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Borehole Summary Report for the 200-UP-2 Operable Unit, 200 West Area

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ACRONYMS

bgs	below ground surface
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act*
CPT	cone penetrometer test
CRBG	Columbia River Basalt Group
DOW	Description of Work
HEIS	Hanford Environmental Information System
HPGe	high-purity Germanium
RCRA	*Resource Conservation and Recovery Act*
RLS	radionuclide logging system
SCA	surface contamination areas

CONTENTS

1.0 INTRODUCTION 1

2.0 HYDROGEOLOGIC FRAMEWORK 2
2.1 INTRODUCTION 2
2.2 REGIONAL AND HANFORD SITE GEOLOGIC SETTING 2
2.2.1 Columbia River Basalt Group 2
2.2.2 Ellensburg Formation 2
2.2.3 Suprabasalt Sediments 3
2.2.4 Ringold Formation 3
2.2.5 Plio-Pleistocene, Early Palouse, and Pre-Missoula Intervals 4
2.2.6 Hanford Formation 4
2.3 200-UP-2 GEOLOGIC SETTING 5
2.3.1 Holocene Deposits 5
2.3.2 Hanford Formation 6
2.3.3 Plio-Pleistocene Unit 6
2.3.4 Ringold Formation 6
2.3.5 Clastic Dikes 7
2.4 REGIONAL AND HANFORD SITE HYDROLOGIC SETTING 8
2.4.1 Surface Hydrology 8
2.4.2 Saturated Zone 8
2.4.3 Unsaturated Zone 9
2.5 200-UP-2 HYDROGEOLOGIC SETTING 9
2.5.1 Surface Water Sources 9
2.5.2 Hydrogeology 9

3.0 SUBSURFACE CHARACTERIZATION ACTIVITIES 11
3.1 INTRODUCTION 11
3.2 DRILLING ACTIVITIES 12
3.2.1 Site Characterization Activities 12
3.2.2 Boreholes 299-W19-95 and 299-W19-97 13
3.2.3 Borehole 299-W19-96 13
3.2.4 Borehole 299-W22-78 14
3.2.5 Borehole 299-W19-94 15
3.2.6 Borehole 299-W19-98 15
3.2.7 216-U-10 Pond Characterization Activities 16
3.3 SAMPLING 19
3.3.1 Archive and Physical Property Sampling 19
3.3.2 Chemical Sampling 20

4.0 BOREHOLE GEOPHYSICS 29
4.1 INTRODUCTION 29
4.1.1 Location 29
4.1.2 Logging Parameters 30
4.1.3 Results 31

CONTENTS (cont.)

4.2 CONCLUSIONS 38
4.2.1 216-U-1 Crib 38
4.2.2 216-U-8 Crib 38
4.2.3 U-4A Reverse Well and French Drain 38
4.2.4 216-U-12 Crib 39
4.2.5 U-10 Pond 39

5.0 REFERENCES 39

6.0 FIGURES AND TABLES 43

APPENDIXES:

A. BOREHOLE LITHOLOGY, GEOPHYSICAL, AND SAMPLING SUMMARY A-1
B. HYDRAULIC CONDUCTIVITY DATA B-1
C. RLS SPECTRAL GAMMA-RAY BOREHOLE SURVEY REPORTS C-1

FIGURES:

1. Location of the 200-UP-2 Operable Unit in the 200 West Area 45
2. 200-UP-2 Operable Unit Well Location Map 47
3. 200-UP-2 Operable Unit Vadose Zone and Groundwater Characterization Map 49
4. Generalized Stratigraphy of the Pasco Basin and Surrounding Area 51
5. Generalized Stratigraphy of the Suprabasalt Sediments in the Pasco Basin 52
6. Cross-Section Location Map 53
7. Cross-Section A-A' 55
8. Cross-Section B-B' 57
9. Cross-Section C-C' 59
10. Generalized Stratigraphy of the 200-UP-2 Operable Unit 61
11. Isopach Map for Hanford Formation, Unit 1 62
12. Isopach Map for Hanford Formation, Unit 2 63
13. Structure Contour Map for Hanford Formation, Unit 2 64
14. Isopach Map for the Plio-Pleistocene Unit (Early Palouse) 65
15. Isopach Map for the Plio-Pleistocene Unit (Carbonate) 66
16. Structure Contour Map for the Plio-Pleistocene Unit (Carbonate) 67
17. Structure Contour Map for the Ringold Formation, Unit E 68
18. Water Table Map of the 200 West Area 69
19. Borehole Location Map for 299-W19-95, 299-W19-96 and 299-W19-97 70
20. Borehole Location Map for 299-W22-78 71
21. Borehole Location Map for 299-W19-94 72
22a. Borehole Location Map for 299-W19-98 73
22b. Borehole Location Map for 299-W19-98 74

CONTENTS (cont.)

FIGURES (cont.):

23a. Cone Penetrometer, Borehole, and Test Pit Locations 75
23b. Cone Penetrometer and Test Pit Locations. 76
23c. Cone Penetrometer and Test Pit Locations 77
24. Vertical Distribution of Americium-241 at the 216-U-1/2 Cribs 78
25. Vertical Distribution of Cobalt-60 at the 216-U-1/2 Cribs 78
26. Vertical Distribution of Cesium-137 at the 216-U-1/2 Cribs 79
27. Vertical Distribution of Radium-228 at the 216-U-1/2 Cribs 79
28. Vertical Distribution of Strontium-90 at the 216-U-1/2 Cribs 80
29. Vertical Distribution of Thorium-228 at the 216-U-1/2 Cribs 80
30. Vertical Distribution of Uranium-233/234 at the 216-U-1/2 Cribs 81
31. Vertical Distribution of Uranium-235 at the 216-U-1/2 Cribs 81
32. Vertical Distribution of Uranium-238 at the 216-U-1/2 Cribs 82
33. Vertical Distribution of Americium-241 at the 216-U-4 French Drain/U4 Reverse Well . . 82
34. Vertical Distribution of Cesium-137 at the 216-U-4 French Drain/U4 Reverse Well 83
35. Vertical Distribution of Europium-152 at the 216-U-4 French Drain/U4 Reverse Well . . . 83
36. Vertical Distribution of Europium-154 at the 216-U-4 French Drain/U4 Reverse Well . . . 84
37. Vertical Distribution of Neptunium-237 at the 216-U-4 French Drain/U4 Reverse Well . . 84
38. Vertical Distribution of Uranium-234 at the 216-U-4 French Drain/U4 Reverse Well 85
39. Vertical Distribution of Uranium-235 at the 216-U-4 French Drain/U4 Reverse Well 85
40. Vertical Distribution of Uranium-238 at the 216-U-4 French Drain/U4 Reverse Well 86
41. Vertical Distribution of Americium-241 at the 216-U-8 Crib 86
42. Vertical Distribution of Cesium-137 at the 216-U-8 Crib 87
43. Vertical Distribution of Neptunium-237 at the 216-U-8 Crib 87
44. Vertical Distribution of Radium-226 at the 216-U-8 Crib 88
45. Vertical Distribution of Radium-228 at the 216-U-8 Crib 88
46. Vertical Distribution of Strontium-90 at the 216-U-8 Crib 89
47. Vertical Distribution of Thorium-232 at the 216-U-8 Crib 89
48. Vertical Distribution of Uranium-233/234 at the 216-U-8 Crib 90
49. Vertical Distribution of Uranium-235 at the 216-U-8 Crib 90
50. Vertical Distribution of Uranium-238 at the 216-U-8 Crib 91
51. Vertical Distribution of Americium-241 at the 216-U-10 Pond 91
52. Vertical Distribution of Cesium-137 at the 216-U-10 Pond 92
53. Vertical Distribution of Plutonium-238 at the 216-U-10 Pond 92
54. Vertical Distribution of Plutonium-239/240 at the 216-U-10 Pond 93
55. Vertical Distribution of Europium-155 at the 216-U-10 Pond 93
56. Vertical Distribution of Radium-226 at the 216-U-10 Pond 94
57. Vertical Distribution of Radium-228 at the 216-U-10 Pond 94
58. Vertical Distribution of Strontium-90 at the 216-U-10 Pond 95
59. Vertical Distribution of Thorium-228 at the 216-U-10 Pond 95
60. Vertical Distribution of Thorium-232 at the 216-U-10 Pond 96
61. Vertical Distribution of Uranium-233/234 at the 216-U-10 Pond 96
62. Vertical Distribution of Uranium-235 at the 216-U-10 Pond 97
63. Vertical Distribution of Uranium-238 at the 216-U-10 Pond 97

CONTENTS (cont.)

TABLES:

1. Borehole Contour Database 99
2. Borehole Drilling Summary Information 102
3. Borehole Field Screening Results 103
4. Borehole Physical Sampling Summary 112
5. Borehole Chemical Sampling Summary 115
6. Borehole Geophysical Survey Summary 124

1.0 INTRODUCTION

This report summarizes the characterization activities performed and the data obtained in the 200 West Area in support of the vadose zone Limited Field Investigations (LFI) for the 200-UP-2 Operable Unit. The purpose of this document is to describe the activities conducted for the acquisition of data and provide an operable unit description of the geology and contaminants reported from past and present characterization activities. Information presented includes a summary of the borehole and operable unit geology, sediment chemistry and physical properties data, and borehole geophysic logging results.

The 200-UP-2 Operable Unit is a vadose zone investigation and is one of two source operable units in the U Plant Aggregate Area at the Hanford Site (Figure 1). The purpose of the field program was to characterize the vertical and horizontal extent of contaminants within the vadose zone at various disposal sites and to obtain sufficient information to perform a qualitative risk assessment to select possible Interim Remedial Measures for the operable unit. Analogue units that had the highest probability of significant contamination and best represented the types of waste facilities in the operable unit were selected for characterization. Characterization activities involved the drilling, soil sampling, and geophysical logging of seven vadose borings; the excavation and soil sampling of one test pit; and the placement and geophysical logging of 10 cone penetrometer test (CPT) sites. The *RCRA Facility Investigation/Corrective Measures Study Work Plan for the 200-UP-2 Operable Unit, Hanford Site, Richland, Washington* (DOE-RL 1991) supplied the rationale and general scope of work for characterization activities described in this report. These activities are presented in the work plan under the Source Characterization, Task 2; Geologic Investigation, Task 3; and the Vadose Zone Investigation, Task 5. Three descriptions of work (DOW) were prepared to supplement the guidance presented in the work plan. The purpose of the DOW was to supply the specific steps and procedures for conducting subsurface characterization activities. A detailed discussion of the analogue unit approach utilized in this report is presented in the *U Plant Source Aggregate Area Management Study Report* (DOE-RL 1992).

The high-priority waste sites selected for this study and grouped in their respective analogue units included (1) the 216-U-1 and 216-U-2 Cribs, 2607-W-5 Septic Tank and Drain Field; (2) the 216-U-8 and 216-U-12 Cribs; (3) the 216-U-4 Reverse Well and 216-U-4A French Drain; and (4) the 216-U-10 Pond.

This report is separated into six chapters. Chapters 2.0 through 4.0 summarize characterization activities performed and associated results. Chapter 2.0 presents a stratigraphic interpretation of the operable unit based on existing boreholes and data collected from drilling, test pit, and CPT activities. Chapter 3.0 describes subsurface investigation activities and presents chemical and physical soil sampling results. Chapter 4.0 presents borehole geophysical information. Chapter 5.0 presents references; figures and tables can be found in Chapter 6.0.

2.0 HYDROGEOLOGIC FRAMEWORK

2.1 INTRODUCTION

The following section is a discussion of the 200-UP-2 Operable Unit geology and hydrogeology. Data from the seven LFI vadose borings and one test pit in the 200-UP-2 Operable Unit were incorporated in the interpretation. Additional data from previous characterization activities, existing borings and monitoring wells within and adjacent to the 200-UP-2 Operable Unit were also used in the interpretation. Site-specific descriptions of lithologies reported for each of the LFI boreholes and the test pit in the 200-UP-2 Operable Unit are presented in Section 3.2 of this report and in Appendix A, "Lithology, Geophysical and Sampling Summary." Additional explanations of regional and 200 West Area geology are available in Delaney et al. (1991), Lindsey et al. (1992), and Reidel et al. (1992). Table 1 presents the borehole depths and elevations of lithologic units used in the preparation of the contour maps. Figures 2 and 3 presents borehole locations used in characterization activities.

2.2 REGIONAL AND HANFORD SITE GEOLOGIC SETTING

The Pasco Basin and Hanford Site (inclusive of the 200 West Area) are underlain by pre-Miocene sedimentary and crystalline rocks (Campbell 1989), Miocene-aged (17.5 to 6 Ma) basalts of the Columbia River Basalt Group (Myers et al. 1979; Reidel and Fecht 1981; DOE 1988; Tolan et al. 1989; Reidel et al. 1989, 1992), interbedded sediments of the Ellensburg Formation (Reidel and Fecht 1981, DOE 1988, Smith 1988), and a Late Miocene to Holocene-aged (less than 8.5 Ma to present) suprabasalt sediment sequence (Myers et al. 1979, Tallman et al. 1981, DOE 1988, Smith et al. 1989, Lindsey 1991, Reidel et al. 1992).

2.2.1 Columbia River Basalt Group

The Columbia River Basalt Group (CRBG) is an assemblage of tholeiitic, continental flood basalts that cover more than 63,000 mi^2 (163,157 km^2) in Washington, Oregon, and Idaho and have an estimated volume of about 40,800 mi^3 (174,356 km^3) (DOE 1988; Reidel and Hooper 1989; Tolan et al. 1989). The CRBG is divided into five formations from oldest to youngest: Imnaha Basalt, Picture Gorge Basalt, Grande Ronde Basalt, Wanapum Basalt, and Saddle Mountains Basalt (DOE 1988; Tolan et al. 1989) (Figure 4). The Saddle Mountains Basalt (the uppermost basalt at the Hanford Site) is divided into (from oldest to youngest) the Umatilla, Wilbur Creek, Asotin, Esquatzel, Pomona, Elephant Mountain, and Ice Harbor Members (Reidel and Fecht 1981). The uppermost basalt member in the 200 West Area is the Miocene Elephant Mountain Member. It is continuous beneath the entire 200 West Area, and there is little evidence of significant erosion into or through the top of the basalt.

2.2.2 Ellensburg Formation

The Ellensburg Formation consists of volcaniclastic and silisiclastic deposits that occur between CRBG basalt flows (DOE 1988; Smith 1988). At the Hanford Site, the three uppermost units of the Ellensburg Formation are, from oldest to youngest, the Selah interbed, the Rattlesnake Ridge

interbed, and the Levy interbed. The Ellensburg Formation at the Hanford Site is discussed in Reidel and Fecht (1981). Smith (1988) and Smith et al. (1989) discuss the Ellensburg Formation and correlative units throughout the region.

2.2.3 Suprabasalt Sediments

Various aspects of suprabasalt sediment geology are found in Myers et al. (1979), Tallman et al. (1979, 1981), PSPL (1982), Bjornstad (1984), Fecht et al. (1987), DOE (1988), Baker et al. (1991), Smith et al. (1989), Delaney et al. (1991), Lindsey (1991, 1992), Lindsey et al. (1991, 1992) and Reidel et al. (1992). Delaney et al. (1991), Lindsey (1991), and Reidel et al. (1992) provide the most recent synopsis of suprabasalt sediment geology for the Hanford Site. The following discussion summarizes these reports and incorporates recent interpretations.

The suprabasalt sedimentary sequence (Figure 5) is up to 229 m (750 ft) thick at the Hanford Site and dominated by the laterally extensive late Miocene to Pliocene Ringold Formation and the Pleistocene Hanford formation. Laterally discontinuous units, referred to as the Plio-Pleistocene unit, early "Palouse" soil, and pre-Missoula gravels separate the Hanford formation and Ringold Formation locally. Holocene-aged alluvial and eolian deposits cap the suprabasalt sequence.

2.2.4 Ringold Formation

The Ringold Formation is up to 183 m (600 ft) thick beneath the Hanford Site. It consists of semi-indurated clay, silt, fine- to coarse-grained sand, and pebble to cobble gravel. Ringold deposits are grouped into five facies (fluvial gravel, fluvial sand, overbank-paleosol, lacustrine, basaltic alluvium) that are defined based on lithology, petrology, stratification, and pedogenic alteration. The facies are summarized as follows:

1. Fluvial gravel--Consists of clast and lesser matrix-supported pebble to cobble gravel with a fine- to medium-grained sand matrix. Grain size distributions tend to be bimodal with granules and coarse-grained sand being rare. Crude to well-defined stratification and low-angle, lenticular bedding geometries generally dominate.

2. Fluvial sand--Fine- to coarse-grained quartzo-feldspathic sands displaying well-defined stratification dominate. Fining upwards packages less than one to several meters thick are common.

3. Overbank-Paleosol--Laminated to massive silty sand, silt, and clay displaying evidence of pedogenic alteration dominates.

4. Lacustrine--Characterized by well-stratified clay with interbedded silt and silty sand.

5. Basaltic alluvium--Massive to crudely stratified, weathered to unweathered, basaltic, pebble to cobble gravel, commonly with a mud-rich matrix dominates.

The distribution of facies within the Ringold Formation forms the basis for stratigraphic subdivision (Lindsey 1991). The lower half of the Ringold Formation is characterized by fluvial gravel and sand dominated intervals, designated units A, B, C, D, and E that interfinger with fine-grained deposits

typical of the overbank-paleosol and lacustrine facies. These units should collectively be referred to as the member of Wooded Island. The lowest of these fine-grained intervals is designated the lower mud unit (see Figure 5). Interstratified deposits of the fluvial sand, overbank-paleosol facies, and strata dominated by the lacustrine facies form the upper half of the Ringold Formation (commonly referred to as the upper unit and recently identified as member of Taylor Flat). The 200 Areas are underlain by units A, B, D and E, the lower mud unit, and remnants of the member of Taylor Flats.

2.2.5 Plio-Pleistocene, Early Palouse, and Pre-Missoula Intervals

Several localized, informal units separate the Ringold Formation from the overlying Hanford formation. They are the Plio-Pleistocene and early Palouse interval and the pre-Missoula gravels (see Figure 5) (Myers et al. 1979; Tallman et al. 1979, 1981; DOE 1988; Reidel et al. 1992). The Plio-Pleistocene and early Palouse interval only underlie the 200 West Area and consists of loess, well-bedded, silty lake deposits, pedogenic calcium carbonate, and basaltic sands and gravels. Uncemented, mixed lithology gravels with a quartzo-feldspathic matrix dominate the pre-Missoula gravels, which does not occur beneath the 200 Areas.

2.2.6 Hanford Formation

The Hanford formation (see Figure 5) consists of uncemented gravel, sand, and silt deposited by Pleistocene cataclysmic flood waters (Fecht et al. 1987, DOE 1988, Baker et al. 1991). The Hanford formation is thickest near the 200 West and 200 East Areas where it can be up to 107 m (350 ft) thick. The Hanford formation is divided into three facies (gravel-, sand-, and silt-dominated), all of which occur beneath the 200 Areas. These facies are gradational with each other and summarized as follows.

1. Gravel-dominated facies--Generally consists of cross-stratified, coarse-grained sands and granule to boulder gravels that contain minor intercalated silt-rich horizons. The gravels generally are uncemented and matrix-poor, displaying an open-framework texture.

2. Sand-dominated facies--Well stratified, fine- to coarse-grained sand and granule gravel dominate. Silt content is variable, but where it is low, an open-framework texture is common. Small pebbles and rip-up clasts in addition to lenticular, pebble-gravel interbeds and silty interbeds may be present.

3. Silt-dominated facies--Interbedded silt and fine- to coarse-grained sand forming well stratified normally graded rhythmites are characteristic. This facies may also be referred to as slackwater deposits, Touchet Beds, and graded rhythmites.

Studying the distribution of Hanford formation facies types and identifying similarities in lithologic succession across the 200 West Area indicates that the 200 Areas can be divided into two widely distributed stratigraphic units. They are an upper gravelly unit referred to as unit 1 (previously referred to as the upper coarse or upper gravel) and a lower sand-rich unit referred to as unit 2 (previously referred to as the lower fine or fine). In addition, three localized units are found in the 200 West Area. They are a sandy unit (1a) overlying unit 1, a second gravel near the bottom of the formation (unit 3), and a silty unit at the base of the section (unit 4). The units are gradational with each other and commonly interfinger. The contact between the Hanford formation and underlying

strata is disconformable and irregular. This contact largely reflects erosion associated with cataclysmic flooding.

In addition to the three facies, clastic dikes are commonly found in the Hanford formation as well as locally in other sedimentary units in the Pasco Basin (Black 1979). These clastic dikes are structures that generally cross-cut bedding, although they do locally parallel bedding. The dikes consist of thin, alternating, vertical to subvertical layers of silt, sand, and granules. A feature known as patterned ground can be observed where the dikes intersect the ground surface.

Observations concerning clastic dikes are largely empirical, but the following conclusions can be made.

1. They are common in the vadose zone beneath the 200 West Area and most abundant within sand- and silt-dominated facies.

2. Their presence is generally difficult to detect in the subsurface.

3. Clastic dikes may act both as barriers and pathways to fluid transport. Their behavior depends on the content of the dike and the type of sediment the dike crosscuts.

2.3 200-UP-2 GEOLOGIC SETTING

Several isopach and structure contour maps are associated with the following discussion. These maps were generated using both MinQ and MinH gridding algorithms that are part of the Stratifact (a trademark of GRC Corp., Wheat Ridge, Colorado) software package. The grids were constructed from borehole data gathered from across the 200 Areas plateau. Individual grid cells were approximately 265 m per side. Because of the irregular data spacing, the grids generated are generalizations of the datasets and are essentially smoothed portrayals of the geologic trends for the various units. Where the computer-generated grid maps deviated highly from the actual data, they were hand modified. The data used to generate the maps and grids are presented in Table 1 and Appendix A. A cross-section location map is shown in Figure 6.

The 200-UP-2 Operable Unit stratigraphically contains holocene deposits, two facies of the Hanford formation (units 1 and 2), the Plio-Pleistocene unit, and the Ringold Formation, member of Taylor Flat and unit E (see Figure 10). This operable unit ranges in thickness from 58 m to 79 m (196 to 259 ft) and is generally thicker towards the east. The bottom of the 200-UP-2 Operable Unit is defined by the elevation of the water table.

2.3.1 Holocene Deposits

Holocene-aged deposits form the uppermost unit in the area. These deposits consist of eolian silt and sand that forms a thin (less than 3 m [less than 10 ft]), discontinuous sheet across the site. In some areas these deposits have been removed by human activities associated with Hanford Site operations. Where found, these deposits are characterized by a mix of silt and fine- to medium-grained sand that generally lacks evidence of significant stratification as displayed by sandy deposits that form much of the Hanford formation.

Holocene-age deposits have also developed along the bottom of the 216-U-14 Ditch into two distinct horizons. The first horizon consists of brown silt. This consists of wind-blown silt and clay that settled out through standing water in the ditch. The second layer is black, fine grained, organic rich (e.g., decaying vegetation), and contains coal ash. These two horizons are generally less than 1.2 m (less than 4 ft) thick and do not extend beyond the ditch boundary.

2.3.2 Hanford Formation

Units 1 and 2 of the Hanford formation are present beneath the entire project area. Unit 1 ranges from 6.7 m (22 ft) to greater than 32.6 m (107 ft) thick and consists of unconsolidated gravel, sandy gravel, gravelly sand, sand, and rare silt stringers (Figures 7, 8, 9, and 11). Sand fractions typically have a distinctive salt-and-pepper texture. Gravels may locally exhibit open-framework textures.

Unit 2 ranges from 8 to 48.6 m (27 to 160 ft) thick within the project areas (see Figures 7, 8, 9, 12, and 13). It consists of unconsolidated sand, gravelly sand, silty sand, and silt. Some sediment packages may have lenticular geometries. The unit typically shows a large-scale tendency to fine downward into more silt-rich sediments. Individual beds, particularly in the lower parts of the unit, tend to be normally graded with a thin silt at the top of each bed. Widely scattered clastic dikes have been observed within the unit, and calcareous (but not cemented) intervals are common. The contact between units 1 and 2 is higher to the east and lowest to the northwest (see Figure 13). However, because strata forming the two units interfinger, the contact is not a continuous, uninterrupted surface.

2.3.3 Plio-Pleistocene Unit

The Plio-Pleistocene unit is present throughout the project area and consists of a combination of calcareous sand, silty sand, silt, and gravelly sand. Individual beds are lenticular, commonly pinching out between boreholes. The upper part of the unit (referred to in many reports as the early Palouse soil) is a massive-to-stratified silt to sandy silt and 0 to 8 m (0 to 26 ft) thick. These strata underlie the project area except in the southwest and southeast corners of the operable unit (Figure 14). Pedogenic calcium carbonate (caliche) horizons forming an interval ranging in thickness from .6 to 13.7 m (2 to 45 ft) (Figures 7, 8, 9, 15, and 16) characterize the lower half of the Plio-Pleistocene unit beneath the site. The interval as a whole is continuous beneath the site, and the abundance of lateral discontinuities in the carbonate horizons indicates the upper surface is in fact not a solid, continuous horizon. Subvertical clastic dikes may cross-cut the unit, and iron oxide stained intervals may occur. This unit is documented as a significant hydrologic barrier (e.g., perching horizon). The Plio-Pleistocene unit is .6 to 20.2 m (2 to 66 ft) thick in the 200-UP-2 Operable Unit.

2.3.4 Ringold Formation

The bottom of the 200-UP-2 Operable Unit is contained within the Ringold Formation, unit E. Unit E consists largely of uncemented to partially cemented fluvial gravel, sandy gravel, and silty sandy gravel. Unit E is about 1.5 to 21.3 m (5 to 70 ft) thick and thins towards the east as controlled by water table elevation and the occurrence of the member of Taylor Flat east of borehole 299-W19-95 (see Figures 7, 8, 9, and 17).

Ringold unit E reaches a total thickness of about 88 m (288 ft) in the 200-UP-2 groundwater operable units and dips to the south and southeast. Silt-rich paleosols and lacustrine deposits of the lower mud unit underlie Ringold unit E throughout the southern 200 West Area. Fluvial gravels similar to those that form unit E comprise the lowest Ringold Formation unit, unit A. Intercalated fluvial sand and mud-rich zones can be found in unit A. Unit A is present beneath the entire site and directly overlies basalt of the Elephant Mountain Member.

Erosional remnants of the member of Taylor Flat occur above unit E east of borehole 299-W19-95. The member of Taylor Flat consists of uncemented, variably calcareous sand and local gravelly sand. The unit is approximately 0 to 10.4 m (0 to 34 ft) thick in the 200-UP-2 Operable Unit.

2.3.5 Clastic Dikes

Clastic dikes are tabular bodies that occur as vertical or near-vertical fissures filled with sand, silt, and/or minor coarser sediments. Clastic dikes are common features observed in excavations and borehole core samples within the 200-UP-2 Operable Unit (Price and Fecht 1976a, 1976b, 1976c, 1976d; Singleton and Lindsey 1994). Clastic dikes are interpreted to be injection features associated with the end of Pleistocene-age cataclysmic glacial-flooding events (Black 1979, Last and Fecht 1986). Dikes range in width from a few centimeters to greater than 1 m and extend to depths greater than 46 m.

Clastic dikes are abundant in the sand- and silt-dominated facies of the Hanford formation. The dikes cross cut and locally disrupt bedding in the Hanford formation and early Palouse/Plio-Pleistocene unit. Clastic dikes may also bend and form sills that parallel bedding. Clastic dikes are common features in matrix-rich gravels of the gravel-dominated facies of the Hanford formation, but are rare features and limited in extent in matrix-poor gravels. Clastic dikes have not been observed in the Ringold Formation in the 200 Areas. However, clastic dikes have been observed in exposures of the Ringold Formation in the White Bluffs along the Columbia River to the east of the operable unit (Brown and Brown 1962). Within the White Bluffs area, clastic dikes in Ringold sediments are a common occurrence, but are not abundant. Whether clastic dikes penetrate to the depths of the Ringold Formation in the operable unit is unknown.

In cross section clastic dikes display multiple layers of unconsolidated sediments that are partitioned by thin layers of silt and clay. The silt and clay layers are commonly referred to as clay skins. Individual layers vary in width from a few millimeters to several centimeters. The layers may be laminated parallel to the dike walls, cross laminated, or relatively structureless.

In plan view, clastic dikes form patterned ground. Patterned ground can be observed in the Pleistocene-age surface exposed by wind erosion in the Cold Creek Valley to the south of the operable unit. The patterns are polygonal in shape with the widest dikes or master dikes forming the boundaries of polygons. Patterned ground has not been observed in the operable unit because a thin veneer of Holocene eolian sand masks the Pleistocene-age surface. However, clastic dikes in the operable unit likely form polygonal patterns similar to those in the Cold Creek Valley.

2.4 REGIONAL AND HANFORD SITE HYDROLOGIC SETTING

2.4.1 Surface Hydrology

Primary surface-water features near the Hanford Site are the Columbia and Yakima Rivers. The free-flowing stretch of the Columbia River adjacent to the Hanford Site is known as the Hanford Reach. It extends from Priest Rapids Dam to the headwaters of Lake Wallula (the reservoir behind McNary Dam). Flow along the Hanford Reach is controlled by Priest Rapids Dam. Approximately one-third of the Hanford Site is drained by the Yakima River system. Cold Creek and its tributary, Dry Creek, are ephemeral streams within the Yakima River drainage system. Both streams drain areas along the western part of the Hanford Site and cross the southwestern part of the Hanford Site toward the Yakima River. West Lake, about 10 acres in size and less than 1 m (3 ft) deep, is the only natural lake within the Hanford Site (DOE 1988). Wastewater ponds, cribs, and ditches associated with nuclear fuel reprocessing and waste disposal activities are also present on the Hanford Site.

2.4.2 Saturated Zone

The Pasco Basin and Hanford Site are underlain by a multiaquifer system that consists of four hydrogeologic units that correspond with the upper three formations of the CRBG and the suprabasalt sediments (DOE 1988, Delaney et al. 1991). The basalt aquifers are generally confined and found within sedimentary interbeds of the Ellensburg Formation and interflow zones that occur between basalt flows. Recharge to the shallow basalt aquifers results from infiltration of precipitation and runoff along the margins of the Pasco Basin. Recharge of the deep basalt aquifers is inferred to result from interbasin groundwater movement originating northeast and northwest of the Pasco Basin in areas where the Wanapum and Grande Ronde Basalts crop out extensively (DOE 1988). Groundwater discharge from shallow basalt aquifers is probably to the overlying aquifers and the Columbia River. Discharge areas for the deeper aquifers are uncertain, but flow is inferred to be generally southeastward with discharge speculated to be south of the Hanford Site (DOE 1988). Erosional "windows" through dense basalt flow interiors at the top of the basalt aquifer system allow direct interconnection between the unconfined and uppermost confined aquifers (Graham et al. 1984).

The suprabasalt sediment aquifer is contained within the Hanford formation and the Ringold Formation. The top of this aquifer lies at depths ranging from less than 0.3 m (1 ft) near West Lake and the Columbia and Yakima Rivers, to greater than 107 m (350 ft) near the center of the Hanford Site. The base of the uppermost aquifer system is defined as the surface of the uppermost basalt flow. The water table beneath the western portion of the Hanford Site is generally within gravels of Ringold unit E. In the northern and eastern portions of the Hanford Site, the water table is generally within the Hanford formation. Overbank and lacustrine deposits in the Ringold Formation locally form confining layers for the underlying Ringold fluvial gravel and sand. The uppermost aquifer system is bounded laterally by anticlinal basalt ridges and is approximately 152 m (500 ft) thick near the center of the basin. Hydraulic conductivities for the Hanford formation (0.71 to 3.53 cm/s [2,000 to 10,000 ft/d]) are much greater than those of the gravel facies of the Ringold Formation (0.22 to 1.08 cm/s [610 to 3,050 ft/d]).

Natural recharge to the uppermost aquifer system consists of rainfall and runoff from the hills bordering the Hanford Site, water infiltrating from small ephemeral streams, and river water along

influent reaches of the Yakima and Columbia Rivers. The mean annual precipitation at the Hanford Meteorology Station is approximately 161 mm (6.3 in.). Evapotranspiration ranges from 805 to 1,450 mm (31 to 57 in.) (DOE 1988). The movement of moisture from precipitation through the unsaturated (vadose) zone varies. Gee (1987) and Routson and Johnson (1990) indicate it is nonexistent across much of the Hanford Site, while Rockhold et al. (1990) suggest that downward water movement below the root zone is common in the 300 Area. For an undisturbed site west of the 200 Areas, meteoric chloride mass balance methods suggest long-term net in filtration of less than 1 mm/yr (less than 0.04 in./yr) (Murphy et al. 1991). Artificial recharge occurs from the disposal of wastewater on the Hanford Site (principally in the 200 Areas) and from large irrigation projects surrounding the Hanford Site.

2.4.3 Unsaturated Zone

Vadose zone conditions across the Hanford Site show variations similar to those displayed by the uppermost aquifer system. Vadose zone sediments range from open-framework gravel-dominated facies of the Hanford formation, to interbedded silt and sand of the silt-dominated facies, to calcium carbonate-rich deposits of the early Palouse/Plio-Pleistocene interval, to cemented gravels of the Ringold Formation. Van Genuchten curve-fitting parameters for the major stratigraphic units beneath the 200 East and 200 West Areas are summarized in Connelly et al. (1992a, Table 3-1; 1992b, Table 3-1), respectively. Parameters from this table are highly variable, and an accurate assessment is dependant on site-specific data.

2.5 200-UP-2 HYDROGEOLOGIC SETTING

2.5.1 Surface Water Sources

In the 200-UP-2 Operable Unit, no natural surface-water bodies exist. The nearest natural surface-water body is located about 4.8 km (3 mi) southwest of the unit in the Cold Creek drainage where runoff from ephemeral waters ponds to several feet during the spring.

Wastewater ponds, cribs, and ditches associated with nuclear fuel reprocessing and related activities have been used to dispose effluent in the soil column. In the vicinity of the operable unit, major sources of artificial recharge to the soil column are the 216-U-10 U-Pond and the 216-U-14 and 216-Z-20 Ditches. Between 1944 and 1984, the 216-U-10 Pond received 1.62E11 L (4.28E10 gal) of wastewater. Since 1985, the 216-U-14 Ditch and 216-Z-20 Ditch collectively have received 4.16E9 L (1.09E9 gal) of water or about 42% and 28%, respectively of the discharge to the soil column in the 200 West Area. The remaining 30% of discharge in the 200 West Area can predominately be attributed to 216-S-10, 216-S-26, 216-U-12, 216-U-16, 216-U-17 Ditches, 216-W-LWC (Laundry Waste Crib), and the 284-WB Powerhouse Pond.

2.5.2 Hydrogeology

Hydrostratigraphic units of concern within the 200-UP-2 Operable Unit (vadose zone) are (1) Holocene deposits, (2) unit 1 of the Hanford formation, (3) unit 2 of the Hanford formation, (4) the Plio-Pleistocene unit, and (5) the Ringold Formation member of Taylor Flat and Unit E. The

vadose zone is 58 m to 79 m (196 to 259 ft) thick and is thinner in the western half of the 200-UP-1 Operable Unit.

Holocene deposits consist predominantly of wind-blown silts and clay, which are expressed on the surface as a thin discontinuous sheet. Wind-blown materials are most significant where they are deposited through standing water as documented at the 216-U-14 Ditch. These materials are known to decrease the infiltration capacity in ditches, selectively absorb certain contaminants, and are likely equivalent to zones that were periodically dredged to increase infiltration capacity. No data are available to determine the hydrologic properties of this horizon.

Unit 1 of the Hanford formation consists of a highly permeable facies. Interbedded horizons typical of the silt-dominated facies are present locally; however, the lack of perched water in areas of effluent discharge indicates that silts within the gravel are not a significant barrier to vadose transport. Calcium carbonate values in this zone are typically less than 1% and range to 3.5%; moisture ranges between 2.1% and 17.3% with the finer grained interbeds having the greater moisture percent. Saturated hydraulic conductivities range between 1.10E-02 cm/s (31 ft/day) and 5.5E-02 cm/s (156 ft/day) in well 299-W18-21.

Unit 2 of the Hanford formation consists mainly of interstratified sands and silts. Where effluent is discharged to the sediment column (as documented at the 216-U-14 Ditch) and wells have been drilled, perched water is intersected in this zone. Perched water occurs at 20 and 30 m (64 and 99 ft) below ground surface (bgs) in wells 299-W18-250 and 299-W18-251, respectively. The saturated thickness of the two zones were 1.2 and 2.1 m (4 and 7 ft), respectively, at the time of construction and perched water flow is to the west. As a result of the abundant lateral discontinuities in the form of lenticular beds and clastic dikes and limited discharge from the 242-S Evaporator, perching in the lower unit appears to be of limited lateral extent and control by interbedded material beneath the western end of the 216-U-14 Ditch. Data collected from this zone during the recent investigation indicate that the calcium carbonate is less than 1 to 9.2%; moisture content ranges between 2.5 to 31.5%. Saturated hydraulic conductivities are between 1E-7 (2.83E-4 ft/day) and 6.9E-5 cm/s (0.2 ft/day).

Perched water also occurs in existing wells 299-W19-91, 299-W19-92, and 299-W19-93 on the eastern end of the 216-U-14 Ditch. The top of the perched water zone has been as high as 199 m (620 ft) above mean sea level and as low as 169 m (555 ft) above sea level over the last four years. It is assumed that the saturated thickness of this zone extends past the screen interval to the top of the Plio-Pleistocene unit. Construction data from the late 1980s indicate that the perched water zone extends to well 299-W19-27. The perched water zone does not extend to the screen interval in well 299-W19-22. The abundance of clastic dikes in the early Palouse/Plio-Pleistocene unit on the eastern end of the ditch may contribute to the apparent limited lateral extent of the perched water zone by providing vertical pathways through the interval.

The thickness of the Plio-Pleistocene ranges between 3 and 20 m (10 and 66 ft) in the 200-UP-2 Operable Unit. Locally this unit is a major component in the subsurface controlling the accumulation of perched water because of the formation of abundant pedogenic calcium carbonate in this horizon. This appears to be the case on the eastern end of the 216-U-14 Ditch where perching can be vertically extensive. Perched water was not observed on top of the early Plio-Pleistocene on the western end of the 216-U-14 Ditch. Data collected from this zone during the recent investigation indicate that the calcium carbonate values are less than 1% to 9.6%; moisture content ranges between 5.42 to 24.8%;

saturated hydraulic conductivities are between 5.5E-6 cm/s (2E-2 ft/day) and 2.58E-3 cm/s (7.3 ft/day).

The Ringold Formation comprises the lower part of the vadose zone and also contains the unconfined aquifer. Ringold Formation strata above the water table in the study area consists of uncemented calcareous sand and gravelly sand of the member of Taylor Flats on the eastern half of the site and partially cemented fluvial gravels and minor sands and silts of unit E beneath the entire site. Data from the member of Taylor Flats indicates the calcium carbonate is less than 1% to 5.3% in this zone, the moisture content is between 3.0 and 18.3%, and the saturated hydraulic conductivity is 4.0E-3 cm/s (11.3 ft/day). Data collected from unit E indicates the calcium carbonate is less than 1% to 2.6% in this zone, moisture content is between 1.46 and 18.3%, and the saturated hydraulic conductivity is 4.0E-3 cm/s (11.3 ft/day). Cemented zones and silt layers within these units may potentially cause perched conditions, although this is not documented.

In descending order, the majority of Ringold unit E, silt-rich paleosols and lacustrine deposits of the lower mud unit, fluvial gravels of Unit A and basalt of the Elephant Mountain Member underlie the 200-UP-2 Operable Unit.

The unconfined aquifer occurs in the partially cemented fluvial gravels of Ringold unit E at depths between 58 m and 79 m (196 to 259 ft) bgs. A water table map of the 200 West Area is shown in Figure 18. The water table is declining at a rate of about .3 m/yr (1 ft/yr). This rate of decline is expected to increase after June 1995 when all effluent discharge to the sediment column in the 200 West Area ceases. Cessation of discharge will increase the vertical thickness of the 200-UP-2 Operable Unit over time.

3.0 SUBSURFACE CHARACTERIZATION ACTIVITIES

3.1 INTRODUCTION

The 200-UP-2 LFI characterization program involved the drilling, soil sampling, and geophysical logging of seven vadose borings; the excavation and soil sampling of one test pit; and the placement and geophysical logging of 10 CPT sites. The general purpose of the 200-UP-2 field program was to characterize the vertical and horizontal extent of contamination at three wastewater disposal cribs, one disposal pond, and one reverse well and adjoining french drain. Table 2 provides applicable waste facilities studied and a general summary of activities conducted. The location for each site is presented in Figures 3 and 6. Specific project objectives were to (1) collect stratigraphic information and characterize subsurface sediments for man-made radionuclides, (2) determine the presence of perched water and perching layers, and (3) evaluate the caliche layer as a potential barrier or perching layer to contaminants in the 200-UP-2 Operable Unit. Site-specific characterization objectives are also presented in Section 3.2.1 of this report and in the *200-UP-2 Operable Unit Work Plan* (DOE-RL 1991) in Sections 4.2 and 5.3.

Three DOWs were prepared as supporting documents to the 200-UP-2 work plan. The purpose of the DOW is to give specific technical guidance for the drilling and sampling of boreholes and test pits and the installation of CPT sites. The DOWs prepared were the *Description of Work for 216-U-10 Pond Test Pits* (WHC 1993b), the *Description of Work for Vadose Borings in Support of*

the 200-UP-2 Unit (WHC 1993c), and the *Description of Work for the 216-U-10 Pond Cone Penetrometer Demonstration* (WHC 1993a). Installation of CPT sites was conducted as part of the Hanford Site technology development.

3.2 DRILLING ACTIVITIES

All boreholes were drilled using the cable tool drilling method. Temporary casing was used to prevent sloughing and was downsized after drilling through contamination zones to prevent the spread of contamination within the vadose zone. Dependent upon the amount and type of subsurface contamination expected, drill sites were designated as either low, moderate, or high risk. Moderate- to high-risk sites were constructed with a flame-retardant tent surrounding the drill rig. The purpose of the tent was to prevent the possible spread of contamination and allow work during adverse weather conditions.

Prior to the start of drilling and test pit excavation, a one-time background level for radiation was established outside each drill site. This activity was performed to ensure that instrument background was defined at each drill site and that all sites were restored to pre-drilling radiological levels.

All the vadose borings were drilled through the caliche layer in the Plio-Pleistocene unit. After reaching the caliche layer, a soil sample was obtained and evaluated by the wellsite geologist for the presence of water. Field screening instruments were also used to check the sediment for the presence of contamination. A small split of the sample was collected, and a total activity analysis was performed. After receiving the results of the total activity testing, a meeting was convened of the field team leader, the project geologist, and the project cognizant engineer to review sampling results. The purpose of the meeting was to establish if perched water or contamination existed at the caliche layer and to determine if the downsizing of casing was the best method for preventing the spread of contamination below the caliche layer. The regulatory agencies were notified if contamination was or was not found at the caliche layer, and approval was obtained before drilling deeper. After advancing the borehole through the caliche layer and reaching the target depth, a soil sample was obtained and evaluated for the presence of contamination as described above. The regulatory agencies were notified again of the sample results, and approval was obtained for abandoning the borehole back to the surface.

3.2.1 Site Characterization Activities

The following sections present the general purpose, geology, and contamination reported using field screening equipment at six of the seven vadose borings constructed in support of characterization activities for the 200-UP-2 Operable Unit. All depths for material reported in each borehole are given as feet below ground surface (bgs). Detailed descriptions of the site activities, borehole lithology, and radiological screening results as recorded by the Health Physics Technician can be found in the 200-UP-2 project file. Borehole summary information is presented in Table 2 and in Appendix A. Table 3 presents radiological field screening results recorded by the field geologist for each borehole.

The site characterization activities for borehole 299-W23-231 are part of subsurface investigations in the 216-U-10 Pond and are therefore presented in Section 3.2.7 of this report.

3.2.2 Boreholes 299-W19-95 and 299-W19-97

Boreholes 299-W19-95 and 299-W19-97 were drilled to delineate the lateral extent of contamination beneath the U-1/U-2 Cribs. Boring 299-W19-95 was located between the U-1/U-2 Cribs to determine if uranium was carried up dip on the caliche layer from the U-16 crib (Figure 19).
Borehole 299-W19-97 was located north of the U-1 Crib and adjacent to the W-5 tile field. The purpose of the boring was both to characterize the possible northern extent of contamination from the U-1/U-2 Cribs and to investigate the presence of perched water near the W-5 drain field. Both borings were designated as low- to moderate-risk holes and were the first holes to be drilled for the project. This allowed field crews to practice procedures and methods for conducting site activities at the high-risk borings.

At borehole 299-W19-95, eolian sands occur from the surface to 5.5 ft. Hanford unit 1 extends from 5.5 to 104 ft and is composed of sandy gravel with interbeds of sand and minor silt lenses. Hanford unit 2, from 104 to 160 ft, consists of sand, sandy gravel, and a lower sequence of sand and silt lenses that fine downward, a feature exhibited by unit 2 throughout the 200-UP-2 project area. The Plio-Pleistocene unit consists of interbedded sandy silt and silt from 160 to 166 ft and caliche-rich gravelly sand from 166 to 168 ft. Upper Ringold sands (member of Taylor Flat) are present from 168 to 181 ft, and are underlain by sandy gravels of the Ringold Formation unit E (member of Wooded Island) from 181.5 to 182 ft.

At borehole 299-W19-97, sandy gravel with intermixed gravelly sand, sand, and silt stringers of Hanford unit 1 extend from the surface to 93.5 ft. Hanford unit 2 continues to 154 ft and contains sand and sporadic silt lenses with thin, discontinuous iron-oxide stained caliche stringers dispersed throughout the unit, a feature common to this unit in the 200-UP-2 project area. The Plio-Pleistocene unit extends from 154 to 171.4 ft. The upper part of the unit, to 169.6 ft, consists of silt, calcarious silt, and sand lenses. Gravelly sand with caliche development forms the lower part of the unit. Upper Ringold calcarious sand (member of Taylor Flat) extends from 171.4 to 175 ft. The boring reached total depth at 177 ft in a sandy gravel of the Ringold unit E (member of Wooded Island).

Field screening results and total activity analysis of archive samples indicate that radiological contamination was below detectable levels for both boreholes. Perched water was not reported on either borehole; however, a slightly damp-to-moist interval was encountered on borehole 299-W19-97 at a depth of 55 ft in a silt lens. Chemical and physical samples were obtained from this interval.

3.2.3 Borehole 299-W19-96

Borehole 299-W19-96 was drilled through the U-1 Crib to characterize the vertical extent of uranium contamination beneath the U-1/2 Cribs. The U-1/2 Cribs are underground timbered structures placed in 25-ft-deep backfilled excavation. The 299-W19-96 boring was placed in the northwest corner of the U-1 Crib (see Figure 18). This allowed drilling through the excavation backfill and placement of the boring just adjacent to the timbered structure of the U-1 Crib. To protect against crib collapse, a steel I-beam structure was placed on top of the U-1 Crib. The steel structure supported the rear of the drill rig and encompassed the drill crew work area.

Crib backfill composed of sand, gravelly sand, and silty sand occurs at 299-W19-96 from the surface to 25.5 ft. Hanford unit 1 consists of interbedded sandy gravel, sand, and minor silt from 25.5 to 100.3 ft. Sand with lenses of sandy silt and silt comprise Hanford unit 2, from 100.3 to 159.5 ft.

The Plio-Pleistocene unit consists of an upper interval of silt, calcarious silt, and intermittent sand from 162 to 169 ft and a lower interval of gravelly silt with caliche development from 169 to 171.6 ft. Iron-oxides are abundant in the Plio-Pleistocene unit. Upper Ringold sand (member of Taylor Flat) extends from 171.6 to 177 ft. The Ringold unit E gravel (member of Wooded Island) continues from 177 to 179 ft.

Radiological contamination was first reported at 4 ft and extended at elevated levels from 15 to 60 ft. Activity levels dropped to below detection limits for field screening instruments by 60 ft, with sporadic contamination occurring to 70 ft. Low-level radiological contamination was reported again in a thin interval of the caliche layer from 169 to 170 ft.

When borehole 299-W19-96 reached a drill depth of 40 ft, the photoionization detector registered 81 ppm at a depth of 25 ft inside the well casing and 71 ppm in the breathing zone. A colorometric tube was used to identify the contamination, but the results were inconclusive. Drilling activities were suspended, and a mobile laboratory analysis was conducted that identified vinyl chloride at 1.4 ppm. To ensure worker safety, the drill crew was placed on supplied air until contamination levels dropped to nondetectable at a drill depth of 60 ft.

