0	2.0242	10.9563	LOGNORMAL	7,8

* 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 D.7.18 Background water quality statistics in the Wasatch Formation, New Rifle Site
SITE: RFN01 RIFLE (NEW)
05/12/86 TO 09/19/90
REPORT DATE: 07/11/91

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
MANGANESE			MG/L								
15	0.0050	0.1200	0.0390	NA	NA	NA	26.7	0.0050	0.0960	NONPARAMETRIC	2
MOLYBDENUM			MG/L								
15	0.0050	0.2500	0.0900	0.1235	0.0869	0.7037	13.3	0.0646	0.1824	NORMAL	
NET GROSS ALPHA ***			PCI/L								
7	-4.0200	5.7400	-0.5300	NA	NA	NA	0.0	-4.0200	5.7400	NONPARAMETRIC	9
NICKEL			MG/L								
2	0.0200	0.0200	0.0200	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
NITRATE			MG/L								
12	0.3000	2.0000	0.5000	NA	NA	NA	66.7	0.5000	2.0000	NONPARAMETRIC	2
NITRITE			MG/L								
5	0.0500	0.0500	0.0500	NA	NA	NA	100.0	0.0500	0.0500	NONPARAMETRIC	2,5
PHOSPHATE			MG/L								
10	0.0500	1.8400	0.0500	NA	NA	NA	70.0	0.0500	0.6000	NONPARAMETRIC	2
POLONIUM-210			PCI/L								
2	0.5000	0.5000	0.5000	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
POTASSIUM			MG/L								
15	1.7800	28.1000	6.8700	7.5147	6.7243	0.8948	0.0	2.9588	12.0705	NORMAL	

*** 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.
9) The nonparametic distribution was used because the data failed the normal distribution test and includes values ≤0.

Table D.7.18 Background water quality statistics in the Wasatch Formation,
New Rifle Site
SITE: RFN01 RIFLE (NEW)
05/12/86 TO 09/19/90
REPORT DATE: 07/11/91

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	PCI/L	12	0.0500	1.7000	0.4500	NA	NA	NA	33.3	0.0500	0.8000	NONPARAMETRIC	2
RADIUM-226 + RADIUM-228	PCI/L	12	0.5500	5.6000	1.1000	1.7417	1.6168	0.9283	0.0	0.4731	3.0102	NORMAL	
RADIUM-228	PCI/L	12	0.4000	3.9000	0.7000	NA	NA	NA	33.3	0.5000	3.7000	NONPARAMETRIC	2
SELENIUM	MG/L	15	0.0025	0.1560	0.0025	NA	NA	NA	60.0	0.0025	0.0530	NONPARAMETRIC	2
SILICA - SIO2	MG/L	12	6.3300	8.0000	7.0000	6.9933	0.4603	0.0658	0.0	6.6322	7.3545	NORMAL	
SILVER	MG/L	5	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2,5
SODIUM	MG/L	15	476.0000	3260.0000	954.0000	1326.4667	1030.3763	0.7768	0.0	628.3724	2024.5609	NORMAL	
SPECIFIC CONDUCTANCE	UMHO/CM	15	1600.0000	11000.0000	3300.0000	4628.6667	3428.5209	0.7407	0.0	2305.7962	6951.5371	NORMAL	
STRONTIUM	MG/L	7	0.2000	8.3000	0.7000	0.8334	3.6800	NA	0.0	0.1773	3.9180	LOGNORMAL	7,8
SULFATE	MG/L	15	14.8000	1190.0000	234.0000	197.9195	3.6089	NA	0.0	82.9582	472.1913	LOGNORMAL	7,8

* The 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.

Table D.7.18 Background water quality statistics in the Wasatch Formation,
New Rifle Site
SITE: RFN01 RIFLE (NEW)
05/12/86 TO 09/19/90
REPORT DATE: 07/11/91

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
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	10.0000	16.5000	12.5000	12.8400	1.8039	0.1405	0.0	11.6178	14.0622	NORMAL	
THORIUM-230			PCI/L								
2	0.5000	0.5000	0.5000	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
TIN			MG/L								
2	0.0025	0.0025	0.0025	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
TOTAL DISSOLVED SOLIDS			MG/L								
15	1220.0000	13300.0000	2750.0000	4279.3333	3745.6307	0.8753	0.0	1741.6166	6817.0501	NORMAL	
TOTAL ORGANIC CARBON			MG/L								
5	27.0000	69.0000	52.0000	52.2000	16.1152	0.3087	0.0	25.1956	79.2044	NORMAL	
URANIUM			MG/L								
15	0.0003	0.0150	0.0015	NA	NA	NA	26.7	0.0005	0.0043	NONPARAMETRIC	2
VANADIUM			MG/L								
12	0.0050	0.0300	0.0050	NA	NA	NA	58.3	0.0050	0.0300	NONPARAMETRIC	2
ZINC			MG/L								
12	0.0025	0.4400	0.0025	NA	NA	NA	66.7	0.0025	0.0370	NONPARAMETRIC	2

* 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.

INPUT DATA FILENAME: N:\DART\RFN01\GW010006.DAT

Table D.7.19 Groundwater quality measurements exceeding maximum concentration limits in background Wasatch Formation wells, New Rifle Site
SITE: RFN01 RIFLE (NEW)
05/12/86 TO 09/19/90
REPORT DATE: 07/11/91

PARAMETER NAME	TOTAL # OF SAMP.	UNITS OF MEASURE	MAX CON. LIMIT	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	VALUE EXCEEDING MAX. CON. LIMIT	PARAMETER UNCERTAINTY
ARSENIC	15	MG/L	0.05000	-	-	-	-	-	-	-
ARSENIC (TOTAL)	0	MG/L	0.05000	-	-	-	-	-	-	-
BARIUM	12	MG/L	1.00000	0646 0646	10/28/87 09/18/90	0001 0001	WS WS	U U	1.30 1.7	- -
BARIUM (TOTAL)	0	MG/L	1.00000	-	-	-	-	-	-	-
CADMIUM	15	MG/L	0.01000	-	-	-	-	-	-	-
CADMIUM (TOTAL)	0	MG/L	0.01000	-	-	-	-	-	-	-
CHROMIUM	10	MG/L	0.05000	-	-	-	-	-	-	-
CHROMIUM (TOTAL)	0	MG/L	0.05000	-	-	-	-	-	-	-
GROSS ALPHA	7	PCI/L	15.00000	0640 0640 0645 0646	05/12/86 09/16/90 05/13/86 09/18/90	0001 0001 0001 0001	WS WS WS WS	C C C U	80. 58. 39. 83.	- 58. - 83.
GROSS ALPHA (TOTAL)	0	PCI/L	15.00000	-	-	-	-	-	-	-
LEAD	12	MG/L	0.05000	-	-	-	-	-	-	-
LEAD (TOTAL)	0	MG/L	0.05000	-	-	-	-	-	-	-
MERCURY	0	MG/L	0.00200	-	-	-	-	-	-	-
MERCURY (TOTAL)	0	MG/L	0.00200	-	-	-	-	-	-	-
MOLYBDENUM	15	MG/L	0.10000	0640 0640 0640 0641 0641	05/12/86 11/02/87 09/16/90 05/14/86 10/29/87	0001 0001 0001 0001 0001	WS WS WS WS WS	C C C C C	0.142 0.23 .21 0.24 0.25	- - - - -

FORMATION OF COMPLETION CODE:
WS - WASATCH FORMATION - UNDIFFERENTIATED

FLOW RELATIONSHIP CODE:
U - UPGRADIENT
C - CROSS GRADIENT

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

Table D.7.19 Groundwater quality measurements exceeding maximum concentration limits in background Wasatch Formation wells, New Rifle Site
SITE: RFN01 RIFLE (NEW)
05/12/86 TO 09/19/90
REPORT DATE: 07/11/91

PARAMETER NAME	TOTAL # OF SAMP.	UNITS OF MEASURE	MAX CON. LIMIT	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	VALUE EXCEEDING MAX. CON. LIMIT	PARAMETER UNCERTAINTY
MOLYBDENUM	15	MG/L	0.10000	0641	09/19/90	0001	WS	C	.23	-
				0647	10/28/87	0001	WS	U	0.11	-
MOLYBDENUM (TOTAL)	0	MG/L	0.10000	-	-	-	-	-	-	-
NET GROSS ALPHA *	7	PCI/L	15.00000	-	-	-	-	-	-	-
NET GROSS ALPHA (TOTAL) **	0	PCI/L	15.00000	-	-	-	-	-	-	-
NITRATE	12	MG/L	44.00000	-	-	-	-	-	-	-
NITRATE (TOTAL)	0	MG/L	44.00000	-	-	-	-	-	-	-
RA-226 & RA-228	12	PCI/L	5.00000	0646	10/28/87	0001	WS	U	5.6	-
RA-226 & RA-228 (TOTAL)	0	PCI/L	5.00000	-	-	-	-	-	-	-
SELENIUM	15	MG/L	0.01000	0640	11/02/87	0001	WS	C	0.117	-
				0641	10/29/87	0001	WS	C	0.053	-
				0645	11/04/87	0001	WS	C	0.037	-
				0646	10/28/87	0001	WS	U	0.156	-
				0647	10/28/87	0001	WS	U	0.023	-
SELENIUM (TOTAL)	0	MG/L	0.01000	-	-	-	-	-	-	-
SILVER	5	MG/L	0.05000	-	-	-	-	-	-	-
SILVER (TOTAL)	0	MG/L	0.05000	-	-	-	-	-	-	-
URANIUM	15	MG/L	0.04400	-	-	-	-	-	-	-
URANIUM (TOTAL)	0	MG/L	0.04400	-	-	-	-	-	-	-

* 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:
WS - WASATCH FORMATION - UNDIFFERENTIATED

FLOW RELATIONSHIP CODE:
U - UPGRADIENT
C - CROSS GRADIENT

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

DATA FILE NAME: M:\DART\RFN01\GWQ10D06.DAT

Table D.7.20 Groundwater quality measurements exceeding maximum concentration limits in alluvial monitor wells, Old Rifle Site
SITE: RF001 RIFLE (OLD)
10/22/87 TO 08/27/90
REPORT DATE: 07/11/91

PARAMETER NAME	TOTAL # OF SAMP.	UNITS OF MEASURE	MAX CON. LIMIT	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	VALUE EXCEEDING MAX. CON. LIMIT	PARAMETER UNCERTAINTY
ARSENIC	21	MG/L	0.05000	0582	10/22/87	0001	AL	O	1.14	-
				0583	08/24/90	0001	AL	O	.24	-
				0594	08/24/90	0001	AL	O	.09	-
ARSENIC (TOTAL)	0	MG/L	0.05000	-	-	-	-	-	-	-
BARIUM	21	MG/L	1.00000	-	-	-	-	-	-	-
BARIUM (TOTAL)	0	MG/L	1.00000	-	-	-	-	-	-	-
CADMIUM	21	MG/L	0.01000	-	-	-	-	-	-	-
CADMIUM (TOTAL)	0	MG/L	0.01000	-	-	-	-	-	-	-
CHROMIUM	21	MG/L	0.05000	0581	12/09/88	0001	AL	D	0.08	-
CHROMIUM (TOTAL)	0	MG/L	0.05000	-	-	-	-	-	-	-
GROSS ALPHA	7	PCI/L	15.00000	0583	08/24/90	0001	AL	D	1300.	100.
				0584	08/24/90	0001	AL	D	120.	40.
				0586	08/24/90	0001	AL	O	63.	16.
				0604	08/27/90	0001	AL	D	61.	21.
GROSS ALPHA (TOTAL)	0	PCI/L	15.00000	-	-	-	-	-	-	-
LEAD	21	MG/L	0.05000	-	-	-	-	-	-	-
LEAD (TOTAL)	0	MG/L	0.05000	-	-	-	-	-	-	-
MERCURY	1	MG/L	0.00200	-	-	-	-	-	-	-
MERCURY (TOTAL)	0	MG/L	0.00200	-	-	-	-	-	-	-
MOLYBDENUM	21	MG/L	0.10000	0581	10/22/87	0001	AL	O	0.15	-
				0582	10/22/87	0001	AL	O	0.17	-
				0583	08/24/90	0001	AL	O	.13	-
				0584	10/22/87	0001	AL	D	0.15	-

FORMATION OF COMPLETION CODE:
AL - ALLUVIUM

FLOW RELATIONSHIP CODE:
O - ON-SITE
D - DOWN GRADIENT

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

Table D.7.20 Groundwater quality measurements exceeding maximum concentration limits in alluvial monitor wells, Old Rifle Site
SITE: RFO01 RIFLE (OLD)
10/22/87 TO 08/27/90
REPORT DATE: 07/11/91

PARAMETER NAME	TOTAL # OF SAMP.	UNITS OF MEASURE	MAX CON. LIMIT	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	VALUE EXCEEDING MAX. CON. LIMIT	PARAMETER UNCERTAINTY
MOLYBDENUM	21	MG/L	0.10000	0585	10/22/87	0001	AL	O	0.11	-
				0586	10/25/87	0001	AL	O	0.12	-
				0588	10/25/87	0001	AL	O	0.12	-
				0590	10/25/87	0001	AL	D	0.15	-
				0600	10/25/87	0001	AL	D	0.15	-
				0603	10/25/87	0001	AL	D	0.15	-
				0604	10/25/87	0001	AL	D	0.13	-
MOLYBDENUM (TOTAL)	0	MG/L	0.10000	-	-	-	-	-	-	-
NET GROSS ALPHA *	7	PCI/L	15.00000	0604	08/27/90	0001	AL	D	43.9	-
NET GROSS ALPHA (TOTAL) **	0	PCI/L	15.00000	-	-	-	-	-	-	-
NITRATE	19	MG/L	44.00000	-	-	-	-	-	-	-
NITRATE (TOTAL)	0	MG/L	44.00000	-	-	-	-	-	-	-
RA-226 & RA-228	18	PCI/L	5.00000	0582	10/22/87	0001	AL	O	5.0	-
RA-226 & RA-228 (TOTAL)	0	PCI/L	5.00000	-	-	-	-	-	-	-
SELENIUM	21	MG/L	0.01000	0581	10/22/87	0001	AL	O	0.017	-
				0581	12/09/88	0001	AL	O	0.021	-
				0584	10/22/87	0001	AL	O	0.071	-
				0584	08/24/90	0001	AL	O	.069	-
				0586	10/25/87	0001	AL	O	0.014	-
				0588	10/25/87	0001	AL	O	0.010	-
				0590	10/25/87	0001	AL	D	0.117	-
				0594	08/24/90	0001	AL	O	.017	-
				0600	10/25/87	0001	AL	D	0.016	-
				0603	10/25/87	0001	AL	D	0.021	-
				0604	10/25/87	0001	AL	D	0.018	-

* 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

FLOW RELATIONSHIP CODE:
O - ON-SITE
D - DOWN GRADIENT

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

Table D.7.20 Groundwater quality measurements exceeding maximum concentration limits in alluvial monitor wells, Old Rifle Site
SITE: RF001 RIFLE (OLD)
10/22/87 TO 08/27/90
REPORT DATE: 07/11/91

PARAMETER NAME	TOTAL # OF SAMP.	UNITS OF MEASURE	MAX CON. LIMIT	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	VALUE EXCEEDING MAX. CON. LIMIT	PARAMETER UNCERTAINTY
SELENIUM (TOTAL)	0	MG/L	0.01000	-	-	-	-	-	-	-
SILVER	10	MG/L	0.05000	-	-	-	-	-	-	-
SILVER (TOTAL)	0	MG/L	0.05000	-	-	-	-	-	-	-
URANIUM	21	MG/L	0.04400	0581	10/22/87	0001	AL	O	0.949	-
				0581	12/09/88	0001	AL	O	0.944	-
				0582	10/22/87	0001	AL	O	1.11	-
				0583	08/24/90	0001	AL	O	2.10	-
				0584	10/22/87	0001	AL	O	0.131	-
				0584	08/24/90	0001	AL	O	0.193	-
				0585	10/22/87	0001	AL	O	0.364	-
				0586	10/25/87	0001	AL	O	0.108	-
				0586	08/24/90	0001	AL	O	0.105	-
				0588	10/25/87	0001	AL	O	0.128	-
				0590	10/25/87	0001	AL	D	0.0995	-
				0594	08/24/90	0001	AL	O	1.08	-
URANIUM (TOTAL)	0	MG/L	0.04400	-	-	-	-	-	-	-

FORMATION OF COMPLETION CODE:
AL - ALLUVIUM

FLOW RELATIONSHIP CODE:
O - ON-SITE
D - DOWN GRADIENT

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

DATA FILE NAME: M:\DART\RF001\GW010006.DAT

Table D.7.21 Groundwater quality measurements exceeding maximum concentration limits in downgradient Wasatch Formation Wells, Old Rifle Site
SITE: RFO01 RIFLE (OLD)
05/16/86 TO 08/24/90
REPORT DATE: 07/11/91

PARAMETER NAME	TOTAL # OF SAMP.	UNITS OF MEASURE	MAX CON. LIMIT	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	VALUE EXCEEDING MAX. CON. LIMIT	PARAMETER UNCERTAINTY
ARSENIC	12	MG/L	0.05000	-	-	-	-	-	-	-
ARSENIC (TOTAL)	1	MG/L	0.05000	-	-	-	-	-	-	-
BARIUM	12	MG/L	1.00000	0623	05/23/86	0001	WS	O	1.64	-
				0623	10/26/87	0001	WS	O	3.01	-
				0623	08/24/90	0001	WS	O	4.2	-
				0644	05/16/86	0001	WS	D	7.92	-
				0644	10/26/87	0001	WS	D	8.44	-
				0644	12/10/88	0001	WS	D	8.63	-
				0645	05/16/86	0001	WS	D	3.61	-
				0645	10/25/87	0001	WS	D	3.84	-
				0645	12/10/88	0001	WS	D	4.21	-
				0645	08/24/90	0001	WS	D	4.4	-
BARIUM (TOTAL)	1	MG/L	1.00000	0644	08/24/90	N001	WS	D	45.4	-
CADMIUM	12	MG/L	0.01000	0624	11/04/87	0001	WS	D	0.014	-
				0644	12/10/88	0001	WS	D	0.070	-
				0645	12/10/88	0001	WS	D	0.063	-
CADMIUM (TOTAL)	1	MG/L	0.01000	0644	08/24/90	N001	WS	D	.044	-
CHROMIUM	8	MG/L	0.05000	0644	12/10/88	0001	WS	D	0.09	-
				0645	12/10/88	0001	WS	D	0.08	-
CHROMIUM (TOTAL)	1	MG/L	0.05000	0644	08/24/90	N001	WS	D	.82	-
GROSS ALPHA	6	PCI/L	15.00000	0623	05/23/86	0001	WS	O	250.	-
				0623	08/24/90	0001	WS	O	100.	100.
				0624	05/27/86	0001	WS	O	120.	-
				0644	05/16/86	0001	WS	D	280.	-
				0645	05/16/86	0001	WS	D	210.	-
				0645	08/24/90	0001	WS	D	60.	130.
GROSS ALPHA (TOTAL)	1	PCI/L	15.00000	0644	08/24/90	N001	WS	D	220.	90.

FORMATION OF COMPLETION CODE:
WS - WASATCH FORMATION - UNDIFFERENTIATED

FLOW RELATIONSHIP CODE:
O - ON-SITE
D - DOWN GRADIENT

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

Table D.7.21 Groundwater quality measurements exceeding maximum concentration limits in downgradient Wasatch Formation Wells,Old Rifle Site
SITE: RFO01 RIFLE (OLD)
05/16/86 TO 08/24/90
REPORT DATE: 07/11/91

PARAMETER NAME	TOTAL # OF SAMP.	UNITS OF MEASURE	MAX CON. LIMIT	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	VALUE EXCEEDING MAX. CON. LIMIT	PARAMETER UNCERTAINTY
LEAD	12	MG/L	0.05000	0644 0645	12/10/88 12/10/88	0001 0001	WS WS	D D	0.05 0.05	- -
LEAD (TOTAL)	1	MG/L	0.05000	0644	08/24/90	N001	WS	D	1.43	-
MERCURY	2	MG/L	0.00200	-	-	-	-	-	-	-
MERCURY (TOTAL)	0	MG/L	0.00200	-	-	-	-	-	-	-
MOLYBDENUM	12	MG/L	0.10000	0623	10/26/87	0001	WS	O	0.12	-
MOLYBDENUM (TOTAL)	1	MG/L	0.10000	0644	08/24/90	N001	WS	D	.21	-
NET GROSS ALPHA *	6	PCI/L	15.00000	0645	08/24/90	0001	WS	D	59.6	-
NET GROSS ALPHA (TOTAL) **	1	PCI/L	15.00000	0644	08/24/90	N001	WS	D	97.9	-
NITRATE	9	MG/L	44.00000	-	-	-	-	-	-	-
NITRATE (TOTAL)	1	MG/L	44.00000	-	-	-	-	-	-	-
RA-226 & RA-228	9	PCI/L	5.00000	0623 0644 0644 0645 0645 0645	08/24/90 05/16/86 10/26/87 05/16/86 10/25/87 08/24/90	0001 0001 0001 0001 0001 0001	WS WS WS WS WS WS	O D D D D D	6.4 7.1 10.8 5.1 7.4 12.4	- - - - - -
RA-226 & RA-228 (TOTAL)	1	PCI/L	5.00000	0644	08/24/90	N001	WS	D	260.0	-
SELENIUM	12	MG/L	0.01000	0623 0624	10/26/87 11/04/87	0001 0001	WS WS	O O	0.138 0.076	- -

* 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:
WS - WASATCH FORMATION - UNDIFFERENTIATED

FLOW RELATIONSHIP CODE:
D - DOWN GRADIENT
O - ON-SITE

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

Table D.7.21 Groundwater quality measurements exceeding maximum concentration limits in downgradient Wasatch Formation Wells, Old Rifle Site
SITE: RFO01 RIFLE (OLD)
05/16/86 TO 08/24/90
REPORT DATE: 07/11/91

PARAMETER NAME	TOTAL # OF SAMP.	UNITS OF MEASURE	MAX CON. LIMIT	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	VALUE EXCEEDING MAX. CON. LIMIT	PARAMETER UNCERTAINTY
SELENIUM	12	MG/L	0.01000	0644 0645	10/26/87 10/25/87	0001 0001	WS WS	D D	0.170 0.041	- -
SELENIUM (TOTAL)	1	MG/L	0.01000	-	-	-	-	-	-	-
SILVER	4	MG/L	0.05000	-	-	-	-	-	-	-
SILVER (TOTAL)	1	MG/L	0.05000	0644	08/24/90	N001	WS	D	.08	-
URANIUM	12	MG/L	0.04400	-	-	-	-	-	-	-
URANIUM (TOTAL)	1	MG/L	0.04400	0644	08/24/90	N001	WS	D	0.178	-