3.2.4 Borehole 299-W22-78

Borehole 299-W22-78 was drilled to collect data that would support the coordination of RCRA and *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) activities at the 216-U-12 Crib. The objective of the drilling and sampling program was to establish the impact of acidic wastes on the soils beneath the crib and on the calcium carbonate cement of the caliche layer. The boring was placed at the edge of the crib (Figure 20) outside the surface contamination area to allow the collection of subsurface information while reducing the exposure of personnel.

At borehole 299-W22-78, Hanford unit 1 sandy gravel, gravelly sand, and sand with up to 40% basalt extend from the surface to 33.5 ft. Hanford unit 2 contains sand that fines downward into sand with intermittent lenses of silty sand from 33.5 to 180 ft. The Plio-Pleistocene unit extends from 180 to 204 ft and consists of sand, sandy silt, and gravelly sand. Sand with caliche development occurs from 186.5 to 193.5 ft. Interstratified sand and silt of the upper Ringold (member of Taylor Flat) extend from 201 to 234 ft. Clastic dikes are present from 163.5 to 164 ft in the Hanford formation, at 200 ft in the Plio-Pleistocene unit, and in the upper Ringold Formation at 208 and 212 ft.

Radiological contamination was first reported using field screening instruments at 19 ft, immediately above a thin layer of silty sand that corresponds closely in depth to the bottom of the crib. Activity levels reached a peak by 23 ft and then dropped off rapidly to slightly above background by 35 ft. Sporadic low-level contamination was reported from 35 ft to 64 ft and then dropped to below detection levels for the remainder of the borehole.

Soil samples obtained for physical property analysis included the standard set of tests and an additional evaluation for pH. This was conducted to assess the impact of acidic wastes to the soil column. Drill cuttings evaluated by the site geologist indicated that the soil displayed no unusual characteristics. There was no color change, and the soil appeared to have the same amount of calcium carbonate cement encountered in other boreholes. Table 4 presents the results of pH analyses conducted for borehole 299-W22-78. Preliminary evaluation of these results indicates that the pH is not significantly outside the range of other Hanford soils. Further interpretation of the pH data will

not be conducted until the downgradient well (699-36-70A) in support of the RCRA 216-U-12 Crib groundwater assessment program has been completed and soil samples evaluated.

3.2.5 Borehole 299-W19-94

Borehole 299-W19-94 was drilled through the 216-U-8 Crib to characterize the vertical extent of contamination beneath the crib. The 216-U-8 Crib consists of three equally spaced underground timbered structures in a 30-ft-deep gravel-filled excavation. Boring 299-W19-94 was placed halfway between the northern and middle crib, and approximately 3 ft west of the transfer line that runs down the middle of the crib (Figure 21). This location allowed the characterization of the crib while avoiding the potential crib collapse zone.

The first 31 ft of drilling was through excavation backfill material consisting of clean sands to 21 ft and coarse gravel from 21 ft to 31 ft. The bottom of the crib, at 31 ft, is identified by a sharp contact between coarse gravel backfill and sand. Hanford unit 1 is not present at this site. Hanford unit 2 extends to 165.5 ft and consists of sand that grades downward into interbedded sand and silt. The Plio-Pleistocene unit extends from 165.5 to 197 ft and consists of silt and fine sand interbeds with caliche development and carbonate nodules. The upper Ringold (member of Taylor Flat) consists of silt and continues to 199 ft.

Radiological contamination was first reported from a split-spoon sample taken across the crib bottom interface. Activity remained at elevated levels to approximately 42 ft and then dropped rapidly to slightly above background. Radiological contamination remained at slightly above background levels from 42 ft to 112 ft. Activity levels then began to rise and remained at elevated levels from 112 ft and through the caliche layer to the bottom of the boring at 199 ft.

3.2.6 Borehole 299-W19-98

Borehole 299-W19-98 was drilled between the 216-U-4 reverse well (U-4 reverse well) and the 216-U-4A french drain (U-4A french drain). The U-4 reverse well is an injection facility constructed of 3-in.-diameter pipe extending 75 ft below surface. The bottom 8 ft of the well is perforated. The U-4A french drain is a 51-in.-diameter concrete pipe extending to a depth of approximately 8 ft and open at the bottom.

The discharge points between the two facilities are separated vertically at depth by approximately 64 ft. Elevated levels of contamination were expected to occur immediately below the U-4A french drain and again near the depth of the discharge point of the U-4 reverse well. The 299-W19-98 boring was placed between the two facilities to characterize the vertical distribution of contaminants between the two discharge points.

The 299-W19-98 boring was drilled midway between the perimeter fence for the 224-U complex and the southwest corner of the 222-U building (Figures 22a and 22b). This location made 299-W19-98 the most difficult boring to obtain drilling access and clearance. Numerous marked and unmarked buried utilities and overhead electrical and steam lines transect the drill site. Surface markers that identify the location of the U-4 reverse well and U-4A french drain are also absent.

After reviewing engineering drawings and performing ground penetrating radar at the proposed drill site, it was determined that to locate the unmarked U-4A french drain and minimize the possibility of damaging any underground utilities, the first 8 to 9 ft of the boring location would be hand excavated. Excavation activities began around the vent for the U-4 reverse well in an attempt to locate a transfer line that connected to the U-4A french drain. Engineering drawings indicated that the U-4A french drain was located to the northwest of the U-4 reverse well at a depth of 4 ft. However, after digging in the target area, the french drain was not located, and the excavation area was expanded to the south. The U-4A french drain was eventually located approximately 1 ft to the southeast of the U-4 reverse well at a depth of 4 ft.

After locating the reverse well and french drain, a site for the borehole was selected approximately 2 ft north of the two waste facilities. The borehole site was then excavated to a depth of approximately 10 ft to ensure that no obstructions or utilities were present. Temporary 12-in. casing was then placed at depth, the surrounding excavation was backfilled, and a drill rig was mobilized to the site.

The uppermost unit at borehole 299-W19-98, Hanford unit 1, is sandy gravel with intermixed gravelly sand and sand with a "salt and pepper" texture from 15 to 56.5 ft. Hanford unit 2 with sand and local gravelly sand and silt lenses extends from 56.5 to 176 ft. The Plio-Pleistocene unit extends from 176 to 191 ft, consists of silty sands and caliche-cemented sands, and is cut by clastic dikes at 184 to 185.5 ft and 189 to 191 ft. Sand with caliche development occurs from 189 to 191 ft. Sandy gravel and sand of the upper Ringold (member of Taylor Flat) occurs from 191 to 194.5 ft.

Field screening first reported radiological contamination from a hand auger sample obtained at 4.5 ft and then dropped to nondetectable by 18 ft. Sporadic contamination slightly above background occurred from 18 ft to 34 ft. Continuous radiological contamination began again at 34 ft and increased to a maximum at 62 ft (the estimated screen interval depth for the reverse well). Alpha activity was identified with the portable alpha monitor within this interval. Contamination dropped rapidly to nondetectable levels by 70 ft and remained at nondetectable levels to the bottom of the borehole.

3.2.7 216-U-10 Pond Characterization Activities

The work plan for the 200-UP-2 Operable Unit originally proposed the excavation of one test pit in the delta area (the discharge point of numerous disposal ditches) and one test pit in the center of the U-10 Pond. The purpose of the delta area test pit was to obtain soil samples that would contain the full inventory of contaminants disposed to the U-10 Pond. The purpose of the center test pit was to obtain soil samples from the deepest area of the pond to determine if the majority of the pond contaminants were retained in the first 3 to 4 ft of the pond bottom.

Prior to initiating the test pit activities as proposed in the 200-UP-2 Work Plan, it was determined with regulatory approval that a phased approach to characterization of the U-10 Pond should be conducted. This would involve the collection and evaluation of surface radiological surveys, the installation of 10 CPT sites, and the construction of one test pit. The test pit construction activities would also be evaluated to determine the quality of samples obtained, control of contamination, impacts to worker health and safety, and alternative sample methods to the construction of test pits. The information collected from the various U-10 Pond characterization activities would then be used

to select the best location and sampling method for the delta area and to determine if any additional subsurface sampling of the U-10 Pond would be conducted.

3.2.7.1 Test Pit 216-U-10-TP-2. The 216-U-10 (U-10 Pond) was constructed in 1944 to receive low-level liquid effluent from the various chemical reprocessing facilities within the 200 West Area. The U-10 Pond covers 30 acres and received approximately 4.3 x 10^{10} gal of contaminated liquid. The pond was deactivated and stabilized in 1985 with clean fill dirt.

Test pit 216-U-10-TP-2 (TP-2) was excavated in the northwest corner of the U-10 Pond (Figure 23a). This location was selected after reviewing engineering drawings that indicated this was the deepest area of the pond with the thickest sequence of clean fill. Excavation activities were conducted using a track-mounted backhoe with a 6-yd bucket. Each bucket of soil removed from the excavation was field screened for radiological contamination. Clean stabilization material was separated from contaminated material. Contaminated soil was placed on a clean sheet of plastic and was then dampened with water to prevent dispersal by winds.

Initial review of engineering drawings of the test pit site indicated that the clean stabilization cover at the test pit site was at least 8 ft thick. However, after advancing the excavation only 6 ft, the contact between the stabilization cover and the pond bottom was reported. A soil sample of the contact was obtained, and the test pit was then advanced through a 0.5-ft black organic-rich silt, which represented the former U-10 Pond bottom. A soil sample of this interval was also taken. The material beneath the pond bottom was sediments of the Hanford formation that consist of gravelly sand from 7 to 9 ft, sand from 9 to 16 ft, and sandy gravel from 16 to 26 ft. Chemical soil samples were taken at each change of lithology (see Appendix A).

Radiological contamination was first reported in the stabilization cover at a depth of 5 ft. Contamination dropped at the contact between the pond sediments and the cover material at 6.5 ft and then increased within the organic-rich sediments of the pond bottom at 6.5 to 7 ft. Radiological contamination dropped rapidly for the remainder of the test pit.

3.2.7.2 Cone Penetrometer Testing. As part of the technology development and demonstration program at the Hanford Site, the CPT system was requested to push 10 holes at the U-10 Pond to a depth of 135 ft and then geophysically log them using a sodium iodide (NaI) scintillator. (The NaI scintillator provides only a qualitative assessment of gamma-emitting nuclides.) The primary objective of this activity was to characterize subsurface radiological contamination and identify isotopes with the scintillator. This data would then be correlated with data obtained from test pit TP-2.

Ten CPT sites were installed on two lines at the approximate locations presented in Figure 23a. A line of seven CPT sites crossed northwest of the U-10 Pond, intersecting test pit TP-2. The purpose of this line was to characterize the vertical and horizontal extent of contaminants within and beneath the U-10 Pond. A second line of three CPT sites extended from the center of the pond to the northeast. The purpose of this line was to establish the vertical and horizontal extent of contaminants within and under the delta area of the pond.

The CPT device consists of a hollow stainless steel rod with a welded tip. The rod is pushed until refusal with hydraulic rams mounted on a truck. All CPT holes were pushed on July 30, 1993, for a total combined footage of 714 ft. The deepest holes were pushed to a depth of 95 ft with an average depth of 71.4 ft. The CPT was unable to reach the target depth of 135 ft at any of the 10 locations

within the U-10 Pond. This may be due to the presence of interbedded silt and caliche stringers within a sand unit that began at a depth of approximately 70 ft.

After reaching total depth, each CPT site was capped and locked until it was geophysically logged on the week of August 30, 1993. Each CPT site was logged to a maximum depth of approximately 82 ft. The logging depth was limited by the amount of cable brought with the scintillator.

Evaluation of the scintillator data indicated that the area of greatest contamination occurred in the material that represents the former pond bottom at a depth of 5 to 6 ft. Radiological contamination dropped rapidly below this depth to less than 5,000 counts per second (c/s) on all but two of the CPT sites. Elevated counts per second occurred at 52 ft on CP-8 and at 42 ft on CP-10 (Figures 23b and 23c). A complete description of activities and CPT findings is presented in *Fiscal Year 1993 Heavy Weight Cone Penetrometer Activities at the Hanford Site* (WHC 1993a).

3.2.7.3 Review of Test Pit and CPT Data. After completing test pit TP-2 and CPT work, the Remedial Investigation Coordinator convened a meeting with the regulatory agencies and project personnel. The purpose of the meeting was to review the results from the test pit and CPT work and to evaluate the need for additional characterization. Test pit activities were also evaluated to determine if they are an efficient sampling method for the U-10 Pond.

The findings of CPT and test pit data indicate that radiological contamination exists at 2 to 4 ft in the former pond bottom. The CPT work also identified possible contamination in deeper zones of the pond at sites CP-8 and CP-10. After evaluating test pit activities, it was determined that controlling contaminated soils was difficult because of the large amount of material removed from the test pit excavation. Representative samples were also hard to obtain because of sloughing from the test pit walls as the excavation was deepened.

Therefore, with regulatory agency approval and project personnel concurrence, it was determined that additional vadose zone characterization should be conducted by the drilling of borehole 299-W23-231. The purpose of this boring would be to evaluate the possible presence of deeper contamination identified at CPT site CP-8 (Figures 23b and 23c) and to allow additional characterization of the caliche layer. It was also determined that test pit sampling created a greater potential for the spread of radioactive contamination during characterization work in the U-10 Pond. Boreholes generate a smaller amount of material than test pits, and sloughing is easily controlled with casing. Therefore, boreholes ensure greater soil sample quality and provide a higher degree of contamination control.

3.2.7.4 Borehole 299-W23-231. Borehole 299-W23-231 was sited in the southwest corner of the U-10 Pond adjacent to CP-8 (Figure 23a). The purpose of this boring was to characterize the vertical distribution of contaminants beneath the pond and to evaluate an area of possible contamination that was identified at 42 ft in CP-8 during scintillator logging.

At borehole 299-W23-231, backfill sand, very fine sand, and silt with organic material extend from 0 to 4.6 ft. Hanford unit 1 consists of sandy gravel with intermixed gravelly sand and sand from 4.6 to 28 ft. Hanford unit 2 sand, very fine sand, and silt laminae continues from 28 to 119 ft. Very fine sand, silt, and silt with carbonate nodules and numerous clastic dikes and rip-up clasts occur from 119 to 137.5 ft. Caliche-cemented silt of the Plio-Pleistocene unit extends from 137.5 to 139.5 ft. Upper Ringold sand and silt (member of Taylor Flat) is not present at the site. Ringold unit E gravel (member of Wooded Island) extends to 141.5 ft.

The first 3 ft of drilling for boring 299-W23-231 was through the clean sand stabilization cover. Radiological contamination (alpha and beta/gamma) was first reported from 3 to 6 ft and was associated with a silty sand interval consisting of roots and organic material. The pond bottom was reported from 4 to 4.3 ft and was represented by a organic-rich silty clay. Contamination dropped to nondetectable below 6 ft and remained at less than detectable through an interval of sandy gravel and gravelly sand. At 28 ft, radiological contamination was reported near the contact between overlying sandy gravel and a sequence of fine sand and silt. Contamination again dropped to nondetectable below 29 ft and remained at less than detectable levels for the remainder of the hole.

3.3 SAMPLING

Samples were collected according to procedures presented in the *Environmental Investigations and Site Characterization Manual* (WHC 1988) and at intervals specified in the drilling and test pit DOW (WHC 1993c, 1993b). Field screening was used to ensure that the most contaminated material from each sampling interval was submitted for analysis. Field screening was also used to monitor drill cuttings obtained with the drive barrel to identify alternate sampling points. Total activity analysis was performed on all material submitted for archive storage and chemical and physical testing. The total activity analysis was performed to determine how samples were shipped, analyzed, and stored. Chemical and physical samples usually were collected with a 4-in.-inside diameter, 2-ft-long split-spoon sampler with stainless steel liners.

A soil sample interval not identified in the project DOWs was collected at 4 to 6 ft in the boreholes and test pit to support the site background modeling program.

A summary of all sampling intervals is presented in Tables 4 and 5 and in the borehole logs in Appendix A.

3.3.1 Archive and Physical Property Sampling

All material removed from the borehole was identified and described by the site geologist and summarized on the Borehole Log. Representative archive samples were collected every 5 ft, at significant changes of lithology, and from scheduled sampling points. Archive samples were usually collected from the drive barrel and then placed in two glass mason jars. Material collected from the chemical and physical sampling points was usually retained in the stainless steel liner from the split spoon. Archive samples were submitted for storage only after determining that the total radiological activity of the sample was below 5 pCi/g. Archive material was never collected from sites with detectable contamination.

Physical property samples were collected using either a drive barrel or split-spoon sampler with stainless steel liners. After obtaining sufficient material for the chemical sample, the remaining split-spoon liner best representing the lithology was selected for physical analysis, capped, and wrapped with tape to preserve sample quality. If insufficient material was available for the physical sample, a second split spoon would be driven and a liner obtained. Material collected with the drive barrel was sometimes collected in place of a split spoon when sufficient liners had been obtained earlier in the borehole. Drive barrel samples were placed in a 1-L plastic bucket and single moisture tin wrapped in tape. All sample containers were labeled with applicable borehole number, sampling date, time depth interval, Hanford Environmental Information System (HEIS) number, and the sampler's initials.

Chain-of-custody documentation was prepared by the site geologist for each day's sampling and accompanied the sample to the temporary sample storage facility and the applicable physical properties laboratory. Total activity analysis was performed on all material collected to determine the appropriate laboratory for analysis. Physical samples with a total activity of less than 5 pCi\g were submitted to the Geotechnical Engineering Cold Laboratory. Samples that did not exceed 25 mrem were submitted to the Geotechnical Engineering Hot Laboratory. Samples exceeding 25 mrem were not collected for analysis. Table 4 lists physical sampling intervals, HEIS database numbers, and physical analysis information. Sieve results are presented graphically on the borehole logs in Appendix A. Hydraulic conductivity data are presented in Appendix B. Physical property information summarized in this report can also be found in the 200-UP-2 project file.

3.3.2 Chemical Sampling

Chemical samples were obtained from intervals best representing the site geology and contaminants present in the subsurface. This was achieved by reviewing construction diagrams for the cribs and preparing geologic cross sections of the proposed drill sites and a conceptual model for the spread of contaminants at cribs. Previous work performed at the 200-BP-1 Operable Unit indicates that the lateral spread of contamination is minimal and is concentrated immediately beneath the point at which it was introduced to the soil. Sampling was therefore concentrated at depths where this contamination was expected.

Chemical samples were collected using a decontaminated split-spoon sampler with stainless steel liners. Field screening was used to ensure that the most contaminated material from each sampling interval was submitted for analysis. This involved screening the ends of the split spoon. If radiological contamination was not present, the split spoon was opened outside the glove box and the liners were surveyed. If radiological contamination was still not present, material best representing the sample was obtained. If radiological contamination was present, the sample was transferred to the glove box. The sample was then screened and the most contaminated material was obtained. Chemical sampling intervals, HEIS sample number, analysis requested, and quality assurance samples are presented in Table 5. Chemical sample results can be found in the HEIS and are listed under their HEIS database number.

3.3.2.1 Nature and Extent of Contamination. This section describes the nature and extent of contamination in the sediment column within the 200-UP-2 operable unit. Results are based upon samples collected from test pits and vadose boring/wells. Only contaminants of potential concern identified in the LFI report, Chapter 4.0, "Qualitative Risk Evaluation Overview," are described. Each contaminant is described relative to the applicable waste management unit (e.g., 216-U-10-Pond Disposal System, 216-U-12 Crib) in the operable unit. Lists of contaminants eliminated in the qualitative risk assessment are provided in the LFI report.

3.3.2.1.1 216-U-1/2 Cribs. Twelve contaminants are identified within the 216-U-1/2 Cribs as potential contaminants of concern. Contaminants of potential concern are americium-241, cobalt-60, cesium-137, europium-152, neptunium-237, plutonium-239/240, radium-228, strontium-90, thorium-228, and uranium-233/234, -235, -238. Data are generally available to determine the extent of contamination to a depth of 175 ft beneath the 216-U-1/2 Cribs. Data in this section are obtained from borehole 299-W19-96.

Americium-241. Americium-241 is between less than 1 pCi/g and 33 pCi/g beneath the 216-U-1/2 Cribs. The maximum activity was detected approximately 22 ft bgs and correlates well with the bottom of the crib. Americium-241 activity decreases with depth to 0.12 pCi/g at 50 ft bgs and was not detected in the remaining section of the borehole. The distribution of americium-241 in the sediment column is shown in Figure 24.

Cobalt-60. Cobalt-60 activity is between 0.37 pCi/g and 10.6 pCi/g beneath the 216-U-1/2 Cribs. The maximum activity was detected approximately 22 ft bgs and correlates well with the bottom of the crib. Cobalt-60 activity decreases with depth to 0.37 pCi/g at 40.5 ft bgs and was not detected in the remaining section of the borehole. The distribution of cobalt-60 in the sediment column is shown in Figure 25.

Cesium-137. Cesium-137 contamination is predominately established less than 40.5 ft bgs and is generally between 320 pCi/g and 1.7E6 pCi/g. The greatest levels of contamination correlates well to the bottom of the crib about 20 ft bgs. Cesium-137 is undetected greater than 40.5 ft bgs with exception of the 175-ft sample. The activity at 175 ft bgs is 0.23 pCi/g and only slightly above the instrument detection limit. The distribution of cesium-137 in the sediment column is shown in Figure 26.

Europium-152. Europium-152 was not detected in borehole 299-W19-96 at the 216-U-1/2 Cribs. Europium-152 is retained as a contaminant of concern due to contamination detected during surface soil sampling activities (BHI 1994).

Neptunium-237. Neptunium-237 was detected in four samples within borehole 299-W19-96. Contaminant level range between 0.011 to 2.1 pCi/g. The greatest contamination (2.1 pCi/g) occurs at a depth of 40.5 ft bgs. Neptunium-237 detected in the remaining three samples (140, 168, and 175 ft bgs) is no greater than 0.06 pCi/g.

Plutonium-239/240. Plutonium-239/240 was detected in one sample from borehole 299-W19-96. This contaminant was detected at a depth of 40.5 pCi/g at an activity of 1.1 pCi/g

Radium-228. Radium-228 activity is between 0.75 and 1.3 pCi/g beneath the 216-U-1/2 Cribs. Maximum contaminant levels occur in the lower section of the sediment column indicating contamination extends to total depth (175 ft bgs). The distribution of radium-228 in the sediment column is shown in Figure 27.

Strontium-90. Contamination by strontium-90 is predominately established less than 40.5 ft bgs and activities are between 42 pCi/g and 2.4E6 pCi/g. Strontium-90 is undetected greater than 40.5 ft bgs with exception of 166 and 168 ft bgs. Activities at these depths are 0.14 and 1.2 pCi/g, respectively and only the latter exceeds background (0.29 pCi/g). The distribution of strontium-90 in the sediment column is shown in Figure 28.

Thorium-228. Thorium-228 is present throughout the sediment column to a depth of 175 ft. Contaminant level range between 0.49 to 1.3 pCi/g and generally increase with depth. The maximum activity is detected on top of the Hanford formation, unit 2 and plio-pleistocene unit. The distribution of thorium-228 in the sediment column is shown in Figure 29.

Uranium-233/234. Uranium-233/234 is present throughout the sediment column to a depth of 168 ft. Contaminant level range between 0.69 to 1,400 pCi/g. The greatest level of contamination

in detected 40.5 ft bgs. The distribution of uranium-233/234 in the sediment column is shown in Figure 30.

Uranium-235. Uranium-235 is detected below 40.5 ft to a depth of 168 ft. Contaminant level range between 0.2 to 2.2 pCi/g with the greater level of contamination near the bottom of the well. The distribution of uranium-235 in the sediment column is shown in Figure 31.

Uranium-238. Uranium-238 is present throughout the sediment column to a depth of 175 ft. Contaminant level range between 0.64 to 1,500 pCi/g. The highest level of contamination is detected 40.5 ft bgs. The distribution of uranium-238 in the sediment column is shown in Figure 32.

Contamination Adjacent to the 216-U-1/2 Cribs. Boreholes 299-W19-95 and 299-W19-97 were drilled adjacent to the 216-U-1/2 Cribs to determine the lateral extent of contamination. Seven contaminants were detected in the subject boreholes.

Cesium-137 was detected only in borehole 299-W19-97. The contaminant was detected 4 ft bgs at an activity of 22 pCi/g.

Neptunium-237 was detected only in borehole 299-W19-95 at a maximum concentration of 0.06 pCi/g. The contaminant was detected 75, 105, and 165 ft bgs.

Radium-228 was detected in boreholes 299-W19-95 and 299-W19-97 throughout the sediment column. Maximum contaminant levels are less than 1 pCi/g in each borehole.

Strontium-90 was detected only in borehole 299-W19-97. The contaminant was detected 4 ft bgs at an activity of 3.3 pCi/g.

Thorium-228 was detected in boreholes 299-W19-95 and 299-W19-97 throughout the sediment column. Maximum contaminant levels occur at depths of 120 and 169 ft bgs and are not greater than 1.4 pCi/g.

Uranium-233/234 and uranium-238 were detected in boreholes 299-W19-95 and 299-W19-97 at levels less than background with the exception of the interval 165 to 169 ft bgs (i.e., Plio-Pleistocene unit/caliche layer). Uranium-233/234 and uranium-238 were detected 167 ft bgs in borehole 299-W19-97 at activities of 1.3 pCi/g. Uranium-233/234 and uranium-238 were detected between 165 and 169 ft bgs in borehole 299-W19-95 not exceeding 2.4 pCi/g.

3.3.2.1.2 216-U-4 French Drain. Fourteen contaminants are identified in the 216-U-4 french drain area as potential contaminants of concern. Contaminants of potential concern are americium-241, cobalt-60, cesium-137, europium-152, 154, neptunium-237, plutonium-239/240, radium-228, strontium-90, thorium-228, 232, and uranium-233/234, -235, -238. Data are generally available to determine the extent of contamination to a depth of 191 ft in borehole 299-W19-98.

Americium-241. Americium-241 was detected throughout the sediment column in the 216-U-4 french drain area. Higher contaminant levels were detected less than 60 ft bgs with a maximum of 200 pCi/g occurring at 11 ft. Greater than 60 ft bgs contamination is less than 1 pCi/g. The distribution of americium-241 in the sediment column is shown in Figure 33.

Cobalt-60. Cobalt-60 was detected in three samples in the 216-U-4 french drain area. Contaminant activities range between 0.23 to 2.08 pCi/g. Cobalt-60 was detected at depths of 4.4 ft, 47 ft and 60 ft bgs. The maximum activity occurs at a depth of 47 ft bgs.

Cesium-137. Cesium-137 was detected to a depth of 60 ft bgs in the 216-U-4 french drain area. Activities range between 5 to 1980 pCi/g with the highest activity at 60 ft bgs. The distribution of cesium-137 in the sediment column is shown in Figure 34.

Europium-152. Europium-152 activity is less than 1.1 pCi/g in the 216-U-4 french drain area. The maximum contaminant level of 1.1 pCi/g is detected 4.4 ft bgs and generally decreases to 183.5 ft. The distribution of europium-152 in the sediment column is shown in Figure 35.

Europium-154. Europium-154 activity is less than 1 pCi/g in the 216-U-4 french drain area. Only two samples exceed background and contamination is within 50 ft of the surface. The distribution of europium-154 in the sediment column is shown in Figure 36.

Neptunium-237. Neptunium-237 activity is less than 1 pCi/g in the area of the 216-U-4 french drain. The extent of contamination is intermittent and extends to a depth of 60 ft bgs. The distribution of neptunium-237 in the sediment column is shown in Figure 37.

Plutonium-239/240. The range of plutonium-239/240 activity is less than 1 pCi/g to 6.81 pCi/g in the 216-U-4 french drain area. The extent of contamination is about 47 ft bgs where the maximum contaminant level is reached. Plutonium 239/240 was detected at two other sample point at depths of 4.4 and 11 ft bgs.

Radium-228. Three data points are available to assess the distribution of radium-228 in the 216-U-4 french drain area. The range of radium-228 activity is less than 1 to 1.6 pCi/g to a depth of 183.5 ft. The higher activity occurs 4.4 ft bgs.

Strontium-90. Strontium-90 was detected in two sample from borehole 299-W19-98. Activities were 93 and 40 pCi/g at depths of 4.4 and 11 ft. The available data suggest than strontium-90 does not extend below 11 ft.

Thorium-228. Three data points are available to assess the distribution of thorium-228 in the 216-U-4 drain area. The range of thorium-228 activity is less than 1 to 1.3 pCi/g to a depth of 183.5 ft. The higher activity occurs 4.4 ft bgs.

Thorium-232. Three data points are available to assess the distribution of thorium-232 in the 216-U-4 french drain area. The range of thorium-228 activity is less than 1 to 1.6 pCi/g to a depth of 183.5 ft. The higher activity occurs 4.4 ft bgs.

Uranium-234. Uranium-234 is present throughout the sediment column to a depth of 183.5 ft. Contaminant levels range from slightly above background to 5.75 pCi/g. The maximum level of contamination (5.75 pCi/g) occurs at a depth of 60 ft. The distribution of uranium-234 in the sediment column is shown in Figure 38.

Uranium-235. Uranium-235 is typically present throughout the sediment column to a depth of 191.1 ft. Contaminant levels are less than 1 pCi/g. The distribution of uranium-235 in the sediment column is shown in Figure 39.

Uranium-238. Uranium-238 is present throughout the sediment column to a depth of 191.1 ft. Contaminant levels range slightly above background to 7.74 pCi/g. The maximum level of contamination occurs at a depth of 60 ft. The distribution of uranium-238 in the sediment column is shown in Figure 40.

3.3.2.1.3 216-U-8 Crib. Nineteen contaminants are identified at the 216-U-8 Crib as potential contaminants of concern. Contaminants of potential concern are arsenic; chromium; nickel; americium-241; cesium-134, -137; europium-152, -154; neptunium 237; plutonium-238, -239/240; radium-226, -228; strontium-90; thorium-232, -234; and uranium-233/234, -235, -238. Data are generally available to determine the extent of contamination to a depth of 197 ft in borehole 299-W19-94.

Arsenic. The sitewide threshold background value for arsenic is 8.9 ppm in the soil column. Sediment samples from borehole 299-W19-94 exceed background in two samples at a depth of 15 and 30 ft bgs. The concentrations are 9.1 and 9.14 ppm, respectively. All other samples collected form this borehole do not exceed background and range between 2.8 and 8.8 ppm.

Chromium. Chromium was detected below the background level of 28 ppm in borehole 299-W19-94 with one exception. Chromium was detected at a depth of 197 ft at a concentration of 28.4 ppm.

Nickel. This contaminant was not detected above background in borehole 299-W19-94 at the 216-U-8 Crib. Nickel is retained as a contaminant of concern due to contamination detected during surface soil sampling activities (BHI 1994).

Americium-241. Detectable levels of americium-241 are less than 1 pCi/g beneath the 216-U-8 Crib. This contaminant was detected at depths between 30 and 38 ft and at 187 bgs. The distribution of americium-241 in the sediment column is shown in Figure 41.

Cesium-134. Cesium-134 was not detected at the 216-U-8 Crib. Cesium-134 is retained as a contaminant of concern due to contamination detected during surface soil sampling activities (BHI 1994).

Cesium-137. Cesium-137 contamination is distributed between 30 and 89.5 ft bgs. Contamination in this zone is generally greater than 3.4 pCi/g and as high as 91,190 pCi/g at a depth of 30 ft. Cesium-137 was not detected below a depth of 90 ft. The distribution of cesium-137 in the sediment column is shown in Figure 42.

Europium-152. This contaminant was not detected at the 216-U-8 Crib. Europium-152 is retained as a contaminant of concern due to contamination detected during surface soil sampling activities (BHI 1994).

Europium-154. Europium-154 was detected in one sample from borehole 299-W19-94 at a depth of 38 ft. The activity is 3.1 pCi/g.

Neptunium-237. Neptunium-237 was detected in four samples within borehole 299-W19-94. The activity of neptunium-237 is less than 1 pCi/g. The distribution of neptunium-237 in the sediment column is shown in Figure 43.

Plutonium-238. Plutonium-238 was detected in one samples within borehole 299-W19-94 at a depth of 30 ft. The activity of plutonium in the crib is less than 0.1 pCi/g.

Plutonium-239/240. This contaminant was not detected at the 216-U-8 Crib. Plutonium-239/240 is retained as a contaminant of concern due to contamination detected during surface soil sampling activities (BHI 1994).

Radium-226. Radium-226 is generally present throughout the sediment column to a depth of 187 ft. Activities range between 0.44 to 5.79 pCi/g and background (0.94 pCi/g) is exceeded in three samples. The distribution of radium-226 in the sediment column is shown in Figure 44.

Radium-228. Radium-228 is present throughout the sediment column to a depth of 187 ft. The activity is between 0.53 and 2.1 pCi/g beneath the 216-U-8 Crib. The distribution of radium-228 in the sediment column is shown in Figure 45.

Strontium-90. Strontium-90 is detected between 30 and 197 ft bgs. Activities are between 36 to 520 pCi/g and generally increases towards the top of the Plio-Pleistocene unit. The distribution of strontium-90 in the sediment column is shown in Figure 46.

Thorium-232. Thorium-232 is present throughout the sediment column to a depth of 175. The activity of thorium-232 is between 0.53 and 2.1 pCi/g. Eight data points exceed the background level (1.1 pCi/g) of thorium-232 in the sediment column. The distribution of thorium-232 in the sediment column is shown in Figure 47.

Thorium-234. Thorium-234 was detected in one sample in borehole 299-W19-94 at a depth of 148 ft. The activity is 8.02 pCi/g.

Uranium-233/234. Uranium-233/234 is present throughout the sediment column to a depth of 197 ft. The activity of this contaminant increases towards the top of the Ringold Formation, unit E, and is between 0.44 and 140 pCi/g. The vertical distribution of uranium-233/234 in the sediment column is shown in Figure 48.

Uranium-235. Uranium-235 is detected below 38 ft to a depth of 197 ft. Contaminant levels range between less than 1 to 6.7 pCi/g with the greater level of contamination near the bottom of the well. The distribution of uranium-235 in the sediment column is shown in Figure 49.

Uranium-238. Uranium-238 is present throughout the sediment column to a depth of 197 ft. Contaminant levels range between 0.43 to 150 pCi/g. The greatest level of contamination in detected 187 ft bgs. The distribution of uranium-238 in the sediment column is shown in Figure 50.

3.3.2.1.4 216-U-10 Pond Disposal System. Twenty-four contaminants are identified at 216-U-10 Pond disposal system as potential contaminants of concern. Contaminants of potential concern are arsenic; barium; chromium; aroclor-1260; manganese; nickel; americium-241; cesium-137; cobalt-60; europium-152, -154, -155; plutonium-238, -239/240; radium-226, -228; sodium-22; strontium-90; technetium-99; thorium-228, -232; and uranium-233/234, -235, -238. Data are generally available to determine the extent of contamination to a depth of 138 ft within the U Pond System. In addition, figures in this section were generated based on data from test pit 216-U-10, TP-2, and borehole 299-W19-231 to show the vertical distribution of contaminants in the

sediment column beneath U Pond. Where two or more samples are collected from the same depth the maximum concentration or activity is plotted.

Arsenic. Samples collected from the U Pond disposal system generally indicate that arsenic is below the sitewide background level (8.9 ppm). Sediment samples from test pits in the 216-U-14 Ditch range between 0.82 and 1.5 ppb. U Pond samples typically range between 1.9 and 4.8 ppm. One sample exceeded the background standard at a depth of 6.5 ft (bottom of U Pond) by 0.50 ppm.

Aroclor-1260. Aroclor-1260 was detected in three samples at depths between 2 and 6.5 ft within U Pond. The contaminant concentration is between 0.048 ppm and 0.220 ppm.

Barium. Barium was detected below the background level of 171.0 ppm in sample collected within and adjacent to the U Pond disposal system with one exception. One sample from test 216-U-10, TP-2 exceeded background by 160.0 ppm at a depth of 6.5 ft (bottom of U Pond).

Chromium. Chromium was detected below the background level of 28.0 ppm in samples collected within the U Pond disposal with one exception. One sample from test 216-U-10, TP-2 exceeded background by 5.4 ppm at a depth of 6.5 ft (bottom of U Pond).

Manganese. Manganese is below the sitewide background level (612.0 ppm) in all samples collected. A maximum concentration of 470.0 ppm was detected within the 216-U-14 Ditch.

Nickel. Nickel was detected below the background level of 25.0 ppm in samples collected within the U Pond disposal system with one exception. One sample adjacent to the 216-U-14 Ditch (borehole 299-W19-250) exceeds background 25 ft bgs by 44.0 ppm.

Americium-241. Americium-241 ranges between less than 1 to 45 pCi/g within the U Pond disposal system and typically does not 1.6 pCi/g. A maximum activity of 45 pCi/g is detected at a depth of 6.5 ft in test pit 216-U Pond, TP-2. The second highest activity (5.45 pCi/g) is detected in borehole 299-W23-231 at a depth of 2 ft bgs. Within the 216-U-14 Ditch americium-241 is between 0.5 and 1.6 pCi/g. This contaminant was not detected in boreholes adjacent to the ditch. The distribution of americium-241 in the sediment column beneath U Pond is shown in Figure 51.

Cesium-137. Cesium-137 ranges between 0.4 and 2,740 pCi/g in sediment samples collected from test pit excavations at the 216-U-14 Ditch. The major concentration of this contaminant is located within 0.3 m (1 ft) of the bottom of the ditch and is between 36 and 2,740 pCi/g. These data are comparable to data collected during the 1980's, which show a similar distribution of cesium contamination (2.3 to 1,500 pCi/g) in the bottom of the ditch. Samples from test pits indicate that contamination ranges between 0.12 and 10.4 pCi/g (average 1.6 pCi/g) greater than 0.3 m (1 ft) but less than 3 m (10 ft) below bottom of the ditch.

Cesium-137 activity detected beneath U Pond is distributed predominately within the upper 6.5 ft of the sediment column. In this zone sediment data suggest contamination is between 66.1 and 4,800 pCi/g. Below 6.5 ft contamination is typically less than 1 pCi/g and ranges to 1.8 pCi/g. The distribution of cesium-137 in the sediment column beneath U Pond is shown in Figure 52.

Cobalt-60. Cobalt-60 was detected in three samples within the U Pond disposal system. Cobalt was detected within the 216-U-14 Ditch at an activity of 2.3 pCi/g and in two samples at U Pond (less than 0.5 pCi/g) at depths of 2 and 6 ft. These results do not agree with data from the

1980's that suggest cobalt-60 is widely distributed in the bottom of the ditch (Singleton 1994). Contaminant levels during the 1980's range between 1.6 and 290 pCi/g (average concentration 34 pCi/g). The current lack of detectable cobalt-60 in the sediment column near the surface may be an indicator of contaminant migration in the subsurface.

Plutonium-238. Plutonium-238 activity is between less than 1 and 23 pCi/g in the U Pond Disposal System. Plutonium-238 was detected in test pit samples from the 216-U-14 ditch between 0.26 and 10 pCi/g. Samples from U Pond were typically less than 0.3 pCi/g or undetected with exception of the 6.5 ft sample collected from the test pit 216-U-10, TP2. The activity at 6.5 ft bgs is 23 pCi/g. The distribution of plutonium-238 in the sediment column beneath U Pond is shown in Figure 53.

Plutonium-239/240. Plutonium-239/240 ranges between less than 1 to 36 pCi/g in the U Pond Disposal System. The greatest activity (36 pCi/g) was detected in test pit 216-U-10, TP-2 at a depth of 6.5 ft. Data from greater than 15 ft bgs are typically less than 1 pCi/g with one exception. Plutonium 239/240 was detected at a depth of 135 ft (Plio-Plio-Pleistocene unit) at an estimated activity of 1.7 pCi/g. The distribution of plutonium-239/240 is shown in Figure 54.

Europium-152. This contaminant was not detected in test pits or boreholes in the 216-U-10 Pond Disposal System. Europium-152 is retained as a contaminant of concern due to contamination detected during surface soil sampling activities (BHI 1994).

Europium-154. Europium-154 was detected in one sample from the borehole 299-W23-231. This contaminant was detected at an activity of 0.17 pCi/g at a depth of 2 ft bgs. Europium-154 was not detected in test pit excavations.

Europium-155. Europium-155 was detected in four samples at activities ranging between 0.07 and 0.11 pCi/g at U pond (borehole 299-W23-231). The extent of contamination is between 15 and 135 bgs but does not exceed the site wide background level (0.14 pCi/g). The distribution of europium in the sediment column is shown in Figure 54. Europium-155 was not detected in test pit excavations.

Radium-226. Radium-226 was detected throughout the sediment column at U Pond ranging between 0.36 and 1.08 pCi/g and only slightly exceeds background (0.94 pCi/g) in three samples. The available data indicate contamination extends to 138 ft. The distribution of radium-226 in the sediment column at U Pond is shown in Figure 56.

Radium-228. Radium-228 was detected throughout the sediment column at U Pond ranging between 0.64 and 1.49 pCi/g. The available data indicate contamination extends to 138 ft. The distribution of radium-228 in the sediment column is shown in Figure 57.

Sodium-22. Sodium-22 is retained as a contaminant of concern due to contamination detected during surface soil sampling activities (BHI 1994). Sodium-22 was detected at a depth of 2 ft in borehole 299-W23-231 at an activity of 0.05 pCi/g.

Strontium-90. Strontium-90 activity is between 0.47 and 190 pCi/g in the U Pond Disposal system. The available test pit data indicate that strontium-90 is between 0.47 and 6.6 pCi/g within the 216-U-14 Ditch. Strontium-90 is between 16 and 190 pCi/g at U Pond with the higher activity at

a depth of 6.5 ft bgs (bottom of U Pond). The distribution of strontium-90 in the sediment column beneath U Pond is shown in Figure 58.

Technetium-99. Technetium-99 ranges from 1.1 to 12 pCi/g in the U Pond Disposal system. The maximum activity (12 pCi/g) was detected at a depth of 0.5 ft in a single sample from the 216-U-14 ditch.

Technetium was detected in two samples from test pit 216-U-10 Pond, TP-2 at depths of 6.5 and 9 ft bgs. Activities are 8.8 pCi/g and 1.1 pCi/g, respectively. Technetium-99 was also detected in two samples from borehole 299-W23-231 at depths of 2 and 135 ft (Plio-Pleistocene unit). The respective activities are less than 1 pCi/g and .07 pCi/g.

Thorium-228. Thorium-288 activity is less than 1 to 1.3 pCi/g within the U Pond Disposal system. Within 25 ft of the surface activities are less than 1 pCi/g. 1.3 pCi/g was detected 138 ft bgs near the top of the Plio-Pleistocene unit. The distribution of thorium-228 in the sediment column beneath U Pond is shown in Figure 59.

Thorium-232. The activity of thorium-232 is less than 1 to 2.6 pCi/g within the 216-U-10 Pond disposal system. The maximum activities are located 6.5 ft bgs (bottom of U-10 Pond) and near the top of the Plio-Pleistocene unit (138 ft bgs). The sitewide background level of thorium-232 is 1.1 pCi/g. The distribution of thorium-232 beneath U Pond is shown in Figure 60.

Uranium-233/234. Uranium-233/234 was detected between less than 1 to 85 pCi/g. The greatest activity (85.0 pCi/g) is detected in test pit 216-U-10 Pond, TP-2 at a depth of 6.5 ft (bottom of U Pond). Elevated activities were also detected at a depth of 135 ft exceeding 1.5 pCi/g. The distribution of uranium-233/234 in the sediment column beneath U Pond is shown in Figure 61.

Uranium-235. Uranium-235 was detected between less than 1 to 0.6 pCi/g 6.5 ft bgs. The distribution of uranium-235 in the sediment column is shown in Figure 62.

Uranium-238. Detectable amount of uranium-238 range between less than 1 pCi/g to 178 pCi/g within the 216-U-10 Pond Disposal System. Maximum levels of contamination are detected in the 216-U-14 Ditch where activities within 4 ft of the ditch bottom range between 24 and 178 pCi/g (average concentration to a depth of 1.2 m [4 ft] is 29 pCi/g). Activities below 1.2 m (4 ft) are between 1 and 7 pCi/g (average concentration is 3 pCi/g).

Activities at U Pond range between less than 1 to 8.26 pCi/g in borehole 299-W23-231 and 1 to 88 pCi/g in test pit 216-U-10 Pond, TP-2. The maximum activity in borehole 299-W23-231 occurs 2 ft bgs. The maximum activity in 216-U-10-Pond, TP-2 occurs at a depth of 6.5 ft (bottom of U Pond). The distribution of uranium-238 in the sediment column beneath U Pond is shown in Figure 63.

3.3.2.1.5. 216-U-12 Crib. No contaminants are identified at the 216-U-12 Crib as potential contaminants of concern by the qualitative risk assessment. Contaminants of concern are likely not identified at the 216-U-12 Crib as characterization was initiated adjacent to the ditch instead of through the crib. Data are generally available to determine the extent of contamination to a depth of 230 ft adjacent to the crib.

4.0 BOREHOLE GEOPHYSICS

4.1 INTRODUCTION

Logging with the high-resolution, high-purity germanium (HPGe) passive spectral gamma ray Radionuclide Logging System (RLS) was completed on 10 boreholes for the 200-UP-2 Project. The logging was conducted on seven new vadose borings and three existing wells/boreholes. The surveys were acquired during the period September 1993 to March 1994. All borings/wells surveyed for the 200-UP-2 project are referred to as boreholes. A summary of the information collected from the logging, including the completion date of the final survey, maximum survey depth, and radionuclides identified is presented in Table 6.

The objective of the borehole surveys was to identify the presence and species of man-made gamma-ray-emitting radionuclides and their relative activity levels and to aid in subsurface stratigraphic correlation. The plots of the decay activities (concentrations) versus depth for the man-made radionuclides and natural radionuclides are presented for each survey. Geologic sample descriptions of the dominant grain size are included on the borehole survey plots of the natural radionuclides. Decay activities are reported in picocuries per gram (pCi/g) of sample.

Geologic variations influence the migration of contaminants through the subsurface. Geologic conditions that can retard or redirect the downward movement of contaminants are (1) low-permeability zones such as caliche, (2) fine-grained sediments such as silt lenses, and (3) finer grained sediments overlaying uncemented coarse matrix such as silts or sands over open-framework gravels. The correlation of geologic conditions with contaminant distribution will be discussed.

A description of the RLS and the limitations of the radioelement analyses are described in Appendix C-1. An explanation of the borehole survey header, plot, and survey report is provided in Appendix C-2. The borehole surveys for each well are provided in Appendix C-3. A summary of the geologic sample descriptions and graphical representation of the RLS survey results are provided in Appendix C-4.

The contents of the report are limited to the description of the survey results for each borehole logged. Details regarding field survey procedures (WHC 1988), equipment configuration, spectra analysis software, data management (Koizumi 1992b), calibration, casing, and water correction factors (Brodeur 1991, 1992; Koizumi 1991, 1992a) are discussed in separate documents.

4.1.1 Location

All boreholes drilled and logged in support of the 200-UP-2 Project were located in or near facilities associated with former U Plant operations. With the exception of three pre-existing boreholes (299-W19-2, 299-W19-70, and 299-W19-71), all boreholes were drilled specifically to acquire characterization data for the 200-UP-2 Project. The borings completed during the 200-UP-2 drilling activities have been backfilled and abandoned. The boreholes were located as follows:

299-W19-2	U-8 Crib
299-W19-70	U-8 Crib
299-W19-71	U-8 Crib

299-W19-94	U-8 Crib
299-W19-95	south of the U-1 Crib
299-W19-96	U-1 Crib
299-W19-97	north of the U-1 Crib
299-W19-98	U-4A reverse well and french drain
299-W22-78	U-12 Crib
299-W23-231	U-10 Pond

The analysis results of the RLS survey for each borehole are presented in Section 4.1.3, "Results," ordered by hole number. Interpretation of the survey results for each disposal facility (crib, reverse well, french drain, or pond) is presented in Section 4.2, "Conclusions."

4.1.2 Logging Parameters

Borehole surveys were conducted in single casing strings in all boreholes. The casings in the pre-existing wells is schedule 40 welded-joint carbon steel with a wall thickness of 0.375 in. All of the 8- and 10-in.-diameter casing used during drilling was threaded-joint casing with a wall thickness of 0.5 in.