FORMATION OF COMPLETION CODE:
WS - WASATCH FORMATION - UNDIFFERENTIATED

FLOW RELATIONSHIP CODE:
D - DOWN GRADIENT

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

DATA FILE NAME: M:\DART\RFO01\GW010009.DAT

Table D.7.22 Downgradient water quality statistics in the alluvium,
New Rifle Site
SITE: RFN01 RIFLE (NEW)
12/11/85 TO 09/18/90
REPORT DATE: 01/23/92

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
ALKALINITY			MG/L CACO3								
35	260.0000	1899.0000	652.0000	726.0286	323.5679	0.4457	0.0	592.5777	859.4794	NORMAL	
ALUMINUM			MG/L								
33	** 0.1000	0.4400	0.1300	NA	NA	NA	42.4	** 0.1000	0.2100	NONPARAMETRIC	2
AMMONIUM			MG/L								
30	** 0.1000	3650.0000	+ 665.0000	249.2723	13.8961	NA	3.3	76.3742	813.5816	LOGNORMAL	7,8
ANTIMONY			MG/L								
17	** 0.0030	0.1740	** 0.0030	NA	NA	NA	82.4	** 0.0030	** 0.0030	NONPARAMETRIC	2
ARSENIC			MG/L								
33	0.0040	2.3900	0.0100	NA	NA	NA	30.3	0.0050	0.0280	NONPARAMETRIC	2
BARIUM			MG/L								
32	0.0200	0.0500	+ 0.0500	NA	NA	NA	53.1	0.0200	0.0500	NONPARAMETRIC	2
BERYLLIUM			MG/L								
3	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
BROMIDE			MG/L								
29	** 0.1000	0.5000	** 0.1000	NA	NA	NA	82.8	** 0.1000	** 0.1000	NONPARAMETRIC	2
CADMIUM			MG/L								
33	** 0.0010	0.0900	0.0025	NA	NA	NA	60.6	** 0.0010	0.0110	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.
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 D.7.22 Downgradient water quality statistics in the alluvium,
New Rifle Site
SITE: RFN01 RIFLE (NEW)
12/11/85 TO 09/18/90
REPORT DATE: 01/23/92

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
CALCIUM			MG/L								
33	122.0000	486.0000	389.0000	340.0909	109.0500	0.3206	0.0	293.6201	386.5617	NORMAL	
CHLORIDE			MG/L								
24	33.0000	710.0000	+ 363.0000	377.7500	216.3199	0.5727	0.0	267.3597	488.1403	NORMAL	
CHROMIUM			MG/L								
32	** 0.0100	0.1200	** 0.0100	NA	NA	NA	90.6	** 0.0100	** 0.0100	NONPARAMETRIC	2
COBALT			MG/L								
3	** 0.0500	0.0700	0.0500	NA	NA	NA	33.3	NA	NA	UNKNOWN	1
COPPER			MG/L								
3	** 0.0200	** 0.0200	** 0.0200	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
CYANIDE			MG/L								
3	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
FLUORIDE			MG/L								
29	0.3000	7.8000	2.5000	2.9524	2.5037	0.8480	0.0	1.8054	4.0994	NORMAL	
GROSS ALPHA			PCI/L								
14	13.0000	300.0000	+ 82.5000	120.2857	107.0912	0.8903	0.0	44.4392	196.1322	NORMAL	
GROSS BETA			PCI/L								
14	18.0000	320.0000	+ 155.0000	145.9286	99.3188	0.6806	0.0	75.5868	216.2703	NORMAL	
IRON			MG/L								
33	0.0400	36.3000	0.1900	0.5514	9.9700	NA	0.0	0.2070	1.4692	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, 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.
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 D.7.22 Downgradient water quality statistics in the alluvium,
New Rifle Site
SITE: RFN01 RIFLE (NEW)
12/11/85 TO 09/18/90
REPORT DATE: 01/23/92

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								
32	** 0.0100	0.0300	** 0.0100	NA	NA	NA	87.5	** 0.0100	** 0.0100	NONPARAMETRIC	2
MAGNESIUM			MG/L								
33	19.6000	229.0000	104.0000	111.9545	57.1454	0.5104	0.0	87.6025	136.3066	NORMAL	
MANGANESE			MG/L								
33	0.6500	14.5000	4.6300	6.2848	4.5038	0.7166	0.0	4.3656	8.2041	NORMAL	
MERCURY			MG/L								
3	** 0.0002	** 0.0002	** 0.0002	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
MOLYBDENUM			MG/L								
33	0.0400	8.3800	1.9300	1.8197	1.7666	0.9708	0.0	1.0669	2.5725	NORMAL	
NET GROSS ALPHA ***			PCI/L								
14	-51.9000	93.1200	+ 5.2350	NA	NA	NA	0.0	-33.0800	47.4500	NONPARAMETRIC	9
NICKEL			MG/L								
3	0.0600	0.2100	0.1000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
NITRATE			MG/L								
30	0.2000	1020.0000	+ 9.7000	NA	NA	NA	26.7	0.5000	45.0000	NONPARAMETRIC	2
NITRITE			MG/L								
15	** 0.1000	** 0.1000	** 0.1000	NA	NA	NA	100.0	** 0.1000	** 0.1000	NONPARAMETRIC	2

*** 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, 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.
9) The nonparametic distribution was used because the data failed the normal distribution test and includes values ≤0.

Table D.7.22 Downgradient water quality statistics in the alluvium,
New Rifle Site
SITE: RFN01 RIFLE (NEW)
12/11/85 TO 09/18/90
REPORT DATE: 01/23/92

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
PH			SU								
35	6.5500	7.3700	6.9700	NA	NA	NA	0.0	NA	NA	UNKNOWN	
PHOSPHATE			MG/L								
29	** 0.1000	8.8900	2.7300	NA	NA	NA	48.3	** 0.1000	6.0100	NONPARAMETRIC	2
POTASSIUM			MG/L								
33	3.9900	215.0000	78.0000	87.4894	66.5835	0.7610	0.0	59.1154	115.8634	NORMAL	
RADIUM-226			PCI/L								
29	** 0.1000	0.9000	0.2000	NA	NA	NA	31.0	** 0.1000	0.3000	NONPARAMETRIC	2
RADIUM-226 + RADIUM-228			PCI/L								
29	0.3500	3.4000	1.4000	1.3948	0.7751	0.5557	0.0	1.0397	1.7499	NORMAL	
RADIUM-228			PCI/L								
29	** 1.0000	2.5000	1.3000	1.1552	0.6484	0.5613	10.3	** 1.0000	1.4522	NORMAL	
SELENIUM			MG/L								
33	** 0.0050	0.8090	0.0220	NA	NA	NA	33.3	** 0.0050	0.1420	NONPARAMETRIC	2
SILICA - SIO2			MG/L								
29	8.0000	26.0000	15.0000	16.0190	4.8191	0.3008	0.0	13.8113	18.2266	NORMAL	
SILVER			MG/L								
17	** 0.0100	0.0200	** 0.0100	NA	NA	NA	82.4	** 0.0100	** 0.0100	NONPARAMETRIC	2
SODIUM			MG/L								
33	151.0000	11300.0000	2360.0000	2808.0606	2488.6048	0.8862	0.0	1747.5613	3868.5599	NORMAL	

** The reported value is the minimum detection limit of the data set
* 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.

Table D.7.22 Downgradient water quality statistics in the alluvium,
New Rifle Site
SITE: RFN01 RIFLE (NEW)
12/11/85 TO 09/18/90
REPORT DATE: 01/23/92

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								
35	980.0000	41500.0000	10900.0000	11356.0000	9642.9634	0.8492	0.0	7378.9019	15333.0981	NORMAL	
STRONTIUM			MG/L								
17	1.1900	5.3000	2.2300	2.7135	1.2991	0.4786	0.0	1.8997	3.5274	NORMAL	
SULFATE			MG/L								
33	550.0000	32100.0000	7350.0000	8620.3333	7224.5229	0.8381	0.0	5541.6600	11699.0067	NORMAL	
SULFIDE			MG/L								
15	** 0.1000	** 0.1000	** 0.1000	NA	NA	NA	100.0	** 0.1000	** 0.1000	NONPARAMETRIC	2
TEMPERATURE			C - DEGREE								
35	10.0000	23.0000	14.0000	14.4429	3.1927	0.2211	0.0	13.1261	15.7596	NORMAL	
THALLIUM			MG/L								
3	0.0100	0.0200	0.0200	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
TIN			MG/L								
3	0.0340	0.0470	0.0350	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
TOTAL DISSOLVED SOLIDS			MG/L								
30	1230.0000	45600.0000	+10290.0000	11804.3333	10406.1065	0.8815	0.0	7126.8131	16481.8535	NORMAL	
URANIUM			MG/L								
33	0.0004	0.4470	0.1080	0.1565	0.1260	0.8054	0.0	0.1028	0.2102	NORMAL	
VANADIUM			MG/L								
33	** 0.0100	9.8600	0.2200	0.1417	6.4336	NA	9.1	0.0641	0.3132	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, 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.
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 D.7.22 Downgradient water quality statistics in the alluvium,
New Rifle Site
SITE: RFN01 RIFLE (NEW)
12/11/85 TO 09/18/90
REPORT DATE: 01/23/92

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
ZINC			MG/L								
32	** 0.0050	0.9200	+ 0.0335	NA	NA	NA	31.3	** 0.0050	0.3330	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, α = 0.01
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.

INPUT DATA FILENAME: M:\DART\RFN01\GW010015.DAT

Table D.7.23 Groundwater quality measurements exceeding maximum concentration limits in downgradient alluvial monitor wells, New Rifle Site
SITE: RFN01 RIFLE (NEW)
12/11/85 TO 09/18/90
REPORT DATE: 01/23/92

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	33	MG/L	0.0500	0581	09/16/90	0001	AL	O	.08	0.01	-
				0583	09/16/90	0001	AL	O	.07	0.01	-
				0588	10/27/87	0001	AL	O	0.132	0.01	-
				0594	10/26/87	0001	AL	O	2.39	0.01	-
				0594	09/18/90	0001	AL	O	.97	0.01	-
ARSENIC (TOTAL)	0	MG/L	0.0500	-	-	-	-	-	-	-	-
BARIUM	32	MG/L	1.0000	-	-	-	-	-	-	-	-
BARIUM (TOTAL)	0	MG/L	1.0000	-	-	-	-	-	-	-	-
CADMIUM	33	MG/L	0.0100	0581	12/10/88	0001	AL	O	0.068	0.001	-
				0584	12/10/88	0001	AL	O	0.090	0.001	-
				0587	12/10/88	0001	AL	O	0.046	0.001	-
				0590	10/27/87	0001	AL	O	0.016	0.001	-
				0594	10/26/87	0001	AL	O	0.011	0.001	-
				0600	10/27/87	0001	AL	O	0.031	0.001	-
				0600	09/16/90	0001	AL	O	.018	0.001	-
				0616	10/27/87	0001	AL	O	0.021	0.001	-
				0616	09/18/90	0001	AL	O	.016	0.001	-
				0619	09/16/90	0001	AL	O	.037	0.001	-
CADMIUM (TOTAL)	0	MG/L	0.0100	-	-	-	-	-	-	-	-
CHROMIUM	32	MG/L	0.0500	0581	12/10/88	0001	AL	O	0.12	0.01	-
				0584	12/10/88	0001	AL	O	0.11	0.01	-
				0587	12/10/88	0001	AL	O	0.11	0.01	-
CHROMIUM (TOTAL)	0	MG/L	0.0500	-	-	-	-	-	-	-	-
GROSS ALPHA	14	PCI/L	15.0000	0581	09/16/90	0001	AL	O	57.	0.2	82.
				0583	09/16/90	0001	AL	O	32.	0.2	73.
				0588	09/18/90	0001	AL	O	28.	0.2	51.
				0596	08/29/90	0001	AL	O	300.	1.0	180.
				0598	08/29/90	0001	AL	O	290.	1.0	150.
				0599	09/18/90	0001	AL	O	230.	0.2	100.

FORMATION OF COMPLETION CODE:
AL - ALLUVIUM

FLOW RELATIONSHIP CODE:
O - ON-SITE
D - DOWN GRADIENT

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

Table D.7.23 Groundwater quality measurements exceeding maximum concentration limits in downgradient alluvial monitor wells, New Rifle Site
SITE: RFN01 RIFLE (NEW)
12/11/85 TO 09/18/90
REPORT DATE: 01/23/92

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.
GROSS ALPHA	14	PCI/L	15.0000	0600	09/16/90	0001	AL	O	100.		0.2	110.
				0603	08/27/90	0001	AL	D	24.		1.0	14.
				0609	08/27/90	0001	AL	D	45.		1.0	19.
				0610	08/29/90	0001	AL	O	110.		1.0	29.
				0616	09/18/90	0001	AL	O	65.		0.2	56.
				0618	08/29/90	0001	AL	D	280.		1.0	190.
				0619	09/16/90	0001	AL	O	110.		0.2	110.
GROSS ALPHA (TOTAL)	0	PCI/L	15.0000	-	-	-	-	-	-		-	-
LEAD	32	MG/L	0.0500	-	-	-	-	-	-		-	-
LEAD (TOTAL)	0	MG/L	0.0500	-	-	-	-	-	-		-	-
MERCURY	3	MG/L	0.0020	-	-	-	-	-	-		-	-
MERCURY (TOTAL)	0	MG/L	0.0020	-	-	-	-	-	-		-	-
MOLYBDENUM	33	MG/L	0.1000	0581	10/27/87	0001	AL	D	2.78		0.01	-
				0581	12/10/88	0001	AL	D	3.01		0.01	-
				0581	09/16/90	0001	AL	D	3.09		0.01	-
				0583	09/16/90	0001	AL	D	2.68		0.01	-
				0584	12/10/88	0001	AL	O	8.38		0.01	-
				0585	10/26/87	0001	AL	C	0.14		0.01	-
				0587	12/10/88	0001	AL	D	3.84		0.01	-
				0588	10/27/87	0001	AL	O	3.35		0.01	-
				0588	09/18/90	0001	AL	D	1.69		0.01	-
				0589	10/27/87	0001	AL	D	2.58		0.01	-
				0590	10/27/87	0001	AL	O	2.41		0.01	-
				0594	10/26/87	0001	AL	D	4.14		0.01	-
				0594	09/18/90	0001	AL	O	2.52		0.01	-
				0595	10/27/87	0001	AL	O	2.24		0.01	-
				0596	08/29/90	0001	AL	D	.10		0.01	-
				0598	08/29/90	0001	AL	O	.41		0.01	-
				0599	10/28/87	0001	AL	O	0.28		0.01	-
				0599	09/18/90	0001	AL	D	.69		0.01	-

FORMATION OF COMPLETION CODE:
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FLOW RELATIONSHIP CODE:
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SAMPLE ID CODES:
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Table D.7.23 Groundwater quality measurements exceeding maximum concentration limits in downgradient alluvial monitor wells, New Rifle Site
SITE: RFN01 RIFLE (NEW)
12/11/85 TO 09/18/90
REPORT DATE: 01/23/92

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.
MOLYBDENUM	33	MG/L	0.1000	0600	10/27/87	0001	AL	O	2.83	0.01	-
				0600	09/16/90	0001	AL	O	2.01	0.01	-
				0603	10/28/87	0001	AL	D	0.11	0.01	-
				0609	10/28/87	0001	AL	D	0.15	0.01	-
				0610	10/28/87	0001	AL	O	0.93	0.01	-
				0610	08/29/90	0001	AL	O	.25	0.01	-
				0615	10/26/87	0001	AL	O	2.71	0.01	-
				0616	10/27/87	0001	AL	O	1.35	0.01	-
				0616	09/18/90	0001	AL	O	1.93	0.01	-
				0618	10/28/87	0001	AL	D	0.20	0.01	-
				0618	08/29/90	0001	AL	D	.10	0.01	-
				0619	09/16/90	0001	AL	O	2.98	0.01	-
MOLYBDENUM (TOTAL)	0	MG/L	0.1000	-	-	-	-	-	-	-	-
NET GROSS ALPHA *	14	PCI/L	15.0000	0596	08/29/90	0001	AL	D	69.5	-	-
				0598	08/29/90	0001	AL	D	93.1	-	-
				0599	09/18/90	0001	AL	D	20.8	-	-
				0618	08/29/90	0001	AL	D	47.4	-	-
NET GROSS ALPHA (TOTAL) **	0	PCI/L	15.0000	-	-	-	-	-	-	-	-
NITRATE	30	MG/L	44.0000	0589	10/27/87	0001	AL	D	1020.	1.0	-
				0590	10/27/87	0001	AL	O	45.0	1.0	-
				0596	08/29/90	0001	AL	D	952.	1.0	-
				0598	08/29/90	0001	AL	D	199.	1.0	-
				0599	09/18/90	0001	AL	D	89.	1.0	-
				0600	10/27/87	0001	AL	O	45.0	1.0	-
				0610	10/28/87	0001	AL	O	50.5	1.0	-
				0618	10/28/87	0001	AL	D	709.	1.0	-
				0618	08/29/90	0001	AL	D	935.	1.0	-
				0619	09/16/90	0001	AL	O	276.	1.0	-
NITRATE (TOTAL)	0	MG/L	44.0000	-	-	-	-	-	-	-	-

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

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Table D.7.23 Groundwater quality measurements exceeding maximum concentration limits in downgradient alluvial monitor wells, New Rifle Site
SITE: RFN01 RIFLE (NEW)
12/11/85 TO 09/18/90
REPORT DATE: 01/23/92

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.
RA-226 & RA-228	29	PCI/L	5.0000	-	-	-	-	-	-	-	-
RA-226 & RA-228 (TOTAL)	0	PCI/L	5.0000	-	-	-	-	-	-	-	-
SELENIUM	33	MG/L	0.0100	0581	10/27/87	0001	AL	O	0.469	0.005	-
				0581	12/10/88	0001	AL	O	0.018	0.005	-
				0581	09/16/90	0001	AL	O	.01	0.005	-
				0584	12/10/88	0001	AL	O	0.015	0.005	-
				0585	10/26/87	0001	AL	C	0.022	0.005	-
				0587	12/10/88	0001	AL	D	0.018	0.005	-
				0588	10/27/87	0001	AL	O	0.108	0.005	-
				0589	10/27/87	0001	AL	D	0.625	0.005	-
				0590	10/27/87	0001	AL	O	0.809	0.005	-
				0594	10/26/87	0001	AL	O	0.185	0.005	-
				0595	10/27/87	0001	AL	D	0.425	0.005	-
				0599	10/28/87	0001	AL	O	0.295	0.005	-
				0600	10/27/87	0001	AL	D	0.421	0.005	-
				0600	09/16/90	0001	AL	D	.03	0.005	-
				0603	10/28/87	0001	AL	D	0.025	0.005	-
				0609	10/28/87	0001	AL	D	0.056	0.005	-
				0610	10/28/87	0001	AL	O	0.066	0.005	-
				0610	08/29/90	0001	AL	O	.024	0.005	-
				0615	10/26/87	0001	AL	O	0.142	0.005	-
				0616	10/27/87	0001	AL	O	0.253	0.005	-
				0618	10/28/87	0001	AL	O	0.295	0.005	-
				0619	09/16/90	0001	AL	O	.02	0.005	-
SELENIUM (TOTAL)	0	MG/L	0.0100	-	-	-	-	-	-	-	-
SILVER	17	MG/L	0.0500	-	-	-	-	-	-	-	-
SILVER (TOTAL)	0	MG/L	0.0500	-	-	-	-	-	-	-	-
URANIUM	33	MG/L	0.0440	0581	10/27/87	0001	AL	O	0.123	0.003	-
				0581	12/10/88	0001	AL	O	0.0602	0.003	-
				0581	09/16/90	0001	AL	O	0.0925	0.003	-

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Table D.7.23 Groundwater quality measurements exceeding maximum concentration limits in downgradient alluvial monitor wells, New Rifle Site
SITE: RFN01 RIFLE (NEW)
12/11/85 TO 09/18/90
REPORT DATE: 01/23/92

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.
URANIUM	33	MG/L	0.0440	0583	09/16/90	0001	AL	O	0.101		0.003	-
				0584	12/10/88	0001	AL	O	0.0629		0.003	-
				0588	10/27/87	0001	AL	O	0.0441		0.003	-
				0589	10/27/87	0001	AL	O	0.241		0.003	-
				0590	10/27/87	0001	AL	O	0.258		0.003	-
				0595	10/27/87	0001	AL	O	0.108		0.003	-
				0596	08/29/90	0001	AL	D	0.336		0.003	-
				0598	08/29/90	0001	AL	O	0.287		0.003	-
				0599	10/28/87	0001	AL	O	0.447		0.003	-
				0599	09/18/90	0001	AL	O	0.305		0.003	-
				0600	10/27/87	0001	AL	O	0.116		0.003	-
				0600	09/16/90	0001	AL	O	0.194		0.003	-
				0603	12/11/85	0001	AL	D	0.0716		0.003	-
				0609	10/28/87	0001	AL	D	0.0915		0.003	-
				0609	08/27/90	0001	AL	D	0.054		0.003	-
				0610	10/28/87	0001	AL	O	0.312		0.003	-
				0610	08/29/90	0001	AL	O	0.197		0.003	-
				0615	10/26/87	0001	AL	O	0.390		0.003	-
				0616	10/27/87	0001	AL	O	0.106		0.003	-
				0616	09/18/90	0001	AL	O	0.127		0.003	-
				0618	10/28/87	0001	AL	D	0.300		0.003	-
				0618	08/29/90	0001	AL	D	0.339		0.003	-
				0619	09/16/90	0001	AL	O	0.236		0.003	-
URANIUM (TOTAL)	0	MG/L	0.0440	-	-	-	-	-	-		-	-

FORMATION OF COMPLETION CODE:
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O - ON-SITE
D - DOWN GRADIENT

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

DATA FILE NAME: M:\DART\RFN01\GWQ10015.DAT

Table D.7.24 Downgradient water quality statistics in the Wasatch Formation, New Rifle Site
SITE: RFN01 RIFLE (NEW)
06/26/85 TO 09/16/90
REPORT DATE: 07/11/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
ALKALINITY	MG/L CACO3	51	39.0000	1390.0000	357.0000	500.1765	408.0495	0.8158	0.0	362.8730	637.4800	NORMAL	
ALUMINUM	MG/L	39	0.0500	0.2600	0.0500	NA	NA	NA	53.8	0.0500	0.1600	NONPARAMETRIC	2
AMMONIUM	MG/L	51	0.1000	3610.0000	3.6000	15.6642	30.2490	NA	0.0	4.9736	49.3344	LOGNORMAL	7,8
ANTIMONY	MG/L	18	0.0015	0.0100	0.0015	NA	NA	NA	66.7	0.0015	0.0060	NONPARAMETRIC	2
ARSENIC	MG/L	51	0.0030	0.0670	0.0050	NA	NA	NA	49.0	0.0050	0.0100	NONPARAMETRIC	2
BARIUM	MG/L	39	0.0100	2.2800	0.0500	NA	NA	NA	43.6	0.0500	0.0900	NONPARAMETRIC	2
BORON	MG/L	1	0.1000	0.1000	0.1000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
BROMIDE	MG/L	31	0.0500	24.0000	0.5000	0.5387	4.5388	NA	9.7	0.2764	1.0502	LOGNORMAL	7,8
CADMIUM	MG/L	51	0.0005	0.0060	0.0005	NA	NA	NA	96.1	0.0005	0.0005	NONPARAMETRIC	2
CALCIUM	MG/L	51	4.9900	692.0000	260.0000	242.0502	188.7025	0.7796	0.0	178.5542	305.5462	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.
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 D.7.24 Downgradient water quality statistics in the Wasatch Formation,
New Rifle Site
SITE: RFN01 RIFLE (NEW)
06/26/85 TO 09/16/90
REPORT DATE: 07/11/91

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								
51	0.9000	7350.0000	1000.0000	512.5934	9.8685	NA	0.0	237.2577	1107.4539	LOGNORMAL	7,8
CHROMIUM			MG/L								
32	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2
COBALT			MG/L								
8	0.0250	0.2100	0.0250	NA	NA	NA	87.5	0.0250	0.2100	NONPARAMETRIC	2
COPPER			MG/L								
8	0.0100	0.0400	0.0100	NA	NA	NA	75.0	0.0100	0.0400	NONPARAMETRIC	2
FLUORIDE			MG/L								
39	0.3500	10.9000	1.7000	2.3715	2.1835	0.9207	0.0	1.5226	3.2205	NORMAL	
GROSS ALPHA			PCI/L								
23	0.1000	150.0000	0.5000	NA	NA	NA	52.2	0.1000	40.0000	NONPARAMETRIC	2
GROSS BETA			PCI/L								
23	0.5000	270.0000	17.0000	NA	NA	NA	26.1	0.5000	120.0000	NONPARAMETRIC	2
IRON			MG/L								
51	0.0150	38.9000	0.1300	NA	NA	NA	19.6	0.0400	3.7900	NONPARAMETRIC	2
LEAD			MG/L								
39	0.0050	0.0500	0.0050	NA	NA	NA	87.2	0.0050	0.0050	NONPARAMETRIC	2
LEAD-210			PCI/L								
7	0.7500	0.7500	0.7500	NA	NA	NA	100.0	0.7500	0.7500	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.

Table D.7.24 Downgradient water quality statistics in the Wasatch Formation, New Rifle Site
SITE: RFN01 RIFLE (NEW)
06/26/85 TO 09/16/90
REPORT DATE: 07/11/91

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
MAGNESIUM			MG/L								
51	0.8500	302.0000	58.7000	103.3494	102.0243	0.9872	0.0	69.0195	137.6793	NORMAL	
MANGANESE			MG/L								
51	0.0050	16.2000	0.2000	0.3724	12.2970	NA	7.8	0.1601	0.8665	LOGNORMAL	7,8
MERCURY			MG/L								
1	0.0001	0.0001	0.0001	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
MOLYBDENUM			MG/L								
51	0.0050	2.5600	0.1420	0.1445	5.9564	NA	9.8	0.0792	0.2633	LOGNORMAL	7,8
NET GROSS ALPHA ***			PCI/L								
23	-624.1600	58.6600	-0.3200	NA	NA	NA	0.0	-3.3400	27.2500	NONPARAMETRIC	9
NICKEL			MG/L								
8	0.0200	0.1400	0.0200	NA	NA	NA	87.5	0.0200	0.1400	NONPARAMETRIC	2
NITRATE			MG/L								
39	0.1000	11.0000	0.5000	NA	NA	NA	64.1	0.5000	0.8000	NONPARAMETRIC	2
NITRITE			MG/L								
15	0.0500	0.1000	0.0500	NA	NA	NA	93.3	0.0500	0.0500	NONPARAMETRIC	2
NITRITE AND NITRATE			MG/L								
1	0.0500	0.0500	0.0500	NA	NA	NA	100.0	NA	NA	UNKNOWN	1

*** 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.
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 nonparametetic distribution was used because the data failed the normal distribution test and includes values ≤0.

Table D.7.24 Downgradient water quality statistics in the Wasatch Formation,
New Rifle Site
SITE: RFN01 RIFLE (NEW)
06/26/85 TO 09/16/90
REPORT DATE: 07/11/91

PARAMETER NAME / # OF SAMP	MINIMUM	MAXIMUM	UNITS / MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 95% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
PHOSPHATE			MG/L								
33	0.0500	11.1000	0.0500	NA	NA	NA	69.7	0.0500	0.2000	NONPARAMETRIC	2
POLONIUM-210			PCI/L								
7	0.5000	0.5000	0.5000	NA	NA	NA	100.0	0.5000	0.5000	NONPARAMETRIC	2
POTASSIUM			MG/L								
51	1.7000	261.0000	18.0000	20.2641	4.2111	NA	0.0	12.4918	32.8722	LOGNORMAL	7,8
RADIUM-226			PCI/L								
38	0.0500	3.6000	0.2000	NA	NA	NA	39.5	0.1000	0.5000	NONPARAMETRIC	2
RADIUM-226 + RADIUM-228			PCI/L								
38	0.1500	23.5000	1.4250	1.4360	2.5712	NA	0.0	0.9895	2.0840	LOGNORMAL	7,8
RADIUM-228			PCI/L								
38	0.1000	23.0000	1.1000	NA	NA	NA	28.9	0.5000	1.6000	NONPARAMETRIC	2
SELENIUM			MG/L								
51	0.0025	0.7490	0.0025	NA	NA	NA	56.9	0.0025	0.0300	NONPARAMETRIC	2
SILICA - SIO2			MG/L								
39	3.0000	14.1000	9.0000	9.5410	2.5985	0.2724	0.0	8.5308	10.5513	NORMAL	
SILVER			MG/L								
18	0.0050	0.0100	0.0050	NA	NA	NA	94.4	0.0050	0.0050	NONPARAMETRIC	2
SODIUM			MG/L								
51	553.0000	10100.0000	3100.0000	3215.3725	2604.9264	0.8101	0.0	2338.8479	4091.8972	NORMAL	

* 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 D.7.24 Downgradient water quality statistics in the Wasatch Formation, New Rifle Site
SITE: RFN01 RIFLE (NEW)
06/26/85 TO 09/16/90
REPORT DATE: 07/11/91

PARAMETER NAME			UNITS		STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN							
SPECIFIC CONDUCTANCE			UMHO/CM								
51	32.5000	33500.0000	9300.0000	10936.7157	8816.9907	0.8062	0.0	7969.9103	13903.5211	NORMAL	
STRONTIUM			MG/L								
24	0.3000	17.3000	3.6300	6.1445	5.7687	0.9388	0.0	3.2007	9.0883	NORMAL	
SULFATE			MG/L								
51	21.0000	26800.0000	1170.0000	1166.7063	10.4616	NA	0.0	529.5164	2570.6543	LOGNORMAL	7,8
SULFIDE			MG/L								
16	0.0500	0.2000	0.0500	NA	NA	NA	93.8	0.0500	0.0500	NONPARAMETRIC	2
TEMPERATURE			C - DEGREE								
51	10.5000	18.0000	12.5000	12.7922	1.4747	0.1153	0.0	12.2959	13.2884	NORMAL	
THORIUM-230			PCI/L								
7	0.5000	63.1000	0.5000	NA	NA	NA	85.7	0.5000	63.1000	NONPARAMETRIC	2
TIN			MG/L								
8	0.0025	0.1040	0.0025	NA	NA	NA	87.5	0.0025	0.1040	NONPARAMETRIC	2
TOTAL DISSOLVED SOLIDS			MG/L								
51	1430.0000	42400.0000	11100.0000	12409.4118	11432.6195	0.9213	0.0	8562.4805	16256.3431	NORMAL	
TOTAL ORGANIC CARBON			MG/L								
17	2.0000	218.0000	52.0000	84.4118	75.3749	0.8929	0.0	37.1917	131.6319	NORMAL	
URANIUM			MG/L								
51	0.0003	0.9100	0.0056	0.0097	9.1663	NA	13.7	0.0046	0.0205	LOGNORMAL	7,8

* 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 D.7.24 Downgradient water quality statistics in the Wasatch Formation, New Rifle Site
SITE: RFN01 RIFLE (NEW)
06/26/85 TO 09/16/90
REPORT DATE: 07/11/91

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								
39	0.0050	0.2200	0.0200	NA	NA	NA	38.5	0.0050	0.0700	NONPARAMETRIC	2
ZINC			MG/L								
39	0.0025	0.6570	0.0060	NA	NA	NA	46.2	0.0025	0.0170	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.

INPUT DATA FILENAME: M:\DART\RFN01\GWQ10007.DAT

Table D.7.25 Groundwater quality measurements exceeding maximum concentration limits in downgradient Wasatch Formation wells,New Rifle Site
SITE: RFN01 RIFLE (NEW)
06/26/85 TO 09/16/90
REPORT DATE: 07/11/91

PARAMETER NAME	TOTAL # OF SAMP.	UNITS OF MEASURE	MAX CON. LIMIT	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	VALUE EXCEEDING MAX. CON. LIMIT	PARAMETER UNCERTAINTY
ARSENIC	51	MG/L	0.05000	0611	11/02/87	0001	WS	O	0.067	-
				0612	11/02/87	0001	WS	D	0.062	-
				0612	09/14/90	0001	WS	O	.058	-
				0613	11/02/87	0001	WS	O	0.053	-
ARSENIC (TOTAL)	0	MG/L	0.05000	-	-	-	-	-	-	-
BARIUM	39	MG/L	1.00000	0625	11/04/87	0001	WS	O	2.28	-
				0625	08/27/90	0001	WS	O	1.0	-
BARIUM (TOTAL)	0	MG/L	1.00000	-	-	-	-	-	-	-
CADMIUM	51	MG/L	0.01000	-	-	-	-	-	-	-
CADMIUM (TOTAL)	0	MG/L	0.01000	-	-	-	-	-	-	-
CHROMIUM	32	MG/L	0.05000	-	-	-	-	-	-	-
CHROMIUM (TOTAL)	0	MG/L	0.05000	-	-	-	-	-	-	-
GROSS ALPHA	23	PCI/L	15.00000	0611	09/12/90	0001	WS	O	150.	140.
				0612	09/14/90	0001	WS	O	90.	140.
				0613	09/14/90	0001	WS	O	130.	130.
				0614	09/12/90	0001	WS	O	100.	100.
				0621	05/16/86	0001	WS	D	230.	-
				0621	09/16/90	0001	WS	D	60.	110.
				0622	05/13/86	0001	WS	D	60.	-
				0624	09/13/90	0001	WS	O	90.	110.
				0625	08/27/90	0001	WS	O	130.	130.
				0627	09/12/90	0001	WS	O	20.	120.
				0629	05/23/86	0001	WS	O	260.	-
				0629	09/12/90	0001	WS	O	40.	110.
				0630	08/29/90	0001	WS	O	28.	20.
				0631	08/29/90	0001	WS	O	35.	39.
				0632	05/23/86	0001	WS	C	120.	-
				0632	08/30/90	0001	WS	C	47.	47.

FORMATION OF COMPLETION CODE:
WS - WASATCH FORMATION - UNDIFFERENTIATED

FLOW RELATIONSHIP CODE:
O - ON-SITE
D - DOWN GRADIENT
C - CROSS GRADIENT

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

Table D.7.25 Groundwater quality measurements exceeding maximum concentration limits in downgradient Wasatch Formation wells, New Rifle Site
SITE: RFN01 RIFLE (NEW)
06/26/85 TO 09/16/90
REPORT DATE: 07/11/91

PARAMETER NAME	TOTAL # OF SAMP.	UNITS OF MEASURE	MAX CON. LIMIT	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	VALUE EXCEEDING MAX. CON. LIMIT	PARAMETER UNCERTAINTY
GROSS ALPHA	23	PCI/L	15.00000	0633	05/27/86	0001	WS	C	37.	-
				0633	08/30/90	0001	WS	C	15.	15.
				0634	08/27/90	0001	WS	C	55.	55.
				0651	05/23/86	0001	WS	D	56.	-
				0651	08/30/90	0001	WS	D	17.	35.
GROSS ALPHA (TOTAL)	0	PCI/L	15.00000	-	-	-	-	-	-	-
LEAD	39	MG/L	0.05000	0624	11/03/87	0001	WS	O	0.05	-
LEAD (TOTAL)	0	MG/L	0.05000	-	-	-	-	-	-	-
MERCURY	1	MG/L	0.00200	-	-	-	-	-	-	-
MERCURY (TOTAL)	0	MG/L	0.00200	-	-	-	-	-	-	-
MOLYBDENUM	51	MG/L	0.10000	0611	05/21/86	0001	WS	O	1.55	-
				0611	11/02/87	0001	WS	O	1.46	-
				0611	09/12/90	0001	WS	O	2.03	-
				0612	05/22/86	0001	WS	O	0.95	-
				0612	11/02/87	0001	WS	O	1.22	-
				0612	09/14/90	0001	WS	O	1.33	-
				0613	05/22/86	0001	WS	O	1.88	-
				0613	11/02/87	0001	WS	O	2.17	-
				0613	09/14/90	0001	WS	O	2.28	-
				0622	05/13/86	0001	WS	D	0.142	-
				0622	11/03/87	0001	WS	D	0.17	-
				0622	09/16/90	0001	WS	D	.16	-
				0623	11/02/87	0001	WS	O	0.13	-
				0624	05/19/86	0001	WS	O	0.9	-
				0624	11/03/87	0001	WS	O	2.46	-
				0624	09/13/90	0001	WS	O	2.56	-
				0627	11/20/85	0001	WS	O	0.21	-
				0627	11/02/87	0001	WS	O	0.22	-
				0629	11/02/87	0001	WS	O	0.20	-
				0630	05/19/86	0001	WS	O	0.15	-

FORMATION OF COMPLETION CODE:
WS - WASATCH FORMATION - UNDIFFERENTIATED

FLOW RELATIONSHIP CODE:
C - CROSS GRADIENT
D - DOWN GRADIENT
O - ON-SITE

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

Table D.7.25 Groundwater quality measurements exceeding maximum concentration limits in downgradient Wasatch Formation wells, New Rifle Site
SITE: RFN01 RIFLE (NEW)
06/26/85 TO 09/16/90
REPORT DATE: 07/11/91

PARAMETER NAME	TOTAL # OF SAMP.	UNITS OF MEASURE	MAX CON. LIMIT	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	VALUE EXCEEDING MAX. CON. LIMIT	PARAMETER UNCERTAINTY
MOLYBDENUM	51	MG/L	0.10000	0630	11/03/87	0001	WS	O	0.18	-
				0630	08/29/90	0001	WS	O	.19	-
				0631	05/19/86	0001	WS	O	0.12	-
				0631	11/04/87	0001	WS	O	0.11	-
				0631	08/29/90	0001	WS	O	.10	-
				0632	05/23/86	0001	WS	C	0.21	-
				0632	11/04/87	0001	WS	C	0.34	-
				0632	08/30/90	0001	WS	C	.26	-
				0633	05/27/86	0001	WS	C	0.66	-
				0633	08/30/90	0001	WS	C	.69	-
MOLYBDENUM (TOTAL)	0	MG/L	0.10000	-	-	-	-	-	-	-
NET GROSS ALPHA *	23	PCI/L	15.00000	0611	09/12/90	0001	WS	O	43.0	-
				0612	09/14/90	0001	WS	O	24.3	-
				0613	09/14/90	0001	WS	O	56.7	-
				0621	09/16/90	0001	WS	D	58.4	-
				0627	09/12/90	0001	WS	O	15.1	-
				0629	09/12/90	0001	WS	O	27.7	-
				0630	08/29/90	0001	WS	O	27.2	-
				0631	08/29/90	0001	WS	O	32.1	-
				0651	08/30/90	0001	WS	D	16.2	-
NET GROSS ALPHA (TOTAL) **	0	PCI/L	15.00000	-	-	-	-	-	-	-
NITRATE	39	MG/L	44.00000	-	-	-	-	-	-	-
NITRATE (TOTAL)	0	MG/L	44.00000	-	-	-	-	-	-	-
RA-226 & RA-228	38	PCI/L	5.00000	0613	06/26/85	0001	WS	O	23.5	-
				0621	11/03/87	0001	WS	D	6.5	-
				0621	09/16/90	0001	WS	D	7.5	-

* 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:
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O - ON-SITE
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D - DOWN GRADIENT

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

Table D.7.25 Groundwater quality measurements exceeding maximum concentration limits in downgradient Wasatch Formation wells,New Rifle Site
SITE: RFN01 RIFLE (NEW)
06/26/85 TO 09/16/90
REPORT DATE: 07/11/91

PARAMETER NAME	TOTAL # OF SAMP.	UNITS OF MEASURE	MAX CON. LIMIT	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	VALUE EXCEEDING MAX. CON. LIMIT	PARAMETER UNCERTAINTY
RA-226 & RA-228	38	PCI/L	5.00000	0625	11/04/87	0001	WS	O	7.1	-
RA-226 & RA-228 (TOTAL)	0	PCI/L	5.00000	-	-	-	-	-	-	-
SELENIUM	51	MG/L	0.01000	0611	11/02/87	0001	WS	O	0.631	-
				0611	09/12/90	0001	WS	O	.01	-
				0612	11/02/87	0001	WS	O	0.749	-
				0612	09/14/90	0001	WS	D	.01	-
				0613	06/26/85	0001	WS	O	0.069	-
				0613	11/02/87	0001	WS	O	0.688	-
				0621	11/03/87	0001	WS	D	0.346	-
				0621	09/16/90	0001	WS	D	.02	-
				0622	11/03/87	0001	WS	O	0.046	-
				0623	11/02/87	0001	WS	O	0.119	-
				0624	11/03/87	0001	WS	O	0.527	-
				0625	11/04/87	0001	WS	O	0.419	-
				0625	08/27/90	0001	WS	O	.03	-
				0627	11/02/87	0001	WS	O	0.255	-
				0629	11/02/87	0001	WS	O	0.223	-
				0630	11/03/87	0001	WS	O	0.042	-
				0631	11/04/87	0001	WS	O	0.037	-
				0632	11/04/87	0001	WS	C	0.068	-
				0634	10/29/87	0001	WS	C	0.105	-
				0651	11/03/87	0001	WS	O	0.055	-
SELENIUM (TOTAL)	0	MG/L	0.01000	-	-	-	-	-	-	-
SILVER	18	MG/L	0.05000	-	-	-	-	-	-	-
SILVER (TOTAL)	0	MG/L	0.05000	-	-	-	-	-	-	-
URANIUM	51	MG/L	0.04400	0611	05/21/86	0001	WS	O	0.42	-
				0611	11/02/87	0001	WS	O	0.224	-
				0611	09/12/90	0001	WS	O	0.156	-
				0612	05/22/86	0001	WS	O	0.33	-
				0612	11/02/87	0001	WS	O	0.208	-

FORMATION OF COMPLETION CODE:
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FLOW RELATIONSHIP CODE:
O - ON-SITE
D - DOWN GRADIENT
C - CROSS GRADIENT

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

Table D.7.25 Groundwater quality measurements exceeding maximum concentration limits in downgradient Wasatch Formation wells, New Rifle Site
SITE: RFN01 RIFLE (NEW)
06/26/85 TO 09/16/90
REPORT DATE: 07/11/91

PARAMETER NAME	TOTAL # OF SAMP.	UNITS OF MEASURE	MAX CON. LIMIT	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	VALUE EXCEEDING MAX. CON. LIMIT	PARAMETER UNCERTAINTY
URANIUM	51	MG/L	0.04400	0612	09/14/90	0001	WS	O	0.0957	-
				0613	06/26/85	0001	WS	O	0.91	-
				0613	05/22/86	0001	WS	O	0.48	-
				0613	11/02/87	0001	WS	O	0.211	-
				0613	09/14/90	0001	WS	O	0.104	-
				0614	05/23/86	0001	WS	O	0.044	-
				0624	05/19/86	0001	WS	O	0.51	-
				0624	11/03/87	0001	WS	O	0.243	-
				0624	09/13/90	0001	WS	O	0.170	-
URANIUM (TOTAL)	0	MG/L	0.04400	-	-	-	-	-	-	-

FORMATION OF COMPLETION CODE:
WS - WASATCH FORMATION - UNDIFFERENTIATED

FLOW RELATIONSHIP CODE:
O - ON-SITE

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

DATA FILE NAME: M:\DART\RFN01\GW010007.DAT

Table D.7.26 Completion intervals and groundwater levels in monitor wells, Estes Gulch site

Monitor well number[a]	Completion interval[b] (depth in ft)	Groundwater level (ft above mean sea level)		
		01/14/86	10/20/87	
952	245.75 to 250.75	Dry		
955	55.00 to 60.00	Dry	Dry	
956	58.00 to 73.00	Dry	Dry	
958	106.40 to 116.40	Dry	Dry	
959	97.25 to 102.25	Dry	Dry	
962	67.25 to 72.25	Dry	Dry	
963	296.0 to 301.0	5773.55[c]	5860.75[c]	
964	212.50 to 217.50	Dry	Dry	
965	97.25 to 102.75	Dry	Dry	
969	97.50 to 102.50	Dry	Dry	
		7/28/88	12/10/88	3/24/89
701	180 to 545	5455	5581	5640
702	355 to 543	5521	5519	5529
703	420 to 502	5516	5558	5585

[a]Monitor well locations are shown on Figure D.7.6.
[b]All monitor wells are completed in the Wasatch Formation and have casing diameters of 4 inches.
[c]The depth from the land surface to groundwater in monitor well 963 was 270.2 feet on 01/14/86 and 183 feet on 10/20/87.