The reference datum for the zero depth position of each borehole is the ground level. The elevation above mean sea level of the ground level adjacent to the borehole was not available at time of logging.

The HPGe detector and electronic instrumentation are configured for detecting low concentration levels of man-made radionuclides (less than 1 pCi/g cesium-137) and surveying over 100 ft of borehole per day. The configuration can detect contaminants with concentrations ranging over four orders of magnitude above the threshold level. The contaminant concentrations in the subsurface have occasionally exceeded the detection range of the HPGe system, causing the counting system to saturate. When saturation occurs, the magnitude of the gamma-ray intensity is lost.

All the RLS data were acquired in the move-stop-acquire mode every 0.5 ft in depth throughout the borehole. The acquisition times for each depth station of a survey were set to 80, 120, or 180 seconds (real "wall clock" time) and were constant for the survey session. The longer survey times of 120 or 180 seconds were specified to reduce the detection threshold for uranium-235 and uranium-238 in the presence of steel casings. Stationary measurements of 300 seconds (real time) were acquired in several boreholes to verify data.

Occasionally a short section of open hole extends below the bottom of casing. When this occurs, the gamma-ray count rate significantly increases when the detector moves below the casing into the open hole.

Most of the casing used during borehole drilling was threaded joint carbon steel with a 0.5-in. wall thickness. Currently the maximum correction factor available for RLS survey analysis is 0.4 in. Therefore, the computed activities are underestimated.

Short casing overlap sections of about 2 ft were surveyed, usually at the beginning of the second, third, or subsequent survey sessions for each borehole. The overlaps were conducted to verify depth control and to provide profile characteristics that aided in combining the individual surveys into a

single survey at the completion of drilling. Additionally, in December 1993, per revision to the borehole logging procedures, repeat sections of 2.5 ft were logged at the conclusion of each survey to verify equipment performance. These casings overlap, and repeat surveys are included on the plots.

4.1.3 Results

Cesium-137 is a fission product from the nuclear reaction and was produced in large quantities. The relatively long decay half life of 30.17 years, high gamma-ray energy (661.6 KeV), and high gamma-ray decay intensity (84.7%) contribute to the abundance of cesium-137 at Hanford.

Cesium-137 is frequently detected on the surface or within a few feet of the surface and there may be indications of its penetration into the subsurface. However, the majority of cesium-137 detected in the borehole survey is not from surface contamination but from effluents discharged to the cribs and other types of disposal facilities. The rate of downward migration of cesium, its rapid absorption into the soil matrix, or movement with the discharge liquid to great depths is strongly influenced by the chemical composition of the discharge liquid. Discharge liquids containing high concentrations of salts effectively compete with cesium for ionic bonding to the soils, driving the cesium to greater depths. Likewise, discharge solutions with low concentrations of salts allow cesium to be absorbed quickly into soil particles and retained close to the discharge point.

Cesium-137 was detected in almost all boreholes logged for this project at depths associated with the release point and was also detected at or very near ground surface from surface deposition. The concentration of cesium-137 in most contaminated areas of the 216-U-1 and 216-U-8 Cribs was high enough to saturate the current configuration of the RLS detector. When saturation occurs, no information is able to be processed for isotope identification or intensity.

As the detector recovered from saturation, additional radionuclides such as the europium isotopes europium-152/154 and uranium isotopes uranium-235/238 were generally identified. The first presence of these radionuclides at or near the effluent discharge depth could not be determined since they were possibly in the zone of detector saturation.

Cobalt was identified in two boreholes. In both boreholes it was found with other radionuclides.

Europium-154 was found in four boreholes. Europium-152 was found in one borehole along with europium-154. The concentration of europium-152 has always been several times lower than the europium-154 concentrations all across the 200 Areas.

The uranium-238 identified from the 1,001 and 767-keV gamma rays of protactinium-234 is probably related to U Plant operations. It should not be confused with naturally occurring uranium that is identified from 609 and 1,764-keV gamma rays of bismuth-214 and lead-214. Natural uranium should be in secular equilibrium with all of its daughter products. The process uranium-238 radionuclide identified in these wells was not in secular equilibrium because the daughters below radium (radium-226) were not identified in the gamma-ray spectra.

Uranium-235 was identified in four borehole surveys, and in all occurrences it was found with uranium-238 but at lower concentrations. The 186-keV gamma ray for uranium-235 is difficult to identify in the presence of cesium-137 when the cesium-137 activity rises above 20 pCi/g.

The RLS borehole survey also records gamma-rays from the natural radionuclides. The activities of the naturally occurring radionuclides potassium, uranium, and thorium (KUT) reported in the surveys were typical for Hanford sediments. The KUT activities have variations in the Hanford sediments as follows:

Potassium	8-20 pCi/g
Uranium	0.2-3 pCi/g
Thorium	0.2-2 pCi/g

An exception to the normal concentrations occurred during surveys conducted at boreholes 299-W19-94 and 299-W19-97. The recorded natural uranium concentrations were higher than expected. Elevated uranium activities were observed for data collected during days of low barometric pressure when radon (radon-222), a gaseous daughter of uranium, vented from the bottom of the well upward through the casing. Radon, although itself is not a strong gamma emitter, decays to lead-214 and bismuth-214, which are strong gamma emitters. The activity due to radon-222 decay contributes to the calculated activity of natural uranium.

The total gamma-ray plot is the count rate observed for all the gamma rays detected. No correction factors for casing or borehole fluids are applied.

The total gamma-ray profile is a useful plot for identifying gross lithologic features and can be correlated with the borehole lithology logs.

Review of the borehole lithology logs, radionuclide profiles, and total gamma-ray profiles prompted the observations in the following sections.

4.1.3.1 Borehole 299-W19-2, 216-U-8 Crib. This is a pre-existing borehole adjacent to the 216-U-8 Crib. Geologic descriptions from the drilling samples were suspect and are not included on the log plot.

Cesium-137 was the only man-made radionuclide identified in the borehole survey. The concentrations detected are very low and nowhere exceeded about 1/25th of the radioactivity that is emitted from the natural radionuclides. Cesium was detected intermittently from 1.5 to 41 ft and at 115 ft with maximum observed decay activity less than 1 pCi/g.

An undocumented starter casing is present from 0 to 40 ft. This is evidenced by the depressed (reduced from 125 to 100 cps) total gamma activity above 40 ft.

The caliche bed under the 200 West Area is identified (185 to 205 ft) by the reduced potassium content and reduced total gamma activity. It appears to be locally overlain by a silt lens (182 to 185 ft) as demonstrated by the increased total gamma response.

4.1.3.2 Borehole 299-W19-70, 216-U-8 Crib. This is a pre-existing borehole within the 216-U-8 Crib that was surveyed to 81 ft. Geologic descriptions from the drilling samples were suspect and are not included on the log plot. The total gamma activity below 24 ft is dominated by the crib contaminants and cannot be used for geologic interpretation. Geologic interpretation in these cases must be gleaned from the lower amplitude natural (KUT) gamma-ray photo peaks.

Three man-made radionuclides were identified in the sediments. The gamma-ray intensity from the contaminants saturated the RLS counting capabilities from 30 to 34 ft. The dominant radionuclide observed immediately before and after saturation occurred was cesium, implying that cesium is most likely the dominant contaminant between 30 and 34 ft.

Cesium-137 is the most abundant contaminant identified in this survey and probably penetrated beyond the maximum survey depth of 81.5 ft. Cesium was detected intermittently above the crib disposal depth from 2.5 to 24 ft at very low concentrations that did not exceed 1 pCi/g. Cesium was the only man-made radionuclide identified from 25 to 30 ft before detector saturation occurred. The concentration rose from nondetectable to over 1,000 pCi/g at 30 ft.

Below the detector saturation interval, the cesium-137 concentration exceeded 5000 pCi/g, dominating the spectra and raising the detection threshold of the other radionuclides. The concentration decreased rapidly below 35 ft to about 1000 pCi/g at 40 ft. The cesium-137 contaminant continued to decrease with depth, falling below 200 pCi/g at 67 ft reaching about 100 pCi/g at the maximum survey depth of 81.5 ft. The maximum extent of cesium contamination could not be determined from this survey.

The distribution profile of cesium-137 is not consistent with most cesium-137 waste released to cribs where the effluent should contain low salts in order to provide for maximum retention in the soil. Normally, cesium concentrations decrease rapidly to below 1 pCi/g within 20 or so feet of the release depth. In this case, the cesium-137 decrease is very gradual and remains above 200 pCi/g for over 40 ft.

Further review indicated that borehole 299-W19-70 was drilled in January 1951. The crib operation dates are from June 1952 to March 1960. Thus, the borehole was in place during the operation of the crib. Boreholes constructed in the earlier years at Hanford did not normally contain any sealing material between the casing and formation and in some cases have been known to act as conduits for the movement of contaminants between the casing and the formation.

Uranium-238 was the second most dominant radionuclide contaminant identified in the borehole survey. The highest concentration interval (36 to 40 ft) occurred below the detector saturation interval. The maximum concentration approached 2000 pCi/g. Uranium detection was intermittent from 40 ft to the maximum survey depth of 81.5 ft. The second highest concentration of uranium-238 identified in the survey occurred at the bottom of the borehole from 78.5 to 81.5 ft with concentration around 50 pCi/g. No uranium-235 was detected in the survey. The absence of ^{235}U in the spectra is expected because high concentrations of cesium-137 result in scattered radiation that masks the 186 KeV gamma-ray for uranium-235.

Europium-154 was detected in one interval from 34 to 40 ft, overlapping uranium-238. The maximum concentration was about 10 pCi/g. Normally europium-154 migrates farther through the sediments than cesium-137. In this case they are reversed, further indicating that the casing acted as a conduit for migration.

4.1.3.3 Borehole 299-W19-71, 216-U-8 Crib. This is the third pre-existing borehole logged for the 216-U-8 Crib. Geologic descriptions from the drilling samples were suspect and are not included on the log plot. The total gamma activity below 26 ft is dominated by the crib contaminants and cannot be used for geologic interpretation.

Three man-made radionuclides were identified in the formation. The gamma-ray intensity from formation contaminants saturated the RLS counting capabilities from 30 to 37 ft. The dominant radionuclide observed immediately before and after saturation was cesium, implying that cesium is likely the dominant contaminant between 30 and 37 ft.

Surface contamination from cesium-137 was identified from 0 to 7 ft. The decay activity of about 10 pCi/g at about 1 ft decreases rapidly to less than 1 pCi/g at about 3 ft.

The majority of the cesium-137 contamination is associated with crib effluent. The cesium concentration exceeds 5,000 pCi/g immediately before and after the counting system saturated. The concentration decreased rapidly below 37 ft to about 1,000 pCi/g at 42 ft and to less than 50 pCi/g at about 48 ft. The cesium-137 activity was less than 1 pCi/g from 75 ft to the maximum survey depth of 79.5 ft, indicating that probably little or no cesium-137 penetrated below 80 ft.

The second dominant contaminant identified in the survey was uranium-238 with concentrations approaching 1,000 pCi/g below the detector saturation interval at 37.5 ft, then falling to below 150 pCi/g at 48 ft. Uranium was detected intermittently to the maximum survey depth of 79.5 ft and attained concentrations of 100 pCi/g as low as 73 to 79.5 ft.

Uranium-235 was not detected in the borehole until concentrations of cesium-137 fell below 50 pCi/g. It was identified at the same depths as uranium-238, at concentrations of about 5 pCi/g.

4.1.3.4 Borehole 299-W19-94, 216-U-8 Crib. Geologic descriptions of the dominant grain size are included on the plot of the natural radionuclides. The influence of geology on the downward migrating contaminants is demonstrated at several intervals. One occurs from 82 to 91 ft where silt content in the sand increases and the cesium-137 contaminant is impeded from its downward migration. Uranium migrated to much greater depths and was identified at the top of the silt interval at 165 ft and the top of the caliche horizon at 188 ft. The caliche interval (187.5 to 197 ft) and thick overlying silt zone (165 to 187.5 ft) of the upper Plio-Pleistocene unit are easily identified in the plot of the natural radionuclides.

Four man-made radionuclides were identified in the sediments. The gamma-ray intensity from formation contaminants saturated the RLS counting capabilities from 30 to 35.5 ft. The dominant radionuclide observed immediately before and after saturation was cesium, implying that cesium is likely the dominant contaminant in the saturated interval.

Surface and low-level vadose contamination from cesium-137 was identified from 0 to 25 ft above the influence of the crib waste. The contamination is almost continuous in this interval and is less than 2 pCi/g. The contamination does not appear to be the result of migration from the surface by natural forces. It is not clear whether the source was in place prior to drilling operations or was the result of small amounts of surface contaminants migrating to lower depths by the drilling process.

The dominant content of the cesium-137 contamination is the result of crib discharge and its downward migration through the sediments. The cesium concentration exceeds 5,000 pCi/g immediately before and after the counting system saturated. Similar to borehole 299-W19-71, the cesium-137 concentration decreased rapidly below 36 ft to less than 100 pCi/g at 43 ft and to nondetectable levels (less than 0.2 pCi/g) at 100 ft.

The second dominant contaminant identified in the survey was uranium-238 with concentrations approaching 1000 pCi/g below the detector saturation interval at 35.5 ft and decreasing to nondetectable levels at 40 ft. Uranium was detected intermittently to the top of caliche (185 to 189 ft) where the second highest concentration was encountered at over 120 pCi/g.

Uranium-235 was not detected in the borehole until cesium-137 contamination levels dropped to low levels. It was identified at the same depths as uranium-238 at concentrations less than 3 pCi/g.

Europium-154 was detected in one interval from 37 to 40 ft. The maximum concentration was about 3 pCi/g. The depth interval is consistent with that encountered in borehole 299-W19-70, indicating that, in both, low concentrations of europium-154 were released to the crib and the properties of the effluent mix allowed it to be retained near the release site.

4.1.3.5 Borehole 299-W19-95, South of 216-U-1 Crib. Geologic descriptions of the dominant grain size are included on the plot of the natural radionuclides. This borehole encountered no radionuclide contamination below 4 ft and can be used to identify geologic variations and their correlation with variations in the natural radionuclide content. The total gamma activity for this survey is lower than the pre-existing well (299-W19-2) discussed earlier, showing natural formation characteristics because the construction casing is thicker and is a better gamma-ray attenuator.

The caliche marker bed is easily identified at 166 ft. The low-permeability caliche is relatively thin at this location. The overlying silt is thicker (150 to 166 ft). Close examination reveals definite survey differences between the alternating beds (150 to 160 ft) and the Plio-Pleistocene fine silt (160 to 166 ft). Gradational changes in the formation material from sandy gravel upward to sand are easily recognized from 65 to 100 ft.

The only man-made radionuclide identified in the borehole survey was cesium-137, occurring from 0 to 4 ft. The concentration is about 10 pCi/g and is not consistent for most surface contamination zones where the concentration decreases rapidly with depth to levels below 1 pCi/g. The contamination in this case remains high to 3 ft before rapidly decreasing.

4.1.3.6 Borehole 299-W19-96, 216-U-1 Crib. Geologic descriptions of the dominant grain size are included on the natural radionuclides plot. Geologic influences on the downward migration of contaminants are present at the interface between sand and sandy gravel (53 ft) where uranium was detected. Additionally, uranium was identified at the top of the caliche at 169 ft. Geologic intervals identified on the borehole survey where no contaminating radionuclides were present are as follows:

- The sand interval between two sandy gravel zones from 66.5 to 69 ft
- Gravel and cobble interval from 88 to 94 ft
- Silts overlaying the caliche from 159 to 169 ft.

Six man-made radionuclides were identified by the RLS survey. The gamma-ray intensity from the contaminants saturated the system's counting capabilities from 11.5 to 35.5 ft. The dominant radionuclide observed immediately before and after saturation was cesium, implying that it is the dominant contaminant in the saturated interval.

A significant amount of cesium-137 contamination was identified above the crib disposal site near the surface at about 3 ft with a decay activity of about 4,000 pCi/g. Below the equipment saturation interval (35.5 ft), the cesium-137 concentration falls rapidly to less than 50 pCi/g at 39 ft and to nondetectable levels at 49 ft.

The second highest concentration of radionuclide contamination is from uranium-238; it was detected in two main intervals. The higher concentration occurred immediately below the saturated interval from 37 to 57 ft. Within this zone, the concentrations exceeded 5000 pCi/g from 38 to 43 ft. The second interval detected was the top of caliche (165 to 169 ft) with concentrations less than 100 pCi/g.

Uranium-235 was detected in the same intervals as uranium-238 at concentrations less than 300 pCi/g.

The third highest concentration of radionuclide contamination is from europium-154 with concentrations approaching 1,000 pCi/g from 38 to 43 ft. The distribution profile for europium-154 is identical to the profile for the two uranium nuclides. The distribution profile exhibits two zones of high concentration. The lower zone appears to be thicker with a lower concentration level.

Europium-152 was detected in the same interval as europium-154 at concentrations that did not exceed 5 pCi/g.

The sixth radionuclide detected in the borehole was cobalt-60 at concentrations less than 3 pCi/g in the same interval as uranium and europium (38 to 43 ft).

4.1.3.7 Borehole 299-W19-97, North of 216-U-1 Crib. Geologic descriptions of the dominant grain size are included on the plot of the natural radionuclides. This borehole encountered no radionuclide contamination below 8 ft and correlates with geologic variations, identifying gradational changes within the documented lithology descriptions. The caliche marker bed with underlying sand and gravels (169 to 177 ft) is easily identified. Other stratigraphic features as noted in 299-W19-95 can be seen in this borehole survey.

The only man-made radionuclide identified in the borehole survey was cesium-137, occurring from 0.5 to 7.5 ft. The maximum concentration is about 20 pCi/g at 5.5 ft. This survey confirms that there is residual subsurface contamination from some source other than recent surface deposits. One likely possibility is new ground cover to stabilize older surface contamination.

4.1.3.8 Borehole 299-W19-98, 216-U-4 Reverse Well and 216-U-4A French Drain. Grain size descriptions of drilling samples show that the borehole survey confirms the stratigraphic changes and records gradational changes within many strata.

Three man-made radionuclides were identified in the borehole survey. Their positioning with the reverse well discharges is unusual as will be discussed.

The dominant radionuclide encountered is cesium-137 from both the reverse well and french drain. Contaminants from the french drain migrated to 16 ft with concentrations of about 200 pCi/g.

The recorded perforation interval of the reverse well was the bottom 8 ft of the casing (67 to 75 ft). Cesium contamination from the reverse well was encountered as high as 37 ft with concentrations exceeding 1,000 pCi/g from 43 to 66 ft. The depth interval between the two (16 to 37 ft) identified

trace amounts of cesium-137 with concentrations not exceeding 1 pCi/g. The maximum extent of cesium-137 contamination is 96 ft with concentrations not exceeding 1 pCi/g below 78 ft. Effluent discharged into the reverse well is not centered around the perforations from 67 to 75 ft. The center of the discharge appears to be around 50 ft.

The second radionuclide encountered is cobalt-60, which was identified with both the french drain and reverse well. The french drain interval extends from 5 to 8.5 ft with concentrations less than 2 pCi/g. The cobalt-60 contamination interval associated with the reverse well centered around a (possible) 50-ft release depth (41 to 67 ft) with concentrations less than 3 pCi/g and the majority of the contaminant between 41 and 55 ft.

The third radionuclide encountered is europium-154, which also was identified with both the french drain and reverse well. The french drain interval is a subset of the cobalt distribution (6 to 7 ft) with concentrations less than 2 pCi/g. The europium-154 contamination associated with the reverse well is also centered around a possible 50 ft release depth (47 to 55 ft) with concentrations reaching 5 pCi/g.

The distribution profile between the europium-154 and cobalt-60 is unusual in that the cobalt-60 contamination extends 6 ft above the first detection of europium-154. The distribution of the radionuclides from the survey indicate that additional undocumented perforations may be present or the casing may be broken, centered around 52 ft.

4.1.3.9 Borehole 299-W22-78, 216-U-12 Crib. Grain size descriptions of drilling samples show that the borehole survey confirms the stratigraphic changes and minor cross bedding of flood deposits. The caliche layer (186 to 194 ft) coincided with a drill casing reduction and is more difficult to identify than normal.

The log interval (143 to 184 ft) survey on October 27, 1994 was a carryover from the previous day's activities. The total gamma curve does not tie in with previous curve and is everywhere greater. This is caused by radon from the formation entering the casing and venting up the borehole on low barometric pressure days. Radon, an inert gas, is a daughter product of natural uranium. The conventional method for measuring the natural uranium activity relies on the gamma-ray emissions of the bismuth-214 and lead-214 daughters of the uranium-238 series. These two radionuclides are below radon and are influenced by displaced radon. Note that the computed natural uranium curve is also elevated from 143 to 184 ft.

The only man-made radionuclide identified in the borehole survey with multiple depth intervals of detection and significant concentrations is uranium-238 (18 to 24 ft) with concentrations approaching 70 pCi/g.

The remaining man-made radionuclides detected in the borehole survey are cesium-137 and ^{235}U. They occurred in only one depth spectra each, at concentrations near the detection threshold, and at depths consistent with their expected location.

4.1.3.10 Borehole 299-W23-231, U-10 Pond. Grain size description of the drilling samples plotted with the natural radionuclide survey reveal that the caliche interval (137 to 139 ft) is easily identified along with intervals of higher silt content within the dominant sand matrix.

The only man-made radionuclide detected in the survey is cesium-137 (0 to 10 ft). The maximum activity of nearly 500 pCi/g occurred at 3 ft. The first several feet of sediment is fill material that was placed over the contaminated U-10 pond surface. This limited investigation borehole indicates that contaminants released to the pond did not migrate significantly into the vadose zone.

4.2 CONCLUSIONS

4.2.1 216-U-1 Crib

Boreholes 299-W19-95, 299-W19-96, and 299-W19-97 are associated with the 216-U-1 Crib, only borehole 299-W19-96 penetrated the crib. Several radionuclides were identified in and immediately below the crib disposal location (cesium-137, cobalt-60, europium-152/154, and uranium-235/238) and migrated to 49 ft. Additionally, uranium-235/238 contamination was identified on top of the low permeable caliche zone (168 ft) confirming the higher mobility of uranium.

Significant cesium-137 contamination (4,00 pCi/g) was detected near the surface (3 ft). The contamination may be the result of an unplanned release of effluent intended for crib discharge.

4.2.2 216-U-8 Crib

Boreholes 299-W19-3, 299-W19-70, 299-W19-71, and 299-W19-94 are associated with the 216-U-8 Crib. Borehole 299-W19-2 had the least amount of contamination surrounding it, but it was located outside of the crib boundary. The remaining wells were located within the crib and measured continuous crib contamination to about 100 ft. Lithologic changes in the sediments were documented through drilling samples and correlated with the total gamma log. The borehole survey confirms that lithologic changes impeded downward movement of the contaminants and assisted in preventing cesium-137 migration beyond 100 ft.

The maximum extent of contamination released to the 216-U-8 Crib (borehole 299-W19-94) is greater than previously understood as demonstrated by the presence of uranium-238 at 190 ft from geophysical borehole surveys.

Borehole 299-W19-70 was in place during crib operations and likely allowed cesium-137 contamination to travel between the casing and formation to the bottom of the hole because of lack of seal material. The maximum extend of the contamination is unknown. Continued monitoring of this borehole should be performed to determine if it continues to be a problem. If contaminants are migrating along the borehole, then it should be plugged and abandoned.

This crib also received uranium waste that migrated to the top of the caliche strata (189 ft). The concentration of uranium contamination at the top of caliche is 120 pCi/g. The mobility of uranium under certain chemical and geologic conditions makes continued monitoring of this contaminant at depths close to the groundwater very important.

4.2.3 U-4A Reverse Well and French Drain

Contaminant discharges to the reverse well and french drain were identified on the investigation borehole drilled between the two disposal sites. There appears to be no co-mingling of the waste streams because the strata between 16 and 37 ft contained only trace amounts, less than 1 pCi/g of cesium-137.

The contaminants discharged to the reverse well were identified from 37 to 96 ft below the ground surface. The radionuclide distribution profile indicates that the central discharge depth was at about 52 ft. This does not necessarily agree with the construction records that indicate the perforations in the 3-in. pipe were from 67 to 75 ft. The distribution of the radionuclides from the survey indicates that additional undocumented perforations may be present or the casing may be broken, centered around 52 ft.

4.2.4 216-U-12 Crib

Limited contaminants were encountered in the single investigative borehole (299-W22-78) drilled at the 216-U-12 Crib site. The borehole was placed at the edge of the original excavation for the crib. Low concentrations of uranium-238 were detected at about 20 ft.

An RLS screening survey in borehole 299-W22-75, located within the 216-U-12 Crib, encountered significantly more contamination and at greater depths (Brodeur 1993). It appears that the bulk of contamination is located within the original boundary of the crib and limited lateral distribution of radionuclide contamination occurred.

4.2.5 U-10 Pond

The contamination encountered in the borehole in the pond area indicated that only cesium-137 was detected and its migration depth was limited. The original pond surface is about 4 ft below ground level. Remediation of the radiologically contaminated area of this pond will be much simpler than the cribs and reverse wells investigated in this operable unit.

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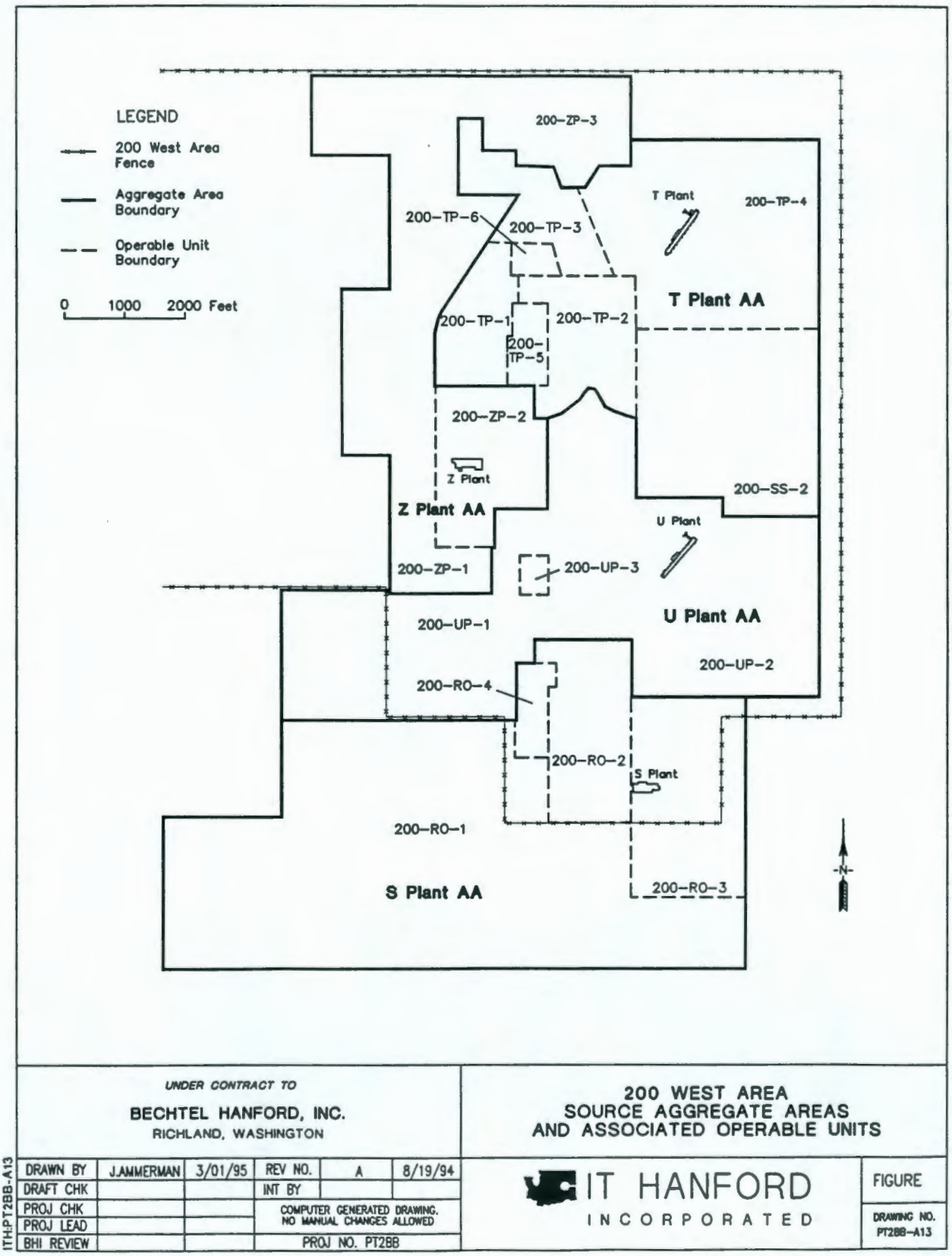
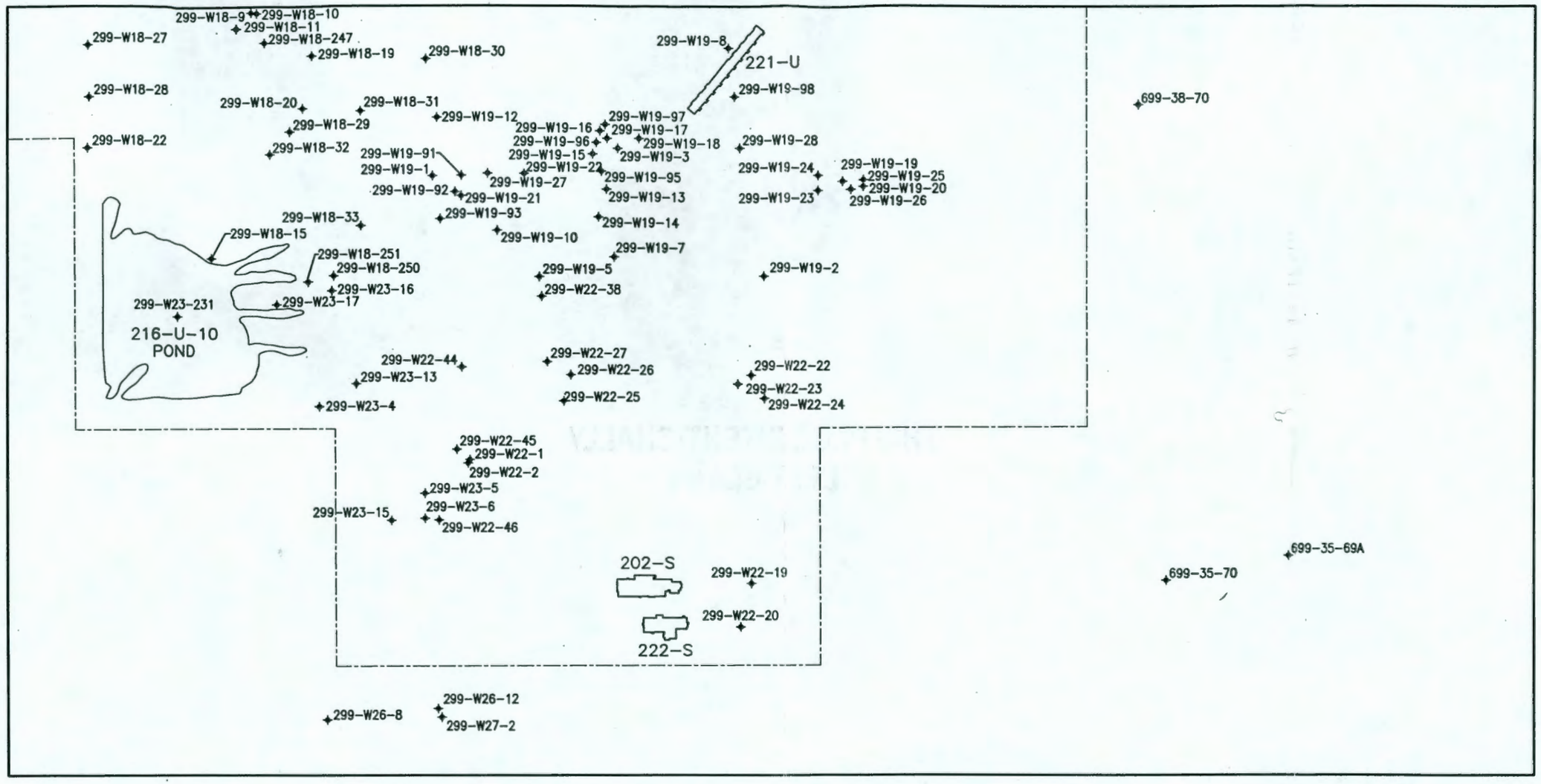
6.0 FIGURES AND TABLES

Figure 1. Location of the 200-UP-2 Operable Unit in the 200 West Area.





✦ MONITORING BOREHOLE LOCATION

---- 200 WEST AREA FENCELINE

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PROJECT NO. PT2BB

IT HANFORD INCORPORATED

UNDER CONTRACT TO
BECHTEL HANFORD, INC.
RICHLAND, WASHINGTON

200-UP-2 OPERABLE UNIT
WELL LOCATION MAP

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DRAWING NO. PT2BB-B3
REVISION A

CURRENT BY: J.AMMERMAN CURRENT DATE: 9/16/94 CAD FILE: PT2BB-B3

Figure 2. 200-UP-2 Operable Unit Well Location Map.

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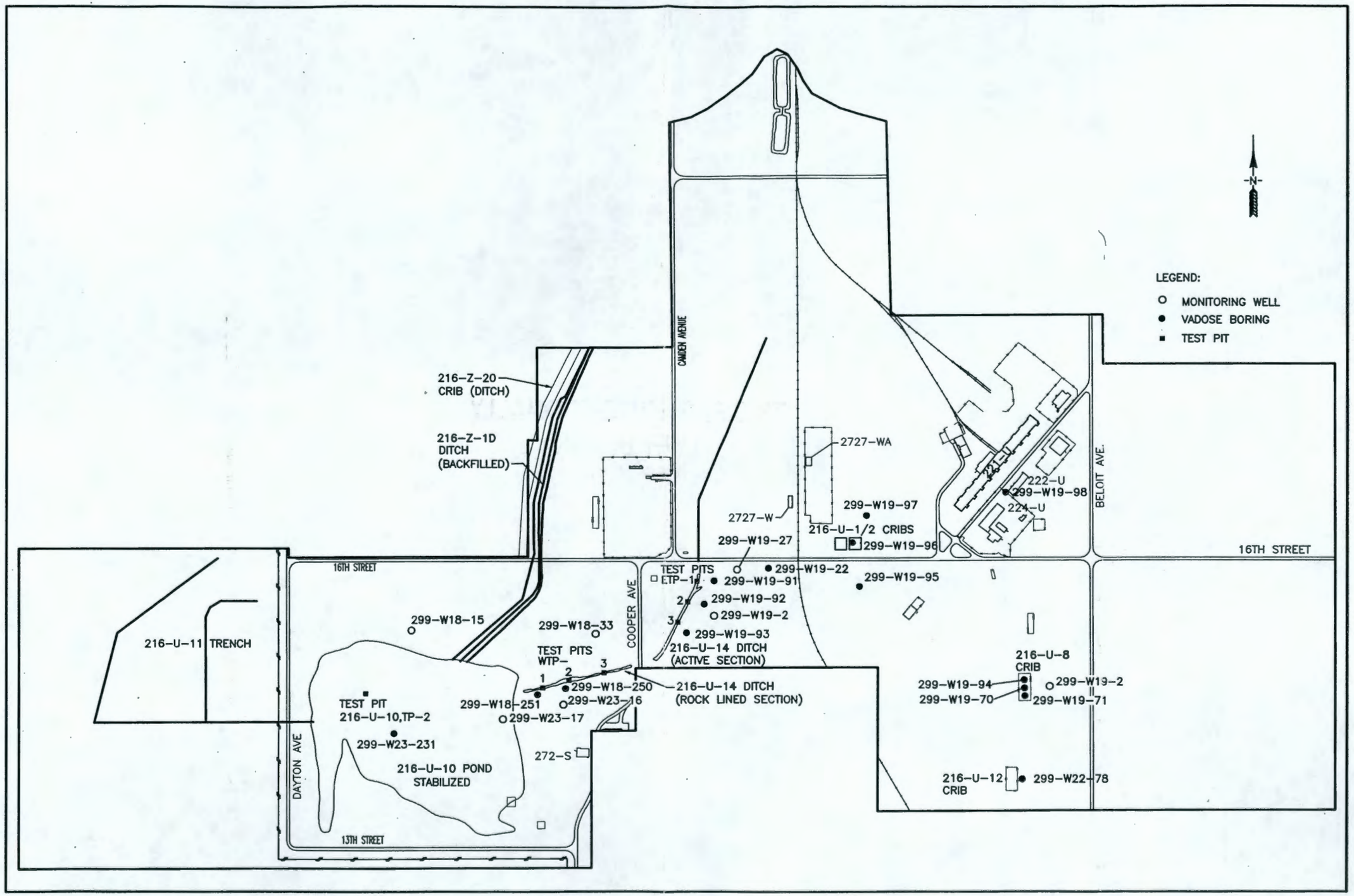

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Figure 3. 200-UP-2 Operable Unit Vadose Zone and Groundwater Characterization Map.

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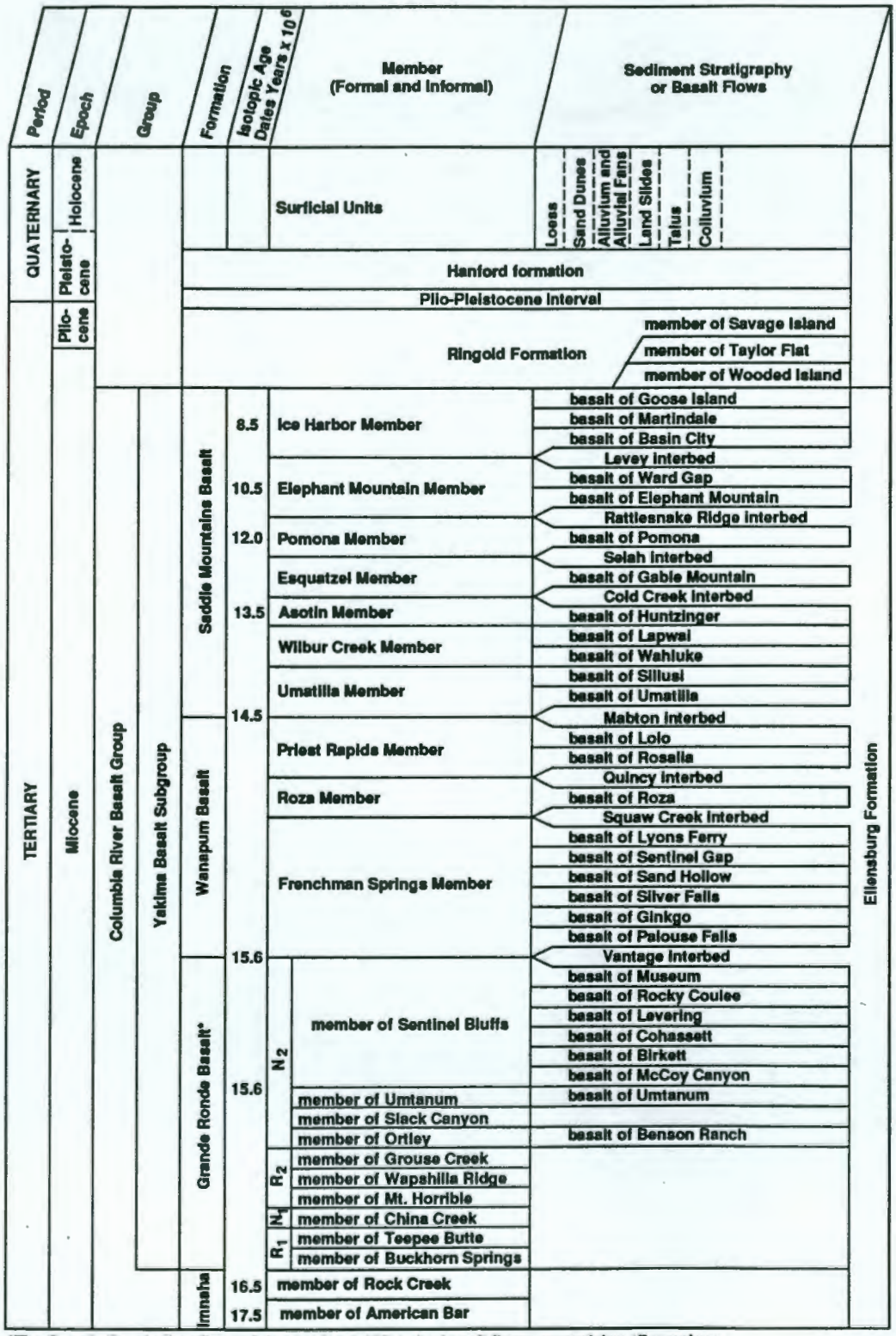
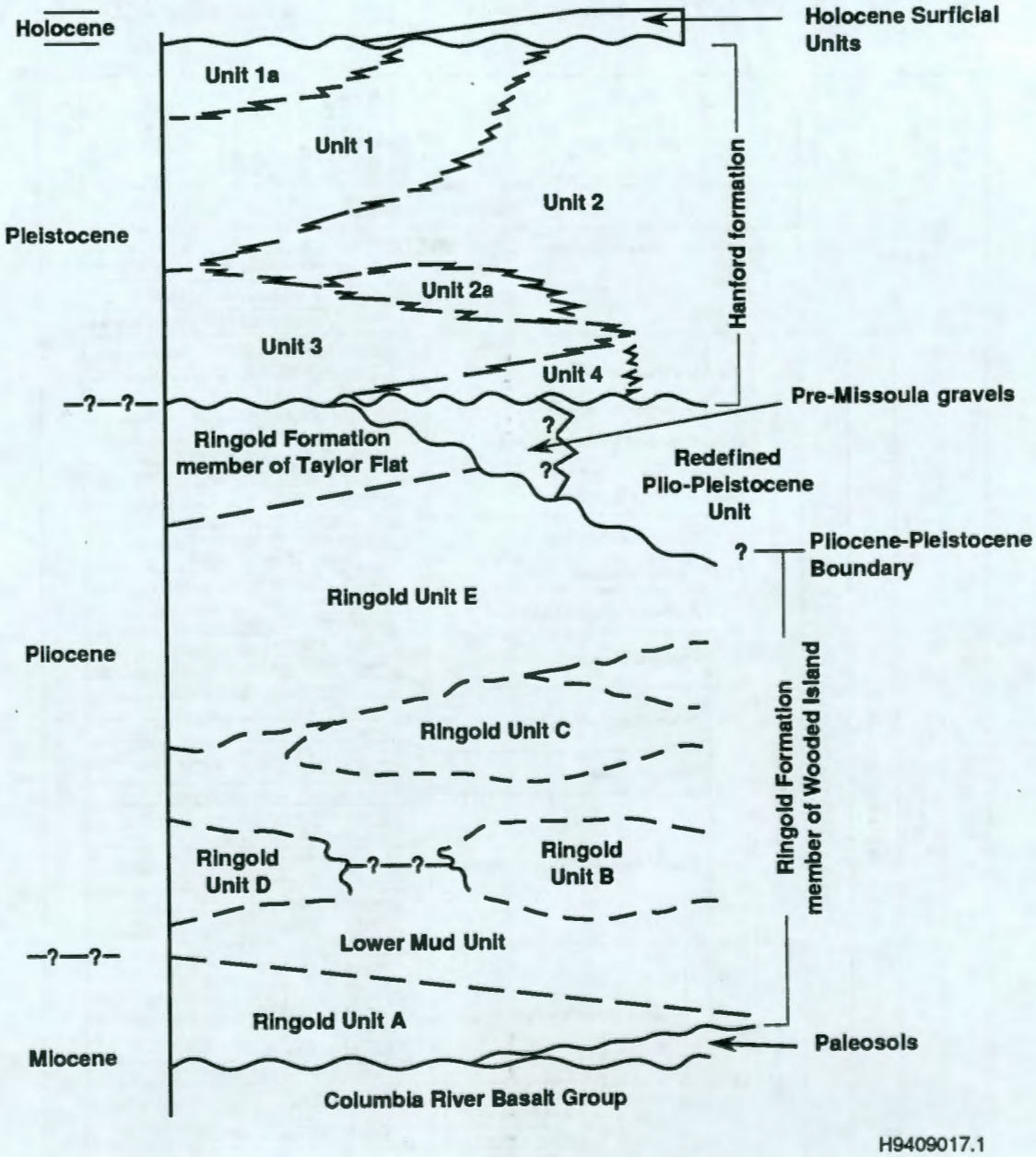
Figure 4. Generalized Stratigraphy of the Pasco Basin and Surrounding Area.

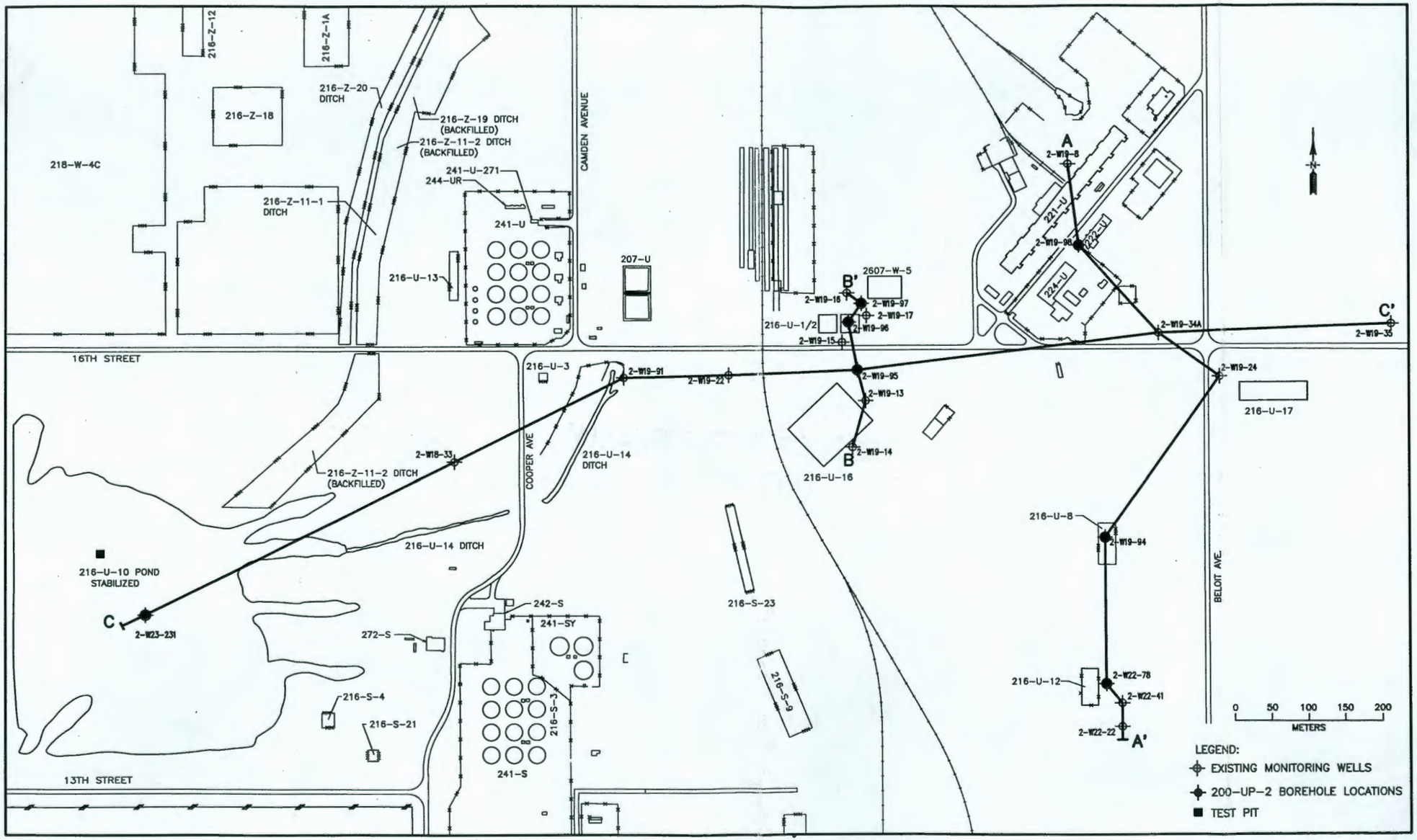


*The Grande Ronde Basalt consists of at least 120 major basalt flows comprising 17 members. N_2, R_2, N_1, and R_1 are magnetostratigraphic units.