Table D.7.27 Borehole depths and saturated hydraulic conductivities measured using packer tests in the Wasatch Formation, Estes Gulch site

Borehole number	Depth below ground (ft)	Depth into bedrock (ft)	Material description	Saturated hydraulic conductivity (cm/s)	Saturated hydraulic conductivity (ft/day)
711	24.5-35	11-21.5	Silty, clayey sandstone, widely fractured	<1. E-07[1]	<3. E-04
	52-60	38.5-46.5	Clayey shale, closely fractured	<1. E-07	<3. E-04
	87-97	73.5-83.5	Clayey shale and sandstone, closely fractured	2. E-05	5. E-02
712	40-50	8-18	Clayey sandstone, very closely to closely fractured	6. E-06	2. E-02
	62-74	30-42	Shale and shaley sandstone, close to medium fractured spacing	2. E-06	4. E-03
	92-105	60-69	Shaley sandstone, medium to widely spaced fractures	2. E-06	5. E-03
	117-127	85-95	Shaley sandstone, massive	2. E-06	7. E-03
713	52-66	12-26	Clayey sandstone and clayey shale, moderately fractured	7. E-06	2. E-02
	74-84	34-44	Clayey sandstone, closely to widely spaced fractures	<1. E-07	<3. E-04
	91-101	51-61	Closely fractured clay shale, widely fractured sandstone	3. E-05	7. E-02
	128-140	88-100	Clay shale, massive	<1. E-07	<3. E-04
714	47-55	4-12	Clay shale, very closely spaced fractures	5. E-06	1. E-02
	87-97	44-54	Silty, clayey sandstone, widely fractured	<1. E-07	<3. E-04
	113-126	70-83	Mostly silty, clayey sandstone, widely fractured, with some conglomeration, widely fractured	<1. E-07	<3. E-04
	131-145	88-102	Closely to widely fractured clay shale, widely fractured clay shale	<1. E-07	<3. E-04
715	43-57	3-17	Mostly clay shale, closely fractured; some massive sandstone	2. E-04	6. E-01
	83-92	43-52	Massive clay shale, some medium spaced fracturing	<1. E-07	<3. E-04
	123-143	83-103	Mostly massive clayey sandstone; some massive shale	<1. E-07	<3. E-04

[1]Hydraulic conductivity values of <1.E-07 cm/s indicate that the formation did not accept water during the testing.

Table D.7.28 Hydraulic conductivity for the Wasatch Formation, Estes Gulch site

Monitor well[a] number	Method	Hydraulic conductivity (cm/s)	Hydraulic conductivity (ft/day)
952	constant head permeability test	4×10^{-9}	1.1×10^{-5}
964	constant head permeability test	2×10^{-9}	5.8×10^{-6}
965[b]	constant head permeability test	6×10^{-8}	1.7×10^{-4}
969	constant head permeability test	2×10^{-7}	7.0×10^{-4}
	Geometric mean:	2×10^{-8}	6×10^{-5}

[a]Monitor well locations shown in Figure D.7.6.
[b]Monitor well 965 is located in the fault zone south of the disposal site.

Table D.7.29 Groundwater quality data for Estes Gulch monitor wells and vicinity domestic wells
SITE: RFL08 ESTES GULCH
11/05/87 TO 03/10/90
REPORT DATE: 07/11/91

		LOC / DATE: 0701 - 08/26/88 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: DOWN GRADIENT LABORATORY CODE: BAR LOT NUMBER: 001 SAMPLE TYPE: FR				LOC / DATE: 0701 - 04/23/89 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: DOWN GRADIENT LABORATORY CODE: BAR LOT NUMBER: 001 SAMPLE TYPE: FR				LOC / DATE: 0701 - 09/22/89 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: DOWN GRADIENT LABORATORY CODE: BAR LOT NUMBER: 001 SAMPLE TYPE: F				LOC / DATE: 0701 - 03/08/90 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: DOWN GRADIENT LABORATORY CODE: COR LOT NUMBER: 001 SAMPLE TYPE: FR			
PARAMETER NAME	UNIT OF MEASURE	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS
ALKALINITY	MG/L CACO3		61.	-			31.	-			19.	-			17.0	-	
ALUMINUM	MG/L		0.3	-		<	0.1	-		<	0.1	-		<	0.05	-	
AMMONIUM	MG/L		1.7	-			0.6	-			1.8	-			1.6	-	
ANTIMONY	MG/L		0.120	-			0.003	-			0.163	-		<	0.03	-	c
ARSENIC	MG/L		0.03	-		<	0.01	-			0.024	-		<	0.05	-	c
BARIUM	MG/L		1.65	-			1.6	-			5.4	-			5.11	-	
BERYLLIUM	MG/L		-	-		<	0.01	-		<	0.01	-		<	0.005	-	
BORON	MG/L	<	0.1	-		<	0.1	-		<	0.1	-		<	0.05	-	
BROMIDE	MG/L		0.3	-			1.2	-	&		0.5	-			6.6	-	
CADMIUM	MG/L		0.013	-			0.007	-			0.016	-		<	0.005	-	c
CALCIUM	MG/L		2430.	-			1360.	-			2370.	-			2440.	-	
CHLORIDE	MG/L		11500.	-			9400.	-			13000.	-			12300.	-	
CHROMIUM	MG/L		0.24	-			0.02	-		<	0.01	-		<	0.01	-	
COBALT	MG/L	<	0.05	-		<	0.05	-		<	0.05	-		<	0.03	-	
COPPER	MG/L		0.04	-			0.07	-		<	0.01	-			0.03	-	
CYANIDE	MG/L	<	0.01	-		<	0.01	-			0.01	-		<	0.02	-	c
FLUORIDE	MG/L		1.3	-			1.2	-			0.9	-			0.5	-	
GROSS ALPHA	PCI/L	<	110.	110.	b		30.	130.			180.	140.		<	1060.	1060.	b
GROSS BETA	PCI/L		120.	80.			54.	66.			180.	70.		<	67.6	67.6	b
IRON	MG/L		0.10	-			0.11	-			0.25	-			0.15	-	
LEAD	MG/L	<	0.01	-			0.06	-			0.02	-		<	0.03	-	c
LEAD-210	PCI/L		0.6	1.7			0.8	0.8		<	2.6	2.6	b		6.4	3.0	
MAGNESIUM	MG/L		32.6	-			34.1	-			41.4	-			38.	-	
MANGANESE	MG/L		0.17	-			0.30	-			0.65	-			0.94	-	
MERCURY	MG/L	<	0.0002	-		<	0.0002	-		<	0.0002	-		<	0.0002	-	
MOLYBDENUM	MG/L		0.25	-			0.15	-			0.07	-			0.03	-	
NET GROSS ALPHA *	PCI/L		-0.72	-			29.31	-			179.79	-			-0.53	-	
NICKEL	MG/L	<	0.04	-		<	0.04	-		<	0.04	-		<	0.04	-	

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

FORMATION OF COMPLETION CODE: WS - WASATCH FORMATION - UNDIFFERENTIATED

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

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

OTHER PARAMETER VALUE FLAGS:
& - THE DATA FAILED THE ACCURACY OF KNOWNS QUALITY CONTROL TEST.
b - CHANGED PARAMETER VALUE
c - CHANGED DETECTION LIMIT
d - CHANGED DETECTION LIMIT AND PARAMETER VALUE

Table D.7.29 Groundwater quality data for Estes Gulch
monitor wells and vicinity domestic wells
SITE: RFL08 ESTES GULCH
11/05/87 TO 03/10/90
REPORT DATE: 07/11/91

		LOC / DATE: 0701 - 08/26/88 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: DOWN GRADIENT LABORATORY CODE: BAR LOT NUMBER: 001 SAMPLE TYPE: FR				LOC / DATE: 0701 - 04/23/89 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: DOWN GRADIENT LABORATORY CODE: BAR LOT NUMBER: 001 SAMPLE TYPE: FR				LOC / DATE: 0701 - 09/22/89 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: DOWN GRADIENT LABORATORY CODE: BAR LOT NUMBER: 001 SAMPLE TYPE: F				LOC / DATE: 0701 - 03/08/90 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: DOWN GRADIENT LABORATORY CODE: COR LOT NUMBER: 001 SAMPLE TYPE: FR			
PARAMETER NAME	UNIT OF MEASURE	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS
NITRATE	MG/L	<	0.1	-			6.7	-		<	1.	-			2.2	-	
NITRITE AND NITRATE	MG/L	<	1.0	-			-	-			-	-			0.65	-	c
PH	SU		8.91	-			7.41	-			8.11	-			8.16	-	
PHOSPHATE	MG/L		0.4	-		<	0.1	-		<	0.1	-			0.1	-	
POLONIUM-210	PCI/L		1.0	0.6			0.4	0.4	c		0.5	0.4	c		0.1	0.3	c
POTASSIUM	MG/L		32.	-			21.2	-			17.8	-			9.1	-	
RADIUM-226	PCI/L		1.0	0.6			0.7	0.4			1.0	0.3			6.2	1.1	
RADIUM-226 + RADIUM-228	PCI/L		11.00	-			4.50	-			5.10	-			6.40	-	
RADIUM-228	PCI/L		10.	3.			3.8	1.1			4.1	1.0			0.2	6.4	
SELENIUM	MG/L		0.975	-			0.034	-			0.022	-		<	0.05	-	c
SILICA - SIO2	MG/L		8.	-			7.	-			6.	-			6.0	-	
SILVER	MG/L		0.04	-		<	0.01	-			0.01	-		<	0.01	-	
SODIUM	MG/L		4780.	-			4180.	-			5320.	-			5680.	-	
SPECIFIC CONDUCTANCE	UMHO/CM		21000.	-			11000.	-			2550.	-			27000.	-	
STRONTIUM	MG/L		53.5	-			32.7	-			58.1	-			59.	-	
SULFATE	MG/L		503.	-			177.	-			48.	-			25.5	-	
SULFIDE	MG/L	<	0.1	-		<	0.01	-		<	0.1	-		<	0.1	-	
TEMPERATURE	C - DEGREE		16.	-			15.0	-			15.5	-			15.0	-	
THALLIUM	MG/L		-	-			0.10	-		<	0.01	-		<	0.1	-	
THORIUM-230	PCI/L	<	0.6	0.6	b		0.4	0.5	c	<	0.3	0.3	d		0.4	0.4	c
TIN	MG/L		0.131	-		<	0.005	-			0.955	-		<	0.05	-	c
TOTAL DISSOLVED SOLIDS	MG/L		25100.	-			14800.	-			22000.	-			21100.	-	
TOTAL ORGANIC CARBON	MG/L		-	-			5.0	-			6.96	-			4.	-	
URANIUM	MG/L		0.0012	-	c		0.0010	-	c		0.0003	-	c	<	0.003	-	
VANADIUM	MG/L		0.08	-			0.08	-		<	0.01	-		<	0.01	-	
ZINC	MG/L		0.102	-			0.412	-			0.010	-			0.093	-	

FORMATION OF COMPLETION CODE: WS - WASATCH FORMATION - UNDIFFERENTIATED

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

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

OTHER PARAMETER VALUE FLAGS:
& - THE DATA FAILED THE ACCURACY OF KNOWNS QUALITY CONTROL TEST.
b - CHANGED PARAMETER VALUE
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d - CHANGED DETECTION LIMIT AND PARAMETER VALUE

Table D.7.29 Groundwater quality data for Estes Gulch monitor wells and vicinity domestic wells
SITE: RFL08 ESTES GULCH
11/05/87 TO 03/10/90
REPORT DATE: 07/11/91

		LOC / DATE: 0702 - 08/26/88 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: DOWN GRADIENT LABORATORY CODE: BAR LOT NUMBER: 001 SAMPLE TYPE: F				LOC / DATE: 0702 - 04/23/89 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: DOWN GRADIENT LABORATORY CODE: BAR LOT NUMBER: 001 SAMPLE TYPE: F				LOC / DATE: 0702 - 09/22/89 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: DOWN GRADIENT LABORATORY CODE: BAR LOT NUMBER: 001 SAMPLE TYPE: F				LOC / DATE: 0702 - 03/09/90 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: DOWN GRADIENT LABORATORY CODE: COR LOT NUMBER: 001 SAMPLE TYPE: F			
PARAMETER NAME	UNIT OF MEASURE	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS
ALKALINITY	MG/L CACO3		548.	-			93.	-			113.	-			171.	-	
ALUMINUM	MG/L		0.3	-		<	0.1	-		<	0.1	-		<	0.05	-	
AMMONIUM	MG/L		7.9	-			7.5	-			6.3	-			5.2	-	
ANTIMONY	MG/L		0.006	-			0.022	-			0.039	-		<	0.03	-	c
ARSENIC	MG/L		0.02	-		<	0.01	-			0.016	-		<	0.05	-	c
BARIUM	MG/L		0.13	-			1.4	-			1.9	-			2.07	-	
BERYLLIUM	MG/L		-	-		<	0.01	-		<	0.01	-		<	0.005	-	
BORON	MG/L	<	0.1	-		<	0.1	-		<	0.1	-		<	0.05	-	
BROMIDE	MG/L		1.3	-			1.7	-	&		2.2	-			5.8	-	
CADMIUM	MG/L		0.007	-			0.010	-			0.016	-		<	0.005	-	c
CALCIUM	MG/L		516.	-			2120.	-			2430.	-			2620.	-	
CHLORIDE	MG/L		4460.	-			13000.	-			14000.	-			13100.	-	
CHROMIUM	MG/L		2.87	-			0.21	-			0.09	-			0.06	-	
COBALT	MG/L	<	0.05	-		<	0.05	-		<	0.05	-		<	0.03	-	
COPPER	MG/L		0.09	-			0.07	-		<	0.01	-			0.02	-	
CYANIDE	MG/L		0.02	-		<	0.01	-			0.01	-		<	0.02	-	c
FLUORIDE	MG/L		0.3	-			0.3	-			0.2	-		<	0.1	-	
GROSS ALPHA	PCI/L	<	43.	43.	b	<	170.	170.	b		140.	130.		<	1085.	1085.	b
GROSS BETA	PCI/L		240.	50.			62.	87.			130.	70.			80.9	73.8	
IRON	MG/L		0.08	-			0.16	-			0.12	-		<	0.03	-	
LEAD	MG/L	<	0.01	-			0.10	-			0.03	-		<	0.05	-	c
LEAD-210	PCI/L		0.1	0.9	c		1.0	0.9			1.5	1.4			5.4	2.6	
MAGNESIUM	MG/L		0.44	-			0.27	-			1.43	-			1.05	-	
MANGANESE	MG/L		0.01	-			0.04	-		<	0.01	-		<	0.01	-	
MERCURY	MG/L	<	0.0002	-		<	0.0002	-		<	0.0002	-		<	0.0002	-	
MOLYBDENUM	MG/L		2.65	-			0.45	-			0.30	-			0.20	-	
NET GROSS ALPHA *	PCI/L		-0.93	-			-0.93	-			139.38	-			-0.53	-	
NICKEL	MG/L	<	0.04	-		<	0.04	-		<	0.04	-		<	0.04	-	

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

FORMATION OF COMPLETION CODE: WS - WASATCH FORMATION - UNDIFFERENTIATED

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

SAMPLE ID CODES:
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Table D.7.29 Groundwater quality data for Estes Gulch monitor wells and vicinity domestic wells
SITE: RFL08 ESTES GULCH
11/05/87 TO 03/10/90
REPORT DATE: 07/11/91

		LOC / DATE: 0702 - 08/26/88 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: DOWN GRADIENT LABORATORY CODE: BAR LOT NUMBER: 001 SAMPLE TYPE: F				LOC / DATE: 0702 - 04/23/89 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: DOWN GRADIENT LABORATORY CODE: BAR LOT NUMBER: 001 SAMPLE TYPE: F				LOC / DATE: 0702 - 09/22/89 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: DOWN GRADIENT LABORATORY CODE: BAR LOT NUMBER: 001 SAMPLE TYPE: F				LOC / DATE: 0702 - 03/09/90 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: DOWN GRADIENT LABORATORY CODE: COR LOT NUMBER: 001 SAMPLE TYPE: F			
PARAMETER NAME	UNIT OF MEASURE	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS
NITRATE	MG/L		4.1	-			5.1	-		<	1.	-		<	1.	-	
NITRITE AND NITRATE	MG/L	<	1.0	-			-	-			-	-			0.66	-	c
PH	SU		11.94	-			10.93	-			11.26	-			11.47	-	
PHOSPHATE	MG/L		0.3	-			0.1	-		<	0.1	-			0.1	-	
POLONIUM-210	PCI/L	<	0.6	0.6	b		1.0	0.5			0.3	0.4	c	<	0.5	0.5	b
POTASSIUM	MG/L		320.	-			101.	-			94.5	-			44.	-	
RADIUM-226	PCI/L		0.4	0.2	c		0.4	0.2	c		0.1	0.2	c		5.6	1.0	
RADIUM-226 + RADIUM-228	PCI/L		1.90	-			1.30	-			3.60	-			5.80	-	
RADIUM-228	PCI/L		1.5	0.9			0.9	0.9			3.5	1.0			0.2	9.2	
SELENIUM	MG/L		0.354	-			0.091	-			0.053	-		<	0.05	-	c
SILICA - SIO2	MG/L		6.	-			12.	-			11.	-			10.1	-	
SILVER	MG/L		0.02	-		<	0.01	-		<	0.01	-		<	0.01	-	
SODIUM	MG/L		3110.	-			5270.	-			5680.	-			6120.	-	
SPECIFIC CONDUCTANCE	UMHO/CM		13000.	-			1850.	-			5900.	-			28000.	-	
STRONTIUM	MG/L		15.3	-			63.9	-			63.5	-			67.	-	
SULFATE	MG/L		1840.	-			292.	-			186.	-			129.	-	
SULFIDE	MG/L	<	0.1	-		<	0.1	-		<	0.1	-		<	0.1	-	
TEMPERATURE	C - DEGREE		15.0	-			15.	-			14.	-			15.0	-	
THALLIUM	MG/L		-	-			0.11	-		<	0.01	-		<	0.1	-	
THORIUM-230	PCI/L	<	0.6	0.6	b		1.0	0.6		<	0.3	0.3	d		0.5	0.5	
TIN	MG/L		0.071	-		<	0.005	-		<	0.005	-		<	0.05	-	c
TOTAL DISSOLVED SOLIDS	MG/L		10200.	-			22400.	-			22400.	-			23000.	-	
TOTAL ORGANIC CARBON	MG/L		-	-			16.8	-			12.2	-			12.	-	
URANIUM	MG/L	<	0.0003	-		<	0.0003	-			0.0009	-	c	<	0.003	-	
VANADIUM	MG/L		0.05	-			0.12	-			0.03	-			0.02	-	
ZINC	MG/L		0.006	-			0.196	-		<	0.005	-		<	0.005	-	

FORMATION OF COMPLETION CODE: WS - WASATCH FORMATION - UNDIFFERENTIATED

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

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

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Table D.7.29 Groundwater quality data for Estes Gulch monitor wells and vicinity domestic wells
SITE: RFL08 ESTES GULCH
11/05/87 TO 03/10/90
REPORT DATE: 07/11/91

		LOC / DATE: 0703 - 08/26/88 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: DOWN GRADIENT LABORATORY CODE: BAR LOT NUMBER: 001 SAMPLE TYPE: F				LOC / DATE: 0703 - 04/23/89 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: DOWN GRADIENT LABORATORY CODE: BAR LOT NUMBER: 001 SAMPLE TYPE: F				LOC / DATE: 0703 - 09/26/89 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: DOWN GRADIENT LABORATORY CODE: BAR LOT NUMBER: 001 SAMPLE TYPE: FR				LOC / DATE: 0703 - 03/09/90 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: DOWN GRADIENT LABORATORY CODE: COR LOT NUMBER: 001 SAMPLE TYPE: F			
PARAMETER NAME	UNIT OF MEASURE	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS
ALKALINITY	MG/L CACO3		343.	-			2751.	-			398.	-			304.	-	
ALUMINUM	MG/L		0.5	-		<	0.1	-			0.2	-			0.11	-	
AMMONIUM	MG/L		8.1	-			9.7	-			6.5	-			4.6	-	
ANTIMONY	MG/L		0.005	-			0.007	-		<	0.003	-		<	0.03	-	c
ARSENIC	MG/L		0.02	-		<	0.01	-		<	0.01	-		<	0.05	-	c
BARIUM	MG/L		0.19	-			2.0	-			0.9	-			1.05	-	
BERYLLIUM	MG/L		-	-		<	0.01	-		<	0.01	-		<	0.005	-	
BORON	MG/L	<	0.1	-		<	0.1	-		<	0.1	-		<	0.05	-	
BROMIDE	MG/L		1.3	-			2.5	-	&		4.9	-			3.0	-	
CADMIUM	MG/L		0.005	-			0.005	-			0.011	-		<	0.005	-	c
CALCIUM	MG/L		390.	-			662.	-			850.	-			940.	-	
CHLORIDE	MG/L		3950.	-			4500.	-			6690.	-			7040.	-	
CHROMIUM	MG/L		0.99	-			0.19	-			0.03	-			0.01	-	
COBALT	MG/L	<	0.05	-		<	0.05	-		<	0.05	-		<	0.03	-	
COPPER	MG/L		0.05	-			0.07	-		<	0.01	-			0.01	-	c
CYANIDE	MG/L		0.03	-		<	0.01	-			0.01	-		<	0.02	-	c
FLUORIDE	MG/L		0.8	-			0.4	-			0.8	-			1.0	-	
GROSS ALPHA	PCI/L		2.	47.		<	77.	77.	b		89.	82.		<	64.6	64.6	b
GROSS BETA	PCI/L		150.	40.			290.	50.			110.	50.			3.7	48.9	
IRON	MG/L		0.25	-			0.09	-			0.10	-		<	0.03	-	
LEAD	MG/L	<	0.01	-			0.04	-			0.03	-		<	0.03	-	c
LEAD-210	PCI/L		0.6	1.1			1.4	0.8			0.4	0.8	c		3.6	2.6	
MAGNESIUM	MG/L		0.29	-			1.65	-			0.93	-			0.74	-	
MANGANESE	MG/L	<	0.01	-			0.02	-		<	0.01	-		<	0.01	-	
MERCURY	MG/L	<	0.0002	-		<	0.0002	-		<	0.0002	-		<	0.0002	-	
MOLYBDENUM	MG/L		1.56	-			0.24	-			0.31	-			0.19	-	
NET GROSS ALPHA *	PCI/L		0.97	-			-0.93	-			88.04	-			-0.53	-	
NICKEL	MG/L	<	0.04	-		<	0.04	-		<	0.04	-		<	0.04	-	