H9102029.6b

Figure 5. Generalized Stratigraphy of the Suprabasalt Sediments in the Pasco Basin.





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RICHLAND, WASHINGTON

200-UP-2 OPERABLE UNIT
CROSS SECTION LOCATION MAP

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Figure 6. Cross-Section Location Map.

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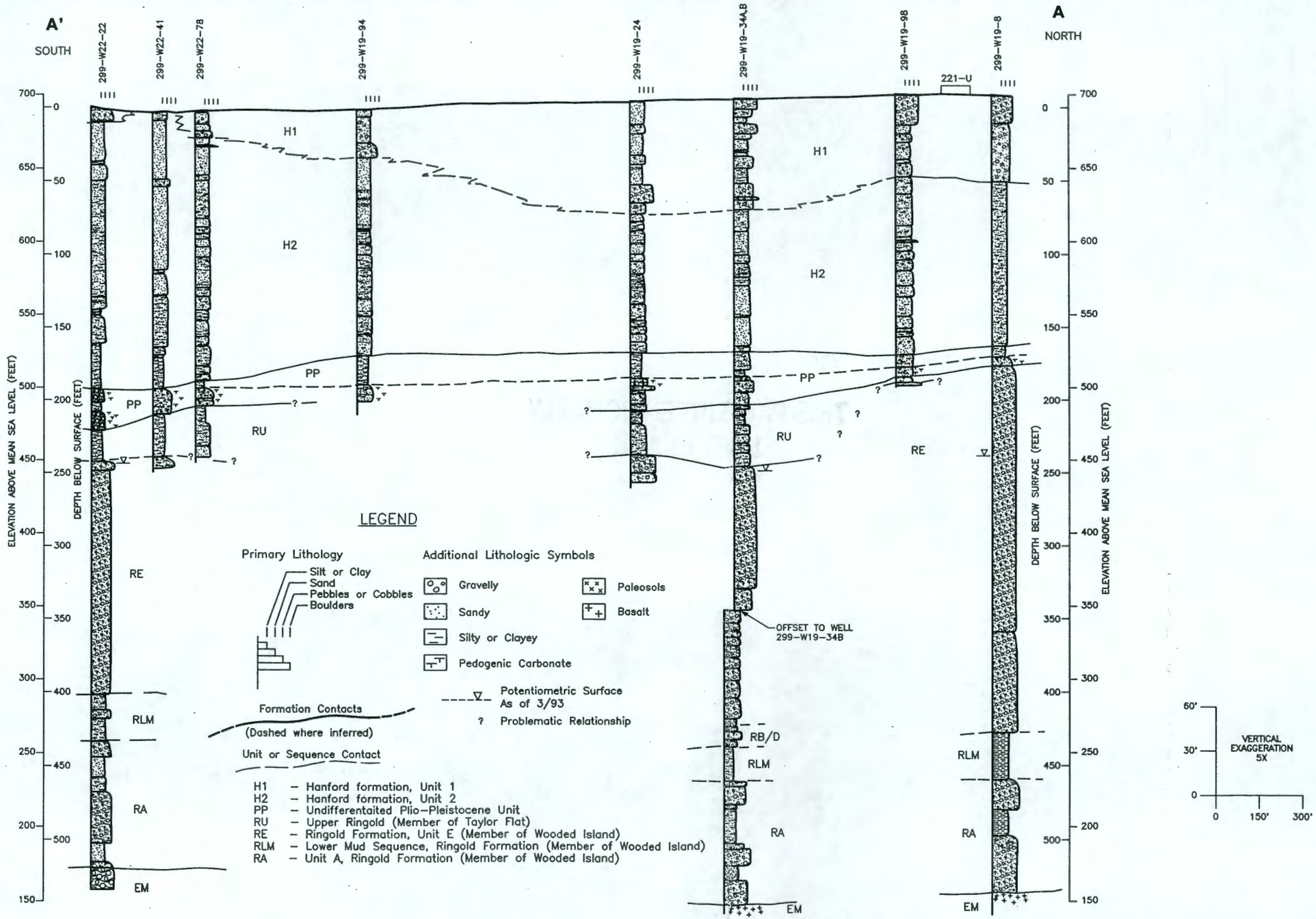

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Figure 7. Cross Section A-A'.

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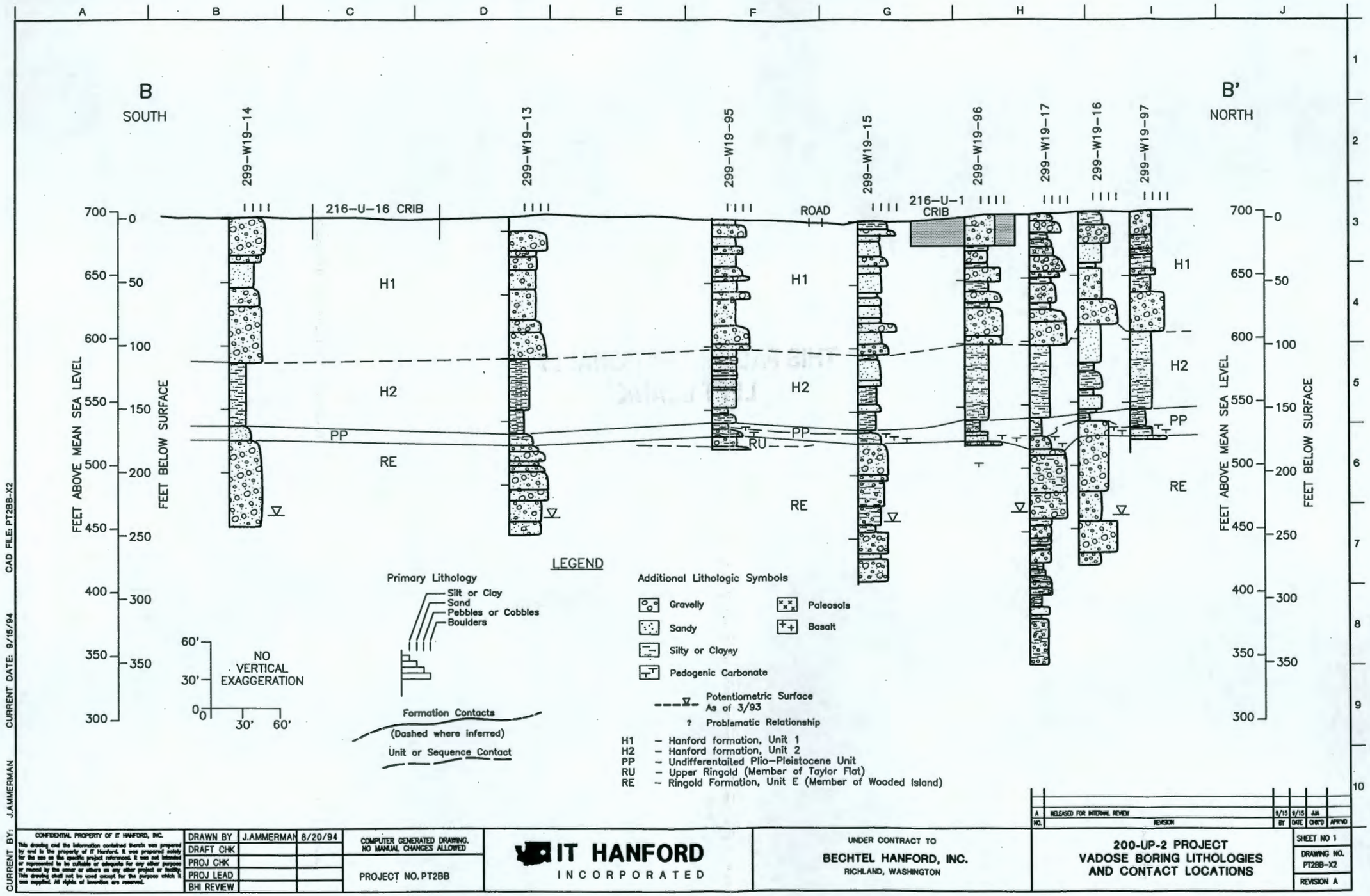

Figure 8. Cross Section B-B'.

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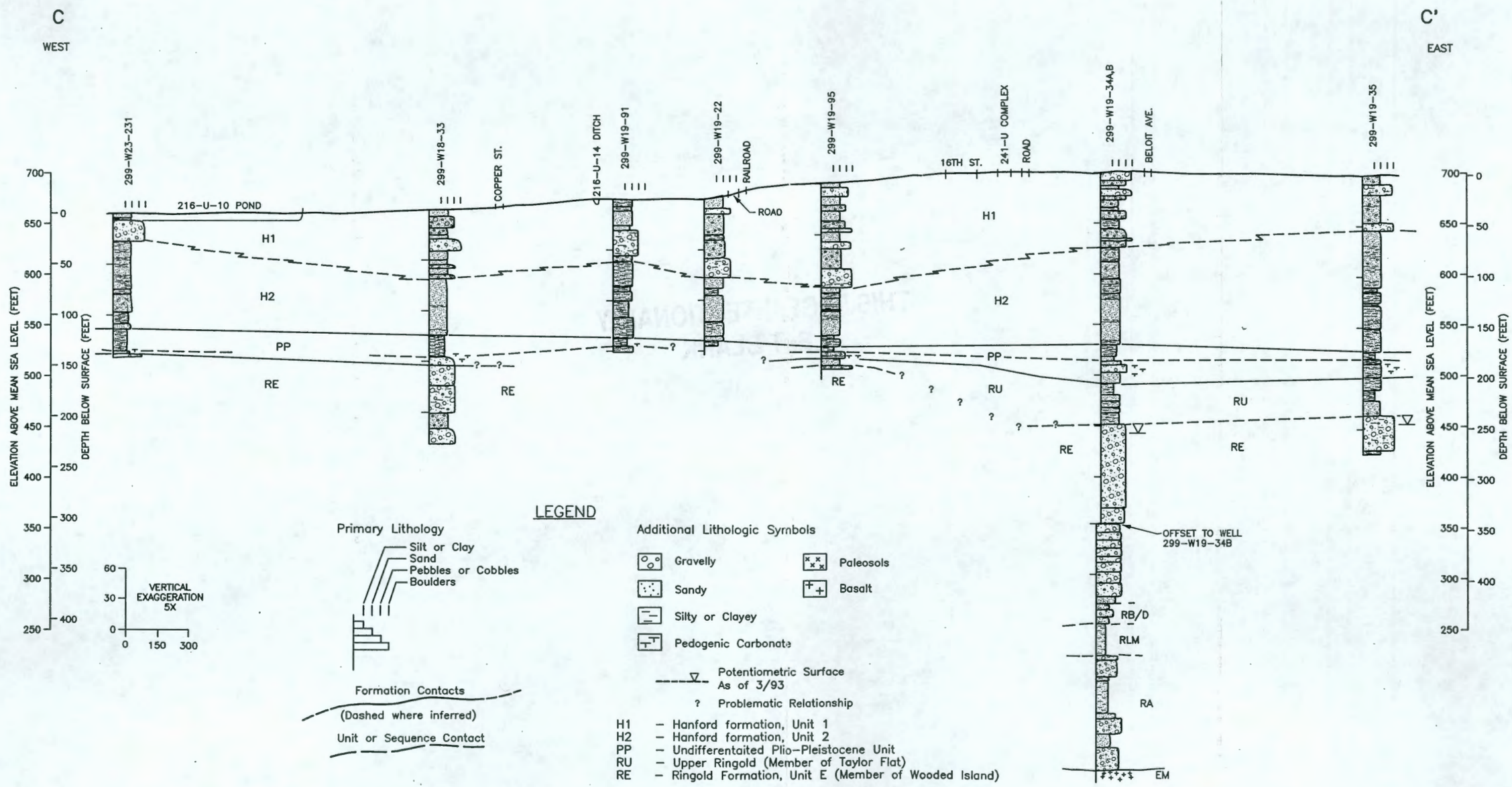

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Figure 9. Cross Section C-C'.

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Figure 10. Generalized Stratigraphy of the 200-UP-2 Operable Unit.

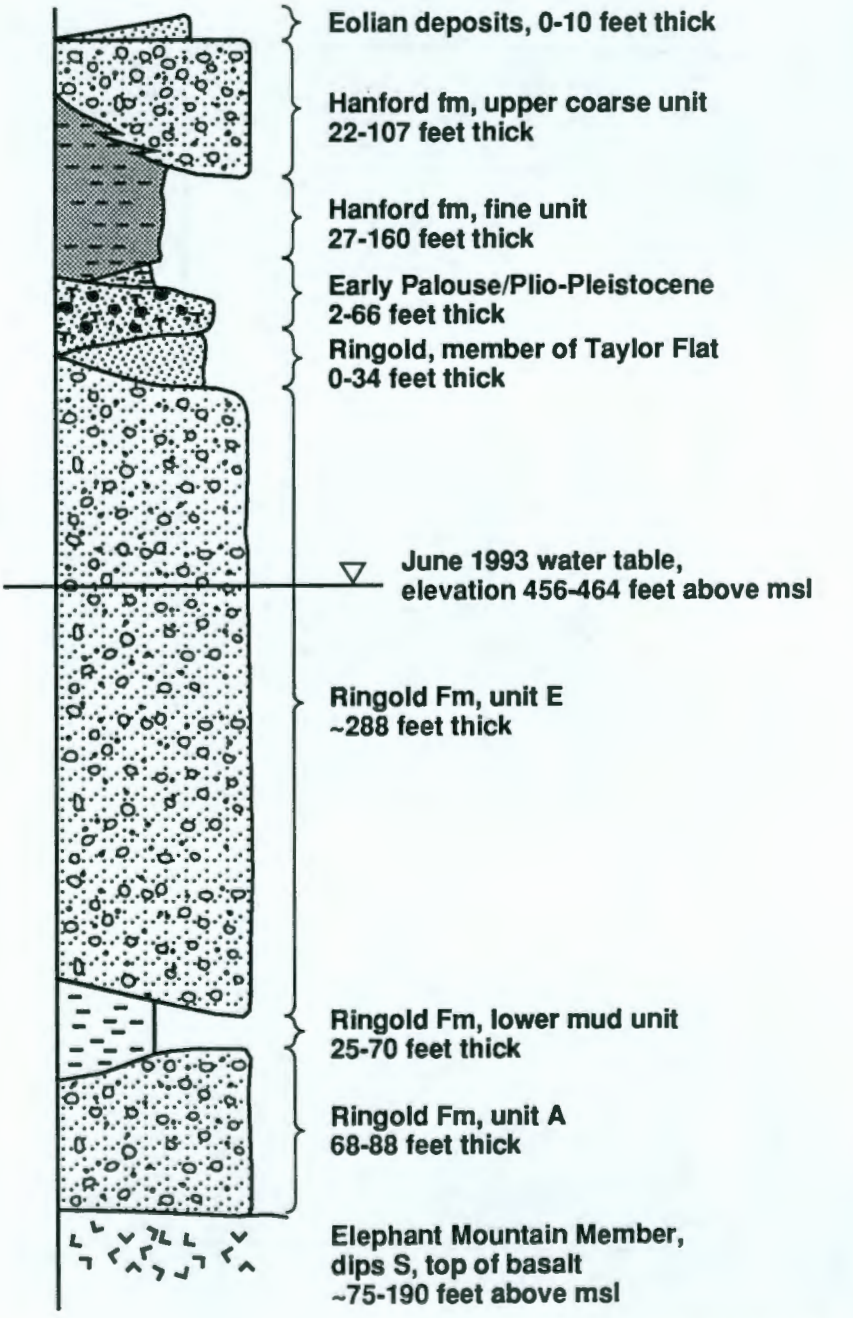
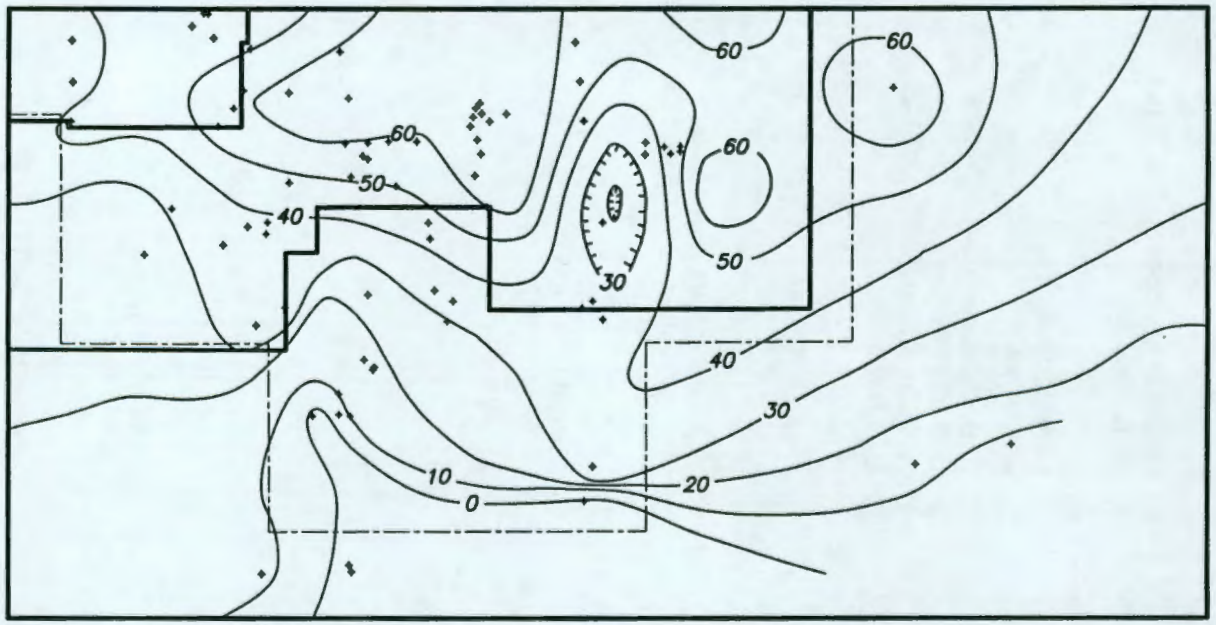


Figure 11. Isopach Map for Hanford Formation, Unit 1.

ITH:CAB:CF3AA-A7



CONTOUR INTERVAL = 10 FEET

CONTOUR LINE

200 WEST AREA FENCELINE

N

0 400 800

METERS

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200-UP-2 OPERABLE UNIT
HANFORD UNIT, ISOPACH

9513335.1113

Figure 12. Isopach Map for Hanford Formation, Unit 2.

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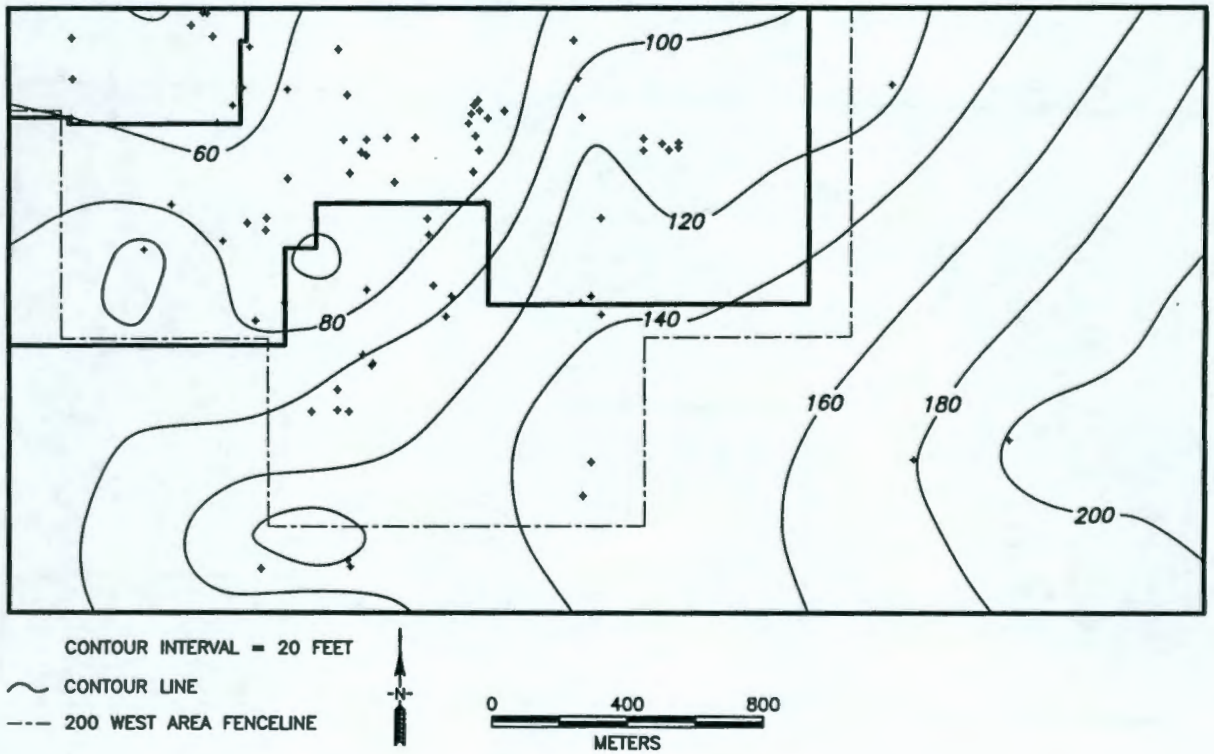

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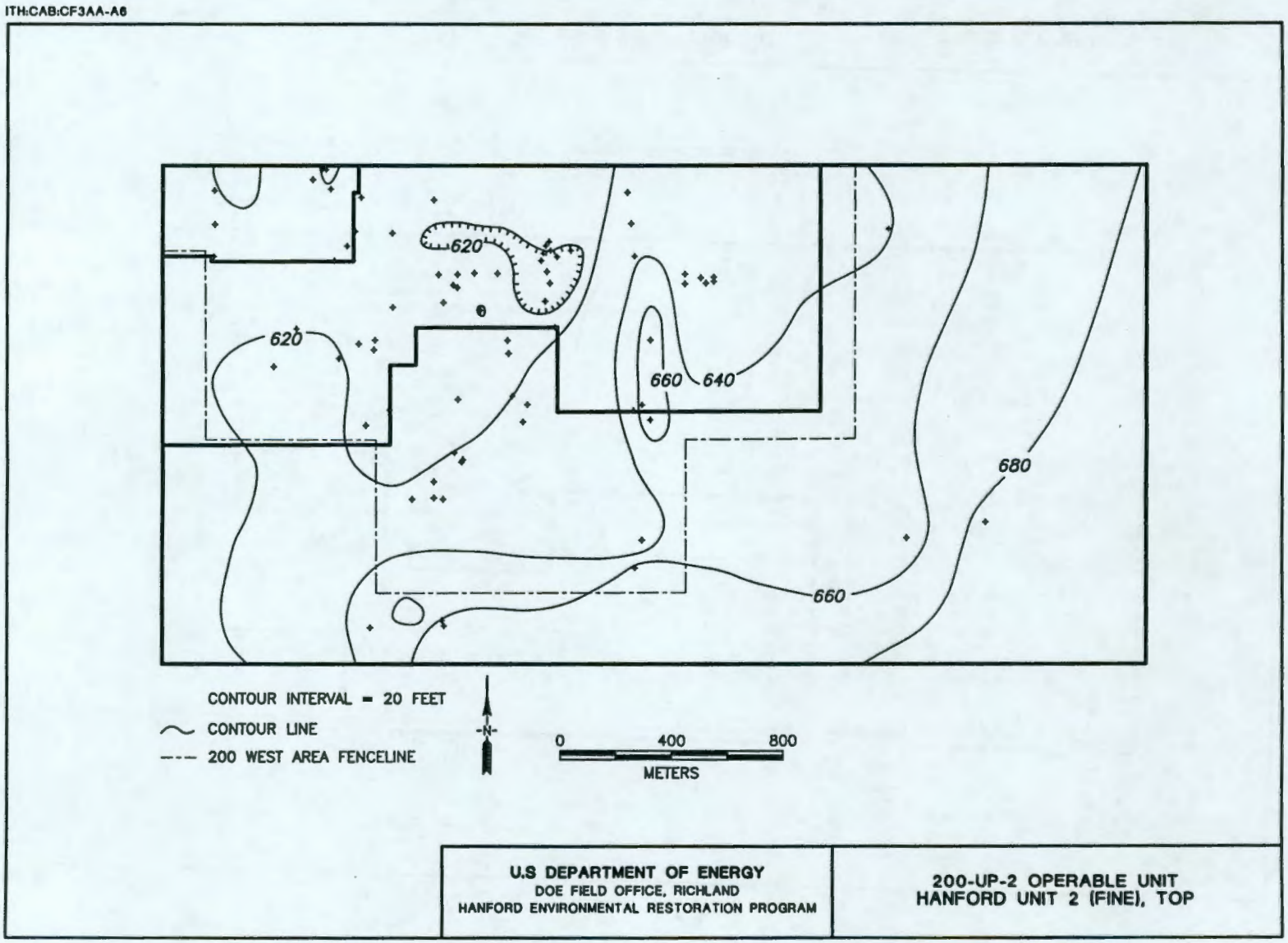
Figure 13. Structure Contour Map for Hanford Formation, Unit 2.



9513335.1114

Figure 14. Isopach Map for the Plio-Pleistocene Unit (Early Palouse).

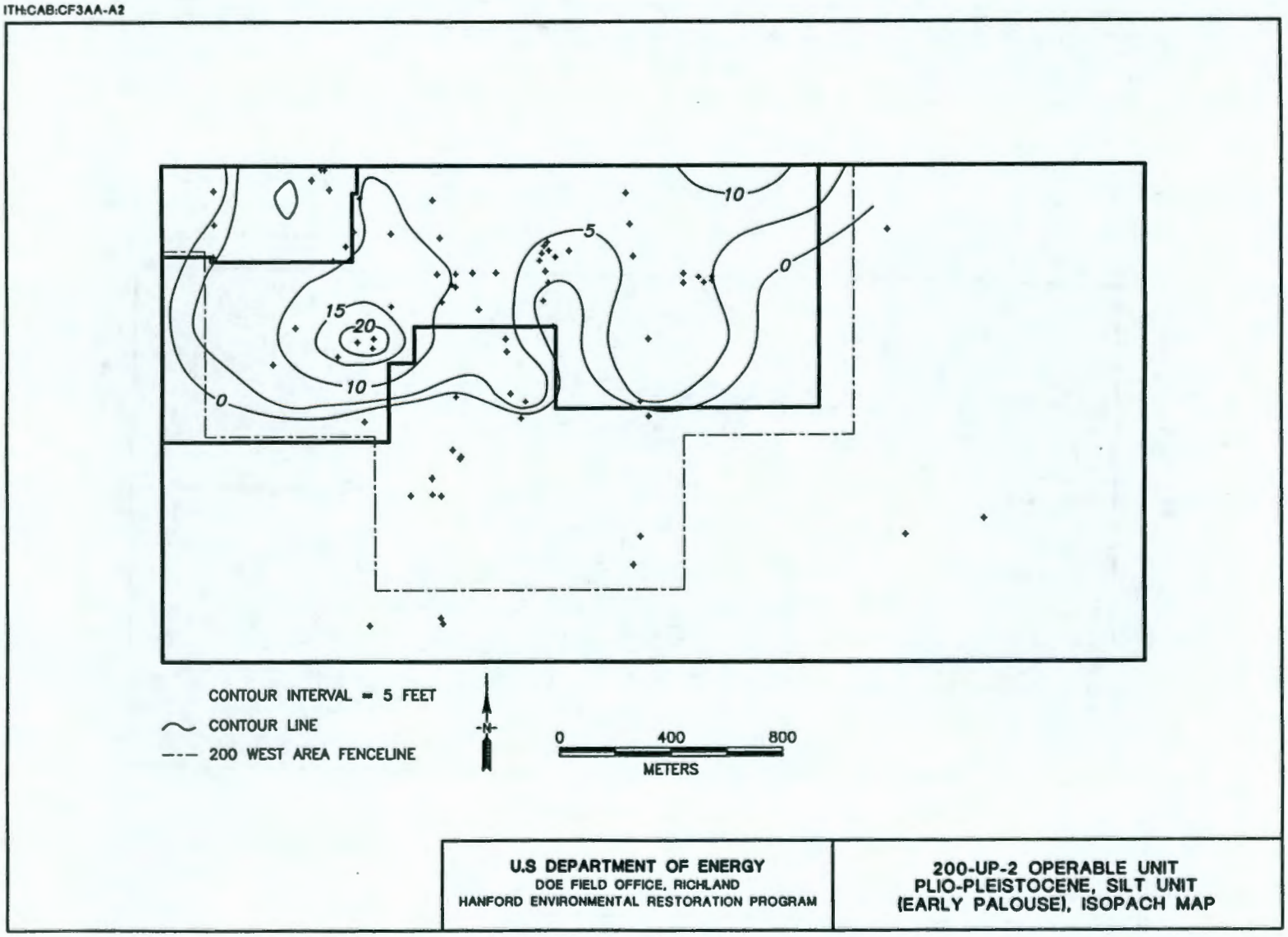
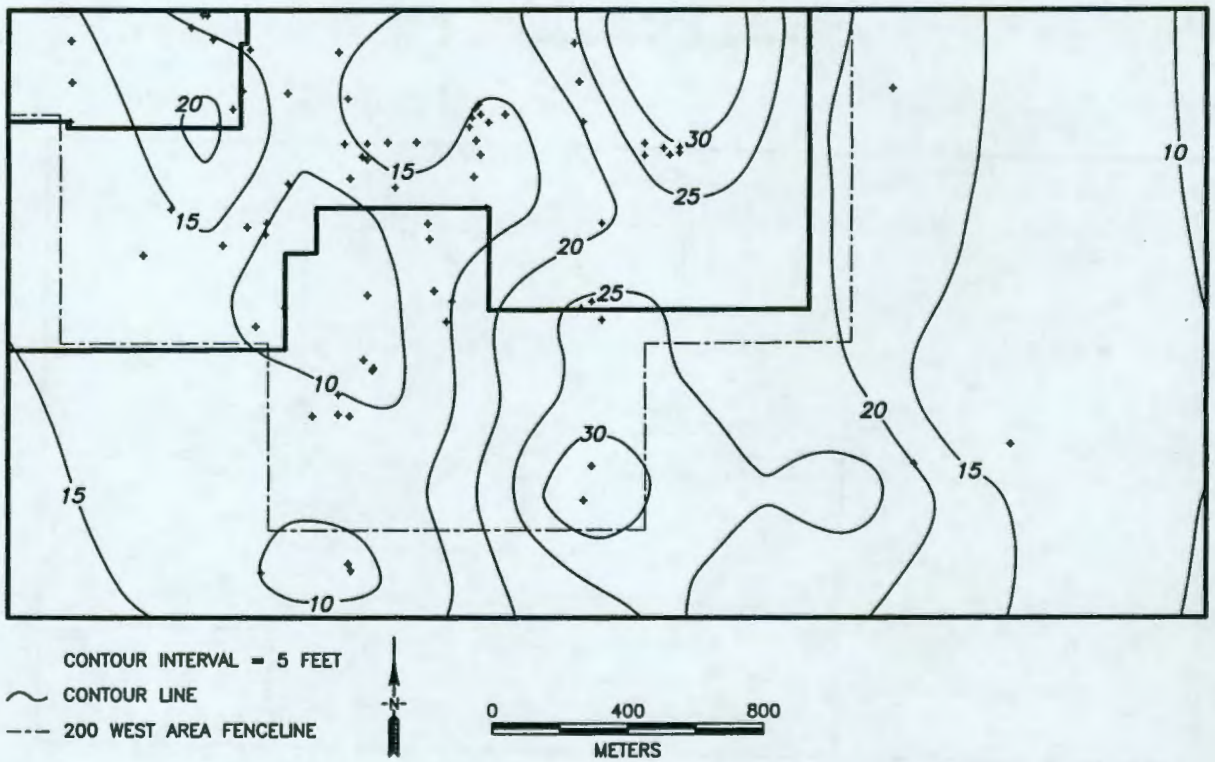


Figure 15. Isopach Map for the Plio-Pleistocene Unit (Carbonate).

ITH:CAB:CF3AA-A11



U.S DEPARTMENT OF ENERGY
DOE FIELD OFFICE, RICHLAND
HANFORD ENVIRONMENTAL RESTORATION PROGRAM

200-UP-2 OPERABLE UNIT
PLIO-PLEISTOCENE,
CARBONATE UNIT, ISOPACH

9513335.1115

Figure 16. Structure Contour Map for the Plio-Pleistocene Unit (Carbonate).

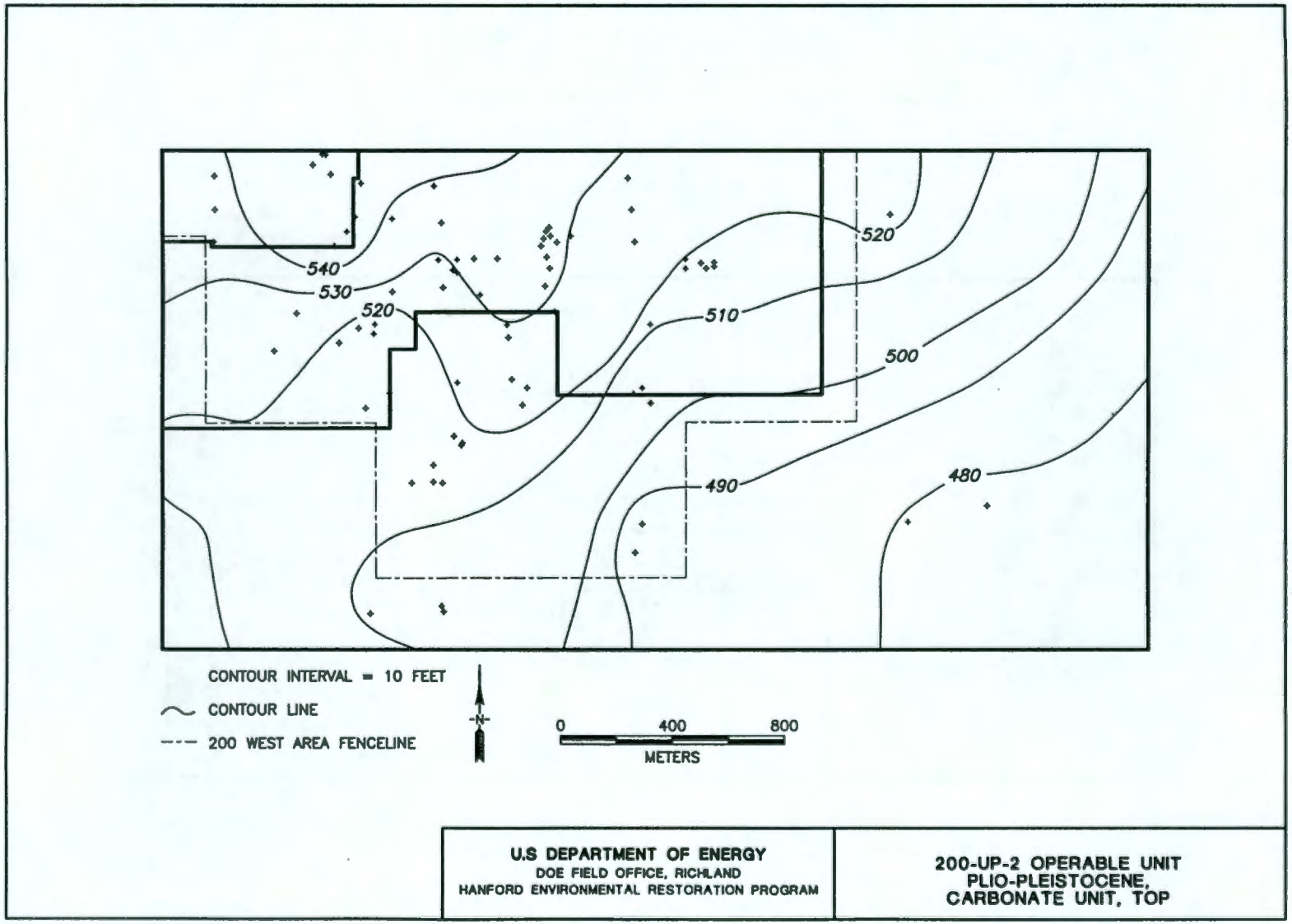


Figure 17. Structure Contour Map for the Ringold Formation, Unit E.

ITH:CAB:CF3AA-A1

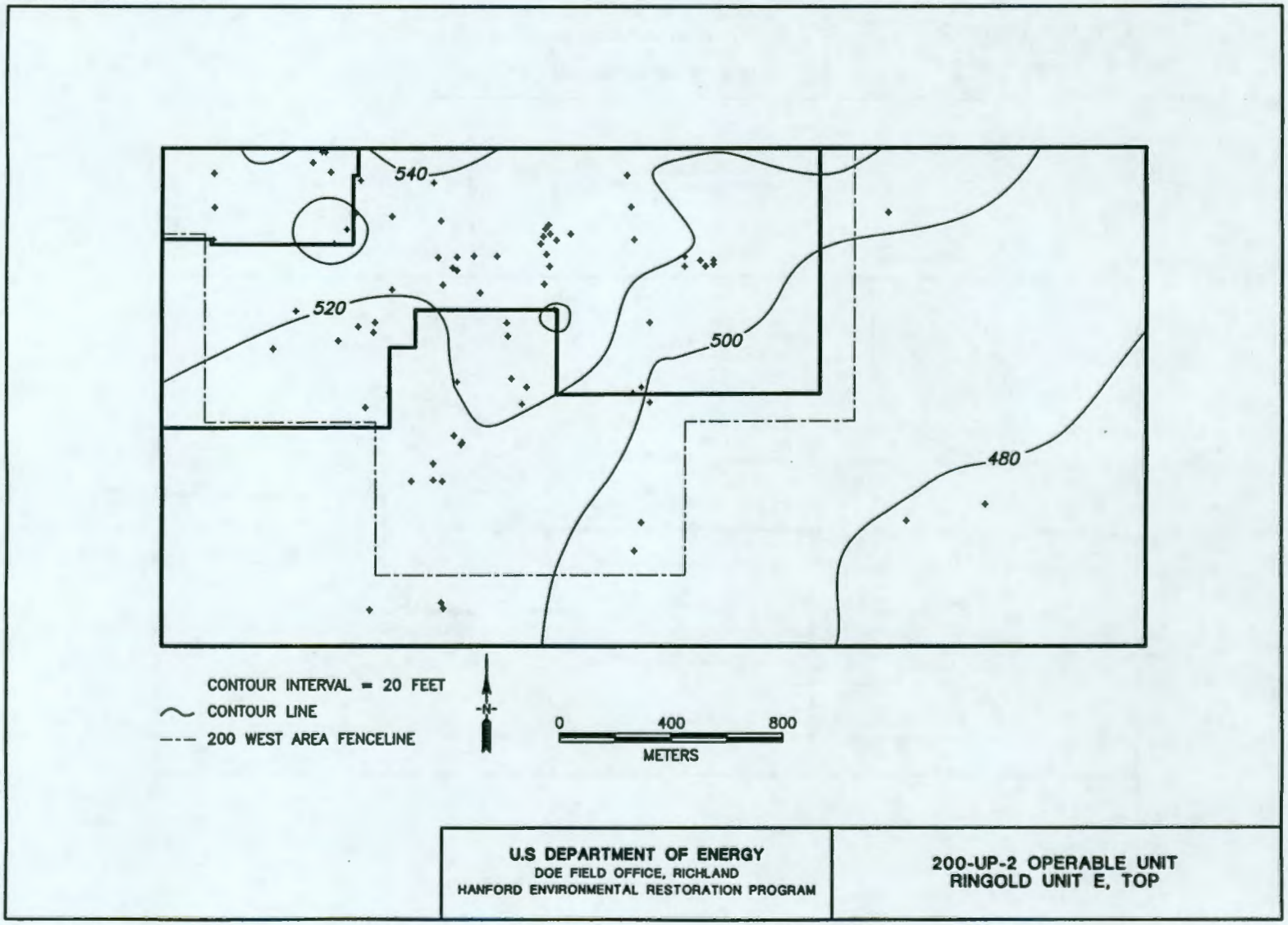
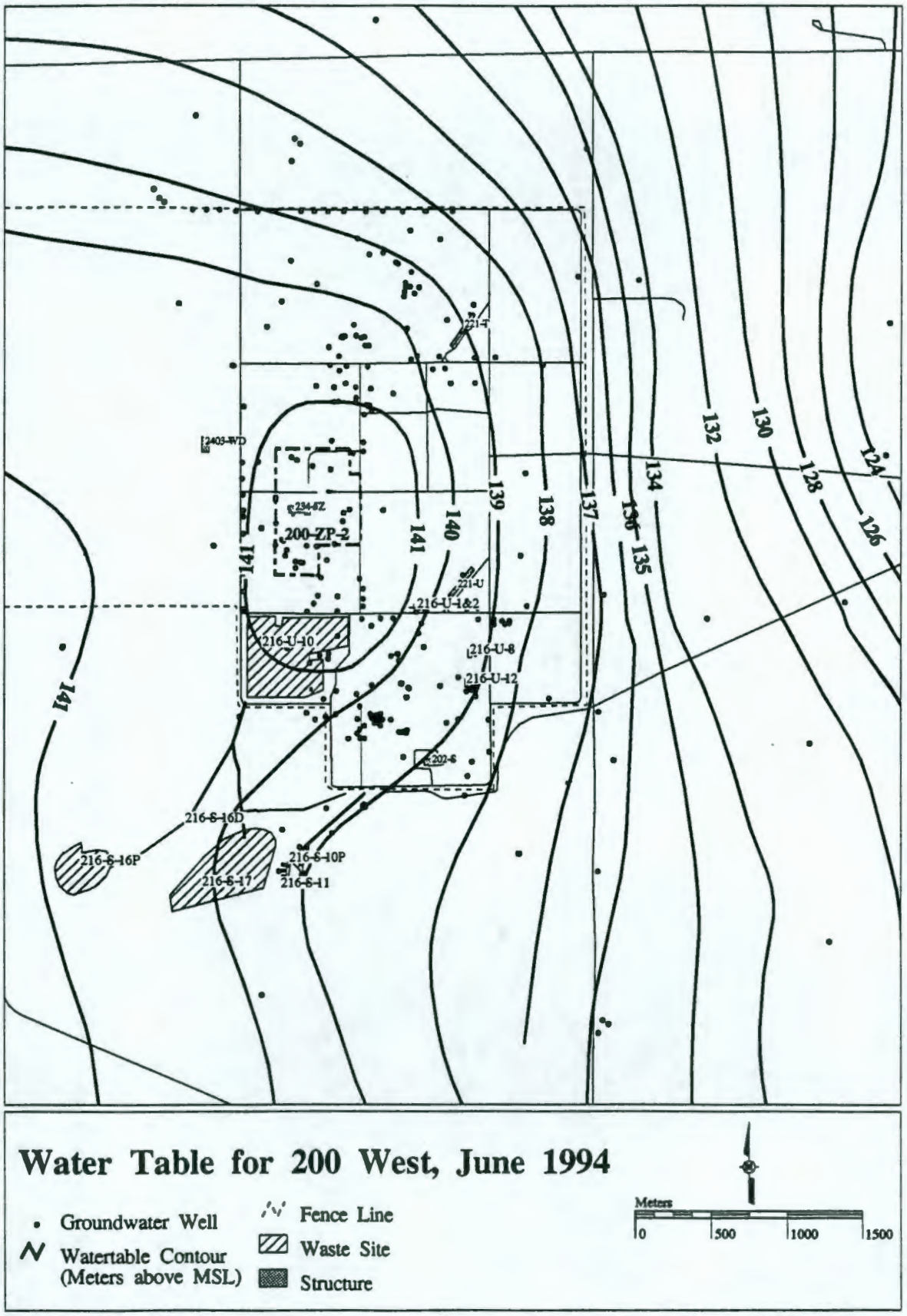


Figure 18. Water Table Map of the 200 West Area.



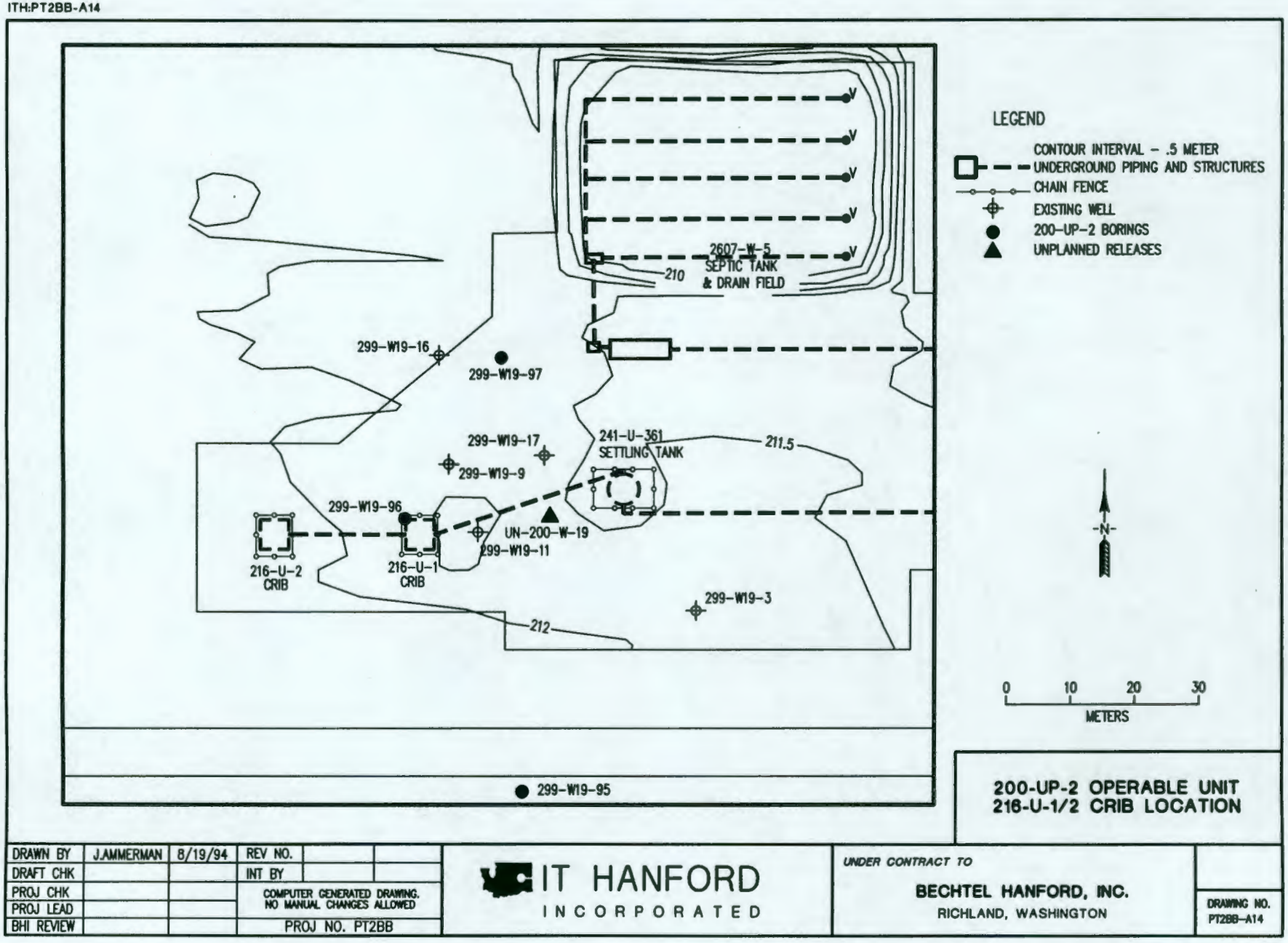


Figure 19. Borehole Location Map for 299-W19-95, 299-W19-96, and 299-W19-97.

Figure 20. Borehole Location Map for 299-W22-78.

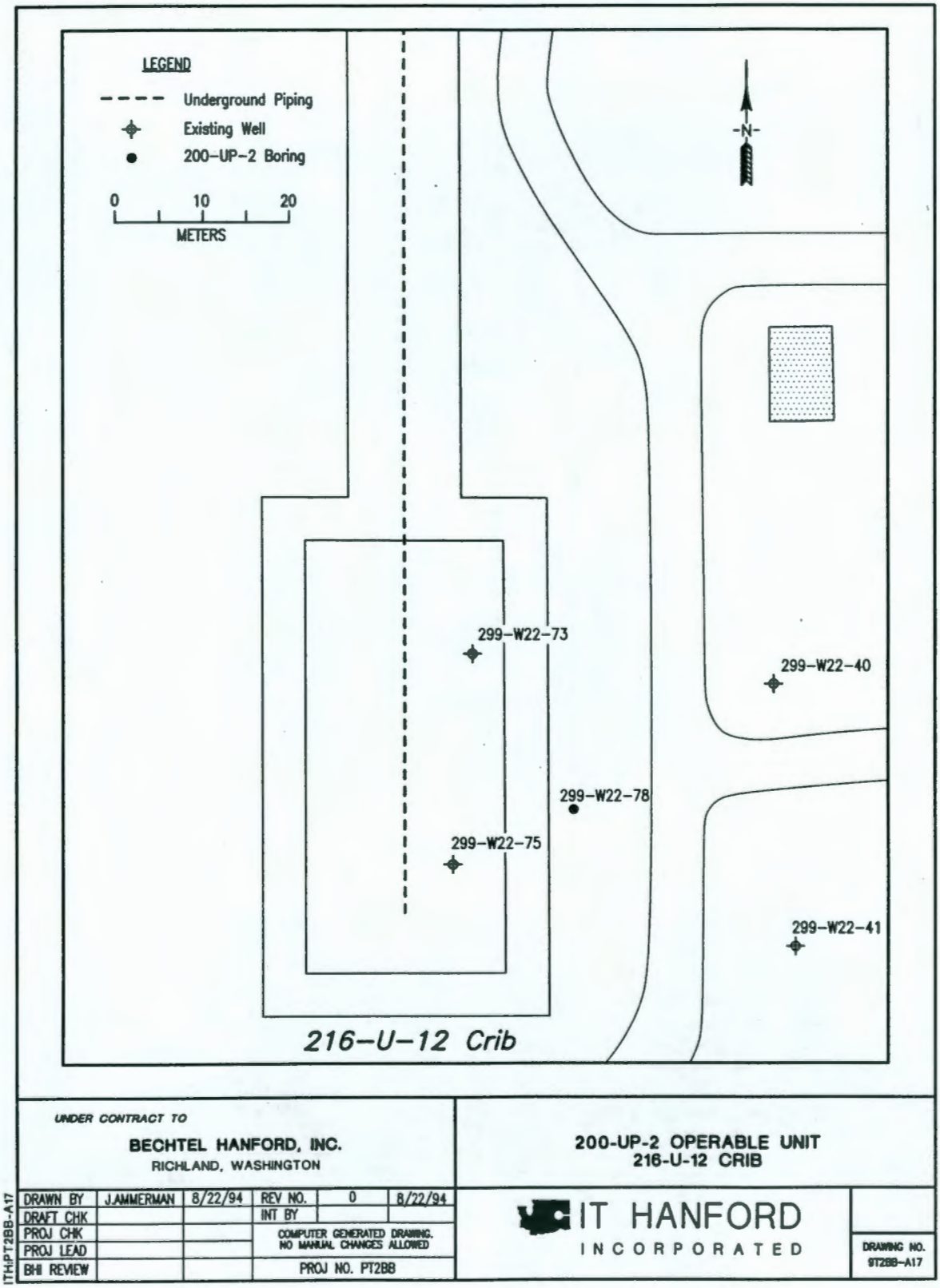


Figure 21. Borehole Location Map for 299-W19-94.

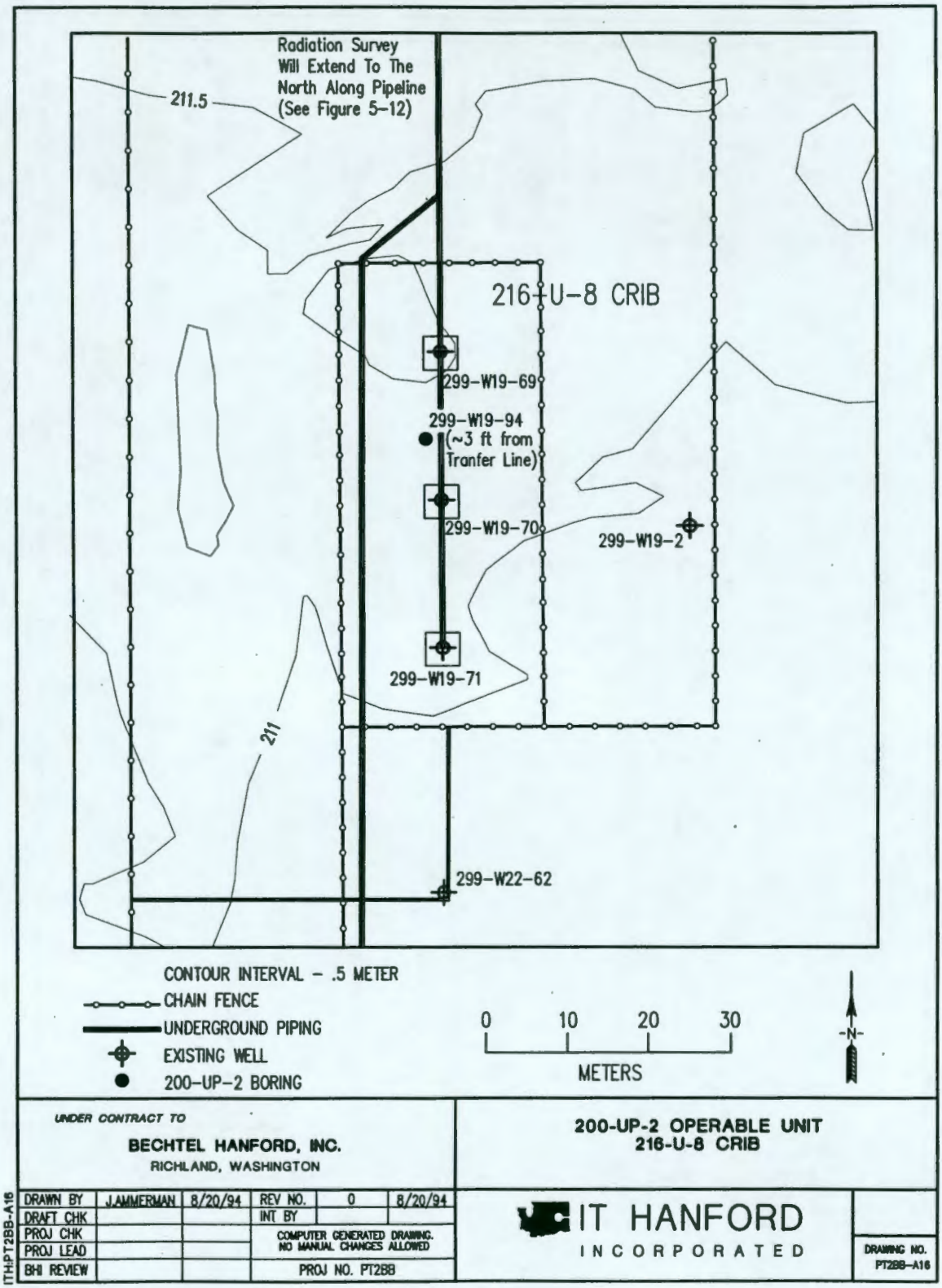
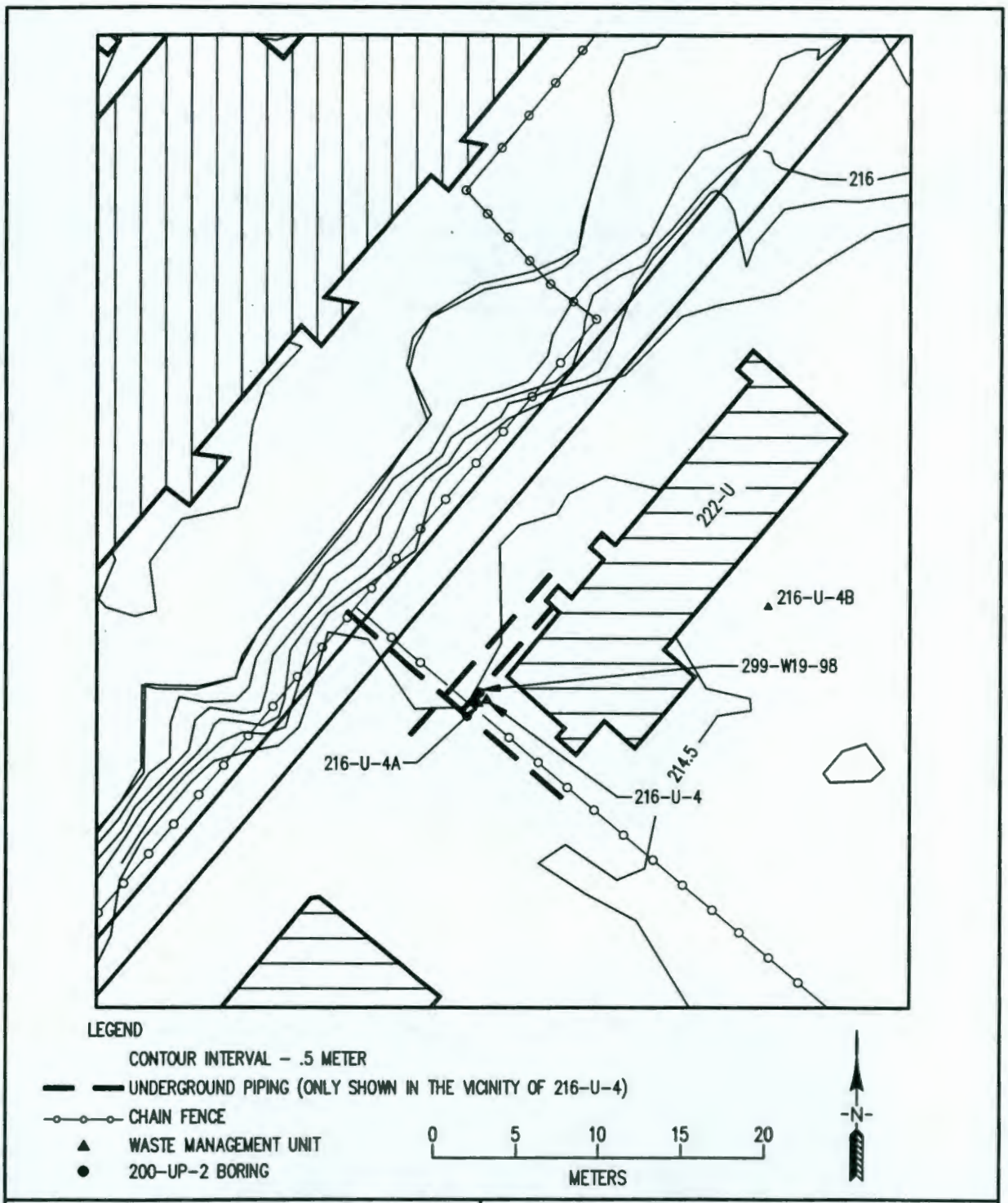


Figure 22a. Borehole Location Map for 299-W19-98.



UNDER CONTRACT TO

BECHTEL HANFORD, INC.
RICHLAND, WASHINGTON

200-UP-2 OPERABLE UNIT BORING LOCATION MAP

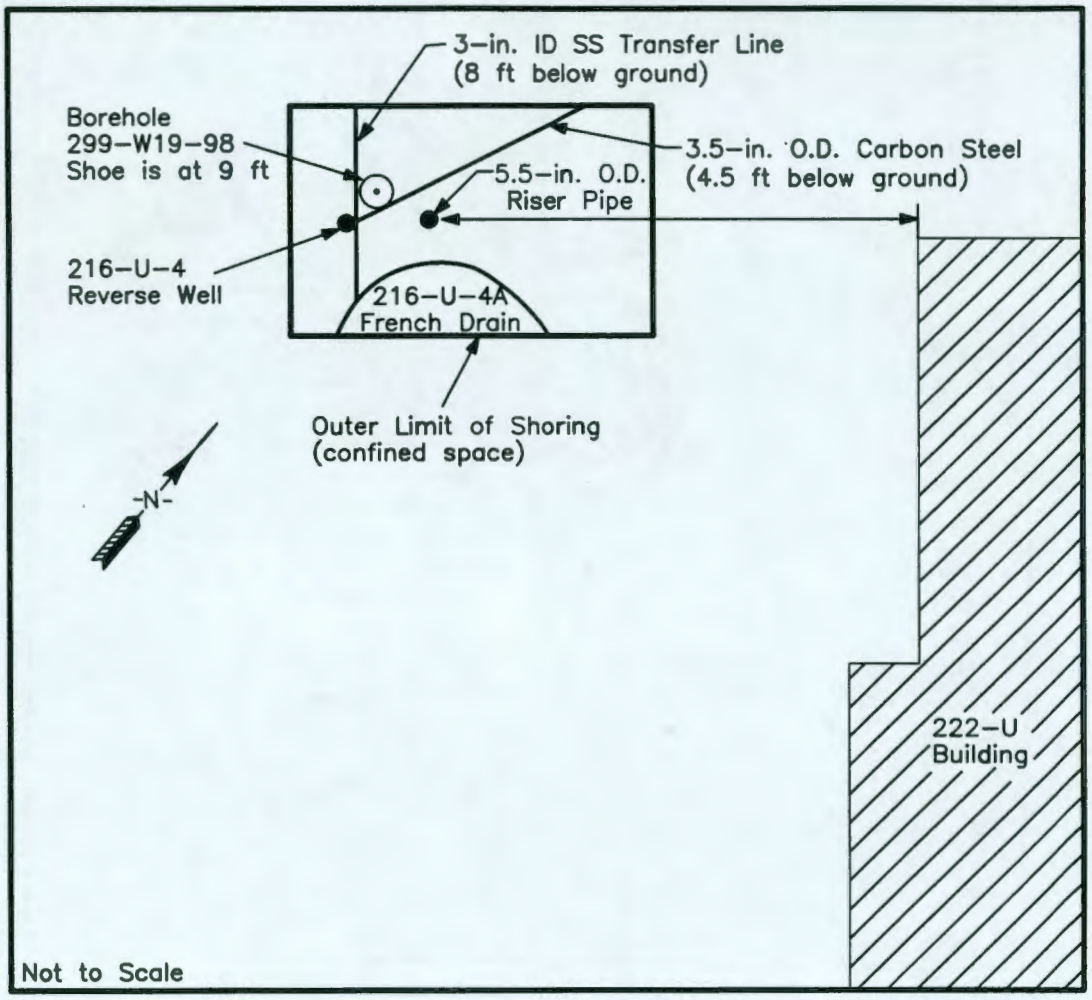
DRAWN BY	J.AMMERMAN	8/20/94	REV NO.	0	8/20/94
DRAFT CHK			INT BY		
PROJ CHK			COMPUTER GENERATED DRAWING. NO MANUAL CHANGES ALLOWED		
PROJ LEAD					
BHI REVIEW			PROJ NO. PT2BB		

IT HANFORD INCORPORATED

DRAWING NO. PT2BB-A15

ITH:PT2BB-A15

Figure 22b. Borehole Location Map for 299-W19-98.



UNDER CONTRACT TO
BECHTEL HANFORD, INC.
RICHLAND, WASHINGTON

200-UP-2 OPERABLE UNIT

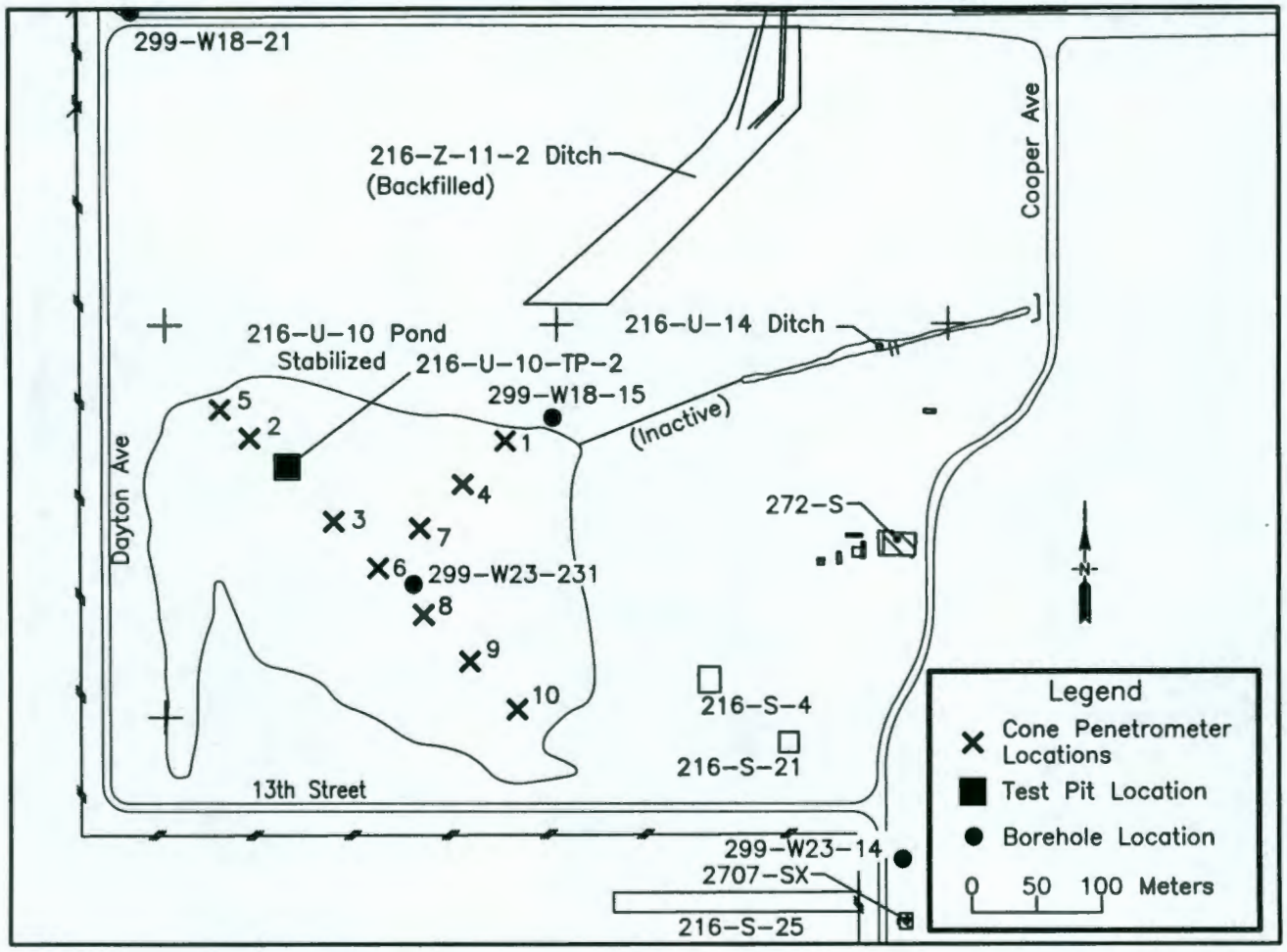
DRAWN BY	J.AMMERMAN	8/22/94	REV NO.		8/22/94
DRAFT CHK			INT BY		
PROJ CHK			COMPUTER GENERATED DRAWING. NO MANUAL CHANGES ALLOWED		
PROJ LEAD					
BHI REVIEW			PROJ NO. PT2BB		

IT HANFORD INCORPORATED

DRAWING NO. PT2BB-A18

ITH:PT2BB-A18

ITH:PT2BB-A17



200-UP-2 OPERABLE UNIT
216-U-10 POND

DRAWN BY	J.AMMERMAN	9/6/94	REV NO.	
DRAFT CHK			INT BY	
PROJ CHK			COMPUTER GENERATED DRAWING. NO MANUAL CHANGES ALLOWED	
PROJ LEAD				
BHI REVIEW			PROJ NO. PT2BB	

IT HANFORD INCORPORATED

UNDER CONTRACT TO
BECHTEL HANFORD, INC.
RICHLAND, WASHINGTON

FIGURE
DRAWING NO. PT2BB-A17

Figure 23a. Cone Penetrometer, Borehole, and Test Pit Locations.

9513335.1119

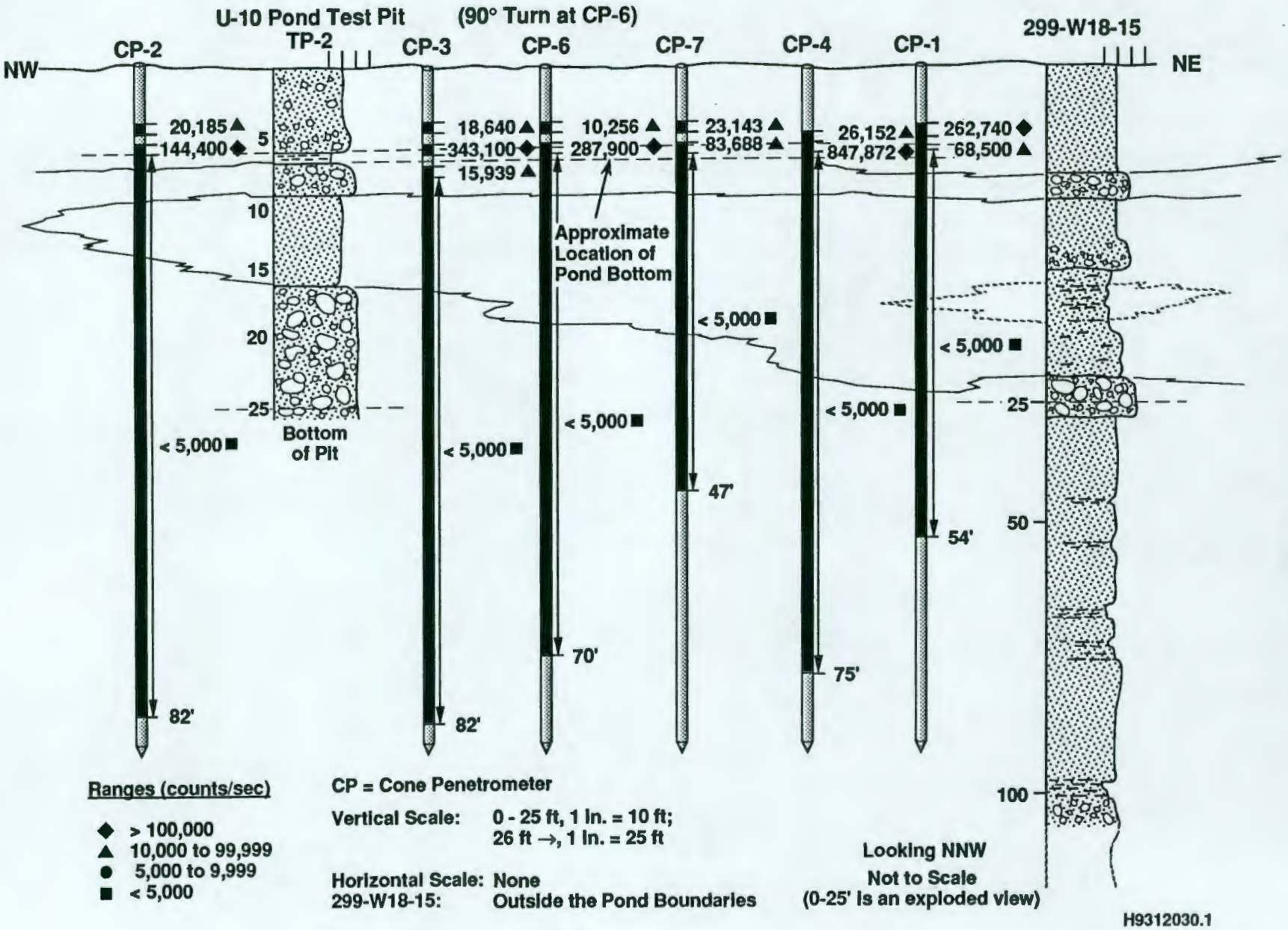


Figure 23b. Cone Penetrometer and Test Pit Locations

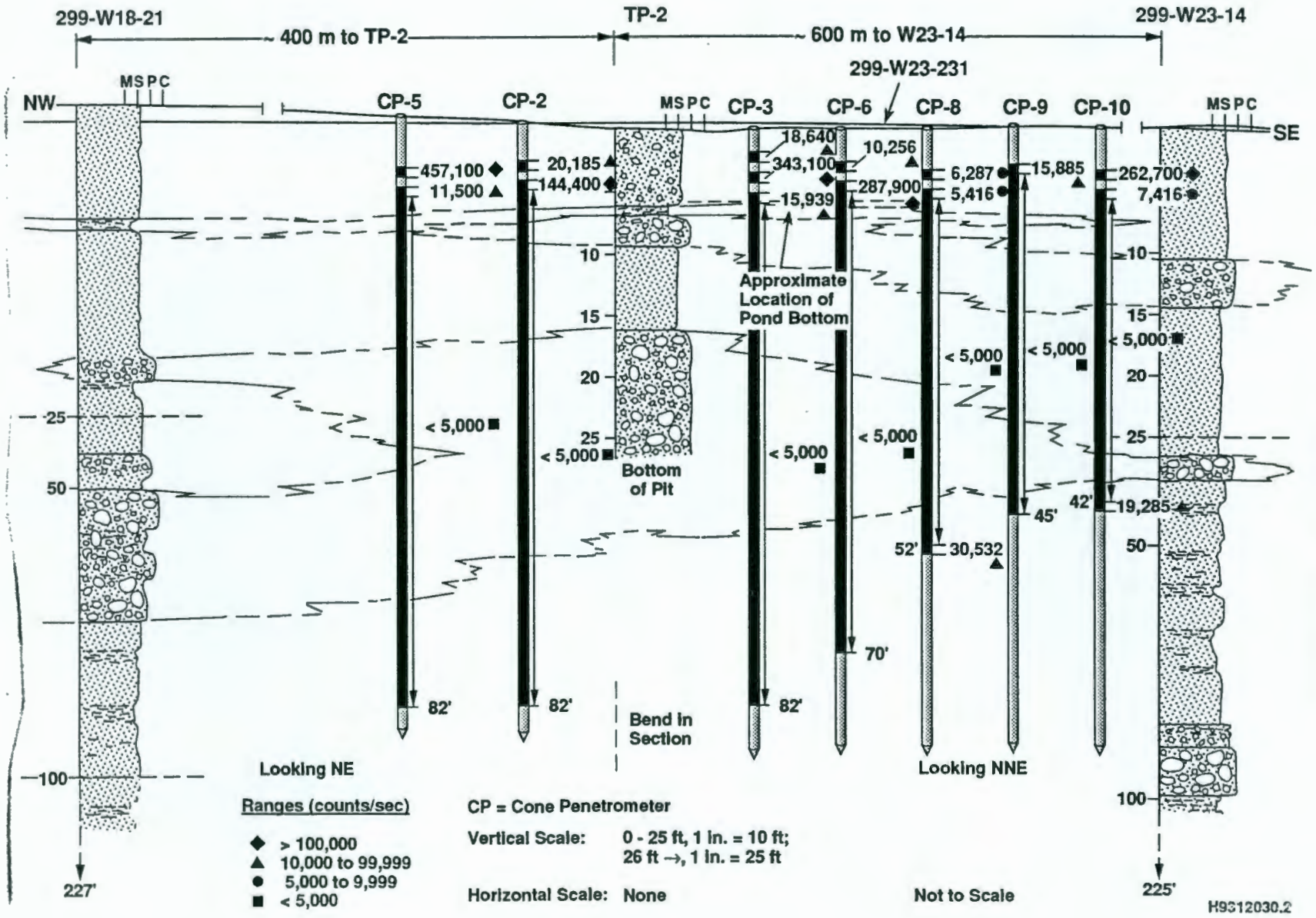


Figure 23c. Cone Penetrometer and Test Pit Locations.

9513335.1120

Figure 24. Vertical Distribution of Americium-241 at the 216-U-1/2 Cribs.

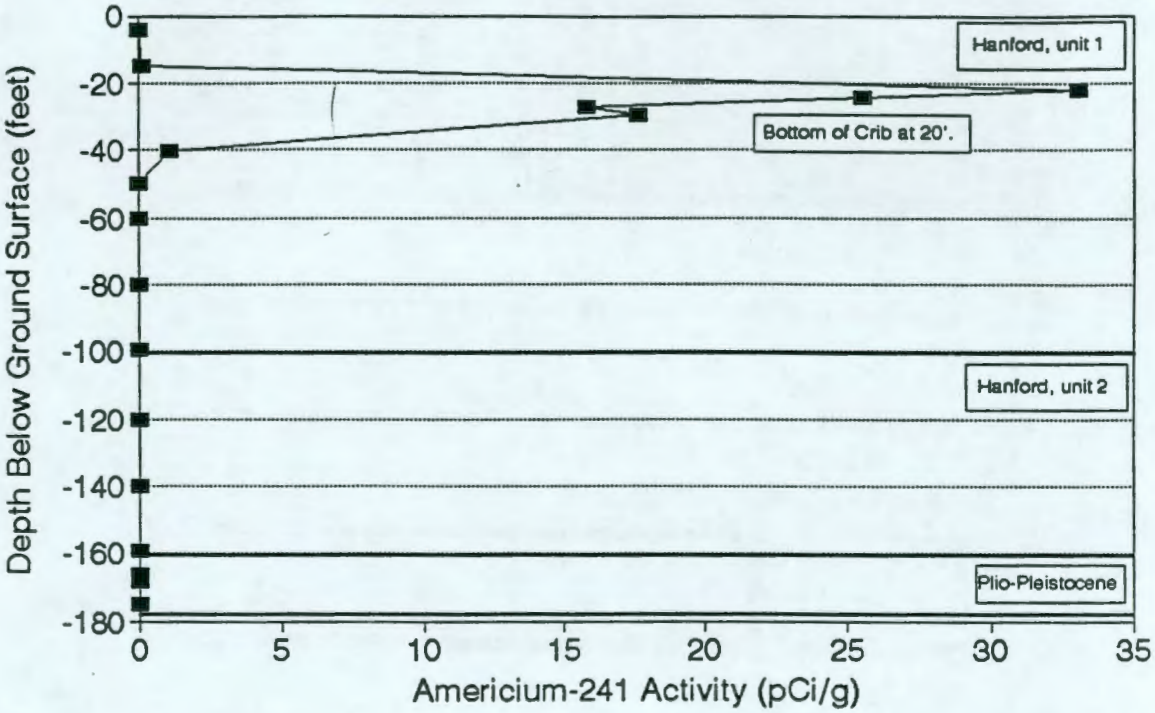


Figure 25. Vertical Distribution of Cobalt-60 at the 216-U-1/2 Cribs.

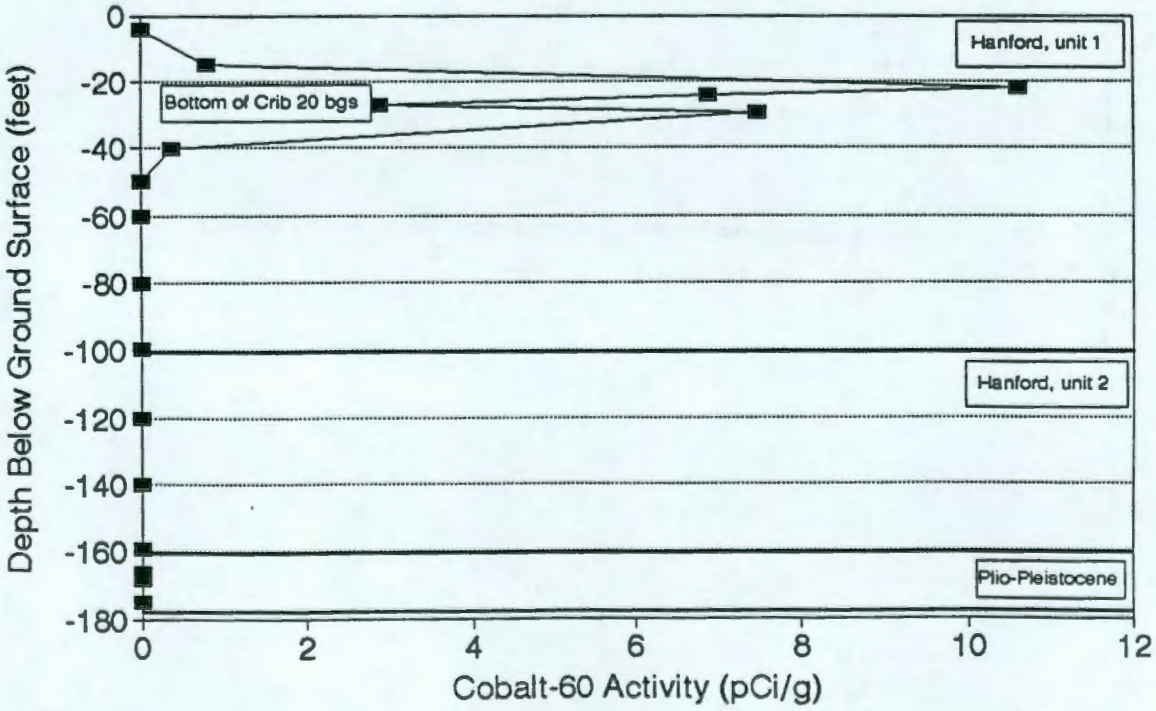


Figure 26. Vertical Distribution of Cesium-137 at the 216-U-1/2 Cribs.

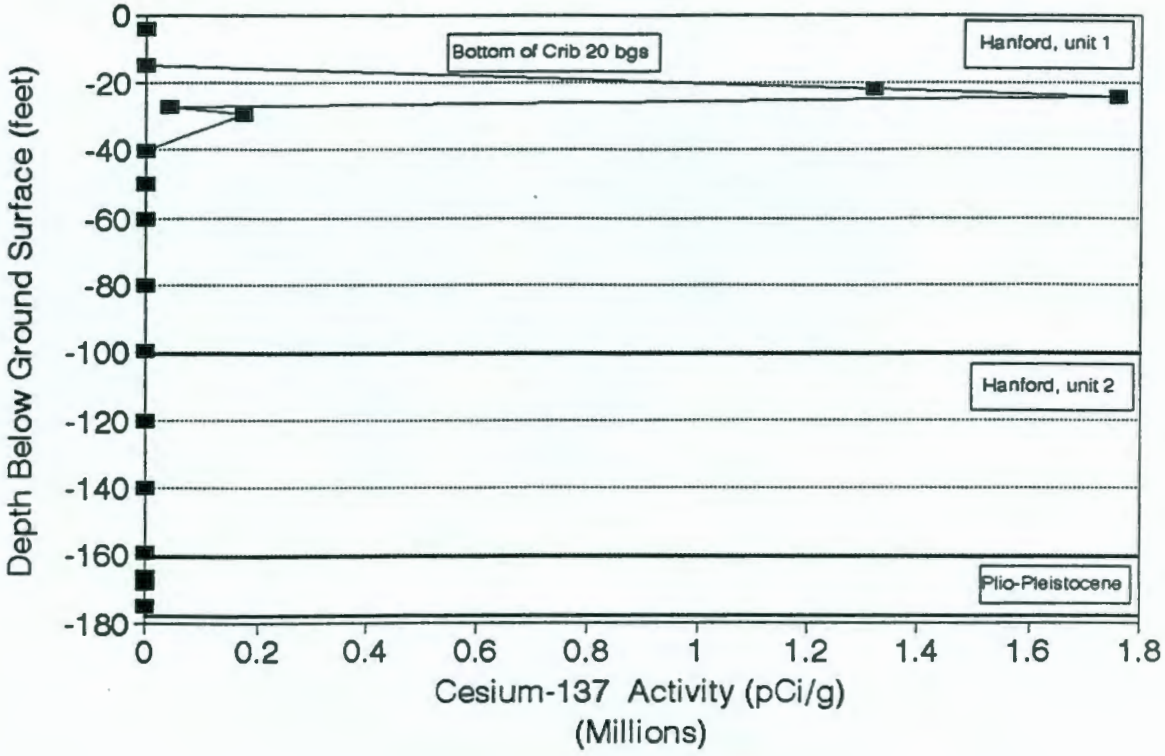


Figure 27. Vertical Distribution of Radium-228 at the 216-U-1/2 Cribs.

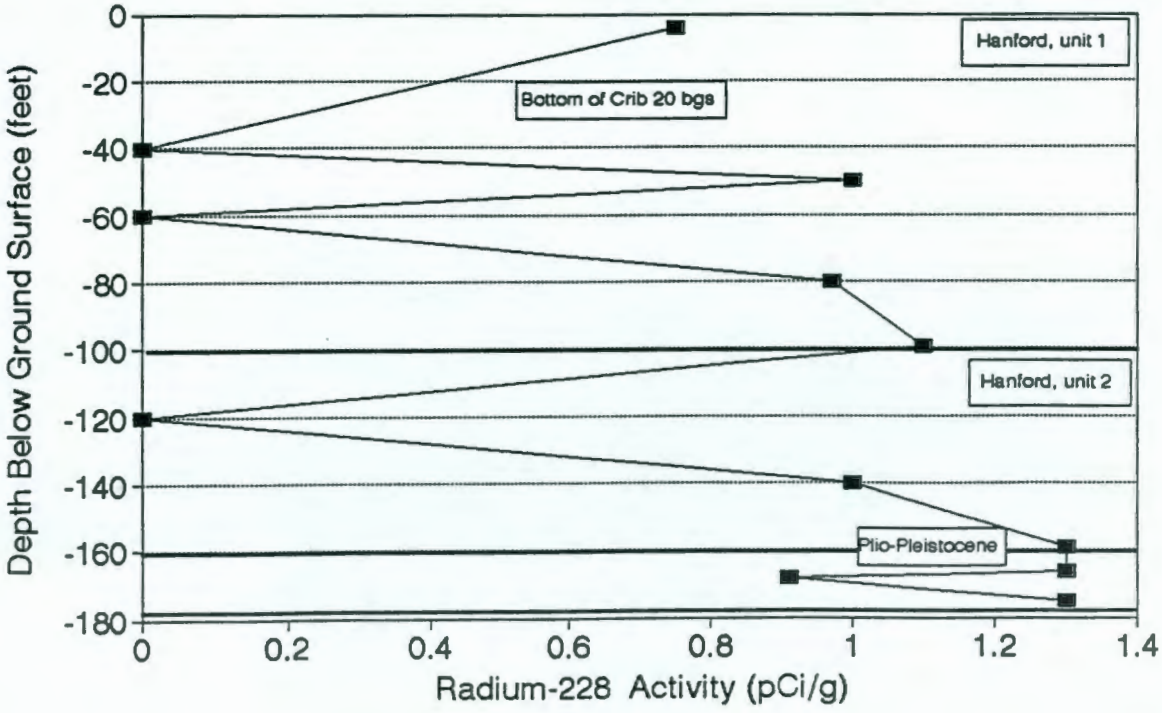


Figure 28. Vertical Distribution of Strontium-90 at the 216-U-1/2 Cribs.

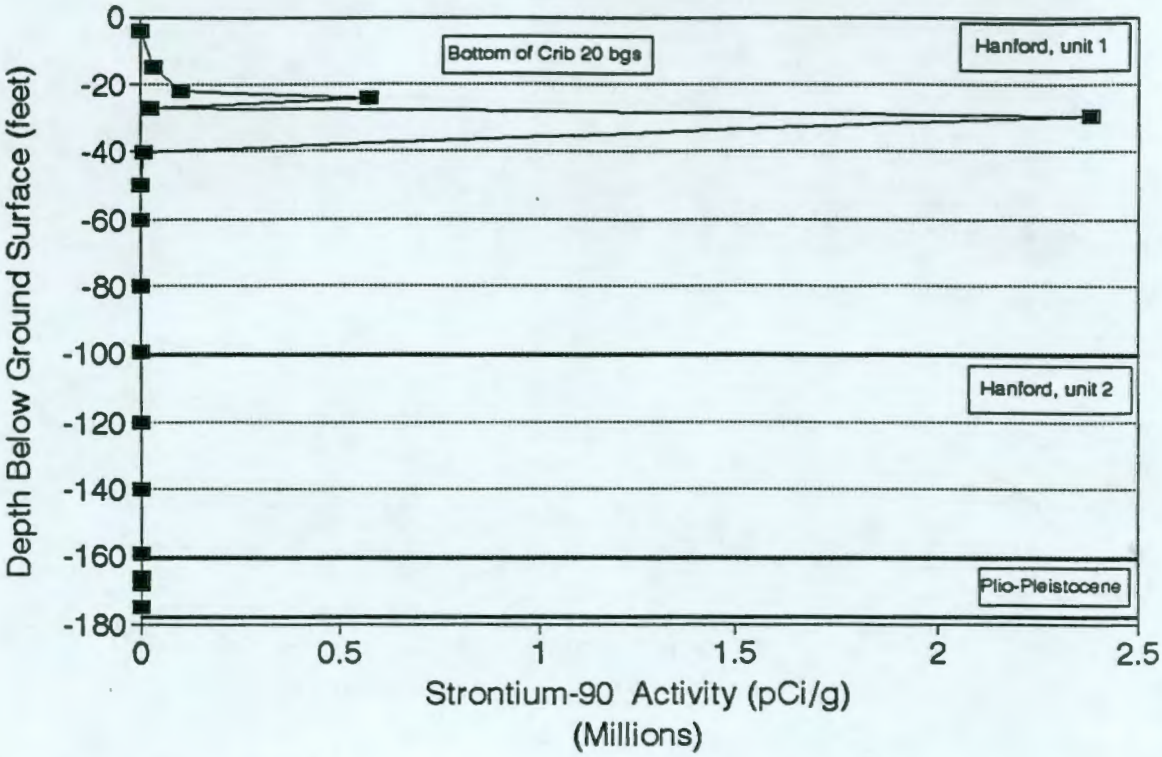


Figure 29. Vertical Distribution of Thorium-228 at the 216-U-1/2 Cribs.

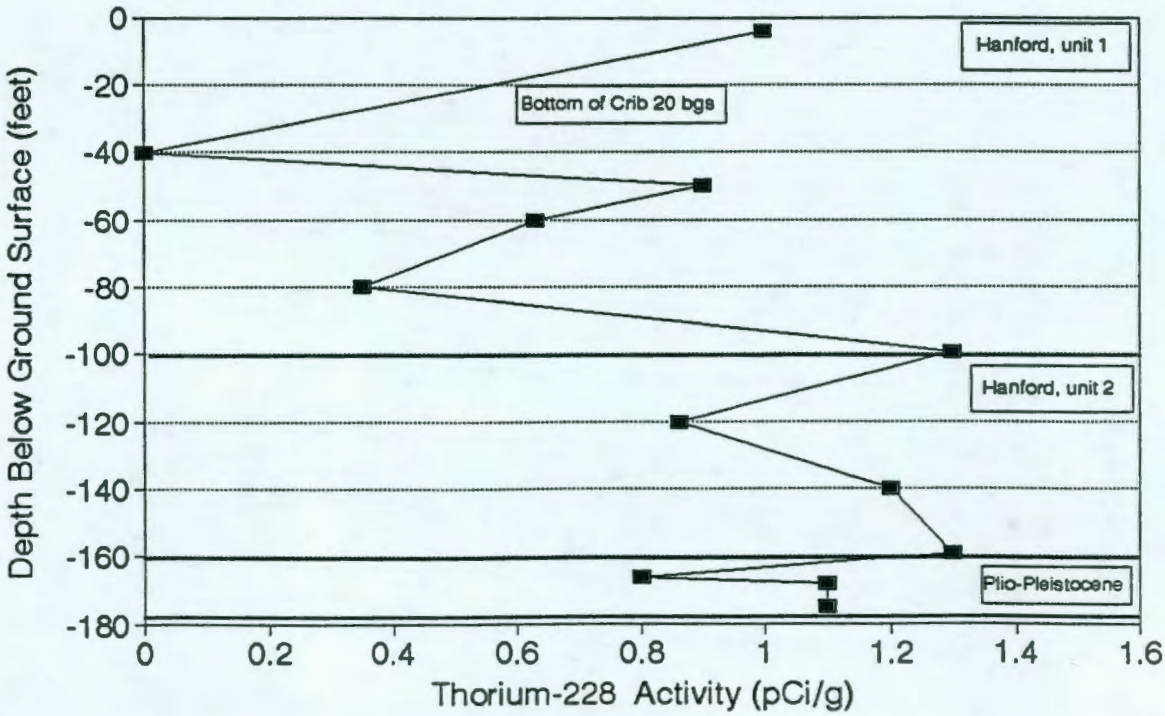


Figure 30. Vertical Distribution of Uranium-233/234 at the 216-U-1/2 Cribs.

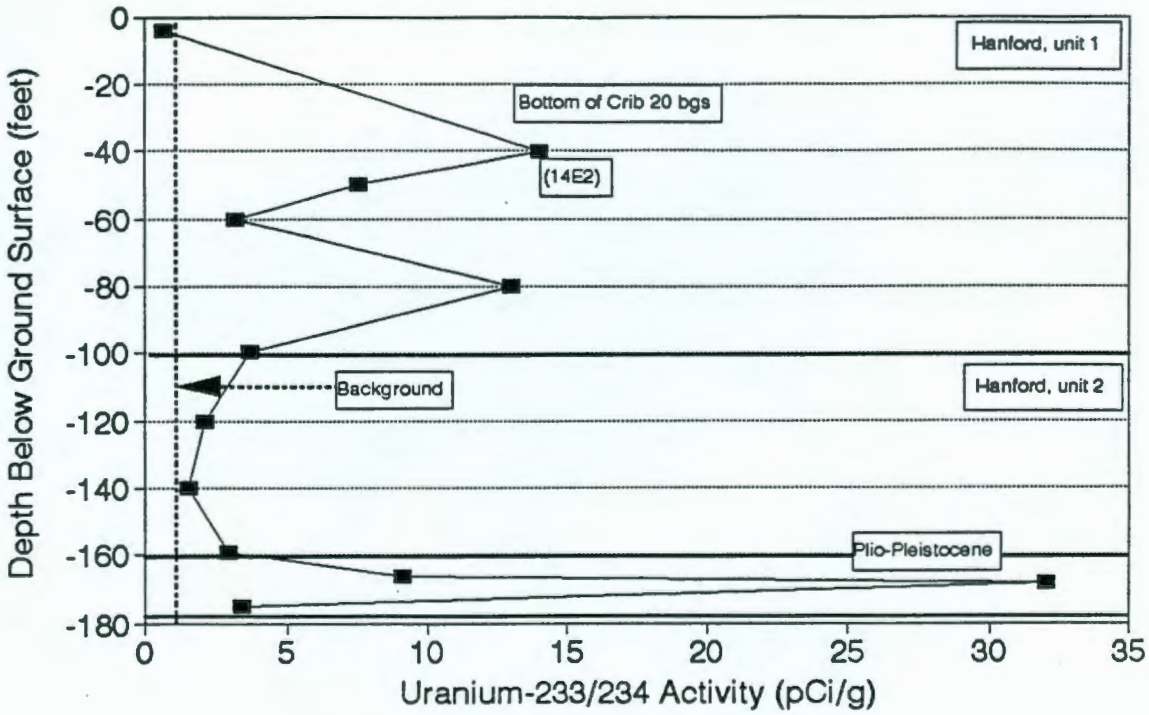


Figure 31. Vertical Distribution of Uranium-235 at the 216-U-1/2 Cribs.

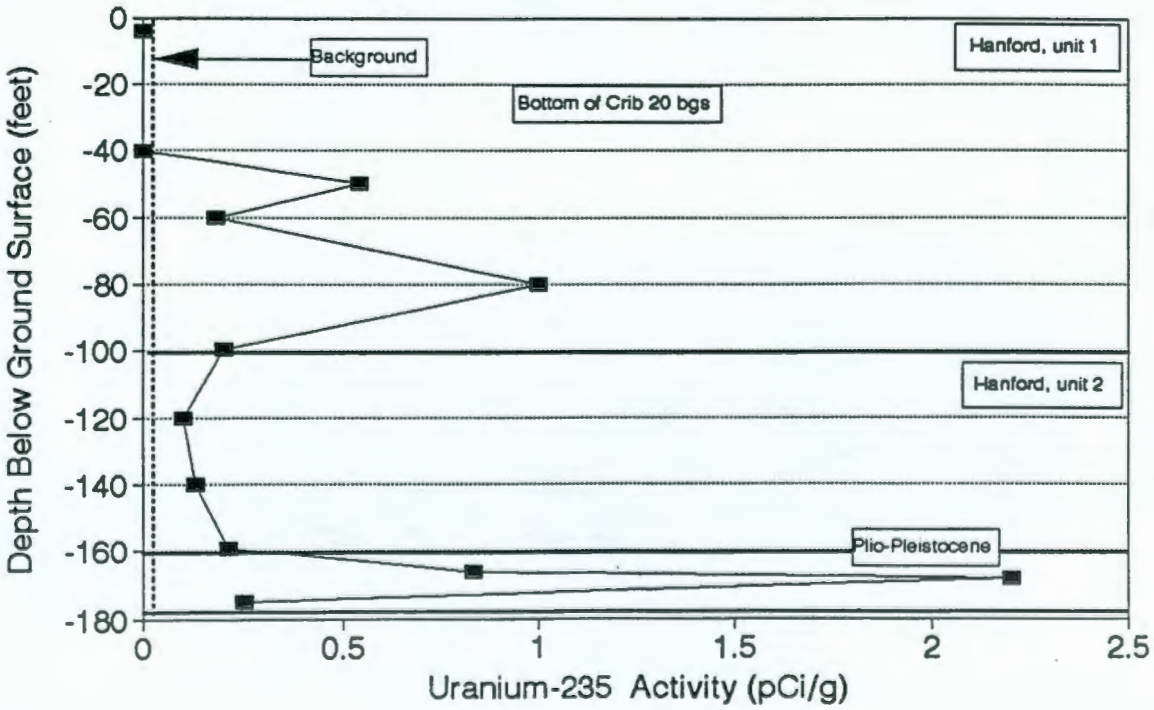


Figure 32. Vertical Distribution of Uranium-238 at the 216-U-1/2 Cribs.