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

FORMATION OF COMPLETION CODE: WS - WASATCH FORMATION - UNDIFFERENTIATED

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

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

OTHER PARAMETER VALUE FLAGS:
& - THE DATA FAILED THE ACCURACY OF KNOWNS QUALITY CONTROL TEST.
b - CHANGED PARAMETER VALUE
c - CHANGED DETECTION LIMIT
d - CHANGED DETECTION LIMIT AND PARAMETER VALUE

Table D.7.29 Groundwater quality data for Estes Gulch monitor wells and vicinity domestic wells
SITE: RFL08 ESTES GULCH
11/05/87 TO 03/10/90
REPORT DATE: 07/11/91

		LOC / DATE: 0703 - 08/26/88 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: DOWN GRADIENT LABORATORY CODE: BAR LOT NUMBER: 001 SAMPLE TYPE: F				LOC / DATE: 0703 - 04/23/89 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: DOWN GRADIENT LABORATORY CODE: BAR LOT NUMBER: 001 SAMPLE TYPE: F				LOC / DATE: 0703 - 09/26/89 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: DOWN GRADIENT LABORATORY CODE: BAR LOT NUMBER: 001 SAMPLE TYPE: FR				LOC / DATE: 0703 - 03/09/90 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: DOWN GRADIENT LABORATORY CODE: COR LOT NUMBER: 001 SAMPLE TYPE: F			
PARAMETER NAME	UNIT OF MEASURE	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS
NITRATE	MG/L		2.1	-			11.	-			2.5	-		<	1.	-	
NITRITE AND NITRATE	MG/L	<	1.0	-			-	-			-	-			0.79	-	c
PH	SU		11.78	-			12.58	-			12.20	-			11.63	-	
PHOSPHATE	MG/L	<	0.1	-		<	0.1	-		<	0.1	-			0.2	-	
POLONIUM-210	PCI/L	<	0.4	0.4	d		0.7	0.4			0.4	0.4	c		0.2	0.6	c
POTASSIUM	MG/L		128.	-			396.	-			58.9	-			26.	-	
RADIUM-226	PCI/L		0.2	0.2	c		0.2	0.2	c		0.2	0.2	c		1.8	0.6	
RADIUM-226 + RADIUM-228	PCI/L		1.10	-			3.00	-			3.40	-			2.00	-	
RADIUM-228	PCI/L		0.9	1.0			2.8	1.0			3.2	1.0			0.2	3.1	
SELENIUM	MG/L		0.212	-			0.029	-			0.029	-		<	0.05	-	c
SILICA - SIO2	MG/L		15.	-		<	2.	-			7.	-			6.4	-	
SILVER	MG/L		0.02	-		<	0.01	-		<	0.01	-		<	0.01	-	
SODIUM	MG/L		2350.	-			2920.	-			3520.	-			3760.	-	
SPECIFIC CONDUCTANCE	UMHO/CM		11500.	-			16500.	-			4600.	-			17500.	-	
STRONTIUM	MG/L		8.5	-			27.3	-			21.8	-			24.	-	
SULFATE	MG/L		974.	-			123.	-			185.	-			135.	-	
SULFIDE	MG/L	<	0.1	-		<	0.1	-		<	0.1	-		<	0.1	-	
TEMPERATURE	C - DEGREE		15.0	-			12.	-			15.5	-			14.0	-	
THALLIUM	MG/L		-	-			0.07	-		<	0.01	-		<	0.1	-	
THORIUM-230	PCI/L	<	0.5	0.5	b	<	0.3	0.3	d		0.1	0.4	c		0.5	0.5	
TIN	MG/L		0.077	-		<	0.005	-			0.499	-		<	0.05	-	c
TOTAL DISSOLVED SOLIDS	MG/L		8260.	-			9390.	-			11900.	-			12900.	-	
TOTAL ORGANIC CARBON	MG/L		-	-			15.6	-			14.7	-			11.	-	
URANIUM	MG/L	<	0.0003	-		<	0.0003	-			0.0014	-	c	<	0.003	-	
VANADIUM	MG/L		0.06	-			0.07	-			0.01	-			0.01	-	
ZINC	MG/L	<	0.005	-			0.127	-		<	0.005	-		<	0.005	-	

FORMATION OF COMPLETION CODE: WS - WASATCH FORMATION - UNDIFFERENTIATED

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

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

OTHER PARAMETER VALUE FLAGS:
a - THE DATA FAILED THE ACCURACY OF KNOWNS QUALITY CONTROL TEST.
b - CHANGED PARAMETER VALUE
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d - CHANGED DETECTION LIMIT AND PARAMETER VALUE

Table 0.7.29 Groundwater quality data for Estes Gulch monitor wells and vicinity domestic wells
SITE: RFL08 ESTES GULCH
11/05/87 TO 03/10/90
REPORT DATE: 07/11/91

		LOC / DATE: 0983 - 11/05/87 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: CROSS GRADIENT LABORATORY CODE: GAR LOT NUMBER: 009 SAMPLE TYPE: F				LOC / DATE: 0983 - 04/23/89 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: CROSS GRADIENT LABORATORY CODE: BAR LOT NUMBER: 001 SAMPLE TYPE: F				LOC / DATE: 0983 - 09/22/89 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: CROSS GRADIENT LABORATORY CODE: BAR LOT NUMBER: 001 SAMPLE TYPE: F				LOC / DATE: 0983 - 03/10/90 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: CROSS GRADIENT LABORATORY CODE: COR LOT NUMBER: 001 SAMPLE TYPE: F			
PARAMETER NAME	UNIT OF MEASURE	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS
ALKALINITY	MG/L CACO3		207.	-			208.	-			214.	-			183.	-	
ALUMINUM	MG/L		0.07	-	c		0.1	-		<	0.1	-		<	0.05	-	
AMMONIUM	MG/L	<	0.1	-		<	0.1	-		<	0.1	-		<	0.1	-	
ANTIMONY	MG/L		-	-			0.003	-			0.029	-		<	0.003	-	
ARSENIC	MG/L		0.003	-	c	<	0.01	-		<	0.01	-		<	0.05	-	c
BARIUM	MG/L		0.01	-	c	<	0.1	-		<	0.1	-			0.02	-	c
BERYLLIUM	MG/L		-	-		<	0.01	-		<	0.01	-		<	0.005	-	
BORON	MG/L		-	-		<	0.1	-		<	0.1	-			0.07	-	c
BROMIDE	MG/L		0.1	-		<	0.1	-	&	<	0.1	-			0.1	-	
CADMIUM	MG/L	<	0.005	-	c		0.001	-			0.002	-		<	0.001	-	
CALCIUM	MG/L		26.3	-			31.6	-			25.1	-			47.	-	
CHLORIDE	MG/L		95.	-			79.	-			83.	-			143.	-	
CHROMIUM	MG/L	<	0.01	-		<	0.01	-		<	0.01	-		<	0.01	-	
COBALT	MG/L		-	-		<	0.05	-		<	0.05	-		<	0.03	-	
COPPER	MG/L		-	-			0.03	-		<	0.01	-		<	0.01	-	
CYANIDE	MG/L		-	-		<	0.01	-		<	0.01	-		<	0.02	-	c
FLUORIDE	MG/L		1.76	-			1.8	-			1.7	-			1.5	-	
GROSS ALPHA	PCI/L		-	-			7.	11.			9.0	11.		<	5.8	5.8	b
GROSS BETA	PCI/L		-	-			7.3	5.8			13.	6.			3.6	4.9	
IRON	MG/L	<	0.01	-			0.04	-		<	0.03	-		<	0.03	-	
LEAD	MG/L	<	0.01	-		<	0.01	-		<	0.01	-		<	0.01	-	
LEAD-210	PCI/L		-	-			1.1	0.9			0.8	0.8		<	2.7	2.7	b
MAGNESIUM	MG/L		1.19	-			3.71	-			1.32	-			9.01	-	
MANGANESE	MG/L	<	0.01	-			0.01	-		<	0.01	-		<	0.01	-	
MERCURY	MG/L		-	-			0.0002	-		<	0.0002	-		<	0.0002	-	
MOLYBDENUM	MG/L		0.10	-			0.07	-			0.07	-			0.05	-	
NET GROSS ALPHA *	PCI/L		-	-			6.11	-			7.35	-			-0.53	-	
NICKEL	MG/L		-	-		<	0.04	-		<	0.04	-		<	0.04	-	

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

FORMATION OF COMPLETION CODE: WS - WASATCH FORMATION - UNDIFFERENTIATED

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

SAMPLE ID CODES:
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Table D.7.29 Groundwater quality data for Estes Gulch monitor wells and vicinity domestic wells
SITE: RFL08 ESTES GULCH
11/05/87 TO 03/10/90
REPORT DATE: 07/11/91

		LOC / DATE: 0983 - 11/05/87 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: CROSS GRADIENT LABORATORY CODE: BAR LOT NUMBER: 009 SAMPLE TYPE: F				LOC / DATE: 0983 - 04/23/89 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: CROSS GRADIENT LABORATORY CODE: BAR LOT NUMBER: 001 SAMPLE TYPE: F				LOC / DATE: 0983 - 09/22/89 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: CROSS GRADIENT LABORATORY CODE: BAR LOT NUMBER: 001 SAMPLE TYPE: F				LOC / DATE: 0983 - 03/10/90 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: CROSS GRADIENT LABORATORY CODE: COR LOT NUMBER: 001 SAMPLE TYPE: F			
PARAMETER NAME	UNIT OF MEASURE	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS
NITRATE	MG/L		0.9	-	c		9.7	-		<	1.	-		<	1.	-	
NITRITE	MG/L	<	0.1	-			-	-			-	-			-	-	
NITRITE AND NITRATE	MG/L		-	-			-	-			-	-			0.17	-	c
PH	SU		8.00	-			7.76	-			8.25	-			8.05	-	
PHOSPHATE	MG/L		1.0	-		<	0.1	-		<	0.1	-			0.1	-	
POLONIUM-210	PCI/L		-	-		<	0.3	0.3	d		0.2	0.4	c	<	0.4	0.4	d
POTASSIUM	MG/L		1.56	-			4.0	-			2.0	-			2.7	-	
RADIUM-226	PCI/L		0.1	0.2	c		0.1	0.2	c	<	0.1	0.1	d	<	0.1	0.1	d
RADIUM-226 + RADIUM-228	PCI/L		0.60	-			0.50	-			0.45	-			1.45	-	
RADIUM-228	PCI/L	<	2.5	2.5	b		0.4	0.8			0.4	0.8			1.4	2.6	
SELENIUM	MG/L		0.047	-			0.003	-	c		0.003	-	c	<	0.05	-	c
SILICA - SIO2	MG/L		6.01	-			6.	-			7.	-			6.8	-	
SILVER	MG/L		-	-		<	0.01	-		<	0.01	-		<	0.01	-	
SODIUM	MG/L		667.	-			627.	-			600.	-			432.	-	
SPECIFIC CONDUCTANCE	UMHO/CM		2180.	-			1450.	-			1400.	-			1500.	-	
STRONTIUM	MG/L		-	-			0.3	-			0.44	-			0.58	-	
SULFATE	MG/L		1130.	-			1040.	-			1060.	-			685.	-	
SULFIDE	MG/L	<	0.1	-		<	0.1	-		<	0.1	-		<	0.1	-	
TEMPERATURE	C - DEGREE		14.2	-			12.0	-			18.0	-			12.	-	
THALLIUM	MG/L		-	-		<	0.01	-		<	0.01	-		<	0.1	-	
THORIUM-230	PCI/L		-	-			0.1	0.4	c	<	0.2	0.2	d		0.2	0.4	c
TIN	MG/L		-	-		<	0.005	-			0.050	-		<	0.05	-	c
TOTAL DISSOLVED SOLIDS	MG/L		1930.	-			1880.	-			1820.	-			1460.	-	
TOTAL ORGANIC CARBON	MG/L		-	-			19.3	-			47.4	-			-	-	
URANIUM	MG/L		0.0013	-	c		0.0013	-	c		0.0024	-	c	<	0.003	-	
VANADIUM	MG/L	<	0.01	-			0.02	-			0.01	-		<	0.01	-	
ZINC	MG/L		0.181	-			0.587	-			0.113	-			0.143	-	

FORMATION OF COMPLETION CODE: WS - WASATCH FORMATION - UNDIFFERENTIATED

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

SAMPLE ID CODES:
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OTHER PARAMETER VALUE FLAGS:
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Table D.7.29 Groundwater quality data for Estes Gulch monitor wells and vicinity domestic wells
SITE: #FL08 ESTES GULCH
11/05/87 TO 03/10/90
REPORT DATE: 07/11/91

		LOC / DATE: 0983 - 03/10/90 SAMPLE ID: N001 FORM. OF COMPLETION: WS FLOW REL: CROSS GRADIENT LABORATORY CODE: COR LOT NUMBER: 001 SAMPLE TYPE: F				LOC / DATE: 0984 - 11/05/87 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: CROSS GRADIENT LABORATORY CODE: BAR LOT NUMBER: 009 SAMPLE TYPE: F				LOC / DATE: 0984 - 04/23/89 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: CROSS GRADIENT LABORATORY CODE: BAR LOT NUMBER: 001 SAMPLE TYPE: F				LOC / DATE: 0985 - 11/05/87 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: CROSS GRADIENT LABORATORY CODE: BAR LOT NUMBER: 009 SAMPLE TYPE: F			
PARAMETER NAME	UNIT OF MEASURE	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS
ALKALINITY	MG/L CACO3		183.	-			195.	-			197.	-			24.	-	
ALUMINUM	MG/L		-	-			0.10	-		<	0.1	-			0.30	-	
ALUMINUM (TOTAL)	MG/L	<	0.05	-			-	-			-	-			-	-	
AMMONIUM	MG/L		-	-			0.1	-		<	0.1	-			1.0	-	
ANTIMONY	MG/L		-	-			-	-			0.022	-			-	-	
ANTIMONY (TOTAL)	MG/L	<	0.003	-			-	-			-	-			-	-	
ARSENIC	MG/L		-	-			0.005	-	c	<	0.01	-			0.021	-	
ARSENIC (TOTAL)	MG/L	<	0.03	-	c		-	-			-	-			-	-	
BARIUM	MG/L		-	-			0.01	-	c	<	0.1	-			0.08	-	c
BARIUM (TOTAL)	MG/L		0.02	-	c		-	-			-	-			-	-	
BERYLLIUM	MG/L		-	-			-	-		<	0.01	-			-	-	
BERYLLIUM (TOTAL)	MG/L	<	0.005	-			-	-			-	-			-	-	
BORON	MG/L		-	-			-	-			0.1	-			-	-	
BORON (TOTAL)	MG/L		0.09	-	c		-	-			-	-			-	-	
BROMIDE	MG/L		-	-			0.1	-		<	0.1	-	&		0.3	-	
CADMIUM	MG/L		-	-		<	0.005	-	c		0.001	-		<	0.005	-	c
CADMIUM (TOTAL)	MG/L	<	0.001	-			-	-			-	-			-	-	
CALCIUM	MG/L		-	-			48.0	-			52.6	-			667.	-	
CALCIUM (TOTAL)	MG/L		48.	-			-	-			-	-			-	-	
CHLORIDE	MG/L		-	-			230.	-			210.	-			6160.	-	
CHLORIDE (TOTAL)	MG/L		149.	-			-	-			-	-			-	-	
CHROMIUM	MG/L		-	-		<	0.01	-		<	0.01	-		<	0.01	-	
CHROMIUM (TOTAL)	MG/L	<	0.01	-			-	-			-	-			-	-	
COBALT	MG/L		-	-			-	-		<	0.05	-			-	-	
COBALT (TOTAL)	MG/L	<	0.05	-			-	-			-	-			-	-	
COPPER	MG/L		-	-			-	-			0.03	-			-	-	
COPPER (TOTAL)	MG/L	<	0.01	-			-	-			-	-			-	-	
CYANIDE	MG/L		-	-			-	-		<	0.01	-			-	-	
FLUORIDE	MG/L		-	-			1.98	-			1.8	-			0.83	-	

FORMATION OF COMPLETION CODE: WS - WASATCH FORMATION - UNDIFFERENTIATED

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

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& - THE DATA FAILED THE ACCURACY OF KNOWNS QUALITY CONTROL TEST.
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SAMPLE ID CODES:
0001 - FILTERED SAMPLE (.45 MICRONS)
N001 - UNFILTERED SAMPLE

Table D.7.29 Groundwater quality data for Estes Gulch monitor wells and vicinity domestic wells
SITE: RFL08 ESTES GULCH
11/05/87 TO 03/10/90
REPORT DATE: 07/11/91

		LOC / DATE: 0983 - 03/10/90 SAMPLE ID: N001 FORM. OF COMPLETION: WS FLOW REL: CROSS GRADIENT LABORATORY CODE: COR LOT NUMBER: 001 SAMPLE TYPE: F				LOC / DATE: 0984 - 11/05/87 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: CROSS GRADIENT LABORATORY CODE: BAR LOT NUMBER: 009 SAMPLE TYPE: F				LOC / DATE: 0984 - 04/23/89 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: CROSS GRADIENT LABORATORY CODE: BAR LOT NUMBER: 001 SAMPLE TYPE: F				LOC / DATE: 0985 - 11/05/87 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: CROSS GRADIENT LABORATORY CODE: BAR LOT NUMBER: 009 SAMPLE TYPE: F			
PARAMETER NAME	UNIT OF MEASURE	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS
FLUORIDE (TOTAL)	MG/L		1.5	-			-	-			-	-			-	-	
GROSS ALPHA	PCI/L		-	-			-	-		<	13.	13.	b		-	-	
GROSS ALPHA (TOTAL)	PCI/L	<	4.1	4.1	b		-	-			-	-			-	-	
GROSS BETA	PCI/L		-	-			-	-			1.1	7.2			-	-	
GROSS BETA (TOTAL)	PCI/L	<	4.0	4.0	b		-	-			-	-			-	-	
IRON	MG/L		-	-			0.03	-			0.04	-			0.15	-	
IRON (TOTAL)	MG/L		0.26	-			-	-			-	-			-	-	
LEAD	MG/L		-	-		<	0.01	-			0.02	-		<	0.01	-	
LEAD (TOTAL)	MG/L	<	0.01	-			-	-			-	-			-	-	
LEAD-210	PCI/L		-	-			-	-			1.0	0.8			-	-	
LEAD-210 (TOTAL)	PCI/L	<	2.9	2.9	b		-	-			-	-			-	-	
MAGNESIUM	MG/L		-	-			12.1	-			2.30	-			9.80	-	
MAGNESIUM (TOTAL)	MG/L		8.98	-			-	-			-	-			-	-	
MANGANESE	MG/L		-	-			0.07	-			0.04	-			1.07	-	
MANGANESE (TOTAL)	MG/L		0.01	-			-	-			-	-			-	-	
MERCURY	MG/L		-	-			-	-			0.0002	-			-	-	
MERCURY (TOTAL)	MG/L	<	0.0002	-			-	-			-	-			-	-	
MOLYBDENUM	MG/L		-	-			0.03	-			0.03	-			0.03	-	
MOLYBDENUM (TOTAL)	MG/L		0.06	-			-	-			-	-			-	-	
NET GROSS ALPHA *	PCI/L		-	-			-	-			-0.45	-			-	-	
NET GROSS ALPHA (TOTAL) **	PCI/L		-0.53	-			-	-			-	-			-	-	
NICKEL	MG/L		-	-			-	-			0.07	-			-	-	
NICKEL (TOTAL)	MG/L	<	0.04	-			-	-			-	-			-	-	
NITRATE	MG/L		-	-			1.3	-			11.	-		<	0.1	-	
NITRITE	MG/L		-	-		<	0.1	-			-	-		<	0.1	-	
PH	SU		8.05	-			7.75	-			7.73	-			8.00	-	
PHOSPHATE	MG/L		-	-			1.10	-		<	0.1	-			2.2	-	

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

FORMATION OF COMPLETION CODE: WS - WASATCH FORMATION - UNDIFFERENTIATED

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

OTHER PARAMETER VALUE FLAGS:
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c - CHANGED DETECTION LIMIT
d - CHANGED DETECTION LIMIT AND PARAMETER VALUE

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

Table D.7.29 Groundwater quality data for Estes Gulch monitor wells and vicinity domestic wells
SITE: RFL08 ESTES GULCH
11/05/87 TO 03/10/90
REPORT DATE: 07/11/91

		LOC / DATE: 0983 - 03/10/90 SAMPLE ID: N001 FORM. OF COMPLETION: WS FLOW REL: CROSS GRADIENT LABORATORY CODE: COR LOT NUMBER: 001 SAMPLE TYPE: F				LOC / DATE: 0984 - 11/05/87 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: CROSS GRADIENT LABORATORY CODE: BAR LOT NUMBER: 009 SAMPLE TYPE: F				LOC / DATE: 0984 - 04/23/89 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: CROSS GRADIENT LABORATORY CODE: BAR LOT NUMBER: 001 SAMPLE TYPE: F				LOC / DATE: 0985 - 11/05/87 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: CROSS GRADIENT LABORATORY CODE: BAR LOT NUMBER: 009 SAMPLE TYPE: F			
PARAMETER NAME	UNIT OF MEASURE	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS
PHOSPHATE (TOTAL)	MG/L	<	0.1	-			-	-			-	-			-	-	
POLONIUM-210	PCI/L		-	-			-	-		<	0.3	0.3	d		-	-	
POLONIUM-210 (TOTAL)	PCI/L	<	0.5	0.5	b		-	-			-	-			-	-	
POTASSIUM	MG/L		-	-			2.04	-			5.3	-			5.48	-	
POTASSIUM (TOTAL)	MG/L		2.8	-			-	-			-	-			-	-	
RADIUM-226	PCI/L		-	-			0.1	0.2	c		0.4	0.2	c		0.4	0.2	c
RADIUM-226 (TOTAL)	PCI/L		0.1	0.2	c		-	-			-	-			-	-	
RADIUM-226 + RADIUM-228	PCI/L		-	-			0.70	-			1.20	-			2.30	-	
RADIUM-226 + RADIUM-228 TOTAL	PCI/L		3.30	-			-	-			-	-			-	-	
RADIUM-228	PCI/L		-	-			0.6	2.3			0.8	0.8			1.9	2.1	
RADIUM-228 (TOTAL)	PCI/L		3.2	3.0			-	-			-	-			-	-	
SELENIUM	MG/L		-	-			0.045	-		<	0.001	-			0.278	-	
SELENIUM (TOTAL)	MG/L	<	0.03	-	c		-	-			-	-			-	-	
SILICA - SIO2	MG/L		-	-			7.49	-			9.0	-			6.97	-	
SILICA - SIO2 (TOTAL)	MG/L		7.3	-			-	-			-	-			-	-	
SILVER	MG/L		-	-			-	-		<	0.01	-			-	-	
SILVER (TOTAL)	MG/L	<	0.01	-			-	-			-	-			-	-	
SODIUM	MG/L		-	-			835.	-			853.	-			4090.	-	
SODIUM (TOTAL)	MG/L		450.	-			-	-			-	-			-	-	
SPECIFIC CONDUCTANCE	UMHO/CM		1500.	-			2760.	-			2450.	-			13310.	-	
STRONTIUM	MG/L		-	-			-	-			0.5	-			-	-	
STRONTIUM (TOTAL)	MG/L		0.60	-			-	-			-	-			-	-	
SULFATE	MG/L		-	-			1420.	-			1450.	-			477.	-	
SULFIDE	MG/L		-	-		<	0.1	-		<	0.1	-		<	0.1	-	
TEMPERATURE	C - DEGREE		12.	-			13.4	-			13.0	-			13.8	-	
THALLIUM	MG/L		-	-			-	-		<	0.01	-			-	-	
THALLIUM (TOTAL)	MG/L	<	0.1	-			-	-			-	-			-	-	
THORIUM-230	PCI/L		-	-			-	-		<	0.3	0.3	d		-	-	
THORIUM-230 (TOTAL)	PCI/L	<	0.4	0.4	d		-	-			-	-			-	-	