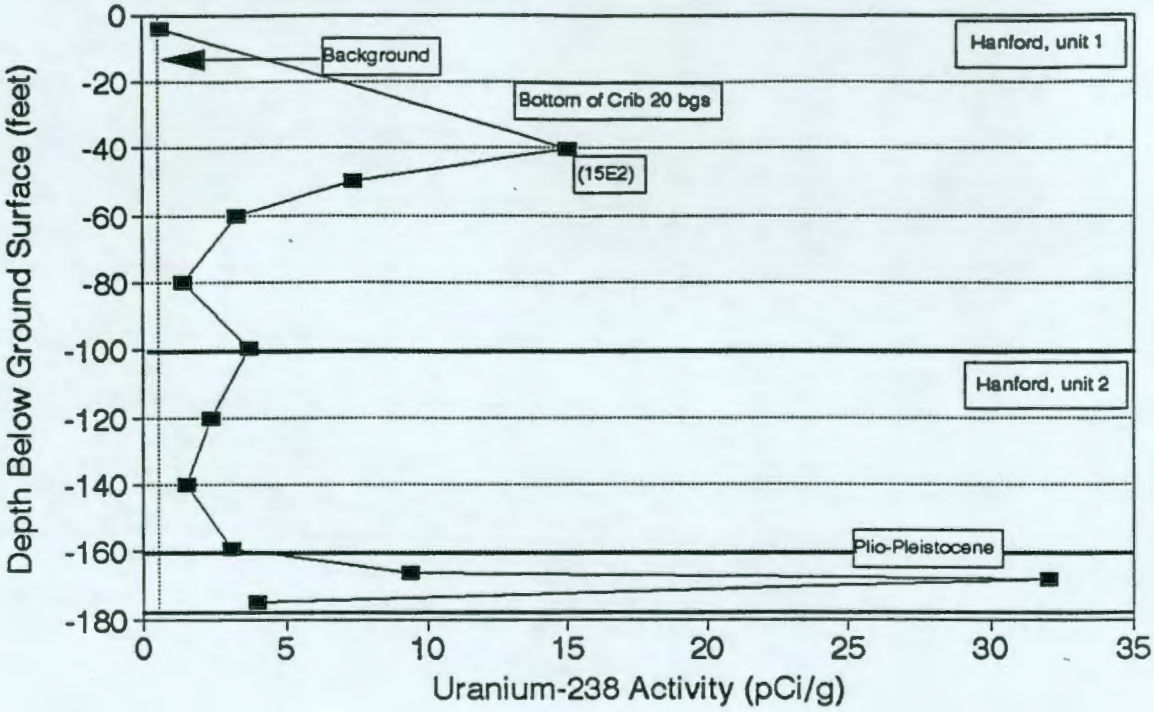


Figure 33. Vertical Distribution of Americium-241 at the 216-U-4 French Drain/U4A Reverse Well.

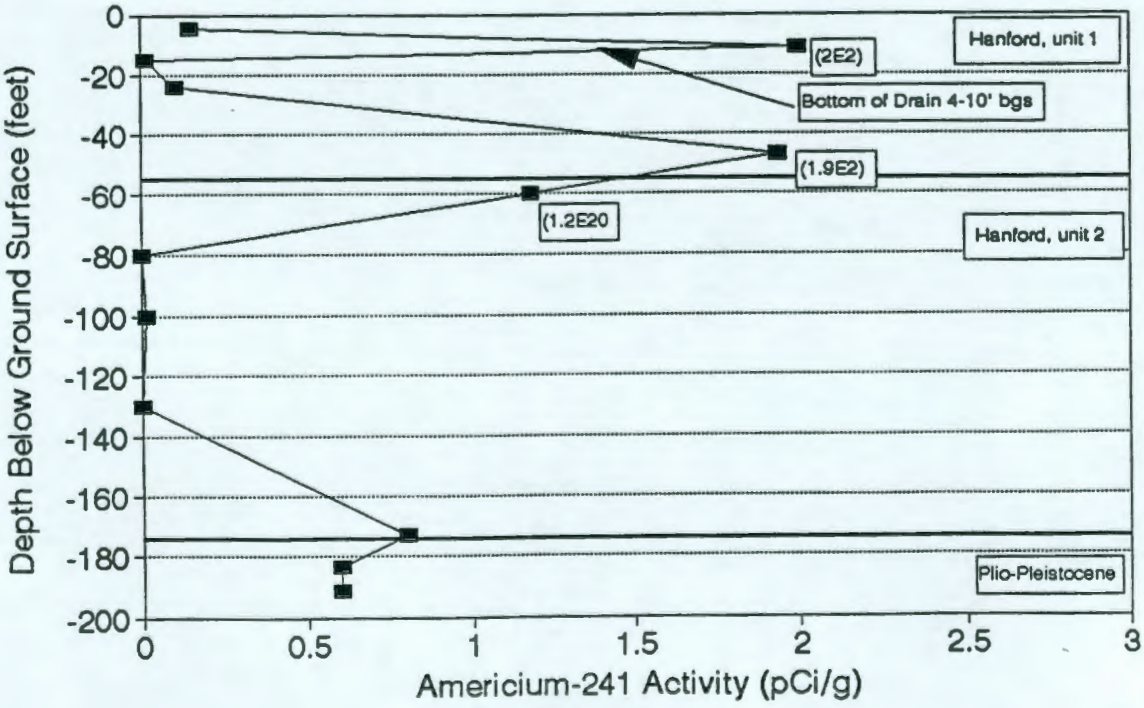


Figure 34. Vertical Distribution of Cesium-137 at the 216-U-4 French Drain/U4A Reverse Well.

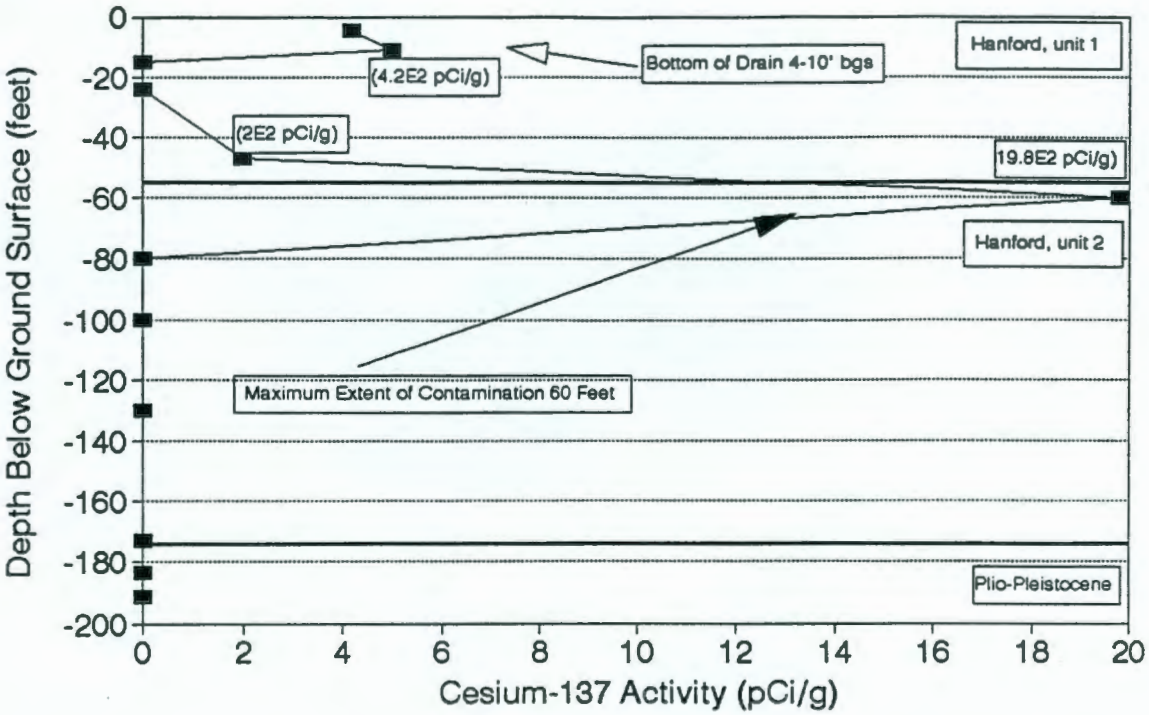


Figure 35. Vertical Distribution of Europium-152 at the 216-U-4 French Drain/U4A Reverse Well.

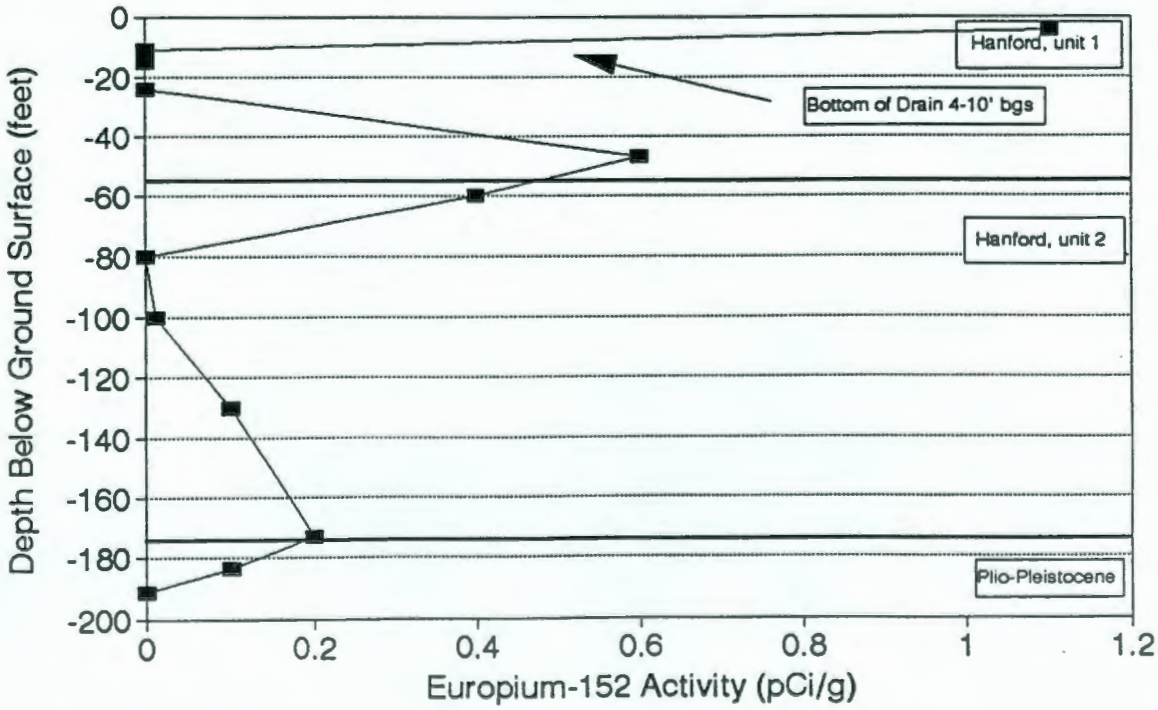


Figure 36. Vertical Distribution of Europium-154 at the 216-U-4 French Drain/U4A Reverse Well.

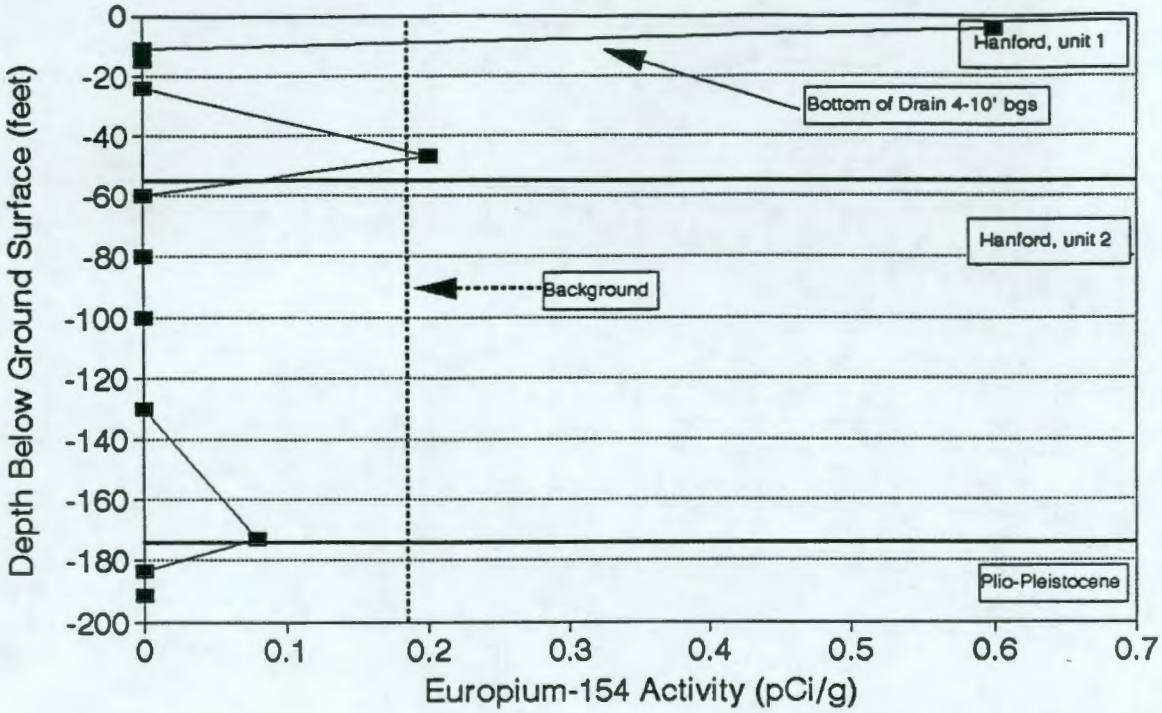


Figure 37. Vertical Distribution of Neptunium-237 at the 216-U-4 French Drain/U4A Reverse Well.

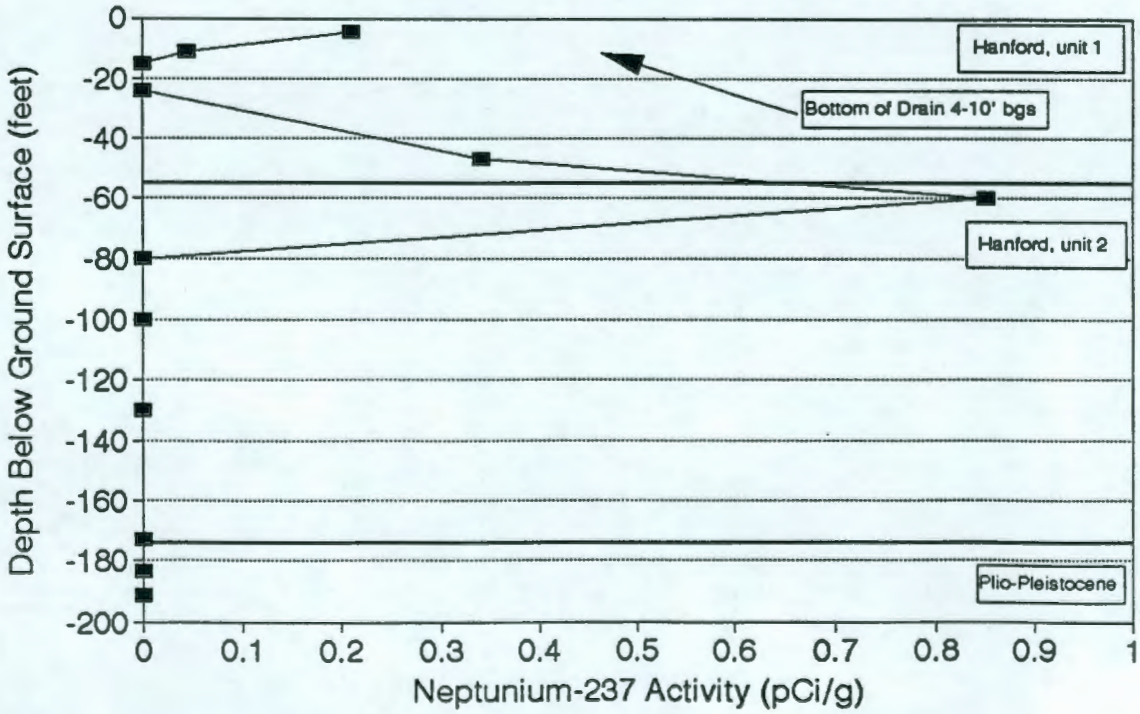


Figure 38. Vertical Distribution of Uranium-234 at the 216-U-4 French Drain/U4A Reverse Well.

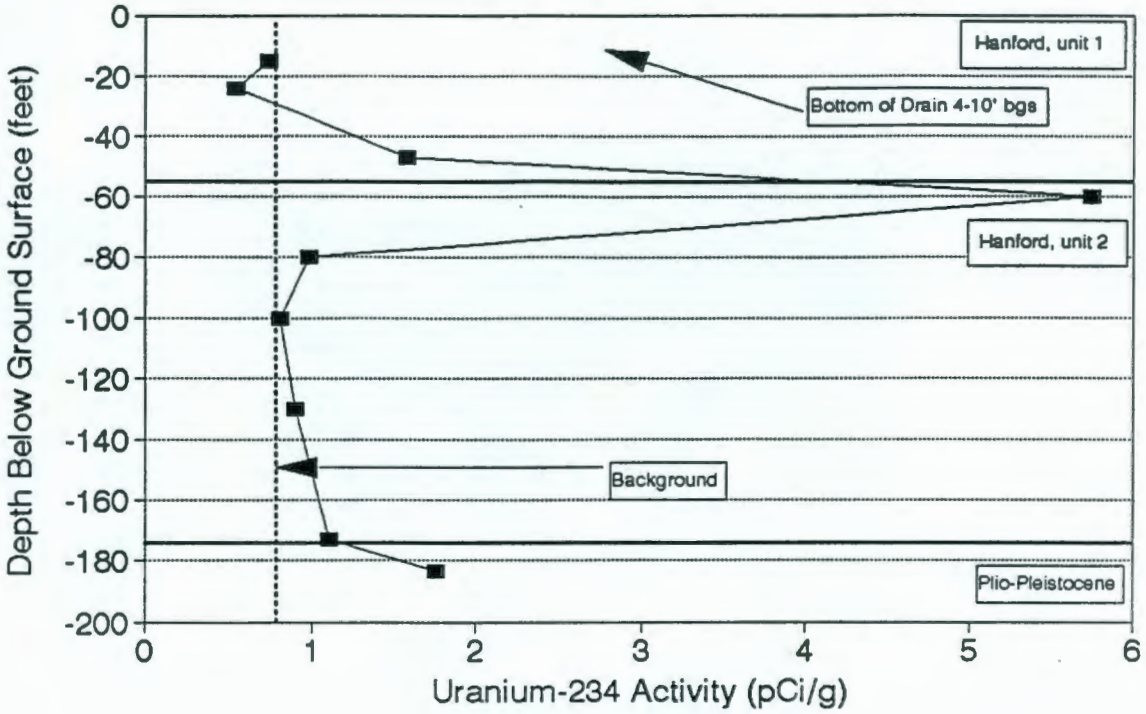


Figure 39. Vertical Distribution of Uranium-235 at the 216-U-4 French Drain/U4A Reverse Well.

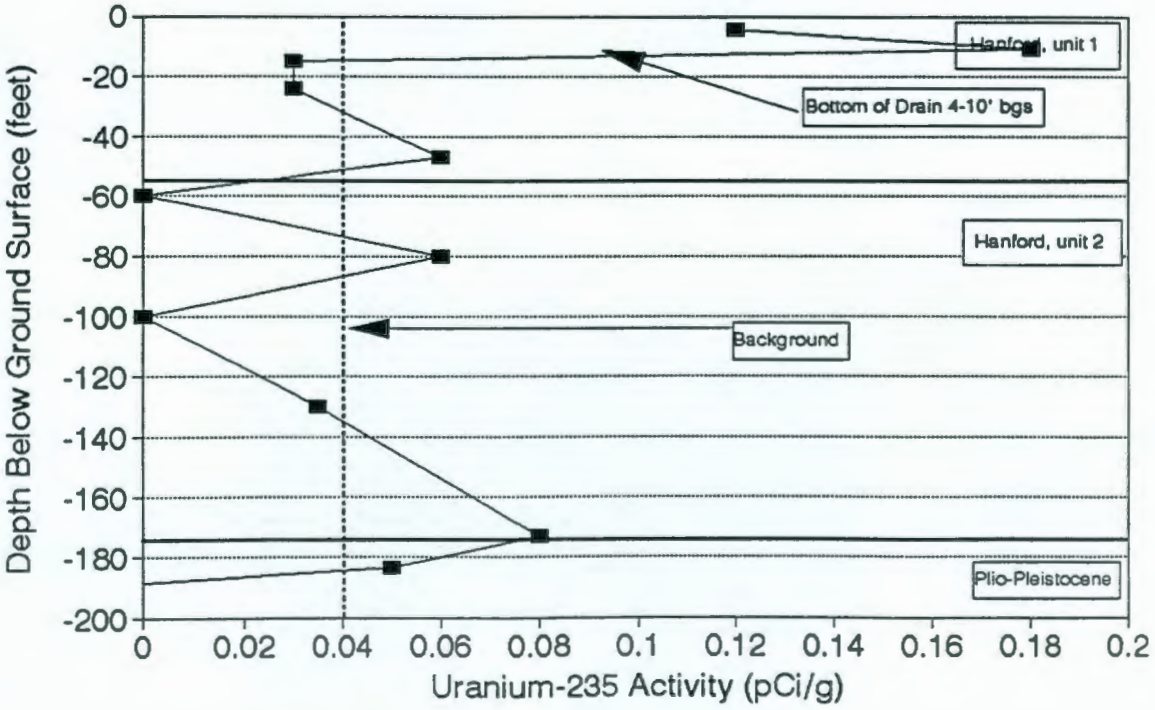


Figure 40. Vertical Distribution of Uranium-238 at the 216-U-4 French Drain/U4A Reverse Well.

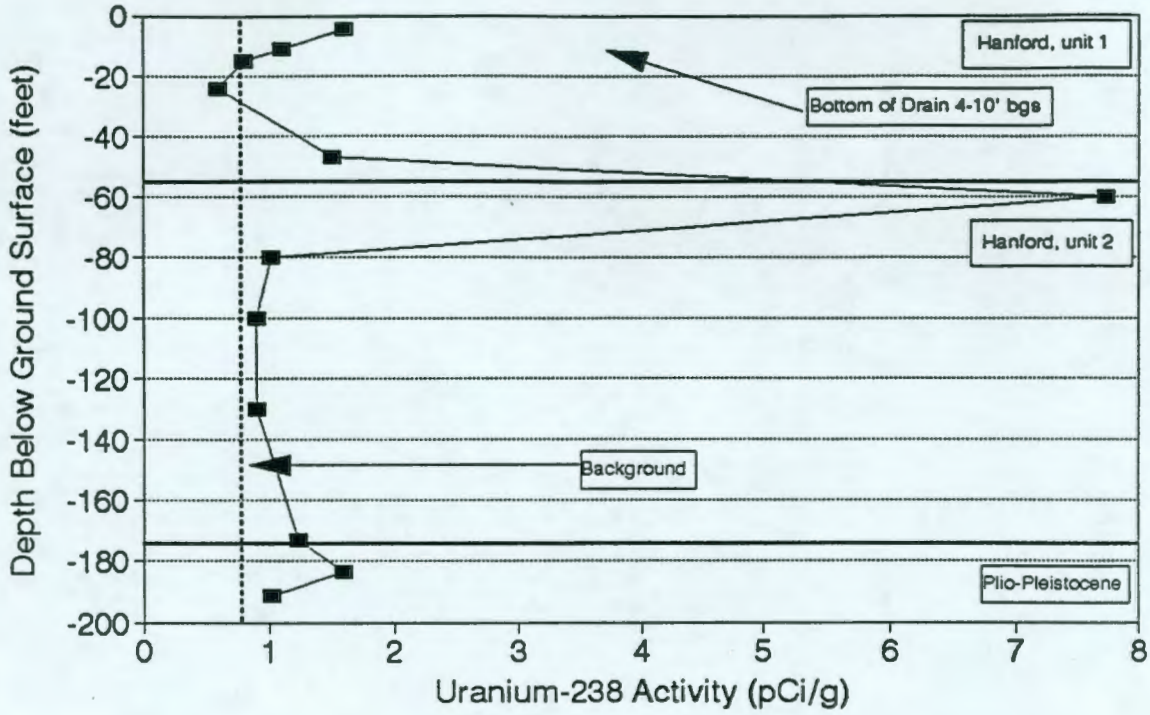


Figure 41. Vertical Distribution of Americium-241 at the 216-U-8 Crib.

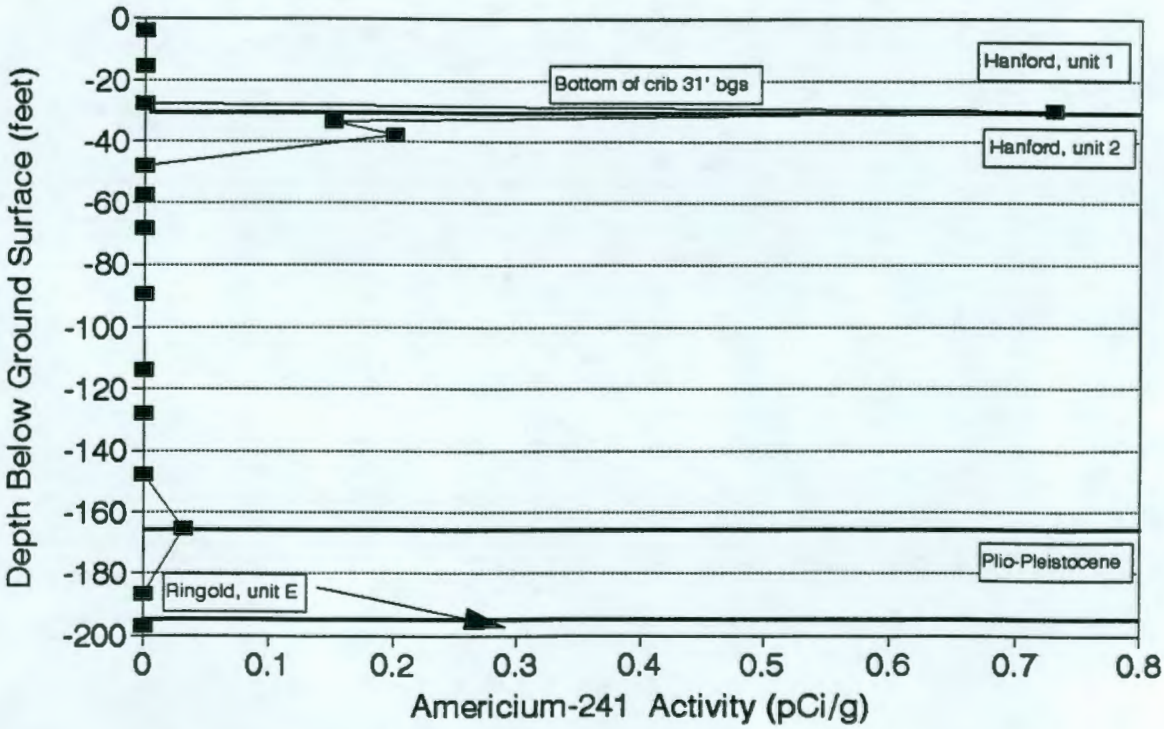


Figure 42. Vertical Distribution of Cesium-137 at the 216-U-8 Crib.

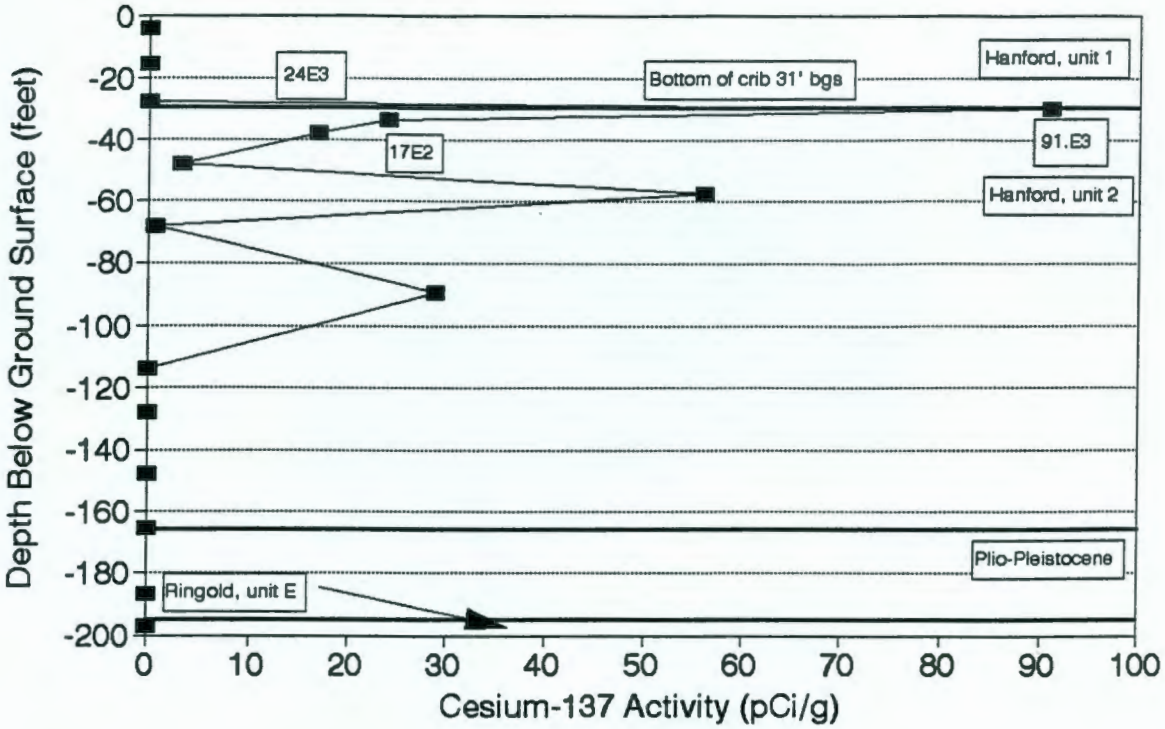


Figure 43. Vertical Distribution of Neptunium-237 at the 216-U-8 Crib.

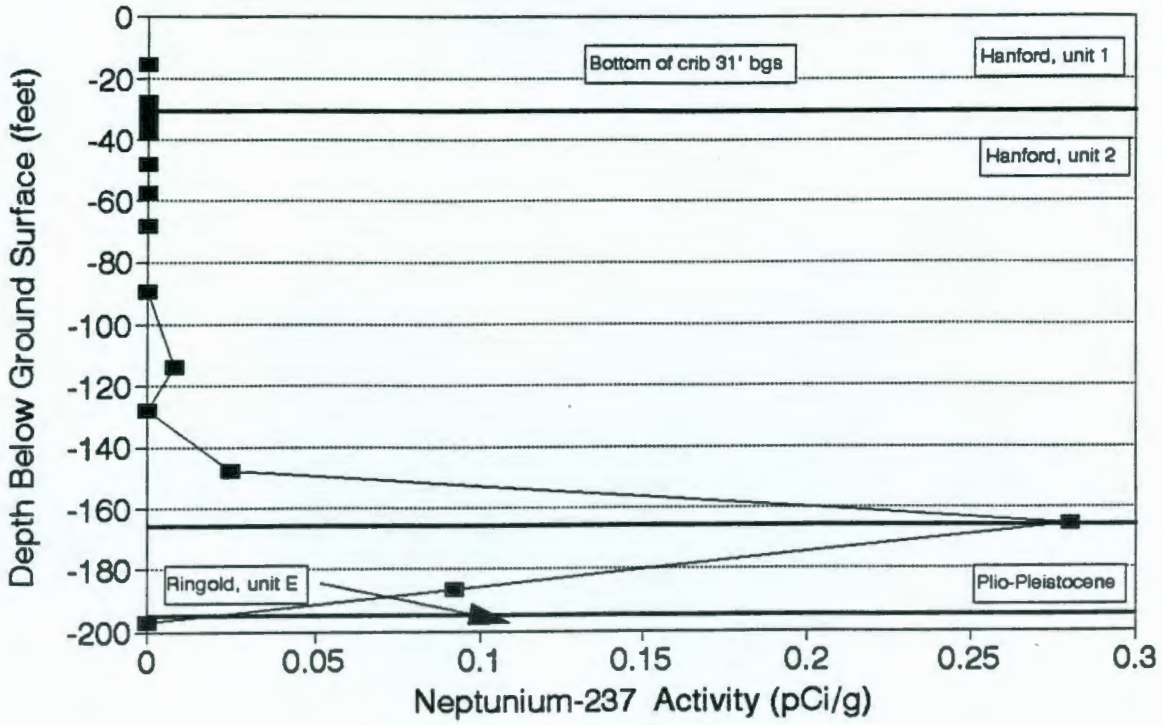


Figure 44. Vertical Distribution of Radium-226 at the 216-U-8 Crib.

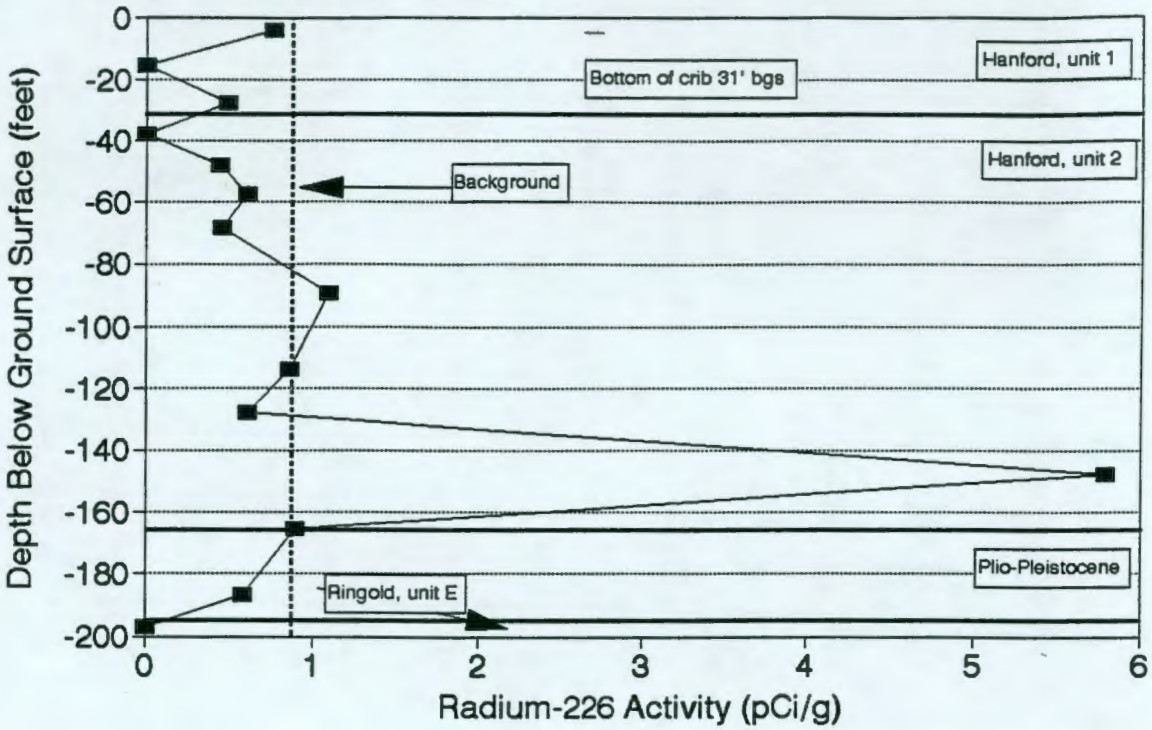


Figure 45. Vertical Distribution of Radium-228 at the 216-U-8 Crib.

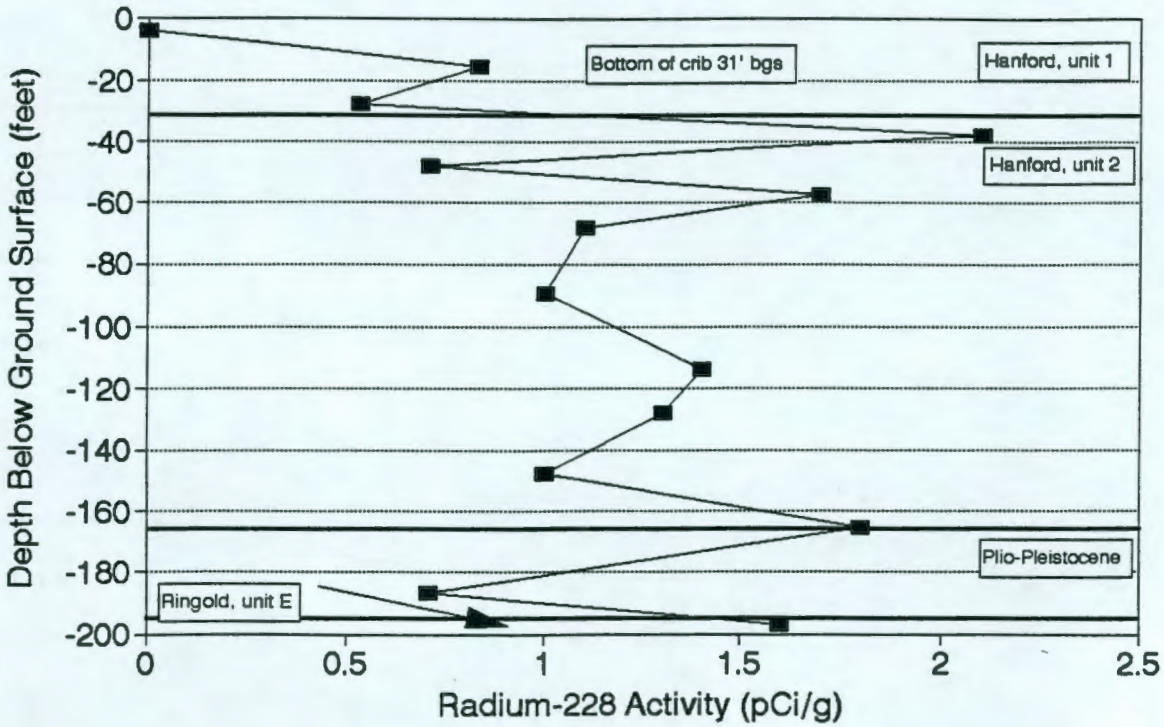


Figure 46. Vertical Distribution of Strontium-90 at the 216-U-8 Crib.

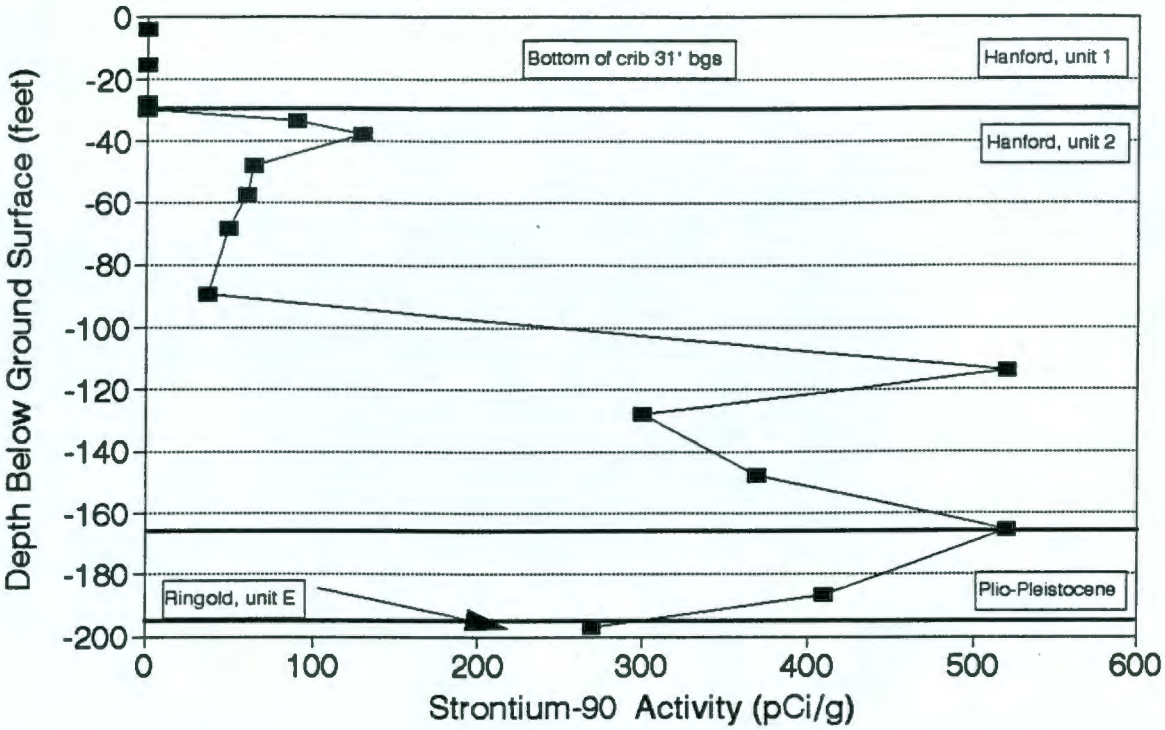


Figure 47. Vertical Distribution of Thorium-232 at the 216-U-8 Crib.

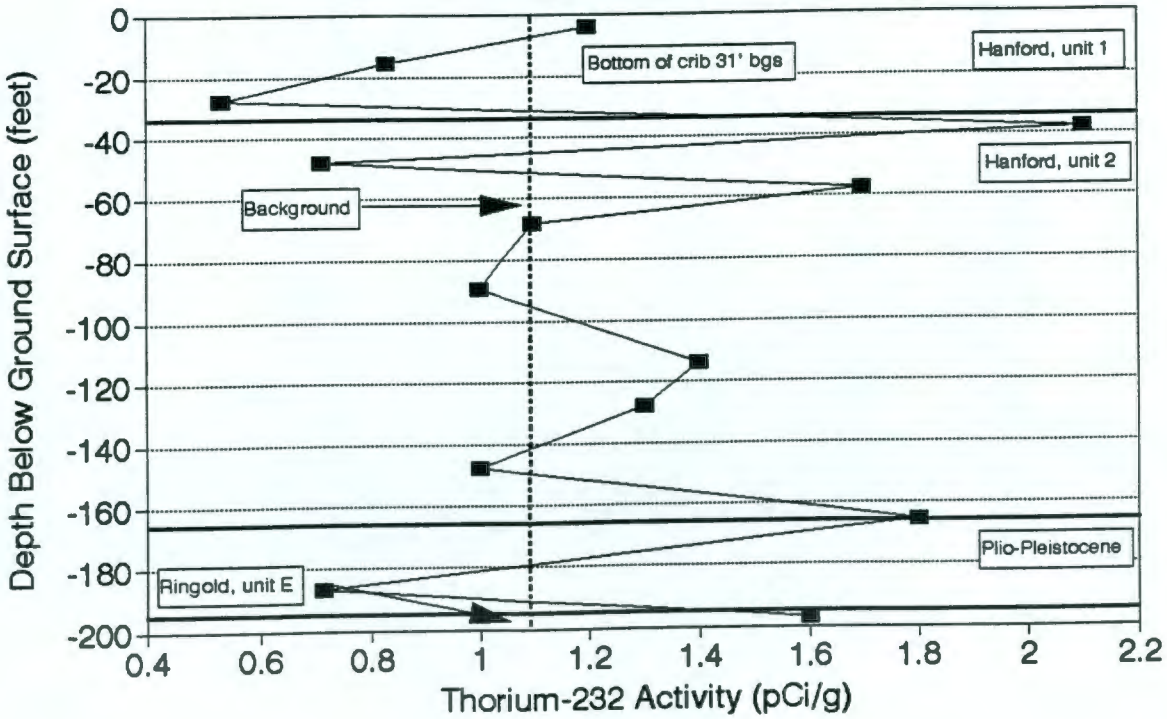


Figure 48. Vertical Distribution of Uranium-233/234 at the 216-U-8 Crib.

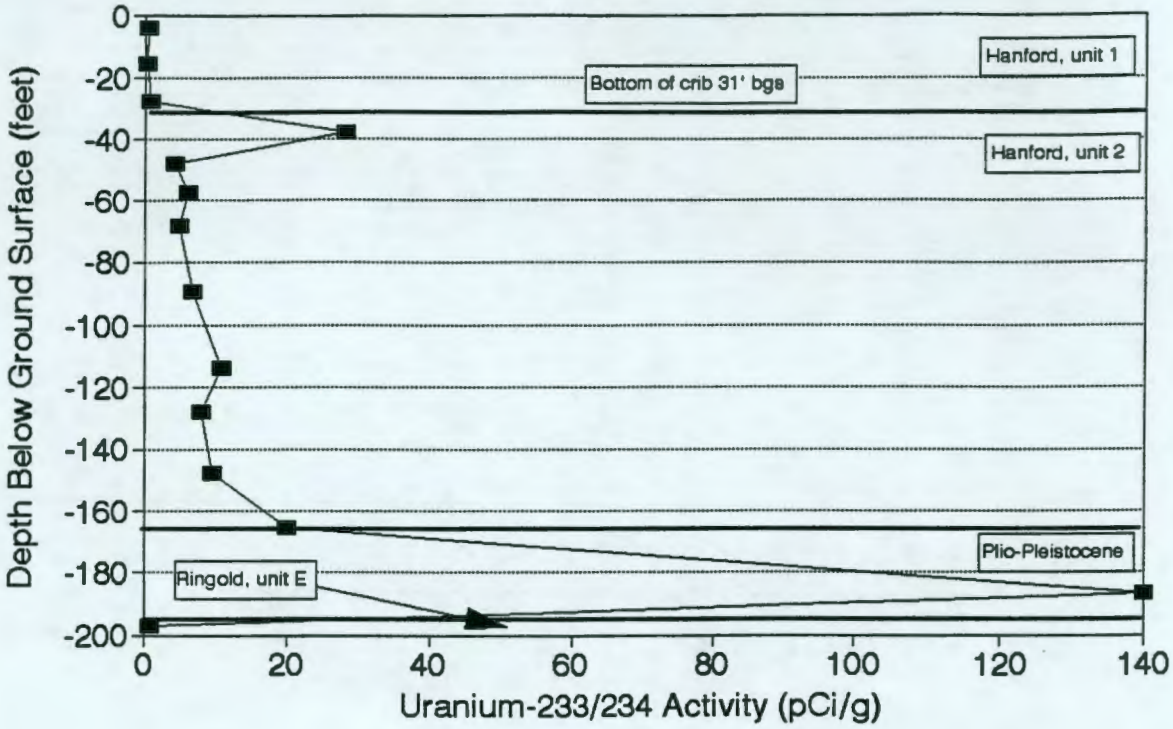


Figure 49. Vertical Distribution of Uranium-235 at the 216-U-8 Crib.

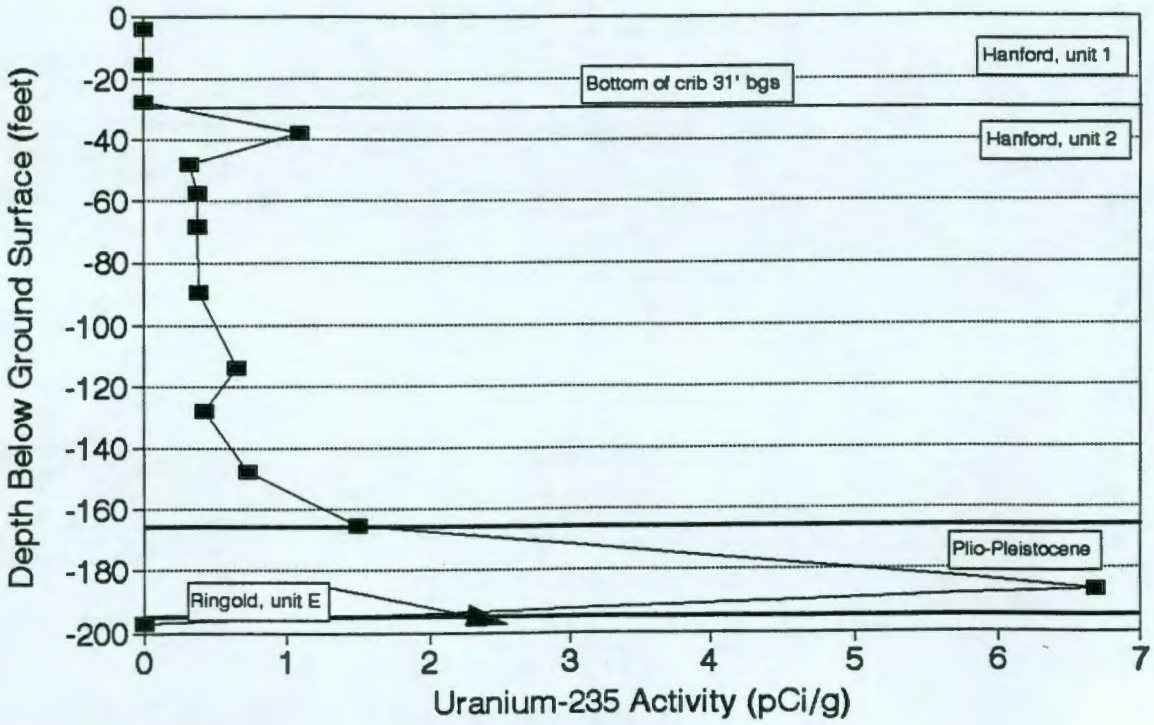


Figure 50. Vertical Distribution of Uranium-238 at the 216-U-8 Crib.

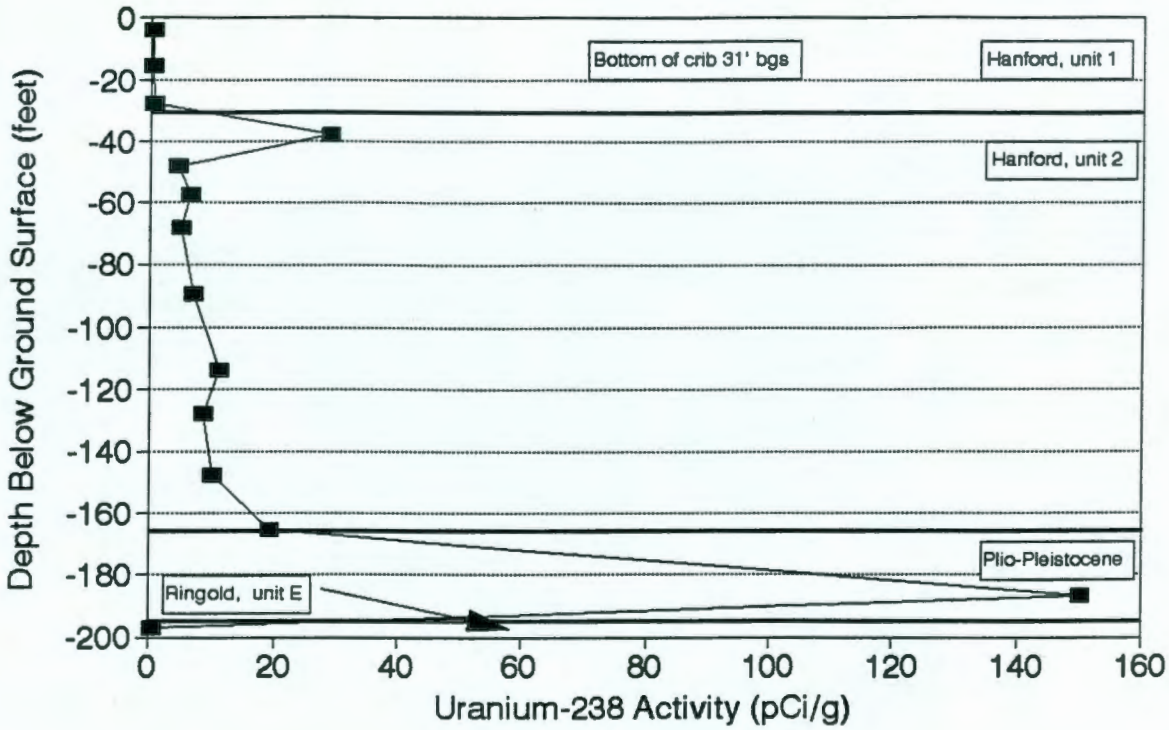


Figure 51. Vertical Distribution of Americium-241 at the 216-U-10 Pond.

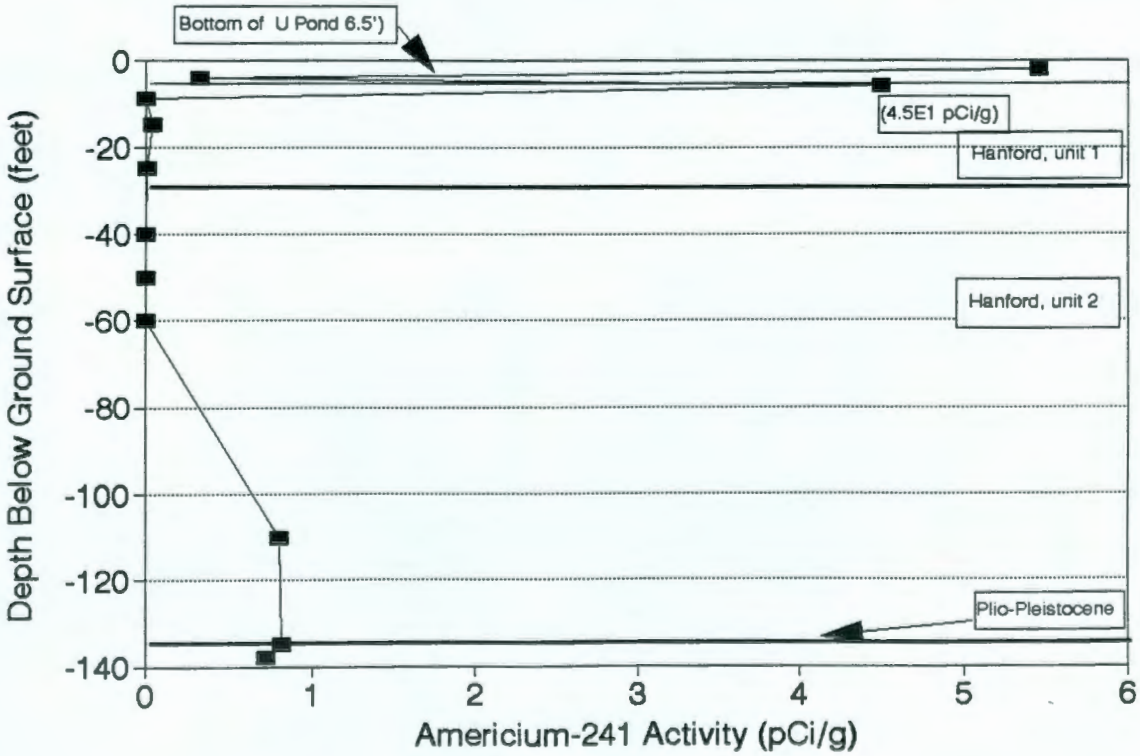


Figure 52. Vertical Distribution of Cesium-137 at the 216-U-10 Pond.

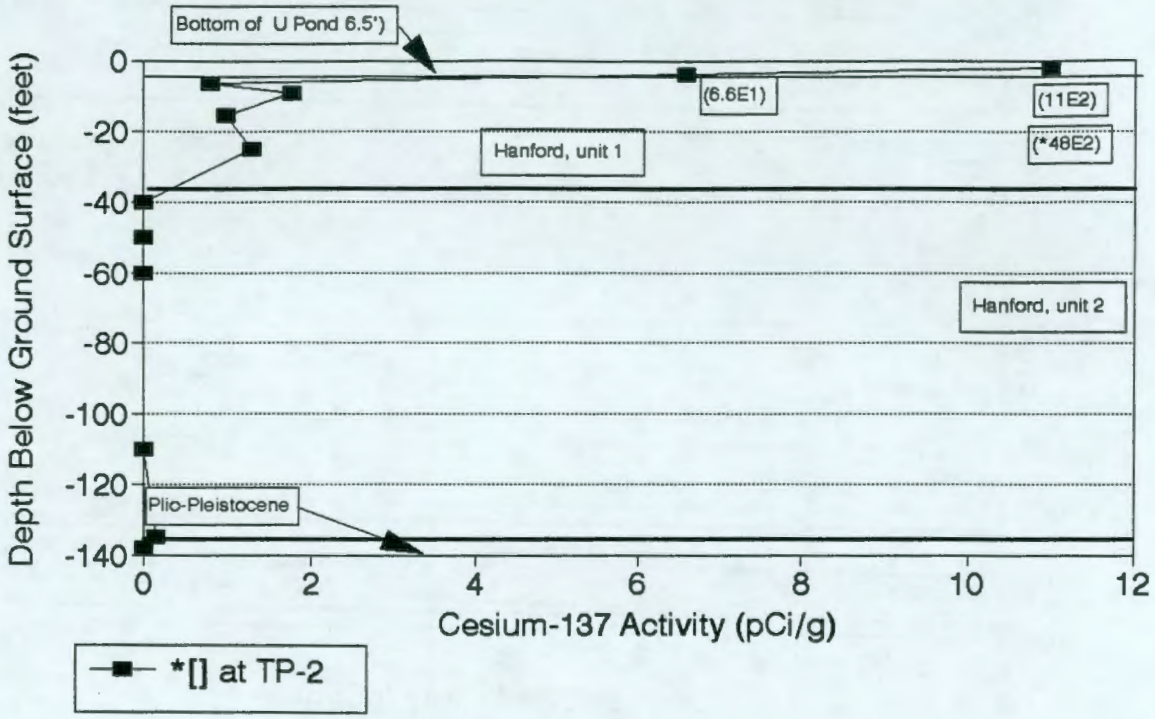


Figure 53. Vertical Distribution of Plutonium-238 at the 216-U-10 Pond.

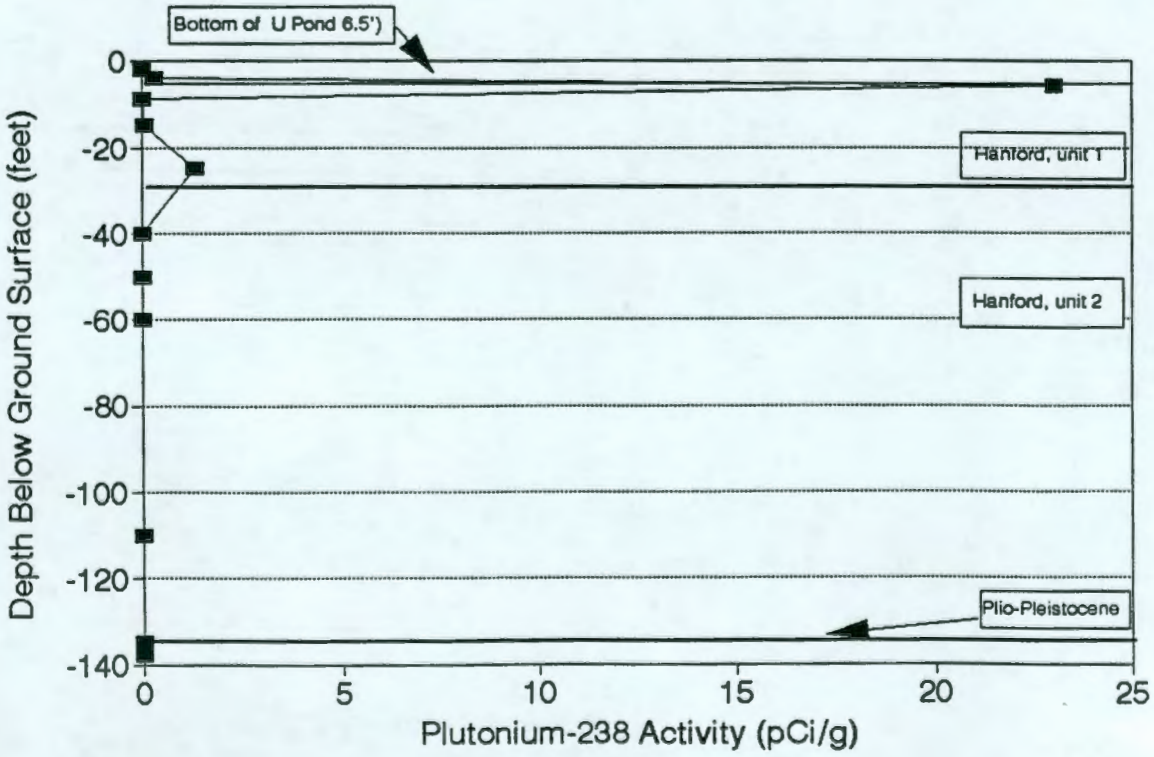


Figure 54. Vertical Distribution of Plutonium-239/240 at the 216-U-10 Pond.

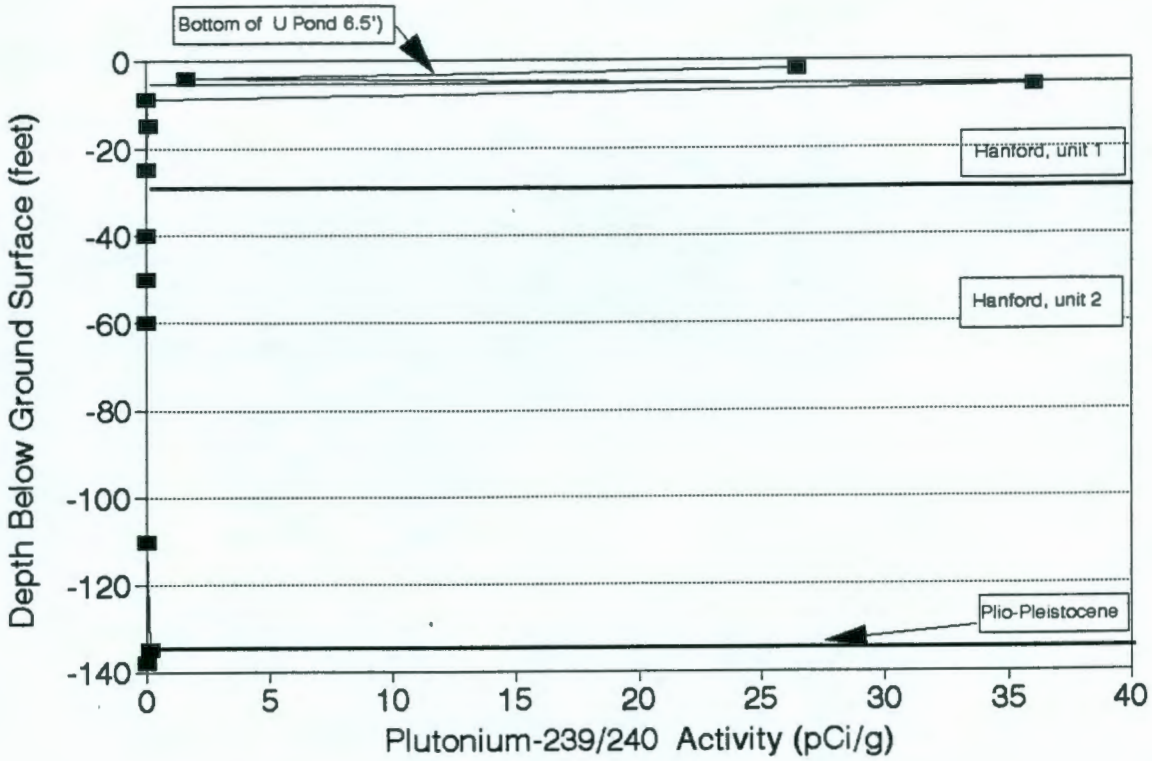


Figure 55. Vertical Distribution of Europium-155 at the 216-U-10 Pond.

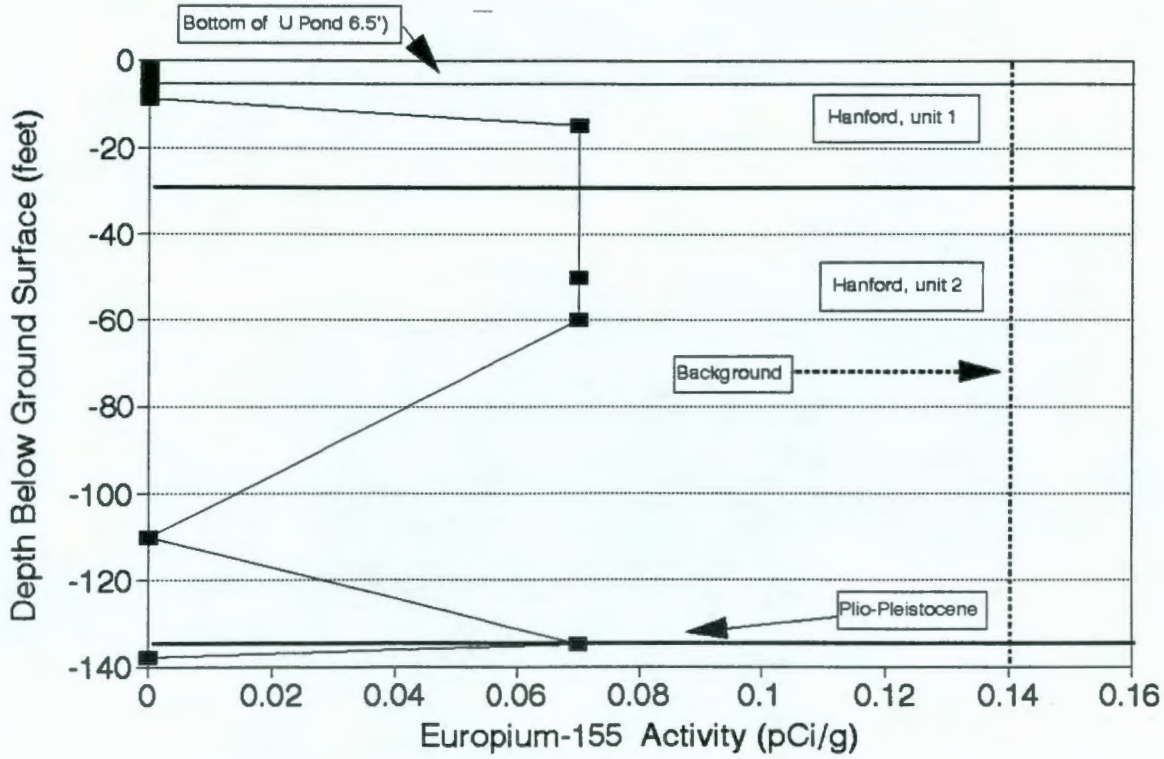


Figure 56. Vertical Distribution of Radium-226 at the 216-U-10 Pond.

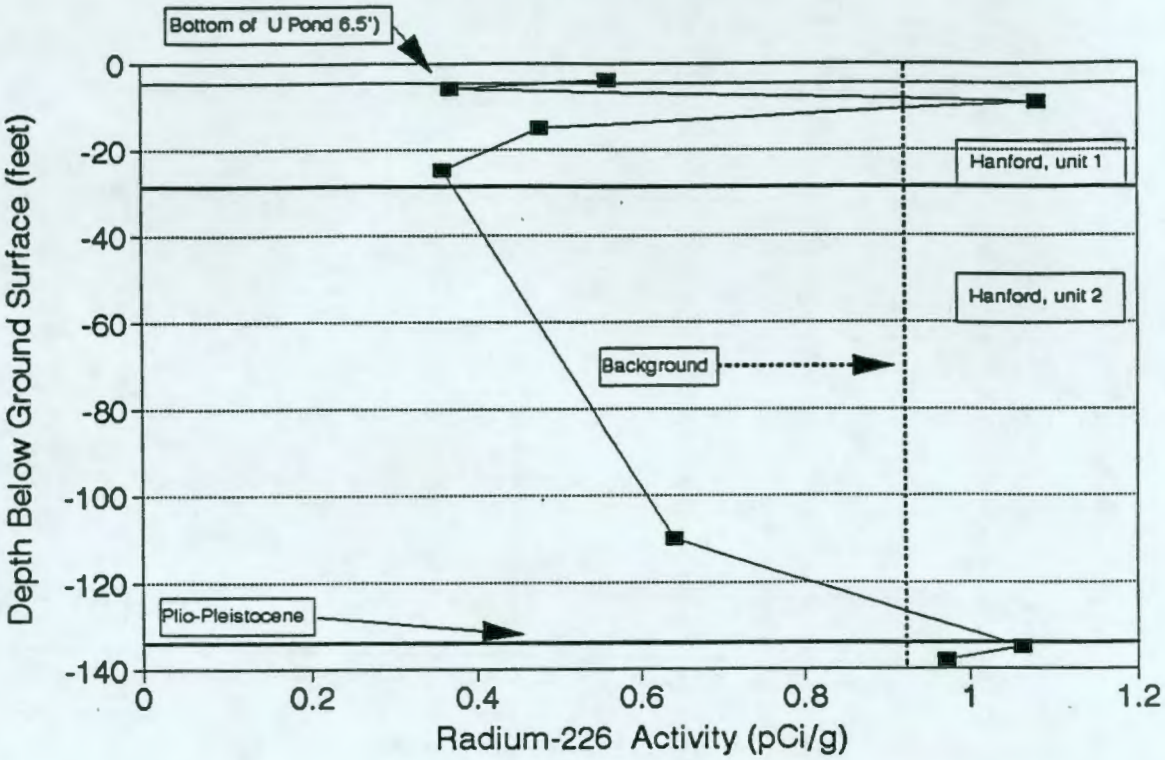


Figure 57. Vertical Distribution of Radium-228 at the 216-U-10 Pond.

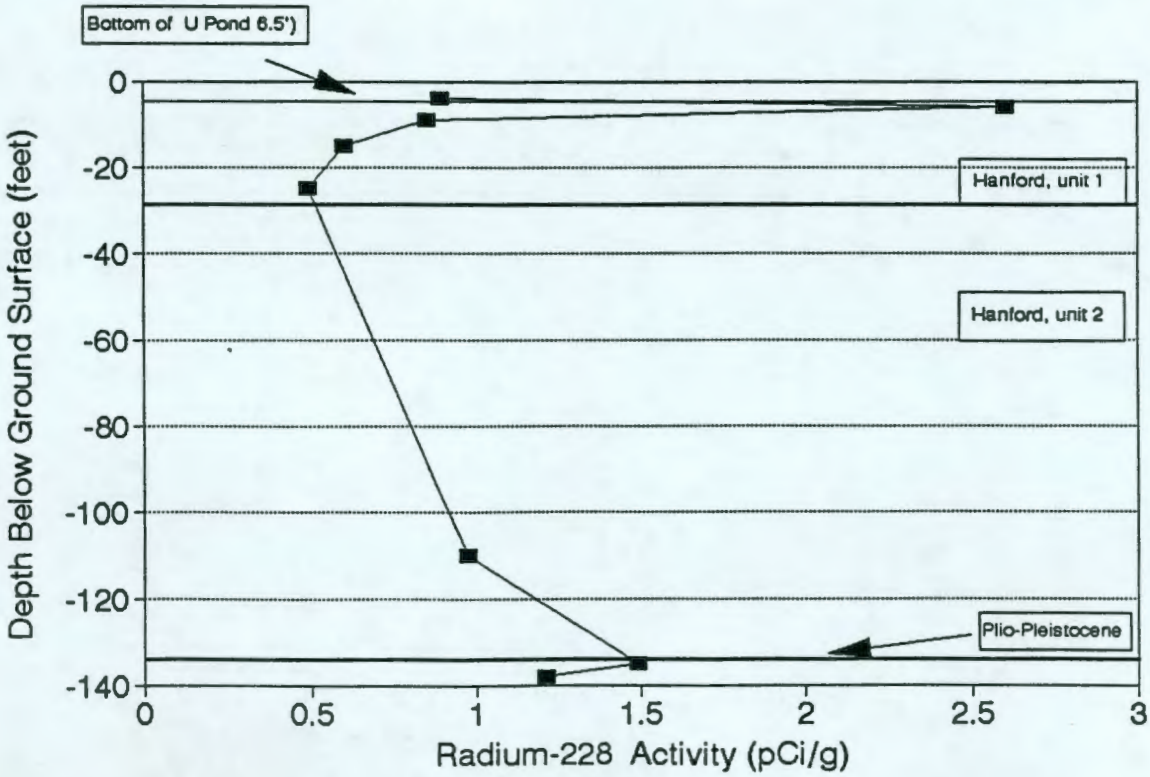


Figure 58. Vertical Distribution of Strontium-90 at the 216-U-10 Pond.

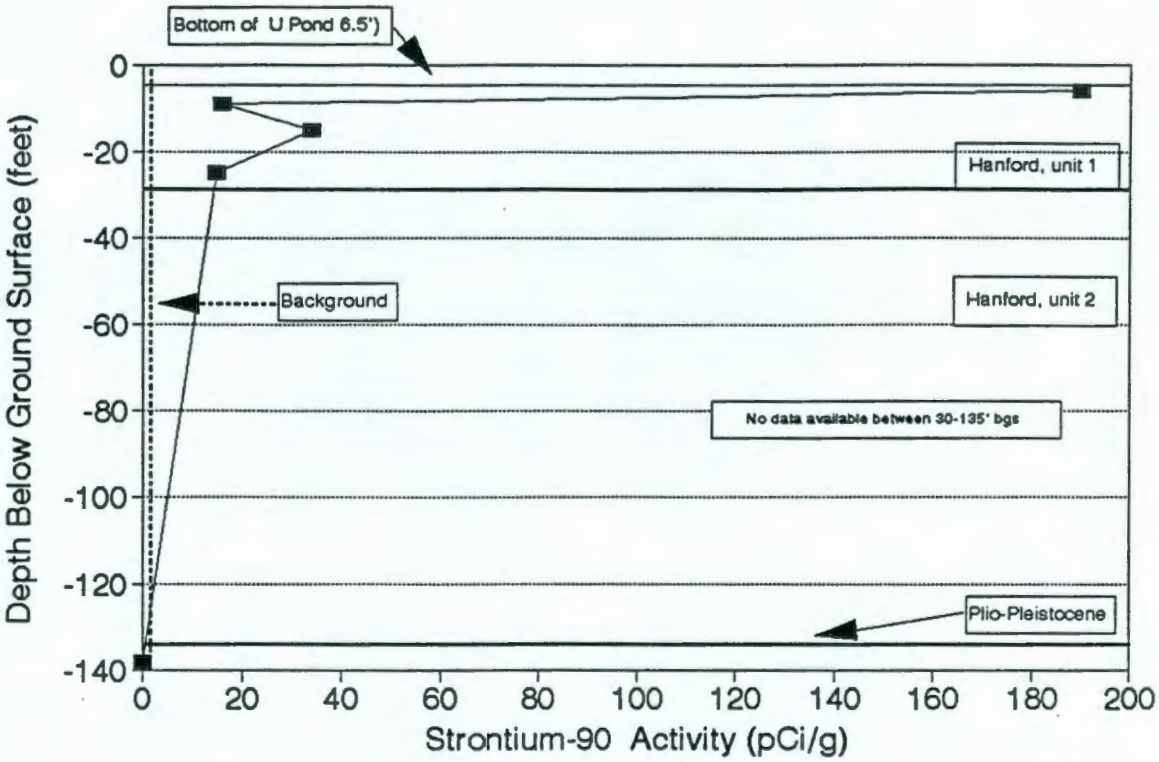


Figure 59. Vertical Distribution of Thorium-228 at the 216-U-10 Pond.

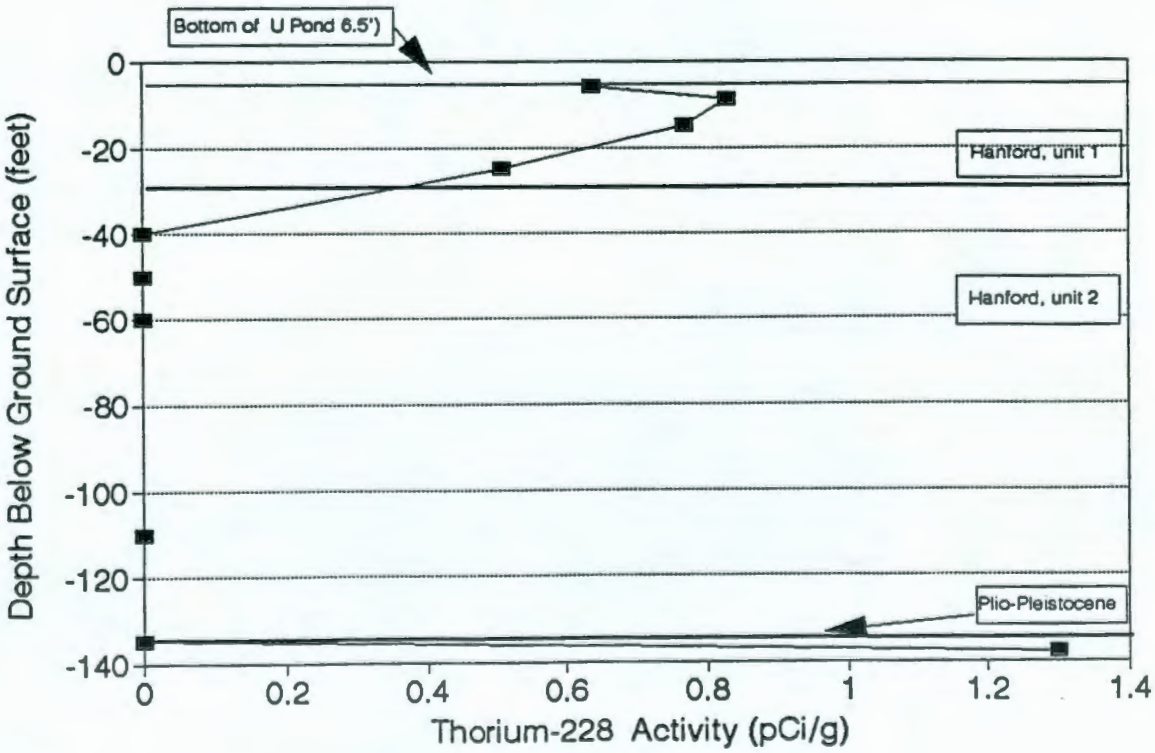


Figure 60. Vertical Distribution of Thorium-232 at the 216-U-10 Pond.

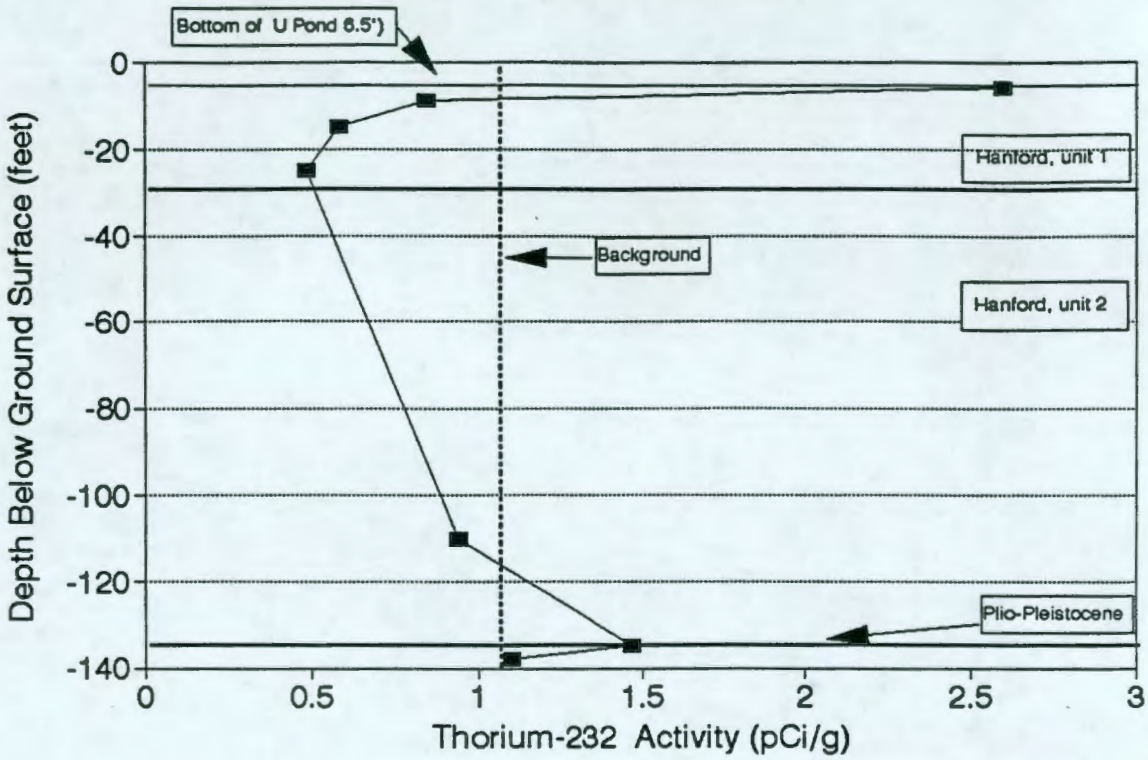


Figure 61. Vertical Distribution of Uranium-233/234 at the 216-U-10 Pond.

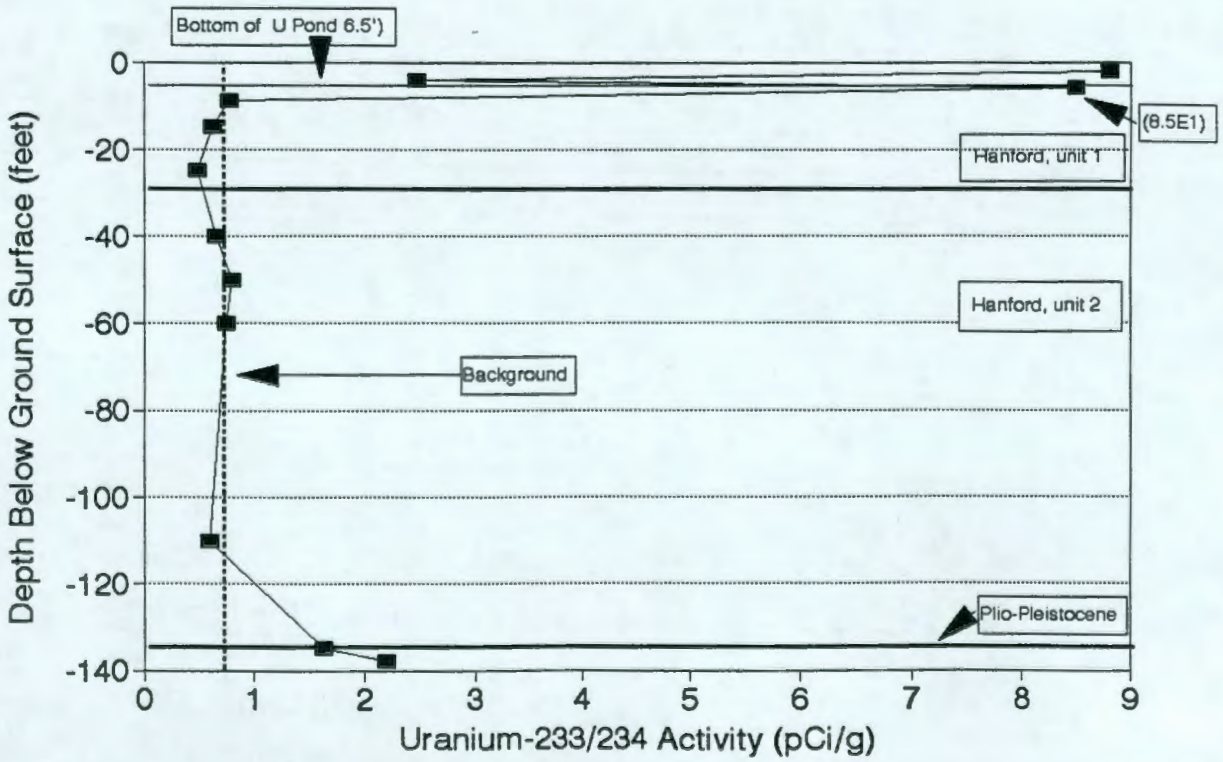


Figure 62. Vertical Distribution of Uranium-235 at the 216-U-10 Pond.

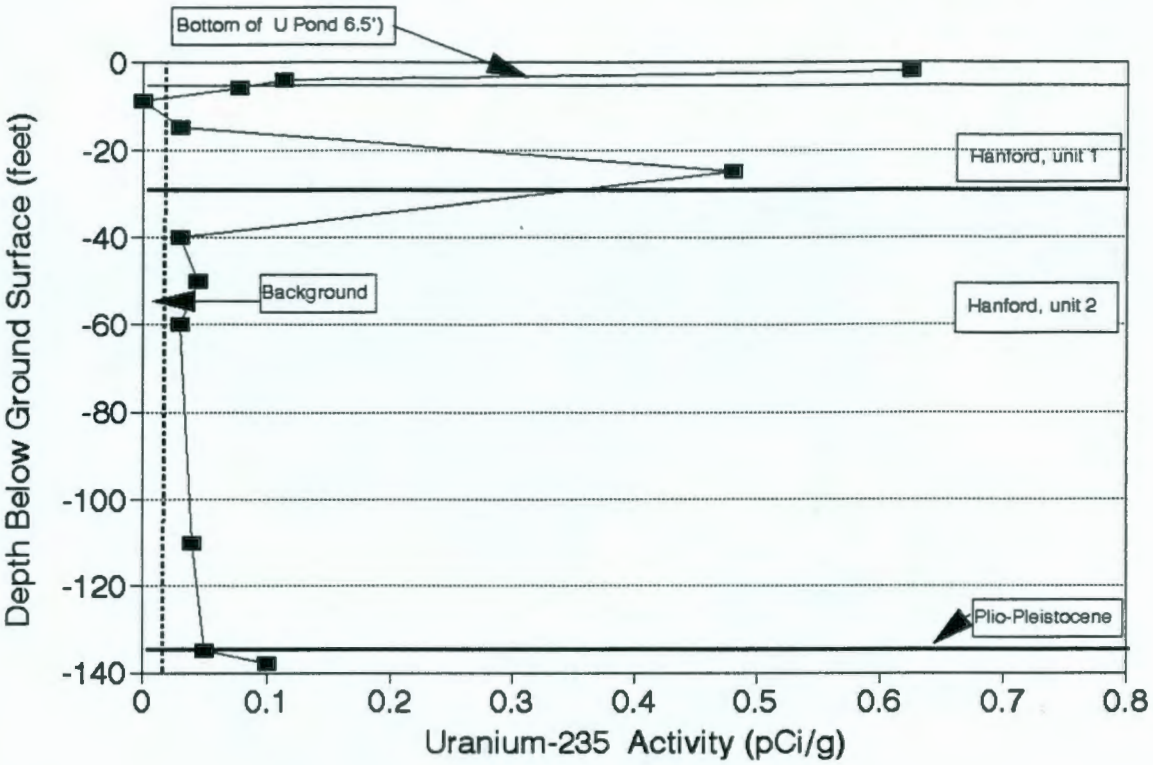


Figure 63. Vertical Distribution of Uranium-238 at the 216-U-10 Pond.

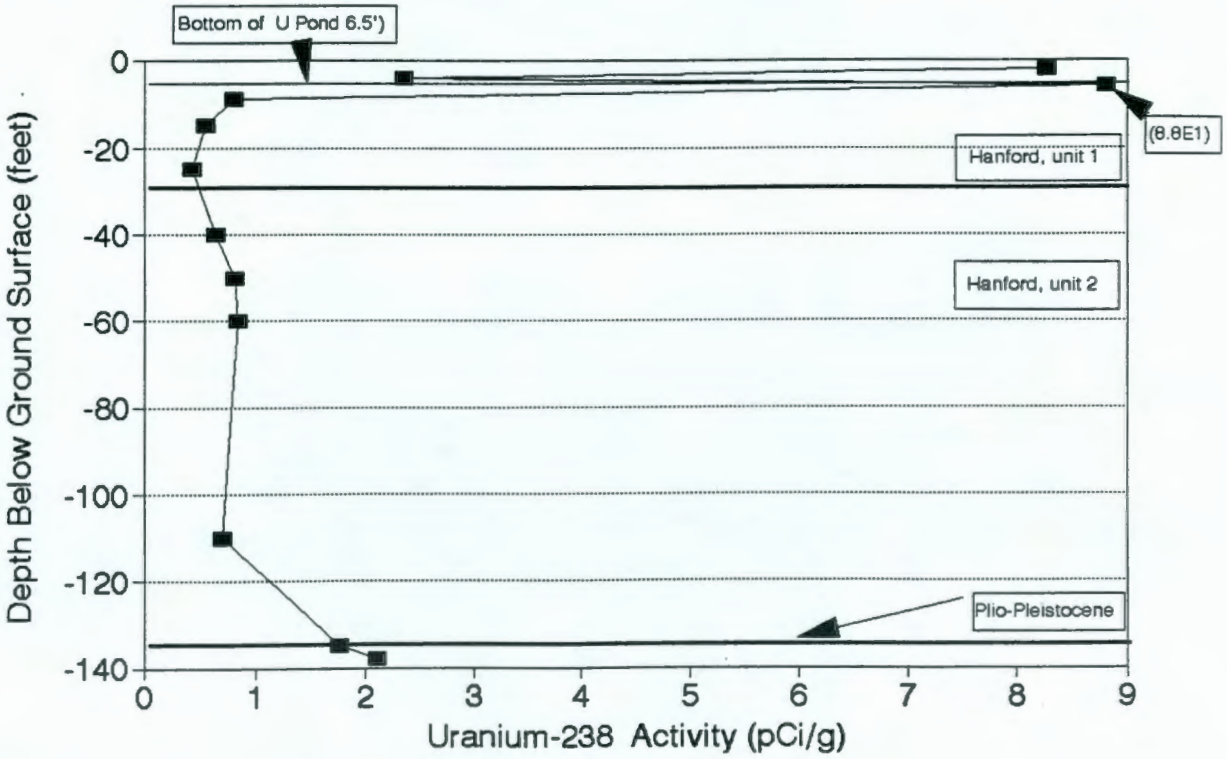


Table 1. Borehole Contour Database. (3 sheets)

Borehole	Elev (ft)	H1AISO	H1ISO	H2TOP	H2ISO	H3ISO	PPTOP	PPFINEISO	PPCRBTOP	PPCRBISO	RINGTOP	RUISO	RETOP
W19-2	694.00	0.00	30.00	664.00	160.00	0.00	504.00	0.00	504.00	25.00	479.00	0.00	479.00
W19-3	693.00	0.00	107.00	591.00	76.00	0.00	515.00	0.00	515.00	15.00	500.00	0.00	500.00
W19-5	698.00	0.00	76.00	622.00	80.00	0.00	542.00	0.00	542.00	12.00	530.00	0.00	530.00
W19-7	698.00	0.00	65.00	618.00	65.00	0.00	553.00	0.00	553.00	15.00	538.00	20.00	518.00
W19-10	680.00	0.00	65.00	615.00	75.00	0.00	540.00	20.00	520.00	11.00	509.00	0.00	509.00
W19-13	693.00	0.00	100.00	583.00	60.00	0.00	523.00	0.00	523.00	10.00	513.00	0.00	513.00
W19-14	691.00	0.00	87.00	579.00	50.00	0.00	529.00	0.00	529.00	10.00	519.00	0.00	519.00
W19-15	691.00	0.00	105.00	586.00	45.00	0.00	541.00	5.00	536.00	21.00	515.00	0.00	515.00
W19-16	693.00	0.00	86.00	602.00	49.00	0.00	553.00	5.00	548.00	22.00	526.00	0.00	526.00
W19-17	695.00	0.00	100.00	590.00	55.00	0.00	535.00	15.00	520.00	10.00	510.00	0.00	510.00
W19-18	699.00	0.00	103.00	591.00	52.00	0.00	539.00	0.00	539.00	23.00	516.00	0.00	516.00
W19-19	693.00	0.00	44.00	631.00	100.00	0.00	531.00	0.00	531.00	66.00	465.00	14.00	451.00
W19-20	689.00	0.00	95.00	594.00	80.00	0.00	514.00	0.00	514.00	30.00	484.00	20.00	464.00
W19-24	695.00	0.00	71.00	624.00	94.00	0.00	530.00	10.00	520.00	30.00	490.00	30.00	460.00
W19-25	690.00	0.00	60.00	630.00	119.00	0.00	511.00	0.00	511.00	31.00	480.00	25.00	455.00
W19-26	692.00	0.00	82.00	602.00	90.00	0.00	512.00	0.00	512.00	20.00	492.00	31.00	461.00
W19-28	700.00	0.00	80.00	620.00	84.00	0.00	536.00	6.00	530.00	35.00	495.00	15.00	480.00
W22-22	688.00	0.00	35.00	653.00	155.00	0.00	498.00	0.00	498.00	40.00	458.00	25.00	433.00
W22-23	689.00	0.00	67.00	622.00	125.00	0.00	497.00	0.00	497.00	21.00	476.00	34.00	442.00
W22-24	690.00	0.00	7.00	683.00	183.00	0.00	500.00	0.00	500.00	27.00	473.00	23.00	450.00
W22-25	679.00	0.00	6.00	668.00	129.00	0.00	539.00	0.00	539.00	11.00	528.00	0.00	528.00
W22-27	679.00	0.00	75.00	604.00	60.00	0.00	544.00	10.00	534.00	10.00	524.00	35.00	489.00
W18-29	671.00	0.00	93.00	570.00	27.00	0.00	543.00	1.00	542.00	19.00	523.00	0.00	523.00
W22-38	684.00	0.00	80.00	604.00	70.00	0.00	534.00	0.00	534.00	10.00	524.00	30.00	494.00
W22-26	678.00	0.00	55.00	618.00	80.00	0.00	538.00	10.00	528.00	25.00	503.00	0.00	503.00
W18-30	669.00	0.00	60.00	609.00	63.00	0.00	546.00	7.00	539.00	10.00	529.00	0.00	529.00
W18-31	661.00	0.00	25.00	636.00	93.00	0.00	543.00	12.00	531.00	10.00	521.00	0.00	521.00
W18-247	678.00	0.00	50.00	624.00	61.00	9.00	543.00	12.00	531.00	7.00	524.00	0.00	524.00
W19-12	672.00	0.00	71.00	597.00	65.00	0.00	532.00	0.00	532.00	20.00	512.00	0.00	512.00

Table 1. Borehole Contour Database. (3 sheets)

Borehole	Elev (ft)	H1AISO	H1ISO	H2TOP	H2ISO	H3ISO	PPTOP	PPFINEISO	PPCRBTOP	PPCRBISO	RINGTOP	RUISO	RETOP
W19-91	676.00	0.00	63.00	613.00	72.00	0.00	541.00	0.00	541.00	>15.00			
W19-21	677.00	0.00	50.00	622.00	80.00	0.00	542.00	5.00	537.00	26.00	511.00	0.00	511.00
W19-1	672.00	0.00	50.00	622.00	75.00	0.00	547.00	20.00	527.00	5.00	522.00	0.00	522.00
W19-27	682.00	0.00	80.00	602.00	65.00	0.00	537.00	5.00	532.00	20.00	512.00	0.00	512.00
W19-92	676.00	0.00	65.00	611.00	82.00	0.00	529.00	>3.00					
W19-93	675.00	0.00	60.00	605.00	>50.00	0.00							
W19-22	686.00	0.00	77.00	608.00	62.00	0.00	546.00						
W19-23	696.00	0.00	54.00	642.00	102.00	0.00	540.00	19.00	531.00	29.00	492.00	34.00	458.00
W18-10	681.00	35.00	25.00	621.00	40.00	35.00	546.00	10.00	535.00	15.00	521.00	0.00	521.00
W18-11	681.00	35.00	20.00	626.00	55.00	25.00	546.00	15.00	531.00	10.00	521.00	0.00	521.00
W18-22	666.00	20.00	55.00	591.00	55.00	0.00	536.00	5.00	531.00	10.00	521.00	0.00	521.00
W18-27	687.00	63.00	38.00	586.00	40.00	0.00	546.00	0.00	546.00	15.00	531.00	0.00	531.00
W18-28	677.00	49.00	23.00	605.00	65.00	0.00	540.00	3.00	537.00	15.00	522.00	0.00	522.00
W18-32	674.00	0.00	42.00	632.00	55.00	10.00	556.00	4.00	552.00	29.00	523.00	0.00	523.00
W19-8	700.00	0.00	65.00	635.00	110.00	0.00	525.00	10.00	515.00	25.00	490.00	0.00	490.00
W22-1	667.00	0.00	20.00	608.00	86.00	0.00	522.00	0.00	522.00	5.00	517.00	0.00	517.00
W22-2	667.00	0.00	12.00	620.00	93.00	0.00	527.00	0.00	527.00	12.00	515.00	0.00	515.00
W23-5	664.00	52.00	16.00	596.00	80.00	0.00	516.00	0.00	516.00	19.00	497.00	0.00	497.00
W23-6	667.00	36.00	16.00	615.00	86.00	0.00	529.00	0.00	529.00	15.00	514.00	10.00	504.00
W26-8	664.00	0.00	0.00	659.00	154.00	0.00		0.00			505.00	0.00	505.00
W18-9	681.00	32.00	26.00	623.00	49.00	25.00	549.00	15.00	534.00	11.00	523.00	0.00	523.00
W18-15	660.00	10.00	25.00	625.00	75.00	9.00	541.00	22.00	519.00	21.00	498.00	0.00	498.00
W18-19	670.00	0.00	34.00	629.00	51.00	10.00	568.00	8.00	560.00	31.00	529.00	0.00	529.00
W22-19	680.00	0.00	41.00	637.00	150.00	0.00	487.00	0.00	487.00	34.00	453.00	0.00	453.00
W22-20	674.00	0.00	0.00	669.00	191.00	0.00	478.00	0.00	478.00	37.00	441.00	0.00	441.00
35-78	658.00	0.00	50.00	608.00	95.00	0.00	513.00	0.00	513.00	15.00	498.00	0.00	498.00
38-70	709.00	0.00	70.00	634.00	110.00	0.00	524.00	0.00	524.00	15.00	509.00	25.00	484.00
W18-20	667.00	0.00	27.00	635.00	39.00	0.00	559.00	0.00	559.00	23.00	536.00	0.00	536.00

9513335.1132

Table 1. Borehole Contour Data Base. (3 sheets)

Borehole	Elev (ft)	H1AISO	H1ISO	H2TOP	H2ISO	H3ISO	PPTOP	PPFINEISO	PPCRBTOP	PPCRBISO	RINGTOP	RUISO	RETOP
W27-2	674.00	0.00		672.00	171.00	0.00	501.00	0.00	501.00	6.00	495.00	0.00	495.00
W22-44	675.00	35.00	20.00	615.00	120.00	0.00	495.00	0.00	495.00	10.00	485.00	0.00	485.00
W22-45	663.00	0.00	15.00	648.00	130.50	0.00	517.50	0.00	517.50	1.50	516.00	0.00	516.00
W22-46	668.00	50.00	15.00	598.00	68.00	0.00	530.00	0.00	530.00	4.00	526.00	0.00	526.00
W23-15	652.00	0.00	0.00	647.00	145.00	0.00	502.00	0.00	502.00	5.00	497.00	0.00	497.00
W26-12	672.00	0.00	0.00	672.00	174.00	0.00	498.00	0.00	498.00	14.00	484.00	0.00	484.00
W18-96	682.00	0.00	41.00	629.00	64.00	0.00	551.00	15.60	535.40				
W18-33	666.00	0.00	50.00	609.00	68.00	0.00	541.00	21.00	520.00	6.00	514.00	0.00	514.00
W18-251	665.00	0.00	37.00	620.00	62.00	0.00	542.00	25.00	517.00	>3.00			
W18-250	665.00	0.00	33.00	624.00	>26.00	0.00							
W23-16	670.00	0.00	45.00	619.00	60.00	0.00	542.00	26.00	516.00	8.00	508.00	0.00	508.00
W23-17	663.00	0.00	33.00	620.00	72.00	0.00	534.00	16.00	518.00	13.00	505.00	0.00	505.00
W23-13	663.00	0.00	35.00	618.00	37.00	0.00	510.00	0.00	510.00	2.00	508.00	0.00	508.00
W23-4	661.00	0.00	36.00	618.00	67.00	0.00	498.00	0.00	498.00	7.00	491.00	0.00	491.00
35-70	692.00	15.00	13.00	659.00	185.00	0.00	474.00	0.00	474.00	30.00	444.00	22.00	422.00
35-69A	705.00	0.00	10.00	691.00	216.00	0.00	475.00	0.00	475.00	4.00	471.00	6.00	465.00
W23-231	658.00	0.00	22.00	630.00	107.00	0.00	523.00	0.00	523.00	6.00	517.00	0.00	517.00
W19-95	693.00	0.00	98.00	589.00	57.00	0.00	532.00	5.00	527.00	8.00	519.00	7.00	512.00
W19-97	695.00	0.00	94.00	601.00	60.00	0.00	541.00	15.00	526.00	2.00	524.00	3.00	521.00
W19-98	704.00	0.00	41.00	648.00	121.00	0.00	527.00	7.00	520.00	7.00	513.00	3.00	510.00
W19-96	695.00	0.00	74.00	595.00	62.00	0.00	533.00	5.00	528.00	5.00	523.00	5.00	518.00
W22-78	689.00	0.00	27.00	656.00	147.00	0.00	509.00	6.00	503.00	18.00	485.00	>30.00	
W19-94	693.00	0.00	0.00	662.00	134.00	0.00	528.00	22.00	506.00	10.00	496.00	>2.00	
35-68A	715.00	0.00	13.00	696.00	218.00	0.00	478.00	0.00	478.00	14.00	464.00	>29.00	

Table 2. Borehole Drilling Summary Information.