FORMATION OF COMPLETION CODE: WS - WASATCH FORMATION - UNDIFFERENTIATED

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SAMPLE ID CODES:
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Table D.7.29 Groundwater quality data for Estes Gulch
monitor wells and vicinity domestic wells
SITE: RFL08 ESTES GULCH
11/05/87 TO 03/10/90
REPORT DATE: 07/11/91

		LOC / DATE: 0983 - 03/10/90 SAMPLE ID: N001 FORM. OF COMPLETION: WS FLOW REL: CROSS GRADIENT LABORATORY CODE: CDR LOT NUMBER: 001 SAMPLE TYPE: F				LOC / DATE: 0984 - 11/05/87 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: CROSS GRADIENT LABORATORY CODE: BAR LOT NUMBER: 009 SAMPLE TYPE: F				LOC / DATE: 0984 - 04/23/89 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: CROSS GRADIENT LABORATORY CODE: BAR LOT NUMBER: 001 SAMPLE TYPE: F				LOC / DATE: 0985 - 11/05/87 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: CROSS GRADIENT LABORATORY CODE: BAR LOT NUMBER: 009 SAMPLE TYPE: F			
PARAMETER NAME	UNIT OF MEASURE	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS
TIN	MG/L		-	-			-	-		<	0.005	-			-	-	
TIN (TOTAL)	MG/L	<	0.05	-	c		-	-			-	-			-	-	
TOTAL DISSOLVED SOLIDS	MG/L		-	-			2560.	-			2610.	-			11100.	-	
TOTAL ORGANIC CARBON	MG/L		-	-			-	-			9.4	-			-	-	
URANIUM	MG/L		-	-			0.0007	-	c		0.0008	-	c	<	0.0003	-	
URANIUM (TOTAL)	MG/L	<	0.003	-			-	-			-	-			-	-	
VANADIUM	MG/L		-	-		<	0.01	-			0.02	-			0.04	-	
VANADIUM (TOTAL)	MG/L	<	0.01	-			-	-			-	-			-	-	
ZINC	MG/L		-	-			1.10	-			1.27	-		<	0.005	-	
ZINC (TOTAL)	MG/L		0.178	-			-	-			-	-			-	-	

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SAMPLE ID CODES:
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Table D.7.29 Groundwater quality data for Estes Gulch monitor wells and vicinity domestic wells
SITE: RFL08 ESTES GULCH
11/05/87 TO 03/10/90
REPORT DATE: 07/11/91

PARAMETER NAME	UNIT OF MEASURE	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS			
		LOC / DATE: 0985 - 04/23/89 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: CROSS GRADIENT LABORATORY CODE: BAR LOT NUMBER: 001 SAMPLE TYPE: F						
ALKALINITY	MG/L CACO3		29.	-				
ALUMINUM	MG/L	<	0.1	-				
AMMONIUM	MG/L		0.4	-				
ANTIMONY	MG/L		0.003	-				
ARSENIC	MG/L	<	0.01	-				
BARIUM	MG/L		0.2	-				
BERYLLIUM	MG/L	<	0.01	-				
BORON	MG/L		0.1	-				
BROMIDE	MG/L	<	0.1	-	&			
CADMIUM	MG/L		0.005	-				
CALCIUM	MG/L		639.	-				
CHLORIDE	MG/L		5800.	-				
CHROMIUM	MG/L		0.02	-				
COBALT	MG/L	<	0.05	-				
COPPER	MG/L		0.08	-				
CYANIDE	MG/L	<	0.01	-				
FLUORIDE	MG/L		0.9	-				
GROSS ALPHA	PCI/L	<	85.	85.	b			
GROSS BETA	PCI/L		120.	50.				
IRON	MG/L		0.11	-				
LEAD	MG/L		0.03	-				
LEAD-210	PCI/L		1.7	0.9				
MAGNESIUM	MG/L		11.5	-				
MANGANESE	MG/L		0.93	-				
MERCURY	MG/L	<	0.0002	-				
MOLYBDENUM	MG/L		0.05	-				
NET GROSS ALPHA *	PCI/L		-0.17	-				
NICKEL	MG/L	<	0.04	-				

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

FORMATION OF COMPLETION CODE: WS - WASATCH FORMATION - UNDIFFERENTIATED

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SAMPLE ID CODES:
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d - CHANGED DETECTION LIMIT AND PARAMETER VALUE

Table D.7.29 Groundwater quality data for Estes Gulch monitor wells and vicinity domestic wells
SITE: RFL08 ESTES GULCH
11/05/87 TO 03/10/90
REPORT DATE: 07/11/91

PARAMETER NAME	UNIT OF MEASURE	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS			
		LOC / DATE: 0985 - 04/23/89 SAMPLE ID: 0001 FORM. OF COMPLETION: WS FLOW REL: CROSS GRADIENT LABORATORY CODE: BAR LOT NUMBER: 001 SAMPLE TYPE: F						
NITRATE	MG/L		27.	-				
PH	SU		7.28	-				
PHOSPHATE	MG/L	<	0.1	-				
POLONIUM-210	PCI/L		0.2	0.3	c			
POTASSIUM	MG/L		6.87	-				
RADIUM-226	PCI/L		0.8	0.3				
RADIUM-226 + RADIUM-228	PCI/L		2.30	-				
RADIUM-228	PCI/L		1.5	1.0				
SELENIUM	MG/L		0.016	-				
SILICA - SIO2	MG/L		6.	-				
SILVER	MG/L	<	0.01	-				
SODIUM	MG/L		3160.	-				
SPECIFIC CONDUCTANCE	UMHO/CM		11000.	-				
STRONTIUM	MG/L		11.3	-				
SULFATE	MG/L		423.	-				
SULFIDE	MG/L	<	0.1	-				
TEMPERATURE	C - DEGREE		13.0	-				
THALLIUM	MG/L		0.08	-				
THORIUM-230	PCI/L	<	0.3	0.3	d			
TIN	MG/L	<	0.005	-				
TOTAL DISSOLVED SOLIDS	MG/L		11500.	-				
TOTAL ORGANIC CARBON	MG/L		4.6	-				
URANIUM	MG/L		0.0004	-	c			
VANADIUM	MG/L		0.07	-				
ZINC	MG/L		0.137	-				

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FORMATION OF COMPLETION CODE: WS - WASATCH FORMATION - UNDIFFERENTIATED

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

SAMPLE ID CODES:
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OTHER PARAMETER VALUE FLAGS:
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DATA FILE NAME: M:\DART\RFL08\GW010003.DAT

Table D.7.30 Regional groundwater quality data for the Mesaverde Group[a]

Well number	35	36	37	38	39	40
Specific conductance (umhos)	360	400	305	115	426	50
pH	7.6	7.4	7.3	6.9	7.4	7.5
Alkalinity (CaCO3)	185.	190.	120.	56.	101.	20.
Arsenic	0.	0.	0.001	0.	N.A.	0.
Bicarbonate	226.	230.	146.	68.	196.	24.
Boron	N/A	N/A	N/A	N/A	0.06	N/A
Calcium	45.	43.	32.	14.	25.	6.8
Chloride	0.9	1.8	3.3	0.5	16.	0.5
Carbonate	0.	0.	0.	0.	0.	0.
Fluoride	0.1	0.1	0.1	0.1	0.4	0.1
Hardness (mg/L CaCO3)	170.	160.	110.	50.	74.	22.
Iron	0.04	0.02	0.08	0.04	2.	0.04
Magnesium	15.	12.	6.7	3.7	2.7	10.
Manganese	0.	0.03	0.01	0.	0.4	0.001
Nitrogen (total)	0.33	0.35	0.54	0.08	0.02	0.36
Potassium	1.1	0.8	0.6	0.6	0.9	0.2
Selenium	0.	0.	0.	0.	N.A.	0.
Sulfate	12.	16.	5.2	2.7	23.	4.
TDS	209.	225.	145.	70.	235.	41.

[a]All units in mg/l unless otherwise noted.

N/A indicates not available.

Ref: Giles, 1980.

Table D.7.31 Groundwater parameters in Rifle domestic wells that exceed MCLs[a]

Well ID	Parameter	Sample date	Max. Conc. Limit	Parameter value[c]
423 (6 and 24) (Trailer park well)	Uranium	9/91	0.044	0.047
426 (Blackmoore Spring well)	Net gross alpha[b]	3/91	15	25.3
427 (All Seasons Propane well)	Selenium	9/91	0.010	0.049
	Net gross alpha[b]	9/91	15	21.8
428 (Ideal Cement Uranium well)	Uranium	3/91	0.044	0.046
		9/91	0.044	0.048
430 (2027 W. 2nd St.)	Net gross alpha[b]	3/91	15	26.7
559 (All Seasons Propane well)	Selenium	9/90	0.010	0.012
	Uranium	9/90	0.044	0.062
560 (Northwest Pipeline well)	Selenium	9/90	0.010	0.015
		3/91	0.010	0.014
	Uranium	9/90	0.044	0.048
		3/91	0.044	0.058

[a]Concentrations in mg/l.
[b]Concentrations in pCi/l.
[c]Concentrations reported as totals.

D.8 SURFACE WATER HYDROLOGY

D.8.1 GENERAL

Surface water hydrology data are required to evaluate flood protection requirements, to evaluate erosive effects of surface runoff on surrounding areas, and to define existing surface characteristics. Both of the Rifle tailings sites lie in the floodplain of the Colorado River. The floodplain at Old Rifle has been naturally and artificially narrowed at the site from over 1200 to 800 feet by geologic features, construction of the railroad, and the I-70 embankment. At New Rifle, the main channel of the Colorado River has been artificially channeled northward by blocking alternative river channels upstream of the site. At New Rifle, the Colorado River is about 1000 feet east and 600 feet south of the tailings pile. Detailed surface water information for both processing sites is presented in the Final Environmental Impact Statement (DOE, 1990).

The Estes Gulch site is at the head of a hollow and has virtually no drainage basin above it. The potential for stream flooding is very low.

D.8.2 SURFACE DRAINAGE AND FLOW

Both the Old and New Rifle sites are in the meander path of the Colorado River and lie on 10 to 25 feet of unconsolidated alluvial material. The narrowing of the river floodplain at the sites tends to result in erosion of the alluvium at the site during floods. Shifts in the river channel can be expected during flood stages, and the river could affect the integrity of the sites if the river is not properly controlled or the sites are not adequately protected.

The Estes Gulch site drains into an ephemeral creek in Estes Gulch approximately 0.5 mile southeast of the site. Gully erosion and surface drainage encroachment have the potential to affect the site. Several of the gullies present at the site are deeply incised, indicating recent downcutting. While current site conditions indicate a localized base as a result of gully development, the potential exists for further erosion and downcutting.

D.8.3 FLOODING ANALYSIS

Historical flood data are presented in detail in Appendix E of the Draft Environmental Impact Statement (DOE, 1986a). Both the Old and New Rifle sites appear to lie within the boundaries of the 100- and 500-year floodplains.

No data on historical floods exist for the Estes Gulch site. Due to the site's distance from and elevation above perennially flowing waters, river flooding would not affect the Estes Gulch site. The Colorado River, at its closest point, is approximately six miles away and 730 feet below the site.

D.8.4 WATER QUALITY

The parameters of interest in characterizing the water quality of the Colorado River in the vicinity of the Rifle tailings site are those that might be elevated because of uranium processing and tailings disposal (NRC, 1980).

Snowmelt provides most of the surface runoff water to Colorado rivers and streams (Iorns et al., 1965). Rising temperatures in the late spring and early summer rapidly melt the snow and cause streamflow to peak and then slowly subside as the supply of snow is exhausted. The highest levels of runoff occur when snowmelt is augmented by heavy rainstorms during the late spring and early summer. Usually by late July, the streams have subsided to base flow conditions, which prevail until the cycle is repeated the following spring. The seasonal pattern of the Colorado River is illustrated in Figure D.8.1.

The chemical quality of surface water in the Colorado River is directly related to the source of recharge waters, which varies seasonally. During most of the year, the river is recharged by groundwater, which introduces high concentrations of dissolved metals and inorganics that have been leached from the soil. During spring and summer high flow periods, the river is recharged primarily by surface runoff, which carries a greater volume of suspended solids; thus, the relative concentration of dissolved species decreases. This seasonal variation in water quality is exhibited in analyses of water samples taken from the Colorado River at New Castle and Parachute (Tables D.8.1 and D.8.2, respectively). Parachute is the location of the next Colorado River water intake downstream of the Rifle processing site. Parachute is approximately 14 miles downstream of the Rifle processing sites.

D.8.4.1 <u>Old and New Rifle tailings sites</u>

<u>Old Rifle site</u>

Surface water quality sampling has been performed during both high and low flow seasons. Most of the sampling events to obtain surface water samples from the river have been conducted during the low-flow period of the year. The Colorado River was sampled during the late fall of 1983 by Markos and Bush (1983), and again in the late spring of 1986, fall of 1987, and summer of 1990 by the DOE. In the course of sampling the river, samples were taken from points upgradient, crossgradient, and downgradient of the Old Rifle tailings pile. Whenever possible, the Markos and Bush sampling locations were resampled by the DOE. The sampling locations are illustrated in Figure D.8.2.

Analytical results indicate that the presence of the tailings is not causing degradation of the surface waters in the Colorado River. No health-threatening chemical species were found to be in excess of the Colorado standards. The analytical data used to support this conclusion are presented in Tables D.8.3 and D.8.4.

The concentration of uranium was equal to the proposed EPA MCL in a surface water sample collected from location 572 in September of 1989. However, this value is less than the statistical maximum background concentration for uranium at the Old Rifle site. Concentrations of sulfate, chloride, and magnesium are elevated above background in samples collected from locations 538, 539, and 544. The source of these elevated concentrations of constituents is unknown. However, since several of the samples were collected several thousand feet upstream of the Old Rifle processing site, these values are probably not due to uranium processing activities at the Old Rifle site.

New Rifle site

Surface water quality sampling has been performed during both high flow and low flow seasons in conjunction with the sampling effort at the Old Rifle tailings site. The Colorado River was sampled at points upgradient, crossgradient, and downgradient of the New Rifle tailings pile during the fall of 1983 by Markos and Bush (1983) and again in the late spring of 1986, fall of 1987, and summer of 1990 by the DOE. Whenever possible, the Markos and Bush sampling locations were resampled by the DOE. The sampling locations are illustrated in Figure D.8.2.

Analytical results indicate that the presence of the tailings is not causing degradation of the surface waters in the Colorado River. None of the contaminant parameters identified by the NRC (NRC, 1980) were found to be elevated in the vicinity of the site. Moreover, none of the water quality standards regulated by the state of Colorado were exceeded. The analytical data used to support this conclusion are presented in Tables D.8.4 and D.8.5.

D.8.4.2 Estes Gulch alternate disposal site

Drainage from the Estes Gulch site flows into ephemeral streams in Estes Gulch 0.5 mile below the site. In turn, Estes Gulch joins Government Creek one mile southeast of the site. The Colorado River is six miles due south of the site.

The ephemeral streams in Estes Gulch were not sampled. The water quality of Government Creek and one of its tributaries, Thirty-Two Mile Gulch, is described from samples obtained by Markos and Bush (1983) (Table D.8.6). Thirty-Two Mile Gulch was sampled 2.5 miles southwest of its confluence with Government Creek, upstream of the Estes Gulch site. Government Creek was sampled along State Highway 13, three miles north of Rifle, downstream of the Estes Gulch site. Analytical results from the Thirty-Two Mile Gulch sample exhibited low levels for all dissolved constituents. The Government Creek sample exhibited high levels of sulfate and calcium.

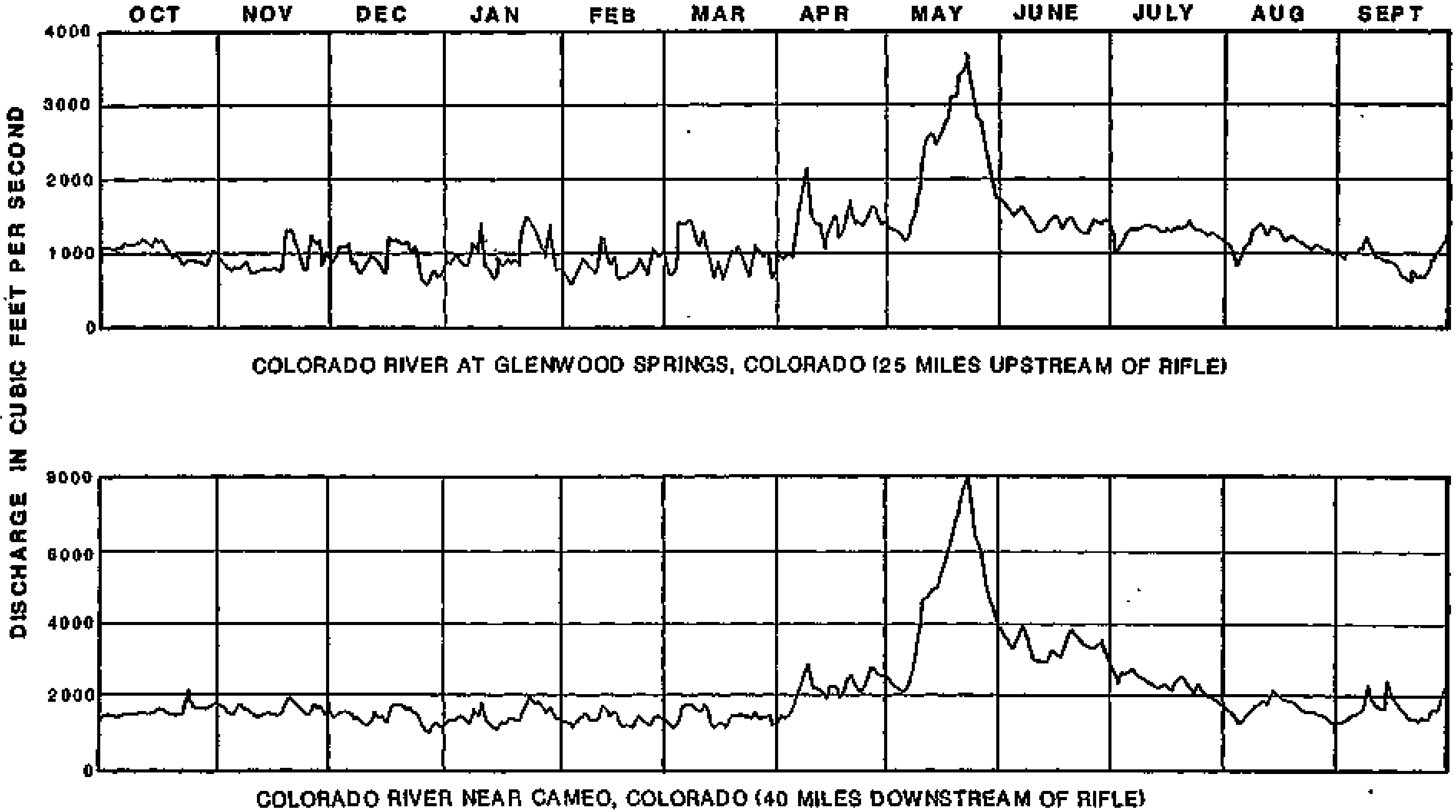
D.8.4.3 Borrow sites

Second Street borrow site

The Second Street borrow site is an active borrow operation approximately one mile north of the Colorado River. There are no surface drainages leading directly from the site to the river. Activities related to supplying borrow materials for the remedial action would be similar to those currently being performed at the site. Thus, the present surface water quality in the vicinity of the site would not be affected by the proposed borrow activities.

New Rifle borrow site

The New Rifle borrow site is an active borrow operation with a pond created by the current operations that has intercepted the water table. The borrow site is 0.5 mile north of the Colorado River; however, there is no surface drainage of the river from the site. Analyses of water samples from the pond at the site are similar to those for groundwater samples from nearby monitor wells. The surface water quality of the pond and Colorado River would not be affected by the proposed borrow activities necessary to supply borrow materials for the remedial action.



NOTE: 1954 WATER YEAR.

REF: IORNS et al., 1965

FIGURE D.8.1
SEASONAL RUNOFF PATTERN OF THE COLORADO RIVER

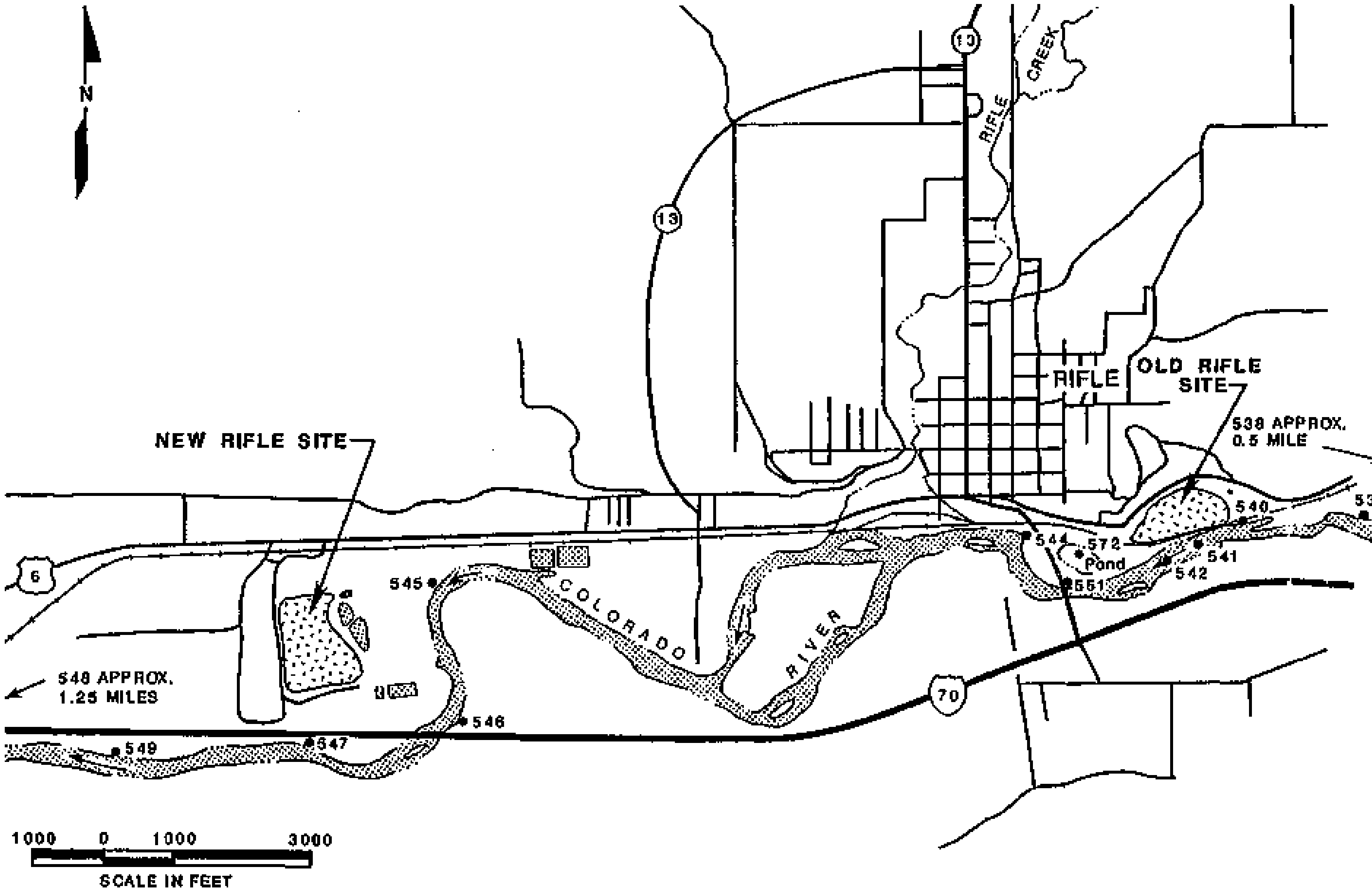


FIGURE D.8.2
SURFACE WATER QUALITY SAMPLING LOCATIONS, OLD AND NEW RIFLE SITES

Table D.8.1 Colorado River water quality at New Castle, Colorado[a]

Constituent	03 Nov 1981	16 Dec 1981	28 Jan 1982	23 Feb 1982	15 Mar 1982	15 Apr 1982
Alkalinity	133.0	131.0	120.0	123.0	117.0	115.0
Aluminum	<0.1	NA	<0.1	NA	NA	<0.1
Arsenic	<0.01	NA	<0.01	NA	NA	<0.01
Cadmium	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Calcium	68.0	74.0	68.0	73.0	64.0	59.0
Chloride	170.0	201.0	170.0	192.0	175.0	106.0
Chromium	<0.01	NA	<0.01	NA	NA	<0.01
Copper	<0.01	NA	<0.01	NA	NA	<0.01
Iron (total)	0.10	<0.02	0.14	0.19	0.28	0.22
Lead	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Magnesium	13.0	12.0	10.0	13.0	15.0	11.0
Manganese	0.03	<0.01	<0.01	<0.01	<0.01	<0.01
Mercury[b]	<0.05	NA	<0.05	NA	NA	<0.05
Molybdenum	<0.1	NA	<0.1	NA	NA	<0.1
Nickel	<0.05	NA	<0.05	NA	NA	<0.05
pH[c]	8.4	8.3	8.3	8.0	8.2	7.9
Potassium	15.0	3.4	18.0	2.1	2.8	2.2
Selenium	<0.01	NA	<0.01	NA	NA	<0.01
Sodium	110.0	147.0	132.0	128.0	124.0	74.0
Solids (dissolved)	700.0	792.0	710.0	742.0	681.0	492.0
Solids (suspended)	16.0	5.0	14.0	12.0	68.0	367.0
Sulfate	115.0	131.0	130.0	121.0	129.0	85.0
Conductivity[d]	1075.0	1295.0	1165.0	1055.0	1025.0	780.0
Discharge[e]	1650.0	1400.0	1365.0	1500.0	1650.0	2550.0

Table D.8.1 Colorado River water quality at New Castle, Colorado[a] (Concluded)

Constituent	28 May 1982	17 Jan 1982	14 Jul 1982	24 Aug 1982	27 Sep 1982	12 Oct 1982
Alkalinity	NA	94.0	90.0	126.0	115.0	178.0
Aluminum	NA	NA	<0.1	NA	NA	<0.1
Arsenic	NA	NA	<0.01	NA	NA	<0.01
Cadmium	NA	<0.005	<0.005	<0.005	<0.005	<0.005
Calcium	NA	38.0	42.0	56.0	61.0	64.0
Chloride	NA	28.0	48.0	98.0	118.0	12.0
Chromium	NA	NA	<0.01	NA	NA	NA
Copper	NA	NA	<0.01	NA	NA	NA
Iron (total)	NA	0.16	0.12	<0.02	<0.02	<0.02
Lead	NA	<0.05	<0.05	<0.05	<0.05	<0.05
Magnesium	NA	5.1	5.0	10.0	10.0	11.0
Manganese	NA	<0.01	<0.01	<0.01	<0.01	<0.01
Mercury[b]	NA	NA	<0.5	NA	NA	NA
Molybdenum	NA	NA	<0.1	NA	NA	NA
Nickel	NA	NA	<0.05	NA	NA	NA
pH[c]	NA	8.2	7.9	8.2	8.2	8.3
Potassium	NA	0.79	1.2	1.9	2.1	2.1
Selenium	NA	NA	<0.01	NA	NA	NA
Sodium	NA	22.0	34.0	69.0	84.0	85.0
Solids (dissolved)	NA	249.0	297.0	363.0	521.0	470.0
Solids (suspended)	NA	60.0	18.0	54.0	18.0	<5.0
Sulfate	NA	28.0	39.0	65.0	84.0	177.0
Conductivity[d]	NA	35.0	465.0	600.0	670.0	730.0
Discharge[e]	8475.0	10,400.0	6250.0	1460.0	2700.0	2550.0

[a]All values are in milligrams per liter unless otherwise noted. No data available is indicated by NA.
[b]Values are in micrograms per liter.
[c]Values are in standard pH units.
[d]Values are in micromhos per centimeter.
[e]Values are in cubic feet per second.

Table D.8.2 Colorado River water quality at Parachute, Colorado[a]

Constituent	03 Nov 1981	16 Dec 1981	28 Jan 1982	23 Feb 1982	15 Mar 1982	15 Apr 1982
Alkalinity	131.0	120.0	140.0	141.0	123.0	123.0
Aluminum	<0.1	NA	<0.1	NA	NA	<0.1
Arsenic	<0.01	NA	<0.01	NA	NA	<0.01
Cadmium	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Calcium	72.0	76.0	70.0	76.0	63.0	59.0
Chloride	162.0	196.0	170.0	186.0	133.0	96.0
Chromium	<0.01	NA	<0.01	NA	NA	<0.01
Copper	<0.01	NA	<0.01	NA	NA	<0.01
Iron (total)	0.14	<0.02	0.09	0.77	0.72	0.23
Lead	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Magnesium	17.0	16.0	14.0	18.0	16.0	17.0
Manganese	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mercury[b]	<0.05	NA	<0.05	NA	NA	<0.05
Molybdenum	<0.1	NA	<0.1	NA	NA	<0.1
Nickel	<0.05	NA	<0.05	NA	NA	<0.05
pH[c]	8.5	8.3	8.4	8.1	8.2	7.9
Potassium	2.3	2.6	4.1	5.1	3.1	2.4
Selenium	<0.01	NA	<0.01	NA	NA	<0.01
Sodium	110.0	130.0	134.0	134.0	111.0	74.0
Solids (dissolved)	700.0	781.0	760.0	804.0	684.0	500.0
Solids (suspended)	22.0	11.0	55.0	145.0	266.0	571.0
Sulfate	131.0	143.0	150.0	164.0	157.0	93.0
Conductivity[d]	1060.0	1225.0	1200.0	975.0	1100.0	760.0
Discharge[e]	1710.0	1470.0	1430.0	1670.0	1730.0	2680.0

Table D.8.2 Colorado River water quality at Parachute, Colorado[a] (Concluded)

Constituent	28 May 1982	17 Jan 1982	14 Jul 1982	24 Aug 1982	27 Sep 1982	12 Oct 1982
Alkalinity	NA	98.0	92.0	134.0	130.0	129.0
Aluminum	NA	NA	<0.1	NA	NA	NA
Arsenic	NA	NA	<0.01	NA	NA	NA
Cadmium	NA	<0.005	<0.005	<0.005	<0.005	<0.005
Calcium	NA	45.0	43.0	60.0	63.0	67.0
Chloride	NA	26.0	49.0	97.0	107.0	118.0
Chromium	NA	NA	<0.01	NA	NA	NA
Copper	NA	NA	<0.01	NA	NA	NA
Iron (total)	NA	0.12	0.33	0.10	0.39	0.70
Lead	NA	<0.05	<0.05	<0.05	<0.05	<0.05
Magnesium	NA	3.0	6.0	11.0	12.0	13.0
Manganese	NA	<0.01	<0.01	<0.01	<0.01	<0.01
Mercury[b]	NA	NA	<0.5	NA	NA	NA
Molybdenum	NA	NA	<0.1	NA	NA	NA
Nickel	NA	NA	<0.05	NA	NA	NA
pH[c]	NA	8.1	8.0	8.2	8.2	8.4
Potassium	NA	1.9	1.1	2.1	2.1	2.1
Selenium	NA	NA	<0.01	NA	NA	NA
Sodium	NA	17.0	34.0	73.0	84.0	85.0
Solids (dissolved)	NA	265.0	312.0	388.0	542.0	493.0
Solids (suspended)	NA	79.0	19.0	119.0	374.0	<5.0
Sulfate	NA	24.0	46.0	80.0	115.0	116.0
Conductivity[d]	NA	300.0	480.0	600.0	805.0	620.0
Discharge[e]	9570.0	10,900.00	3720.0	1570.0	2750.0	2600.0

[a]All values are in milligrams per liter unless otherwise noted. No data available is indicated by NA.
[b]Values are in micrograms per liter.
[c]Values are in standard pH units.
[d]Values are in micromhos per centimeter.
[e]Values are in cubic feet per second.

Table D.8.3 Colorado River water quality, Old Rifle site[a]

Constituent	Surface water quality sampling station[b]					
	538	539	540	541	542	544
Aluminum	0.170	0.220	<0.03	0.030	0.290	<0.03
Arsenic	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Barium	0.056	0.075	0.075	0.043	0.032	0.053
Cadmium	<0.0005	<0.0005	<0.0006	<0.0005	<0.0005	<0.0005
Calcium	130.0	130.0	48.0	47.0	43.0	43.0
Chloride	5.0	170.0	52.0	50.0	50.0	50.0
Chromium	<0.02	<0.02	0.07	<0.02	<0.02	<0.02
Cobalt	<0.03	<0.03	0.014	<0.03	<0.03	<0.03
Iron	<0.02	<0.02	0.27	0.31	<0.02	<0.02
Lead	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Magnesium	12.0	84.0	12.0	12.0	11.0	11.0
Manganese	<0.01	1.80	0.07	0.08	<0.01	<0.01
Molybdenum	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Nickel	<0.04	<0.04	<0.55	<0.04	<0.04	<0.04
pH	7.9	7.7	7.8	7.6	7.6	7.6
Potassium	<1.0	7.40	3.30	1.40	<1.0	1.10
Selenium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silicon	5.60	5.70	4.70	4.60	4.50	4.50
Silver	<0.04	0.05	NA	<0.04	<0.04	<0.04
Sodium	44.0	3609.0	54.0	33.0	43.0	47.0
Strontium	0.371	1.360	0.334	0.327	0.307	0.346
Sulfate	79.0	885.0	83.0	76.0	69.0	73.0
Uranium	0.0025	0.0180	0.0032	0.0050	0.0028	<0.04
Vanadium	<0.04	<0.04	0.150	<0.040	<0.040	<0.04

[a]All values are in milligrams per liter except pH, which is given in standard pH units.
[b]Station locations are shown on Figure D.8.2. Samples were taken during September 1983 (Markos and Bush, 1983).

Table D.8.4 Recent surface water quality data for the Rifle processing sites
SITE: RF001 RIFLE (OLD)
11/05/87 TO 09/16/90
REPORT DATE: 07/11/91

		LOC / DATE: 0538 - 11/05/87 SAMPLE ID: 0001				LOC / DATE: 0539 - 11/05/87 SAMPLE ID: 0001				LOC / DATE: 0544 - 11/05/87 SAMPLE ID: 0001				LOC / DATE: 0545 - 11/05/87 SAMPLE ID: 0001			
PARAMETER NAME	UNIT OF MEASURE	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS
ALKALINITY	MG/L CACO3		150.	-			139.	-			146.	-			140.	-	
AMMONIUM	MG/L	<	0.1	-		<	0.1	-		<	0.1	-		<	0.1	-	
ARSENIC	MG/L		0.001	-	c		0.002	-	c		0.002	-	c	<	0.001	-	
BARIUM	MG/L		0.05	-	c		0.05	-	c		0.05	-	c		0.05	-	c
BROMIDE	MG/L	<	0.1	-		<	0.1	-		<	0.1	-		<	0.1	-	
CADMIUM	MG/L	<	0.005	-	c	<	0.005	-	c	<	0.005	-	c	<	0.005	-	c
CALCIUM	MG/L		76.9	-			73.1	-			75.5	-			73.2	-	
CHLORIDE	MG/L		165.	-			167.	-			166.	-			164.	-	
CHROMIUM	MG/L	<	0.01	-		<	0.01	-		<	0.01	-		<	0.01	-	
FLUORIDE	MG/L		0.29	-			0.28	-			0.28	-			0.28	-	
IRON	MG/L		0.04	-			0.04	-			0.04	-			0.04	-	
LEAD	MG/L	<	0.01	-		<	0.01	-		<	0.01	-		<	0.01	-	
MAGNESIUM	MG/L		17.3	-			15.9	-			16.1	-			16.5	-	
MANGANESE	MG/L		0.04	-			0.02	-			0.02	-			0.02	-	
MOLYBDENUM	MG/L		0.02	-			0.02	-			0.02	-			0.02	-	
NITRATE	MG/L	<	0.1	-		<	0.1	-		<	0.1	-		<	0.1	-	
NITRITE	MG/L	<	0.1	-		<	0.1	-		<	0.1	-		<	0.1	-	
PH	SU		8.3	-			8.4	-			8.2	-			8.4	-	
POTASSIUM	MG/L		3.70	-			3.61	-			3.29	-			3.27	-	
RADIUM-226	PCI/L		0.1	0.2	c		0.3	0.2	c		0.1	0.2	c		0.2	0.2	c
RADIUM-226 + RADIUM-228	PCI/L		0.40	-			0.80	-			1.50	-			0.70	-	
RADIUM-228	PCI/L		0.3	1.5		<	1.6	1.6	b		1.4	2.7			0.5	1.7	
SELENIUM	MG/L		0.006	-			0.008	-			0.009	-			0.010	-	
SODIUM	MG/L		120.	-			112.	-			111.	-			110.	-	
SPECIFIC CONDUCTANCE	UMHO/CM		800.	-			1470.	-			700.	-			780.	-	
SULFATE	MG/L		153.	-			143.	-			135.	-			149.	-	
TEMPERATURE	C - DEGREE		9.0	-			8.0	-			6.0	-			10.	-	
TOTAL DISSOLVED SOLIDS	MG/L		644.	-			600.	-			605.	-			611.	-	
URANIUM	MG/L		0.0030	-			0.0029	-	c		0.0030	-			0.0030	-	

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

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

OTHER PARAMETER VALUE FLAGS:
b - CHANGED PARAMETER VALUE
c - CHANGED DETECTION LIMIT

Table D.8.4 Recent surface water quality data for the Rifle processing sites
SITE: RF001 RIFLE (OLD)
11/05/87 TO 09/16/90
REPORT DATE: 07/11/91

PARAMETER NAME	UNIT OF MEASURE	LOC / DATE: 0549 - 09/16/90 SAMPLE ID: N001 PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	LOC / DATE: 0551 - 09/16/90 SAMPLE ID: N001 PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	LOC / DATE: 0572 - 09/26/89 SAMPLE ID: 0001 PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	LOC / DATE: 0572 - 03/10/90 SAMPLE ID: 0001 PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS
ALKALINITY	MG/L CACO3		99.	-			98.	-			136.	-			209.	-	
ALUMINUM	MG/L		-	-			-	-		<	0.1	-		<	0.05	-	
ALUMINUM (TOTAL)	MG/L		.4	-			.4	-			-	-			-	-	
AMMONIUM	MG/L		-	-			-	-		<	0.1	-			0.2	-	
AMMONIUM (TOTAL)	MG/L		.9	-		<	.1	-			-	-			-	-	
ANTIMONY	MG/L		-	-			-	-		<	0.003	-		<	0.003	-	
ANTIMONY (TOTAL)	MG/L		.003	-		<	.003	-			-	-			-	-	
ARSENIC	MG/L		-	-			-	-		<	0.01	-		<	0.01	-	
ARSENIC (TOTAL)	MG/L	<	.01	-		<	.01	-			-	-			-	-	
BARIUM	MG/L		-	-			-	-			0.2	-			0.17	-	
BARIUM (TOTAL)	MG/L	<	.1	-		<	.1	-			-	-			-	-	
BERYLLIUM	MG/L		-	-			-	-		<	0.01	-		<	0.005	-	
BORON	MG/L		-	-			-	-			0.1	-			0.08	-	c
BROMIDE	MG/L		-	-			-	-		<	0.1	-		<	0.1	-	
BROMIDE (TOTAL)	MG/L	<	.1	-	c	<	.1	-	c		-	-			-	-	
CADMIUM	MG/L		-	-			-	-		<	0.001	-			-	-	
CADMIUM (TOTAL)	MG/L	<	.001	-		<	.001	-			-	-			-	-	
CALCIUM	MG/L		-	-			-	-			54.1	-			-	-	
CALCIUM (TOTAL)	MG/L		59.3	-			60.9	-			-	-			-	-	
CHLORIDE	MG/L		-	-			-	-			150.	-			146.	-	
CHLORIDE (TOTAL)	MG/L		148.	-			148.	-			-	-			-	-	
CHROMIUM	MG/L		-	-			-	-		<	0.01	-			-	-	
CHROMIUM (TOTAL)	MG/L	<	.01	-		<	.01	-			-	-			-	-	
COBALT	MG/L		-	-			-	-		<	0.05	-			-	-	
COPPER	MG/L		-	-			-	-		<	0.02	-			-	-	
CYANIDE	MG/L		-	-			-	-		<	0.01	-		<	0.02	-	c
FLUORIDE	MG/L		-	-			-	-			0.520	-			0.5	-	
FLUORIDE (TOTAL)	MG/L		0.4	-			0.4	-			-	-			-	-	
GROSS ALPHA	PCI/L		-	-			-	-			54.	9.0			-	-	
GROSS ALPHA (TOTAL)	PCI/L		4.6	4.6			2.7	4.5			-	-			-	-	
GROSS BETA	PCI/L		-	-			-	-			34.	5.			-	-	
GROSS BETA (TOTAL)	PCI/L		7.5	2.5			5.0	2.5			-	-			-	-	
IRON	MG/L		-	-			-	-			0.06	-			-	-	
IRON (TOTAL)	MG/L		.50	-			.57	-			-	-			-	-	
LEAD	MG/L		-	-			-	-			0.04	-			-	-	
LEAD (TOTAL)	MG/L	<	.01	-		<	.01	-			-	-			-	-	
LEAD-210	PCI/L		-	-			-	-			0.2	0.7	c		-	-	
MAGNESIUM	MG/L		-	-			-	-			31.9	-			-	-	
MAGNESIUM (TOTAL)	MG/L		12.6	-			12.8	-			-	-			-	-	

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

OTHER PARAMETER VALUE FLAGS:
c - CHANGED DETECTION LIMIT
d - CHANGED DETECTION LIMIT AND PARAMETER VALUE

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

Table D.8.4 Recent surface water quality data for the Rifle processing sites
SITE: RFO01 RIFLE (OLD)
11/05/87 TO 09/16/90
REPORT DATE: 07/11/91

PARAMETER NAME	UNIT OF MEASURE	LOC / DATE: 0549 - 09/16/90 SAMPLE ID: N001				LOC / DATE: 0551 - 09/16/90 SAMPLE ID: N001				LOC / DATE: 0572 - 09/26/89 SAMPLE ID: 0001				LOC / DATE: 0572 - 03/10/90 SAMPLE ID: 0001			
		PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS
MANGANESE	MG/L		-	-			-	-			0.03	-			-	-	
MANGANESE (TOTAL)	MG/L		.04	-			.03	-			-	-			-	-	
MERCURY	MG/L		-	-			-	-		<	0.0002	-			-	-	
MOLYBDENUM	MG/L		-	-			-	-			0.04	-			-	-	
MOLYBDENUM (TOTAL)	MG/L		.03	-			.03	-			-	-			-	-	
NET GROSS ALPHA *	PCI/L		-	-			-	-			23.82	-			-	-	
NET GROSS ALPHA (TOTAL) **	PCI/L		-0.13	-			-1.90	-			-	-			-	-	
NICKEL	MG/L		-	-			-	-		<	0.04	-			-	-	
NITRATE	MG/L		-	-			-	-		<	0.1	-		<	1.	-	
NITRATE (TOTAL)	MG/L		1.	-		<	1.	-			-	-			-	-	
NITRITE AND NITRATE	MG/L		-	-			-	-			-	-		<	0.05	-	
PH	SU		8.66	-			8.48	-			8.56	-			7.87	-	
PHOSPHATE	MG/L		-	-			-	-		<	0.1	-		<	0.1	-	
PHOSPHATE (TOTAL)	MG/L		.6	-			.6	-			-	-			-	-	
POLONIUM-210	PCI/L		-	-			-	-			0.2	0.3	c		-	-	
POTASSIUM	MG/L		-	-			-	-			5.8	-			-	-	
POTASSIUM (TOTAL)	MG/L		4.1	-			3.4	-			-	-			-	-	
RADIUM-226	PCI/L		-	-			-	-			0.5	0.3	c		-	-	
RADIUM-226 (TOTAL)	PCI/L		0.1	0.2	c		0.2	0.2	c		-	-			-	-	
RADIUM-226 + RADIUM-228	PCI/L		-	-			-	-			1.10	-			-	-	
RADIUM-226 + RADIUM-228 TOTAL	PCI/L		0.70	-			1.20	-			-	-			-	-	
RADIUM-228	PCI/L		-	-			-	-			0.6	0.9			-	-	
RADIUM-228 (TOTAL)	PCI/L		0.6	0.9			1.0	1.0			-	-			-	-	
SELENIUM	MG/L		-	-			-	-		<	0.005	-			-	-	
SELENIUM (TOTAL)	MG/L	<	.005	-		<	.005	-			-	-			-	-	
SILICA - SIO2	MG/L		-	-			-	-			1.	-	c		-	-	
SILICA - SIO2 (TOTAL)	MG/L		8.	-			8.	-			-	-			-	-	
SILVER	MG/L		-	-			-	-		<	0.01	-			-	-	
SILVER (TOTAL)	MG/L	<	.01	-		<	.01	-			-	-			-	-	
SODIUM	MG/L		-	-			-	-			106.	-			-	-	
SODIUM (TOTAL)	MG/L		110.	-			107.	-			-	-			-	-	
SPECIFIC CONDUCTANCE	UMHO/CM		810.	-			820.	-			620.	-			700.	-	
STRONTIUM	MG/L		-	-			-	-			0.77	-			-	-	
STRONTIUM (TOTAL)	MG/L		.5	-			.5	-			-	-			-	-	
SULFATE	MG/L		-	-			-	-			174.	-			180.	-	
SULFATE (TOTAL)	MG/L		126.	-			112.	-			-	-			-	-	
SULFIDE	MG/L		-	-			-	-		<	0.005	-		<	0.1	-	

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

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

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

Table D.8.4 Recent surface water quality data for the Rifle processing sites
SITE: RF001 RIFLE (OLD)
11/05/87 TO 09/16/90
REPORT DATE: 07/11/91

		LOC / DATE: 0549 - 09/16/90 SAMPLE ID: N001				LOC / DATE: 0551 - 09/16/90 SAMPLE ID: N001				LOC / DATE: 0572 - 09/26/89 SAMPLE ID: 0001				LOC / DATE: 0572 - 03/10/90 SAMPLE ID: 0001			
PARAMETER NAME	UNIT OF MEASURE	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS
TEMPERATURE	C - DEGREE		20.0	-			21.0	-			21.0	-			11.0	-	
THALLIUM	MG/L		-	-			-	-		<	0.01	-			-	-	
THORIUM-230	PCI/L		-	-			-	-		<	0.3	0.3	d		-	-	
TIN	MG/L		-	-			-	-		<	0.005	-			-	-	
TOTAL DISSOLVED SOLIDS	MG/L		-	-			-	-			607.	-			631.	-	
TOTAL DISSOLVED SOLIDS (TOTAL)	MG/L		504.	-			500.	-			-	-			-	-	
TOTAL ORGANIC CARBON	MG/L		-	-			-	-			32.5	-			5.	-	
TOTAL ORGANIC CARBON (TOTAL)	MG/L		22.	-			21.	-			-	-			-	-	
URANIUM	MG/L		-	-			-	-			0.044	-			-	-	
URANIUM (TOTAL)	MG/L		0.0069	-			0.0067	-			-	-			-	-	
VANADIUM	MG/L		-	-			-	-			0.02	-			-	-	
VANADIUM (TOTAL)	MG/L	<	.01	-		<	.01	-			-	-			-	-	
ZINC	MG/L		-	-			-	-			0.021	-			-	-	
ZINC (TOTAL)	MG/L		.019	-			.063	-			-	-			-	-	

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

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

Table D.8.4 Recent surface water quality data for the Rifle processing sites
SITE: RF001 RIFLE (OLD)
11/05/87 TO 09/16/90
REPORT DATE: 07/11/91

PARAMETER NAME	UNIT OF MEASURE	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS
		LOC / DATE: 0572 - 03/10/90 SAMPLE ID: N001			
ALKALINITY	MG/L CACO3		209.	-	
ALUMINUM (TOTAL)	MG/L		0.33	-	
ANTIMONY (TOTAL)	MG/L	<	0.003	-	
ARSENIC (TOTAL)	MG/L	<	0.01	-	
BARIUM (TOTAL)	MG/L		0.19	-	
BERYLLIUM (TOTAL)	MG/L	<	0.005	-	
BORON (TOTAL)	MG/L		0.10	-	
CADMIUM (TOTAL)	MG/L	<	0.001	-	
CALCIUM (TOTAL)	MG/L		65.	-	
CHLORIDE (TOTAL)	MG/L		152.	-	
CHROMIUM (TOTAL)	MG/L	<	0.01	-	
COBALT (TOTAL)	MG/L	<	0.03	-	
COPPER (TOTAL)	MG/L	<	0.01	-	
FLUORIDE (TOTAL)	MG/L		0.3	-	
GROSS ALPHA (TOTAL)	PCI/L		14.7	4.1	
GROSS BETA (TOTAL)	PCI/L		14.3	2.5	
IRON (TOTAL)	MG/L		0.41	-	
LEAD (TOTAL)	MG/L	<	0.01	-	
LEAD-210 (TOTAL)	PCI/L		0.6	2.9	
MAGNESIUM (TOTAL)	MG/L		33.	-	
MANGANESE (TOTAL)	MG/L		0.12	-	
MERCURY (TOTAL)	MG/L	<	0.0002	-	
MOLYBDENUM (TOTAL)	MG/L		0.02	-	
NET GROSS ALPHA (TOTAL) **	PCI/L		-14.11	-	
NICKEL (TOTAL)	MG/L	<	0.04	-	
PH	SU		7.87	-	
PHOSPHATE (TOTAL)	MG/L		0.1	-	
POLONIUM-210 (TOTAL)	PCI/L		0.1	0.7	c
POTASSIUM (TOTAL)	MG/L		4.2	-	
RADIUM-226 (TOTAL)	PCI/L		1.0	0.4	
RADIUM-226 + RADIUM-228 TOTAL	PCI/L		1.50	-	
RADIUM-228 (TOTAL)	PCI/L	<	2.7	2.7	b
SELENIUM (TOTAL)	MG/L	<	0.005	-	
SILICA - SIO2 (TOTAL)	MG/L		2.6	-	
SILVER (TOTAL)	MG/L	<	0.01	-	
SODIUM (TOTAL)	MG/L		116.	-	
SPECIFIC CONDUCTANCE	UMHO/CM		700.	-	
STRONTIUM (TOTAL)	MG/L		0.86	-	

** NET GROSS ALPHA (TOTAL) (TOTAL GROSS ALPHA - TOTAL URANIUM)

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

SAMPLE ID CODES:
N001 - UNFILTERED SAMPLE

OTHER PARAMETER VALUE FLAGS:
b - CHANGED PARAMETER VALUE
c - CHANGED DETECTION LIMIT

Table D.8.4 Recent surface water quality data for the Rifle processing sites
SITE: RFO01 RIFLE (OLD)
11/05/87 TO 09/16/90
REPORT DATE: 07/11/91

		LOC / DATE: 0572 - 03/10/90 SAMPLE ID: N001						
PARAMETER NAME	UNIT OF MEASURE	PVI	PARAMETER VALUE	PARAMETER UNCERT.	FLAGS			
TEMPERATURE	C - DEGREE		11.0	-				
THALLIUM (TOTAL)	MG/L	<	0.1	-				
THORIUM-230 (TOTAL)	PCI/L		4.2	1.3				
TIN (TOTAL)	MG/L	<	0.05	-	o			
URANIUM (TOTAL)	MG/L		0.042	-				
VANADIUM (TOTAL)	MG/L	<	0.01	-				
ZINC (TOTAL)	MG/L		0.021	-				

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

SAMPLE ID CODES:
N001 - UNFILTERED SAMPLE

DATA FILE NAME: N:\DART\RFO01\SW910100.DAT

Table D.8.5 Colorado River water quality, New Rifle site[a]

Constituent	Surface water-quality sampling station[b]				
	545	546	547	548	549
Aluminum	<0.03	<0.03	NA	<0.03	<0.03
Arsenic	<0.01	<0.01	<0.01	<0.01	<0.01
Barium	0.063	0.061	0.055	0.056	0.055
Cadmium	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Calcium	47.0	47.0	46.0	48.0	45.0
Chloride	48.0	47.0	50.0	48.0	50.0
Chromium	<0.02	<0.02	<0.02	<0.02	<0.02
Cobalt	<0.03	<0.03	<0.03	<0.03	<0.03
Iron	0.16	0.19	<0.02	<0.02	<0.02
Lead	<0.005	<0.005	<0.005	<0.005	<0.005
Magnesium	12.0	12.0	11.0	11.0	12.0
Manganese	0.03	0.03	<0.01	<0.01	<0.01
Molybdenum	0.05	<0.04	<0.04	<0.04	<0.04
Nickel	<0.04	<0.04	<0.04	<0.04	<0.04
pH	7.9	7.8	7.6	7.6	7.8
Potassium	<1.0	<1.0	<1.0	<1.0	<1.0
Selenium	<0.01	<0.01	<0.01	<0.01	<0.01
Silicon	4.90	5.00	4.90	5.10	5.10
Silver	<0.04	<0.04	NA	<0.04	<0.04
Sodium	64.0	56.0	<20.0	56.0	<20.0
Strontium	0.367	0.374	0.357	0.366	0.362
Sulfate	76.0	73.0	76.0	73.0	79.0
Uranium	<0.01	0.0021	0.0022	0.0028	0.0200
Vanadium	<0.04	<0.04	<0.04	<0.04	<0.04

[a]All values are in milligrams per liter except pH, which is given in standard pH units.
[b]Station locations are shown on Figure D.8.2. Samples were taken during September 1983 (Markos and Bush, 1983).

Table D.8.6 Surface water quality near the Estes Gulch site

Constituent[a]	Thirty-Two Mile Gulch[b]	Government Creek[c]
Aluminum	<0.03	<0.03
Arsenic	<0.01	<0.01
Barium	0.054	0.065
Cadmium	<0.0005	<0.0005
Calcium	43.0	963.0
Chloride	50.0	11.0
Chromium	<0.02	<0.02
Cobalt	<0.03	<0.03
Iron	<0.02	<0.02
Lead	<0.005	<0.005
Magnesium	13.0	53.0
Manganese	<0.01	<0.01
Molybdenum	<0.04	<0.04
Nickel	<0.04	<0.04
pH	8.0	8.3
Potassium	<1.0	1.5
Selenium	<0.01	<0.01
Silicon	5.70	6.50
Silver	<0.04	<0.04
Sodium	26.0	130.0
Strontium	0.36	0.96
Sulfate	76.0	370.0
Uranium	0.0020	0.0070
Vanadium	<0.04	<0.04

[a]All values are in milligrams per liter except pH, which is given in standard pH units. Samples were taken during September 1983 (Markos and Bush, 1983).
[b]Sample location was approximately three miles southwest and upstream of the Estes Gulch site.
[c]Sample location was approximately three miles southeast and downstream of the Estes Gulch site.

D.9 METEOROLOGICAL DATA

Meteorological data are required to estimate the length of the construction season, plan construction dust and runoff control, design long-term erosion control features, determine the long-term moisture content of cover materials, and determine any extraordinary protection required for personnel or equipment.

D.9.1 WEATHER PATTERNS

The region has a semiarid, continental climate with low precipitation and humidity, large temperature variations, and high evaporation. The Rifle area is topographically and meteorologically complex, consisting of the Colorado River valley surrounded by steep canyons and plateaus. Elevations range from over 8700 feet on the plateaus to approximately 5000 feet in the Colorado River valley. Elevation, exposure, aspect, and topographic channeling of winds affect the weather at any specific location. Changes in the weather are often caused by cold fronts moving from the Pacific Ocean or from the north. During the winter, polar cold fronts usually carry little moisture and generally produce light snow in the region (DOE, 1983).

Weather data are not available for the Estes Gulch site. Temperature and precipitation at Estes Gulch are expected to be similar to those recorded at Rifle. However, the temperatures may be slightly cooler on the average because Estes Gulch is approximately 600 feet higher than Rifle. Wind flow patterns at Estes Gulch would be different than at Rifle due to the local topographic relief.

D.9.2 WINDS

Long-term wind speed and direction data are available for the city of Rifle. An analysis of these data from 1959 through 1963 indicated that the winds blew most frequently out of the northeast and the west (Figure D.9.1). The average wind speed for this period was 4.5 miles per hour (mph). Prevailing winds were also out of the northeast for each month except April, when they were from the west (DOC, 1968a,b).

Wind speed and direction data collected at the New Rifle tailings site between July 1982 and June 1983 are in fairly close agreement with the data for the city of Rifle. Winds blew most frequently from the east and west-southwest while the mean wind speed was greatest from the west-southwest and north-northwest (Figure D.9.1). The natural dominant wind directions at both Rifle tailings sites correspond to the orientation of the Colorado River valley. The average wind speed at the New Rifle site (4.7 mph) was similar to the average wind speed measured in the city of Rifle.

D.9.3 TEMPERATURE

The temperature of the region is strongly affected by elevation and the local terrain. Temperatures decrease an average of approximately 3.5°F per 1000 feet of increased elevation. However, weather stations in sheltered locations, such as valley floors, tend to have lower minimum temperatures from cold air drainage (DOE, 1983).

The temperatures recorded at Rifle have ranged from 104°F in July 1948 to -38°F in January 1949. Temperatures above 100°F are infrequent, and approximately one-third of the winters have no readings below 0°F. Summer days with maximum temperatures in the middle and low 80s and minimum temperatures in the low 60s are common. In the period 1931 though 1980, the average air temperature was 47.3°F, the average maximum annual air temperature was 64.3°F, and the average minimum annual air temperature was 30.3°F. Monthly average air temperatures ranged from 22.6°F in January to 70.3°F in July (Colorado Climate Center, 1982).

D.9.4 PRECIPITATION

The Colorado River valley is surrounded by mountains in virtually all directions and receives little precipitation. Summer rains occur mainly as scattered light showers from thunderstorms that develop over the nearby mountains. Winter snows are fairly frequent; however, they are mostly light and quickly melt off. Blizzard conditions in valley locations are extremely rare (NOAA, 1980).

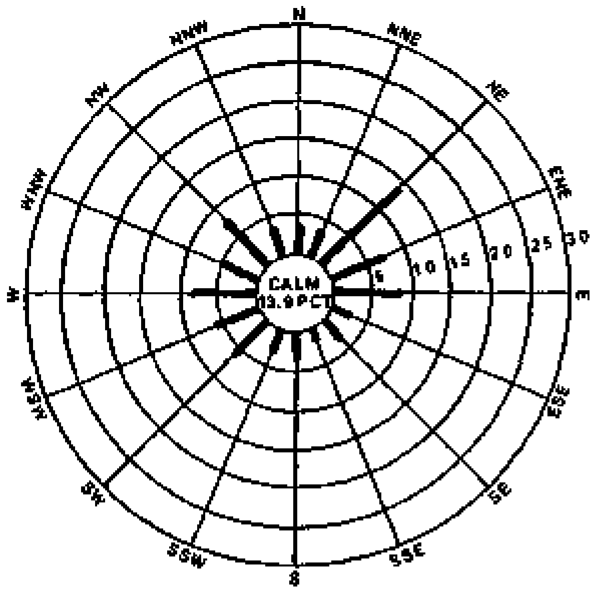
The average annual precipitation for Rifle is 11.02 inches for the period 1931 through 1980. The maximum monthly precipitation was 4.18 inches in August 1957, and the minimum was 0.00 inch in October 1952. Snowfall at Rifle averages 41.1 inches per year. The maximum monthly snowfall recorded was 38.0 inches during December 1972 (Colorado Climate Center, 1982).

D.9.5 FROST

No specific frost data were available for Rifle sites or the Estes Gulch disposal site. The Climatic Atlas of the United States indicates that there are approximately 180 days per year when the mean minimum temperature is 32°F and below (DOC, 1968a).

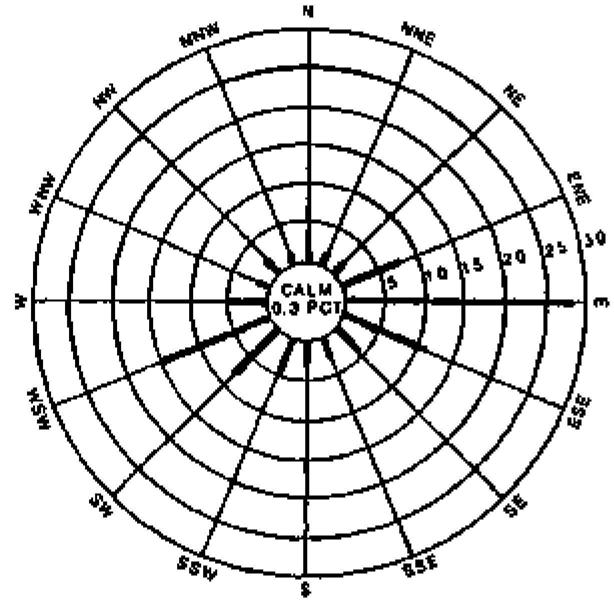
D.9.6 EVAPORATION

The mean annual lake evaporation at Rifle is approximately 34 inches. Approximately 74 percent of this total occurs between the months of May and October (DOC, 1968a).



RIFLE

PERIOD OF RECORD: 1959 – 1963



NEW RIFLE SITE

PERIOD OF RECORD: JULY 1982 – JUNE 1983

REF: DOC, 1968b; DOE, 1983.

LEGEND

WIND DIRECTION FREQUENCY (PERCENT)

FIGURE D.9.1
WIND ROSES

D.10 LAND SURVEY

D.10.1 PURPOSE

The purpose of the land survey data section is to describe and include all available land survey data for the Old and New Rifle mill sites and the Estes Gulch site.

D.10.2 TOPOGRAPHY SURVEY

Old Rifle and New Rifle

Topographic maps of Old Rifle (east mill site and tailings) and New Rifle (west mill site and tailings) were prepared by Olympus Aerial Surveys, Inc., Salt Lake City, Utah, dated July 10, 1982. The maps were prepared using aerial photographs, at a scale of 1" = 100', 1" = 200', and a contour interval of two feet. Ground control was provided by Eldorado Engineering Company of Rifle, Colorado. The topography is tied to the Modified State Plane Coordinate System, U.S. Geological Survey Monument, "Rifle No. 1." No alterations to the topographic maps have been made since they were prepared. The resulting topographic maps can be viewed at the DOE UMTRA Project Office, Albuquerque, New Mexico.

Estes Gulch site

A topographic survey map of the Estes Gulch site was prepared by QED Surveying Systems Inc., of Palisade, Colorado, in January 1986. The scale of the map is 1" = 200' with a two-foot contour interval. A similar map was also prepared which shows monitoring well and test pit locations.

QED Surveying established horizontal control using the modified Colorado State Plane Coordinate System. Vertical control was established using U.S. Geological Survey (USGS) data.

Using the QED data, a horizontal and vertical control sheet has been developed in support of the field data acquisition program, showing location and coordinates of control points at the site. The horizontal and vertical control sheet and the topographic survey map can be viewed at the DOE UMTRA Project Office, Albuquerque, New Mexico.

D.10.3 LAND SURVEY

Old Rifle

A boundary survey map of Old Rifle was prepared by Eldorado Engineering of Rifle, Colorado, dated September 7, 1982, scale 1" = 100'. The site boundary is tied to the Modified State Plane Coordinate System, USGS Monument, "Rifle No. 1."

No alterations to the survey have been made since the survey was completed. The resulting boundary survey can be viewed at the DOE UMTRA Project Office, Albuquerque, New Mexico.

New Rifle

A boundary survey map of New Rifle (west mill site and tailings) was prepared by Eldorado Engineering of Rifle, Colorado, dated September 3, 1982, scale 1" = 200'. The site boundary is tied to the Modified State Plane Coordinate System, USGS Monument, "Rifle No. 1." No alterations to the survey have been made since the survey was prepared. The resulting boundary survey can be viewed at the DOE UMTRA Project Office, Albuquerque, New Mexico.

Estes Gulch

At the time of this document, a boundary survey map of the Estes Gulch site has not been prepared.

D.10.4 AERIAL PHOTOGRAPHS

Old Rifle

The following aerial photographs of the Old Rifle site are available:

- o Olympus aerial photograph, 1" = 100'.
- o Oblique photograph 8 1/2" x 11", by GECR, Inc., Rapid City, South Dakota, dated February 1980.

New Rifle

The following aerial photographs of the New Rifle site are available:

- o Olympus aerial photograph, 1" = 200'.
- o Oblique photograph 8 1/2" x 11", by GECR, Inc., Rapid City, South Dakota, dated February 1980.

Estes Gulch

The following aerial photograph of the Estes Gulch is are available:

- o QED surveying photograph, 1" = 200'.

D.10.5 OWNERSHIP AND EASEMENTS

Old Rifle and New Rifle

All ownerships and easements are shown on the boundary survey map and can be viewed at the DOE UMTRA Project Office, Albuquerque, New Mexico.

Estes Gulch

The disposal site will be located in Section 14, Township 5 South, Range 93 West, approximately six miles north of Rifle in Garfield County. The disposal site falls within Federal lands managed by the Bureau of Land Management (BLM). A land withdrawal request has been filed with the BLM.

D.10.6 UTILITIES AND SUBSURFACE

Old Rifle and New Rifle

Utilities

Maps and plans have been obtained from the utility companies and agencies showing the location of existing gas, water, telephone, power, and the like, in the vicinity of the mill tailings sites. The above maps and plans can be viewed at the DOE UMTRA Project Office, Albuquerque, New Mexico.

Estes Gulch

There are no known utilities at Estes Gulch.

D.10.7 DRAINAGE STRUCTURES AND FEATURES

Old Rifle

The site is bounded on the north by the U.S. Highway 6-24, and on the south by the Denver and Rio Grande Western Railroad and the Colorado River. The site drains generally to the south into the Colorado River.

New Rifle

The site is bounded on the north by the U.S. Highway 6-24 and the Denver and Rio Grande Western Railroad and on the south by the Colorado River and Interstate 70. The site drains generally to the south into the Colorado River.

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