Facility	Permanent borehole number	Start drilling date	End drilling date	Total depth (ft)	Geophysical logging intervals (ft)	Coordinates (Lambert)	Number of chemical samples collected/ analyzed	Number of physical samples collected/ analyzed	Elevation brass cap
South of U-8 Crib	299-W19-94	12-3-93	1-27-94	199	0-36 35-94.5 93.5-194 190.1-197	N:134,706.80 E:567,614.16	18	9	693.18
South of U-1/2 Crib	299-W19-95	9-2-93	9-23-93	182	0-100 99.5-179.6	N:134,937.83 E:567,275.32	12	12	692.71
U-1/2 Crib	299-W19-96	11-5-93	1-21-94	179	0-38.5 37-99 95-166.5 155-175.5	N:135,003.79 E:567,263.16	19	8	694.74
North of U-1/2 Crib	299-W19-97	9-3-93	9-28-93	177	0-99.5 101-176.5	N:135,044.06 E:567,283.78	12	11	694.81
U-4/4A	299-W19-98	3-2-94	3-29-94	194.5	0-9 9-96.5 95.5-145 145-184 181.5-191.5	N:135,109.57 E:567,578.43	13	11	704.20
U-12 Crib	299-W22-78	10-7-93	11-17-93	234	0-39 36-93 92-184 180-233.5	N:134,499.76 E:567,606.03	17	16	688.86
U-10 Pond	299-W23-231	3-10-94	3-28-94	141.5	0-11.5 10.5-79 78-140	N:134,601.06 E:566,301.33	11	5	657.60
U-10 Pond	216-U-10-TP-2	8-21-93	8-22-93	26	NA	N:134,672.00 E:566,227.10	5	5	656.90

Table 3. Borehole Field Screening Results. (9 sheets)

Depth (ft)	Alpha Activity@		Beta/Gamma Activity+		Dose rate >0.5 mRem/hr~
	CPM	DPM	CPM	DPM	
299-W19-94 -- Background 80 cpm					
30-32	-	-	-	-	yes
33.5-35.5	-	-	-	-	yes
37	-	-	-	-	yes
38-40	-	-	-	100,000	yes
40	-	<	-	35,000*	-
40.5	-	<	-	25,000*	-
41.5	-	<	-	25,000*	_
42	-	<	-	15,000*	-
44	-	<	-	6,000*	_
48-50	<	-	300	_	_
57.5-59.5	<	-	400	-	-
64-68	<	-	200	-	-
68-70	-	-	-	-	-
72-73	<	-	250	-	-
74	<	-	250	-	-
80.5	<	-	250	-	-
87	<	-	200	-	-
89.5-91.5	<	-	350	-	-
93	<	-	200	-	-
96	<	-	500	-	-
97.5	<	-	400	-	-
98	<	-	500	-	-
100	<	-	100	-	-
100-103	<	-	300	-	-

* Measurement through protective sleeve
\- Measurement not obtained
< Measurement less than detectable
\+ Beta/gamma contamination surveys are performed with P-11 or hp-206 pancake-type Geiger-Mueller probes attached to Eberline E-140b count rate meters.
@ Alpha surveys were performed exclusively with portable alpha monitors (PAM) consisting of a Hanford alpha scintillation detector attached to a Bicron "X" count rate meter
~ Dose rates were taken with Eberline RO-3B dose rate meters, which use an ion chamber to detect radiation.

Table 3. Borehole Field Screening Results. (9 sheets)

Depth (ft)	Alpha Activity@		Beta/Gamma Activity+		Dose rate >0.5 mRem/hr~
	CPM	DPM	CPM	DPM	
299-W19-94 -- Background 80 cpm (cont.)					
107	<	-	300	-	-
108	<	-	350	-	-
111	<	-	400	-	-
112	<	-	500	-	-
113	<	-	1100	_	_
114.5	<	-	1500	-	-
114.5-116.5	<	-	2000	_	_
120	-	<	-	10000	_
122	-	<	-	10000	-
123	<	-	900	-	-
128-130	-	-	1000	-	-
135-136	-	<	-	7300	-
139.5	-	<	-	5500	-
142.5	-	<	-	6500	-
143.5	-	<	-	6000	-
144	-	<	-	8500	
145.5	-	<	-	6500	-
146.5	-	<	-	8500	-
148-150	<	-	1200	-	-
149	-	<	-	7000	-
150.5	-	<	-	7500	-
154	-	<	-	6500	-
155	<	-	800	-	-
156	<	-	950	-	-

* Measurement through protective sleeve
\- Measurement not obtained
< Measurement less than detectable
\+ Beta/gamma contamination surveys are performed with P-11 or hp-206 pancake-type Geiger-Mueller probes attached to Eberline E-140b count rate meters.
@ Alpha surveys were performed exclusively with portable alpha monitors (PAM) consisting of a Hanford alpha scintillation detector attached to a Bicron "X" count rate meter
~ Dose rates were taken with Eberline RO-3B dose rate meters, which use an ion chamber to detect radiation.

Table 3. Borehole Field Screening Results. (9 sheets)

Depth (ft)	Alpha Activity@		Beta/Gamma Activity+		Dose rate >0.5 mRem/hr~
	CPM	DPM	CPM	DPM	
299-W19-94 -- Background 80 cpm (cont.)					
157	-	<	-	11,000	-
158	<	-	-	1000	-
159	-	<	-	8500	_
161	-	<	-	7500	-
162	<	-	650	_	_
163	-	<	-	8,000	_
165.5	-	<	-	13,000	-
168-170	-	<	-	15,000	-
169.5	-	<	-	9,500	-
173	-	<	-	9500	-
173.5	-	<	-	12,000	-
180-182	-	<	-	7500	-
183	-	<	-	14,000	-
183-185	<	-	700	-	
185-187	<	-	800	-	-
187-189	<	-	1400	-	-
190	-	<	-	10,000	-
193	-	<	-	7,000	-
194	-	<	-	8,000	-
196	-	<	-	7,000	-
197	-	<	-	9,000	-
197-199	-	<	-	9,000	-
299-W19-95 -- Background 60 cpm					
0-TD	<	<	<	<	-

* Measurement through protective sleeve
\- Measurement not obtained
< Measurement less than detectable
\+ Beta/gamma contamination surveys are performed with P-11 or hp-206 pancake-type Geiger-Mueller probes attached to Eberline E-140b count rate meters.
@ Alpha surveys were performed exclusively with portable alpha monitors (PAM) consisting of a Hanford alpha scintillation detector attached to a Bicron "X" count rate meter
~ Dose rates were taken with Eberline RO-3B dose rate meters, which use an ion chamber to detect radiation.

Table 3. Borehole Field Screening Results. (9 sheets)

Depth (ft)	Alpha Activity@		Beta/Gamma Activity+		Dose rate >0.5 mRem/hr~
	CPM	DPM	CPM	DPM	
299-W19-96 -- Background 50 cpm					
4.0	<	<	<	-	-
4.5	<	<	<	-	-
5.0	<	<	300	-	-
5.5	<	<	<	-	-
6.0	-	ND	2400	-	-
6-8	-	ND	8000	-	-
8-10**	-	-	7500	_	_
10-12	<	<	400	-	-
12-13.5	<	<	4000	_	_
13.5-15	<	<	1000	_	_
15	<	<	-	200,000	yes
16.5-17	-	-	-	100,000	yes
19.5	-	-	GM offscale	-	yes
20	-	-	-	-	yes
20-22	-	-	-	-	yes
23	-	-	-	-	yes
24.5-26.5	-	-	-	-	yes
25-25.5	-	-	-	-	yes
27-29	-	-	-	5600	yes
29.5-31.5	620 B Liner	-	-	-	yes
35-37	-	-	-	8000	yes
41-43	<	<	-	250,000- 500,000	-
43-45	-	-	-	300,000	yes

* Measurement through protective sleeve
** Measurement through casing
\- Measurement not obtained
< Measurement less than detectable
\+ Beta/gamma contamination surveys are performed with P-11 or hp-206 pancake-type Geiger-Mueller probes attached to Eberline E-140b count rate meters.
@ Alpha surveys were performed exclusively with portable alpha monitors (PAM) consisting of a Hanford alpha scintillation detector attached to a Bicron "X" count rate meter
~ Dose rates were taken with Eberline RO-3B dose rate meters, which use an ion chamber to detect radiation.

Table 3. Borehole Field Screening Results. (9 sheets)

Depth (ft)	Alpha Activity@		Beta/Gamma Activity+		Dose rate >0.5 mRem/hr~
	CPM	DPM	CPM	DPM	
299-W19-96 -- Background 50 cpm (cont.)					
46	-	-	-	100,000	-
47	<	-	-	200,000	yes
48-50	<	-	-	50,000	-
50-52	<	<	-	4,000	-
55	<	<	-	5,000	-
56	<	<	_	12,000	_
58	<	<	-	6,000	-
60	<	<	<	<	_
60-62	<	<	<	<	_
63	<	<	<	<	-
68	<	<	<	4000	-
69	<	<	<	<	_
70	<	<	<	4000	_
72	<	<	<	3000	-
75 through 168	<	<	<	<	-
168-170	-	-	250		-
170 to TD	<	<	<	<	-
299-W19-97 -- Background equals 500 ppm					
2-3	<	<	<	500	-
4-6	<	<	<	<	-
6-8	<	<	-	600	-
9	<	<	<	<	-
10-TD	-	ND	<	<	-

* Measurement through protective sleeve
- Measurement not obtained
< Measurement less than detectable
+ Beta/gamma contamination surveys are performed with P-11 or hp-206 pancake-type Geiger-Mueller probes attached to Eberline E-140b count rate meters.
@ Alpha surveys were performed exclusively with portable alpha monitors (PAM) consisting of a Hanford alpha scintillation detector attached to a Bicron "X" count rate meter
~ Dose rates were taken with Eberline RO-3B dose rate meters, which use an ion chamber to detect radiation.

Table 3. Borehole Field Screening Results. (9 sheets)

Depth (ft)	Alpha Activity@		Beta/Gamma Activity+		Dose rate >0.5 mRem/hr~
	CPM	DPM	CPM	DPM	
299-W19-98 – Background 75 cpm					
4.4-5.	<	<	1000	-	-
11	105	<	500	-	-
11-13.5	<	-	150-200	-	-
14	<	-	200	-	-
15	<	-	250	-	-
15-17.25	<	-	100	-	-
18-22	<	-	<	_	_
23	<	-	150	-	-
24	<	-	900	_	_
24-26.5	<	-	<	_	_
28-32	<	-	<	-	-
33	14	-	150	-	-
33.5	14	-	<	-	-
34.5	-	7000	300	-	-
34.5-36.6	<	-	100	-	-
37	<	-	220	-	-
38.8	<	-	200	-	-
39	<	-	200	-	
40.5	-	-	350	-	-
42	<	-	350	-	-
44	<	-	650	-	-
46	<	-	550	-	-
46.5	<	-	850	-	-
47	<	<	1500	-	-
47-49.5	-	-	-	2000-15000	-

* Measurement through protective sleeve
- Measurement not obtained
< Measurement less than detectable
+ Beta/gamma contamination surveys are performed with P-11 or hp-206 pancake-type Geiger-Mueller probes attached to Eberline E-140b count rate meters.
@ Alpha surveys were performed exclusively with portable alpha monitors (PAM) consisting of a Hanford alpha scintillation detector attached to a Bicron "X" count rate meter
~ Dose rates were taken with Eberline RO-3B dose rate meters, which use an ion chamber to detect radiation.

Table 3. Borehole Field Screening Results. (9 sheets)

Depth (ft)	Alpha Activity@		Beta/Gamma Activity+		Dose rate >0.5 mRem/hr~
	CPM	DPM	CPM	DPM	
299-W19-98 – Background 75 cpm (cont.)					
50	-	210	-	2500	-
51	-	3150	-	15000	-
52.5	-	5950	-	15000	-
54	-	3850	-	20000	_
54.5	-	8400	-	30000	-
56.5	-	140	-	6000	_
57	-	3500	-	25000	_
58.5	-	140	-	4000	-
59	-	140	-	2000	-
60	-	<	-	8000	-
60-62.5	<-8	-	-	750-12,500	-
64	-	140	-	9000	-
66	<	-	-	20,000	-
67.5	<	-	-	5500	-
68.5	<	-	-	7000	
69.5	<	-	-	1500	-
71-TD	<	-	-	<	-
299-W22-78 – Background 75 cpm					
19	<	-	400	-	-
19-21	<	-	200-400	-	-
21-23	<	-	200-800	-	-
24.5	<	-	350	-	-
25.5	<	-	400	-	-
26	<	-	400	-	-

* Measurement through protective sleeve
- Measurement not obtained
< Measurement less than detectable
+ Beta/gamma contamination surveys are performed with P-11 or hp-206 pancake-type Geiger-Mueller probes attached to Eberline E-140b count rate meters.
@ Alpha surveys were performed exclusively with portable alpha monitors (PAM) consisting of a Hanford alpha scintillation detector attached to a Bicron "X" count rate meter
~ Dose rates were taken with Eberline RO-3B dose rate meters, which use an ion chamber to detect radiation.

Table 3. Borehole Field Screening Results. (9 sheets)

Depth (ft)	Alpha Activity@		Beta/Gamma Activity+		Dose rate >0.5 mRem/hr~
	CPM	DPM	CPM	DPM	
299-W22-78 – Background 75 cpm (cont.)					
28	<	-	28	-	_
29	<	<	150	-	-
30	<	-	200	_	_
31	<	-	350	-	_
32.5	<	-	250	-	-
33.5	<	-	425	-	-
34.5	<	-	125	-	-
38-40	<	-	250	-	-
39	<	-	250	-	-
40.5	<	-	250	-	-
43	<	-	275	-	-
44	<	-	200	-	-
47	<	-	250	-	-
48	<	-	200	-	-
54.5	<	-	200	-	-
56.0	<	-	175	-	-
56.5	<	-	150	-	-
59.5	<	-	200	-	-
60	<	-	300	-	-
61	<	-	350	-	-
61.5	<	-	200	-	-
63.5	<	-	325	-	-
64	<	-	300	-	-
64.5	<	-	300	-	-
64 to TD	<	-	-	-	-

* Measurement through protective sleeve
- Measurement not obtained
< Measurement less than detectable
+ Beta/gamma contamination surveys are performed with P-11 or hp-206 pancake-type Geiger-Mueller probes attached to Eberline E-140b count rate meters.
@ Alpha surveys were performed exclusively with portable alpha monitors (PAM) consisting of a Hanford alpha scintillation detector attached to a Bicron "X" count rate meter
~ Dose rates were taken with Eberline RO-3B dose rate meters, which use an ion chamber to detect radiation.

Table 3. Borehole Field Screening Results. (9 sheets)

Depth (ft)	Alpha Activity@		Beta/Gamma Activity+		Dose rate >0.5 mRem/hr~
	CPM	DPM	CPM	DPM	
299-W23-231 – Background 50 cpm (cont.)					
2-4	<	-	8000	-	-
4-6	200-1000	-	100-1500	-	-
26.5	-	<	-	2000	-
28	-	<	-	1500	-
83	<	<	-	-	-
84-141	<	-	<	-	-
Test Pit 216-U-10-TP-2 – Background 50 cpm					
6.5	-	-	2500	-	-
6.5-6.8	-	-	15,000	-	-
9-10	-	-	-	2000	-
11	-	-	50	-	-
12	-	<	1000	-	-
12.5	-	<	2000	-	-
13	-	<	<	-	-
14	-	<	<	-	-
14.5	-	<	-	1000	-
15-17	<	-	-	1000	-
17.5	<	-	-	2500	-
22	<	-	-	1500	-
25-26	-	-	-	2000	-

* Measurement through protective sleeve

\- Measurement not obtained

< Measurement less than detectable

\+ Beta/gamma contamination surveys are performed with P-11 or hp-206 pancake-type Geiger-Mueller probes attached to Eberline E-140b count rate meters.

@ Alpha surveys were performed exclusively with portable alpha monitors (PAM) consisting of a Hanford alpha scintillation detector attached to a Bicron "X" count rate meter

~ Dose rates were taken with Eberline RO-3B dose rate meters, which use an ion chamber to detect radiation.

Table 4. Borehole Physical Sampling Summary. (3 sheets)

Well	Sample number	Sample Depth (ft)	$CaCO_3$ Conc. (%)	Moisture (Wt %)	Compacted Porosity (%)	Specific Gravity	Dry Density (g/cc)	pH	Unsat-K (cm/sec)
W19-94	B094M0	38-40	<1	5.8	44.08	2.70	1.51	NA	NA
W19-94	B094M1	57.5-59.5	1.9	4.9	35.84	2.70	1.73	NA	NA
W19-94	B094M2	68-70	<1	2.3	35.99	2.70	1.73	NA	NA
W19-94	B094M3	89.5-91.5	ND	2.7	35.14	2.70	1.75	NA	NA
W19-94	B094M4	114.5-116.5	1.3	4.8	42.73	2.70	1.55	NA	NA
W19-94	B094M5	128-130	<1	2.5	37.26	2.70	1.69	NA	NA
W19-94	B094M6	168-170	1.7	8.5	35.21	2.70	1.75	NA	NA
W19-94	B094M7	185-187	2.9	7.0	39.30	2.70	1.64	NA	NA
W19-95	B094P5	47-49.5	*	*	*	*	*	NA	NA
W19-95	B094P8	90.25-92.75	*	*	*	*	*	NA	NA
W19-95	B094P3	14.5-17	<1	4.8	37.49	2.76	1.7	NA	NA
W19-95	B094P4	30-32.5	<1	ND	ND	2.75	1.86	NA	NA
W19-95	B094P4	30-32.5	<1	2.75	33	2.79	1.86	NA	see Appendix B
W19-95	B094P6	60-62.5	<1	2.70	24.96	2.71	2.03	NA	NA
W19-95	B094P7	74.8-77.3	<1	3.12	32.8	2.7	1.8	NA	NA
W19-95	B094Q0	120-122.25	<1	3.82	37.8	2.7	1.7	NA	NA
W19-95	B094Q1	140-142.25	1.1	ND	37	2.70	1.71	NA	see Appendix B
W19-95	B094Q2	151-153	2.1	ND	36	2.71	1.74	NA	see Appendix B
W19-95	B094Q3	165-167	3.5	ND	39	2.78	1.68	NA	see Appendix B
W19-95	B094Q4	169-171.5	5.3	4.51	37.3	2.6	1.7	NA	NA
W19-95	B094T3	181-182	2.6	1.46	21.63	2.64	2.1	NA	NA
W19-96	B094K8	50-52	<1	2.7	29.56	2.7	1.90	NA	NA
W19-96	B094K9	80-82	<1	2.51	NA	NA	NA	NA	NA
W19-96	B094L0	99.5-101.5	1.6	17.42	40.96	2.76	1.63	NA	NA
W19-96	B094L1	120-122	1.4	20.49	43.58	2.70	1.52	NA	NA
W19-96	B094L2	143-145	<1	3.83	NA	NA	NA	NA	NA
W19-96	B094L3	159-161	1.6	9.7	41.0	2.7	1.6	NA	NA
W19-96	B094L5	168-170	8.7	20.2	38.29	2.70	1.67	NA	NA
W19-96	B094L6	175-177	<1	4.01	36.92	2.67	1.68	NA	NA

Table 4. Borehole Physical Sampling Summary. (3 sheets)

Well	Sample number	Sample Depth (ft)	$CaCO_3$ Conc. (%)	Moisture (Wt %)	Compacted Porosity (%)	Specific Gravity	Dry Density (g/cc)	pH	Unsat-K (cm/sec)
W19-97	B094N2	4-6	<1	3.91	35.41	2.70	1.74	NA	NA
W19-97	B094N3	10-12	<1	10.07	41.50	2.79	1.63	NA	NA
W19-97	B094N4	30-32	<1	4.28	34.10	2.83	1.9	NA	NA
W19-97	B094N5	50-52.5	<1	5.13	37.86	2.70	1.7	NA	NA
W19-97	B094N5	50-52.5	<1	14.02	37.98	2.71	1.7	NA	NA
W19-97	B094N6	70-72.5	<1	2.39	28.93	2.71	1.9	NA	NA
W19-97	B094N6	70-72.5	<1	2.37	29.84	2.69	1.9	NA	NA
W19-97	B094N7	101-103	<1	8.63	NA	NA	NA	NA	NA
W19-97	B094N8	130-132.5	<1	6.71	30.5	2.7	1.90	NA	NA
W19-97	B094N8	130-132.5	<1	6.62	29.0	2.7	1.9	NA	NA
W19-97	B094N9	146-148.5	1.6	8.54	NA	NA	NA	NA	NA
W19-97	B094P0	156-158.5	1.8	17.3	36.9	2.7	1.7	NA	NA
W19-97	B094P0	156-158.5	1.8	17.0	38.2	2.7	1.7	NA	NA
W19-97	B094P1	167.5-169.6	3.5	13.83	32.4	2.8	1.9	NA	NA
W19-97	B094P1	167.5-169.6	1.8	18.58	34.9	2.7	1.8	NA	NA
W19-97	B094P2	175.7-177	1.8	3.94	21.42	2.75	2.2	NA	NA
W19-98	B094Q7	11-13.5	ND	3.6	31.89	2.70	1.84	NA	NA
W19-98	B094Q8	24-26.5	<1	12.2	38.10	2.70	1.67	NA	NA
W19-98	B094Q9	34.5-36.8	1.0	4.4	36.94	2.70	1.70	NA	NA
W19-98	B094R0	47-49.5	ND	2.80	31.47	2.70	1.85	NA	NA
W19-98	B094R1	60-62.2	ND	5.3	37.63	2.70	1.68	NA	NA
W19-98	B094R2	80-82.1	<1	8.7	37.7	2.7	1.7	NA	NA
W19-98	B094R3	100-102.5	<1	6.7	37.7	2.7	1.7	NA	NA
W19-98	B094R4	130-132.5	<1	4.2	48.7	2.7	1.4	NA	NA
W19-98	B094R5	173-175.3	1.4	10.7	49.7	2.7	1.4	NA	NA
W19-98	B094R6	183.5-185.5	4.5	11.2	21.2	2.8	2.2	NA	NA
W19-98	B094R7	191.1-193	<1	4.7	36.6	2.70	1.7	NA	NA
W22-78	B094R9	9-11	<1	10.49	ND	ND	ND	5.78	NA
W22-78	B094S0	19-21	<1	2.8	37.15	2.70	1.70	NA	NA
W22-78	B094S1	21-23	<1	4.5	41.75	2.70	1.57	NA	NA

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Table 4. Borehole Physical Sampling Summary. (3 sheets)

Well	Sample number	Sample Depth (ft)	$CaCO_3$ Conc. (%)	Moisture (Wt %)	Compacted Porosity (%)	Specific Gravity	Dry Density (g/cc)	pH	Unsat-K (cm/sec)
W22-78	B094S2	38-40	<1	4.8	40.97	2.70	1.59	NA	NA
W22-78	B094S3	49.5-51.75	<1	4.36	NA	NA	NA	6.0	NA
W22-78	B094S4	70-72.5	<1	2.06	NA	NA	NA	6.1	NA
W22-78	B094S5	90-92.5	<1	5.82	NA	NA	NA	6.1	NA
W22-78	B094S6	109.5-112	<1	3.96	NA	NA	NA	6.0	NA
W22-78	B094S7	129.75-135.25	1.1	3.96	NA	NA	NA	6.1	NA
W22-78	B094S8	150-152	1.1	3.10	NA	NA	NA	6.2	NA
W22-78	B094S9	170-172.5	1.4	11.63	NA	NA	NA	6.5	NA
W22-78	B094T4	185-187.5	4.7	10.57	NA	NA	NA	6.6	NA
W22-78	B094T5	194-196.5	<1	12.05	NA	NA	NA	6.6	NA
W22-78	B094T6	198.5-200	<1	20.67	NA	NA	NA	5.6	NA
W22-78	B094T7	209.5-212	<1	21.16	NA	NA	NA	6.0	NA
W22-78	B094Q5	222-224.5	<1	16.46	NA	NA	NA	6.05	NA
W22-78	B094Q6	230-232.5	3	19.52	NA	NA	NA	6.1	NA
W23-231	B0BGD2	25	<1	3.1	ND	2.70	ND	NA	NA
W23-231	B0BGD3	41-42	<1	8.1	44.2	2.79	1.6	NA	NA
W23-231	B0BGD5	60-62	1.1	9.1	41.0	2.69	1.6	NA	NA
W23-231	B0BGD4	98-99	1.8	19.36	ND	2.70	ND	NA	NA
W23-231	B0BGD6	110-112	1.6	18.33	53.2	2.80	1.3	NA	NA
W23-231	B0BGD7	135-137	9.2	20.7	36.7	2.80	1.7	NA	NA
W23-231	B0BGD8	138-140	8.9	15.6	ND	2.70	ND	NA	NA
U-10-TP2	B09316	6.5	<1	7.1	NA	NA	NA	NA	NA
U-10-TP2	B09313	6.5-7.5	<1	8.8	NA	NA	NA	NA	NA
U-10-TP2	B09317	9-10	<1	5.0	NA	NA	NA	NA	NA
U-10-TP2	B09318	15-17	<1	4.7	NA	NA	NA	NA	NA
U-10-TP2	B09319	25-26	<1	4.6	NA	NA	NA	NA	NA

* Sample condition not acceptable for testing purpose
ND = Analytical results not documented
NA = Analysis not requested

Table 5. Borehole Sampling Summary. (9 sheets)

Sample Number	Interval Sampled	Sample Type	ANALY	Sample Date	Ship Date	Lab	Offsite Number
299-W19-94							
B09DP9	N/A	TRIP	SS	12-03-93	12-07-93	TMA	W94-0-0138-22
B09DQ0	4'-6'	SOIL	"	12-03-93	12-07-93	TMA	W94-0-0138-22
B09DQ1	15.1'-17.5'	SOIL	"	12-06-93	12-07-93	TMA	W94-0-0138-22
B09DQ2	28'-30'	SOIL	@	12-07-03	12-17-93	TMA	W94-0-0138-33
B09DQ3	30'-32'	SOIL	!	11-15-93	11-19-93	PNL	ORSR-17385
B09DQ3	30'-32'	SOIL	!!	11-16-93	11-19-93	PNL	ORSR-17873
B09DQ3	30'-32'	SOIL	!!!	11-17-93	11-19-93	PNL	ORSR-17386
B09DQ4	33.5'-36'	SOIL	!	12-08-93	12-10-93	PNL	ORSR-17385
B09DQ4	33.5'-36'	SOIL	!!	12-08-93	12-10-93	PNL	ORSR-17873
B09DQ4	33.5'-36'	SOIL	!!!	12-08-93	12-10-93	PNL	ORSR-17386
B09DQ8	38'-40'	SOIL	"	12-13-93	12-17-93	TMA	ORSR-17892
B09DQ9	48'-50'	SOIL	"	12-14-93	12-17-93	TMA	ORSR-17885
B09DR0	57.5'-59.5'	SOIL	"	12-14-93	12-17-93	TMA	ORSR-17885
B09DR3	68'-70'	SOIL	"	12-15-93	12-17-93	TMA	ORSR-17892
B09DR5	89.5'-91.5'	SOIL	"	12-16-93	12-21-93	TMA	ORSR-17388
B09DR7	114'-116'	SOIL	"	01-03-04	01-08-94	TMA	ORSR-17890
B09DR8	N/A	TRIP	SS	01-03-94	01-08-94	TMA	ORSR-17890
B09DS3	128'-130'	SOIL	"	01-04-94	01-08-94	TMA	ORSR-17890
B09DS9	148'-150'	SOIL	"	01-06-94	01-10-94	TMA	ORSR-17894
B09DT0	148'-150'	SPLT	""	01-06-94	01-10-94	WESTON	ORSR-17596
B09DT1	165.5'-167.5'	DUPE	"	01-07-94	01-11-94	TMA	ORSR-17389
B09DT2	165.5'-167.5'	SOIL	"	01-07-94	01-11-94	TMA	ORSR-17389
B09DT3	N/A	TRIP	SS	01-07-94	01-11-94	TMA	ORSR-17389
B09DT8	185'-187'	SOIL		01-12-94	DISCARDED		
B09DT9	187'-189'	SOIL	"	01-13-94	01-17-94	TMA	ORSR-17394
B09WF5	N/A	FLDBLK	"	01-13-94	01-17-94	TMA	W94-0-0-216-3
B09WF6	N/A	EQTBLK	"	01-13-94	01-17-94	TMA	W94-0-0-216-3
B09WF4	197'-199'	SOIL	"	01-17-94	01-20-94	TMA	ORSR-17895
B09WF7	N/A	TRIP	SS	01-17-94	01-20-94	TMA	ORSR-17895

299-W19-94 TD at 199 ft.

@ANALYSIS-G, 1000ml;Gross alpha/beta,Gamma Spec to include, Cs-134,Cs-137,Co-60,Eu-152,Eu-154,Eu-155,K-40,
Ru-106,Na-22;Total Uranium, U-235,U-234,U-238,Np-237,Pu-238,Pu-239/240,I-129,Sr-90,Tc-99,
Am-241,Cm-244,Se-79

"ANALYSIS-G,1000ml;Gross alpha/beta,Gamma Spec to include, Cs-134,Cs-137,Co-60,Eu-152,Eu-154,Eu-155,
K-40,Ru-106,Na-22;Total Uranium, U-235,U-234,U-238,Np-237,Pu-238,Pu-239/240,I-129,
Sr-90,Tc-99,Am-241,Cm-244,Se-79
Gs,125ml;Kerosene
G,125ml;Cyanide
G,125ml;Anions (NO2,NO3)
G,125ml;Anions (F,Cl,SO4)
aG,250ml;Semi-VOA CLP
aGs,250ml;VOA CLP
aG,250ml;Metals TAL CLP ; Hg,Ti

""ANALYSIS-G,1000ml;Gross alpha/beta,Gamma Spec to include, Cs-134,Cs-137,Co-60,Eu-152,Eu-154,Eu-155,
K-40,Ru-106,Na-22;Total Uranium, U-235,U-234,U-238,Np-237,Pu-238,Pu-239/240,
Sr-90,Tc-99,Am-241,Cm-244,Se-79
G,250ml;Cyanide
G,125ml;Anions (NO2,NO3)
G,250ml;Anions (F,Cl,SO4)
aG,500ml;Semi-VOA CLP
aGs,125ml;VOA CLP
aG,500ml;Metals TAL CLP ; Hg,Ti

!ANALYSIS-Gs,125ml;Kerosene
aG,250ml;Semi-VOA CLP
aGs,250ml;VOA CLP

!!ANALYSIS-G,125ml;Cyanide
G,125ml;Anions (NO2,NO3)
G,125ml;Anions (F,Cl,SO4)
aG,250ml;Metals TAL CLP ; Hg,Ti

!!!ANALYSIS-G,1000ml;Gross alpha/beta,Gamma Spec to include, Cs-134,Cs-137,Co-60,Eu-152,Eu-154,Eu-155,
K-40,Ru-106,Na-22;Total Uranium, U-235,U-234,U-238,Np-237,Pu-238,Pu-239/240,I-129,
Sr-90,Tc-99,Am-241,Cm-244,Se-79.

SSANALYSIS-aGs,250ml;VOA CLP

Table 5. Borehole Sampling Summary. (9 sheets)

Sample Number	Interval Sampled	Sample Type	ANALY	Sample Date	Ship Date	Lab	Offsite Number
299-W19-95							
B09323	4'-6'	SOIL	**	09-02-93	09-07-93	TMA	W93-0-0667#46
B09324	14.5'-16.5'	SOIL	*	09-03-93	09-07-93	TMA	W93-0-0667#46
B09326	30'-32.5'	SOIL	*	09-07-93	09-09-93	TMA	W93-0-0667#47
B09329	45'-47.5'	SOIL	*	09-08-93	09-09-93	TMA	W93-0-0667#47
68K-4332	N/A	SOIL	*	09-08-93	N/A	222-S	OIL SPILL SAMPLE
B09331	N/A	TRIP	$$	09-08-93	09-09-93	TMA	W93-0-0667#47
B09332	60'-62.5'	SOIL	*	09-09-93	09-13-93	TMA	W93-0-0764#2
B09336	74.8'-77.3'	SOIL	*	09-10-93	09-13-93	TMA	W93-0-0764#2
B09337	90.25'-92.25'	SOIL	*	09-13-93	09-16-93	TMA	W93-0-0764#10
B09340	105'-107.5'	SOIL	*	09-15-93	09-16-93	TMA	W93-0-0764#10
B09343	105'-107.5'	SPLT	$	09-15-93	09-16-93	WESTON	W93-0-0764#11
B09344	120'-122.5'	SOIL	*	09-15-93	09-16-93	TMA	W93-0-0764#10
B09345	140'-142.5'	SOIL	*	09-16-93	09-20-93	TMA	W93-0-0764#16
B09349	165'-167.5'	SOIL	*	09-16-93	09-20-93	TMA	W93-0-0764#16
B09358	N/A	TRIP	$$	09-20-93	09-20-93	TMA	W93-0-0764#16
B09356	169'-171.5'	SOIL	*	09-20-93	09-23-93	TMA	W93-0-0764#23
B09357	169'-171.5'	DUPE	*	09-20-93	09-23-93	TMA	W93-0-0764#23
B09359	N/A	FLDBLK	*	09-20-93	09-23-93	TMA	W93-0-0764#23
B09360	N/A	EQTBLK	*	09-20-93	09-23-93	TMA	W93-0-0764#23
B09361	181'-182'	SOIL	*	09-20-93	09-23-93	TMA	W93-0-0764#23

299-W19-95 TD at 182 ft.

**ANALYSIS-G,1000ml;Gross alpha/beta,Gamma Spec to include, Cs-134,Cs-137,Co-60,Eu-152,Eu-154,Eu-155,
K-40,Ru-106,Na-22;Total Uranium, U-235,U-234,U-238,Np-237,Pu-238,Pu-239/240,I-129,
Sr-90,Tc-99,Am-241,Cm-244,Se-79

*ANALYSIS-G,1000ml;Gross alpha/beta,Gamma Spec to include, Cs-134,Cs-137,Co-60,Eu-152,Eu-154,Eu-155,
K-40,Ru-106,Na-22;Total Uranium, U-235,U-234,U-238,Np-237,Pu-238,Pu-239/240,I-129,
Sr-90,Tc-99,Am-241,Cm-244,Se-79
Gs,125ml;Kerosene
G,125ml;Cyanide
G,125ml;Anions (NO2,NO3)
G,125ml;Anions (F,Cl,SO4)
aG,250ml;Semi-VOA CLP
aGs,250ml;VOA CLP
aG,250ml;Metals TAL CLP ; Hg,Ti

$ANALYSIS-G,1000ml;Gross alpha/beta,Gamma Spec to include, Cs-134,Cs-137,Co-60,Eu-152,Eu-154,Eu-155,
K-40,Ru-106,Na-22; U-235,U-234,U-238,Np-237,Pu-238,Pu-239/240,
Sr-90,Tc-99,Am-241,Cm-244,Se-79
G,250ml;Cyanide
G,125,ml:Anions (NO2,NO3)
G,250ml;Anions (F,Cl,SO4)
aG,500ml;Semi-VOA CLP
Gs,125ml;VOA CLP
aG,500ml;Metals TAL CLP ; Hg,Ti

$$ANALYSIS-aGs,250ml;VOA CLP

Table 5. Borehole Sampling Summary. (9 sheets)

Sample Number	Interval Sampled	Sample Type	ANALY	Sample Date	Ship Date	Lab	Offsite Number
			299-W19-96				
B09DP0	4'-6'	SOIL	*	11-05-93	11-09-93	TMA	ORSR-17891
B09DP1	15'-17'	SOIL	!	11-10-93	11-16-93	PNL	ORSR-17862
B09DP1	15'-17'	SOIL	!!	11-10-93	11-16-93	PNL	ORSR-17868
B09DP1	15'-17'	SOIL	!!!	11-10-93	11-16-93	PNL	ORSR-17863
B09DP2	N/A	TRIP	SS	11-10-93	11-16-93	PNL	ORSR-17862
B09DP3	22'-24'	SOIL	!	11-12-93	11-16-93	PNL	ORSR-17862
B09DP3	22'-24'	SOIL	!!	11-12-93	11-16-93	PNL	ORSR-17868
B09DP3	22'-24'	SOIL	!!!	11-12-93	11-16-93	PNL	ORSR-17863
B09DP4	24.5'-27'	SOIL	!	11-15-93	11-19-93	PNL	ORSR-17878
B09DP4	24.5'-27'	SOIL	!!	11-15-93	11-19-93	PNL	ORSR-17598
B09DP4	24.5'-27'	SOIL	!!!	11-15-93	11-19-93	PNL	ORSR-17879
B09DP5	27'-29.5'	SOIL	!	11-16-93	11-19-93	PNL	ORSR-17878
B09DP5	27'-29.5'	SOIL	!!	11-16-93	11-19-93	PNL	ORSR-17598
B09DP5	27'-29.5'	SOIL	!!!	11-16-93	11-19-93	PNL	ORSR-17879
B09DP6	29.5'-32'	SOIL	!	11-17-93	11-19-93	PNL	ORSR-17878
B09DP6	29.5'-32'	SOIL	!!	11-17-93	11-19-93	PNL	ORSR-17598
B09DP6	29.5'-32'	SOIL	!!!	11-17-93	11-19-93	PNL	ORSR-17879
B09DP7	35'-37'	SOIL		11-19-93	DISCARDED		
B09DP8	N/A	TRIP		11-19-93	DISCARDED		
B09DQ6	40.5'-42.5'	SOIL	*	12-09-93	12-14-93	TMA	ORSR-17867
B09DQ7	50'-52'	SOIL	*	12-13-93	12-17-93	TMA	ORSR-17892
B09DR1	60'-62'	SOIL	*	12-15-93	12-17-93	TMA	W94-0-0138-33
B09DR2	N/A	TRIP	SS	12-15-93	12-17-93	TMA	W94-0-0138-33
B09DR4	80'-82'	SOIL	*	12-16-93	12-21-93	TMA	W94-0-0138-39
B09DR6	99.5'-101.5'	SOIL	*	12-20-93	12-21-93	TMA	W94-0-0138-39
B09DR9	120'-122'	SOIL	*	01-03-94	01-06-94	TMA	W94-0-0138-45
B09DS0	N/A	TRIP	SS	01-03-94	01-06-94	TMA	W94-0-0138-45
B09DS1	140'-142'	SOIL	*	01-03-94	01-06-94	TMA	W94-0-0138-45
B09DS2	140'-142'	DUPE	*	01-03-94	01-06-94	TMA	W94-0-0138-45
B09DS4	159'-161'	SOIL	*	01-05-94	01-06-94	TMA	W94-0-0138-45
B09DS5	166'-168'	SPLT	**	01-05-94	01-06-94	WESTON	W94-0-0138-46
B09DS6	166'-168'	SOIL	*	01-05-94	01-06-94	TMA	W94-0-0138-45
B09DS7	N/A	TRIP	SS	01-05-94	01-06-94	WESTON	W94-0-0138-46
B09DS8	168'-170'	SOIL	*	01-05-94	01-08-94	TMA	ORSR-17890

Table 5. Borehole Sampling Summary. (9 sheets)

Sample Number	Interval Sampled	Sample Type	ANALY	Sample Date	Ship Date	Lab	Offsite Number
B09DT4	N/A	FLDBLK	*	01-11-94	01-14-94	TMA	W94-0-0216
B09DT5	N/A	EQTBLK	*	01-11-94	01-14-94	TMA	W94-0-0216
B09DT6	N/A	TRIP	$$	01-11-94	01-14-94	TMA	W94-0-0216
B09DT7	175'-177'	SOIL	*	01-11-94	01-14-94	TMA	W94-0-0216-1

299-W19-96 TD of 179 ft.
*ANALYSIS-G,1000ml;Gross alpha/beta,Gamma Spec to include, Cs-134,Cs-137,Co-60,Eu-152,Eu-154,Eu-155,
K-40,Ru-106,Na-22;Total Uranium, U-235,U-234,U-238,Np-237,Pu-238,Pu-239/240,I-129,
Sr-90,Tc-99,Am-241,Cm-244,Se-79
Gs,125ml;Kerosene
G,125ml;Cyanide
G,125ml;Anions (NO2,NO3)
G,125ml;Anions (F,Cl,SO4)
aG,250ml;Semi-VOA CLP
aGs,250ml;VOA CLP
aG,250ml;Metals TAL CLP ; Hg,Ti
**ANALYSIS-G,1000ml;Gross alpha/beta,Gamma Spec to include, Cs-134,Cs-137,Co-60,Eu-152,Eu-154,Eu-155,
K-40,Ru-106,Na-22;Total Uranium, U-235,U-234,U-238,Np-237,Pu-238,Pu-239/240,
Sr-90,Tc-99,Am-241,Cm-244,Se-79
G,250ml;Cyanide
G,125ml;Anions (NO2,NO3)
G,250ml;Anions (F,Cl,SO4)
aG,500ml;Semi-VOA CLP
aGs,125ml;VOA CLP
aG,500ml;Metals TAL CLP ; Hg,Ti
!ANALYSIS-Gs,125ml;Kerosene
aG,250ml;Semi-VOA CLP
aGs,250ml;VOA CLP
!!ANALYSIS-G,125ml;Cyanide
G,125ml;Anions (NO2,NO3)
G,125ml;Anions (F,Cl,SO4)
aG,250ml;Metals TAL CLP ; Hg,Ti
!!!ANALYSIS-G,1000ml;Gross alpha/beta,Gamma Spec to include, Cs-134,Cs-137,Co-60,Eu-152,Eu-154,Eu-155,
K-40,Ru-106,Na-22;Total Uranium, U-235,U-234,U-238,Np-237,Pu-238,Pu-239/240,I-129,
Sr-90,Tc-99,Am-241,Cm-244,Se-79
$$ANALYSIS-aGs,250ml;VOA CLP

Table 5. Borehole Sampling Summary. (9 sheets)

Sample Number	Interval Sampled	Sample Type	ANALY	Sample Date	Ship Date	Lab	Offsite Number
299-W19-97							
B09325	4'-6'	SOIL	"	09-07-93	09-09-93	TMA	W93-0-0667#47
B09327	10'-12.5'	SOIL	"	09-08-93	09-09-93	TMA	W93-0-0667#47
B09328	20'-22.5'	SOIL	"	09-08-93	09-09-93	TMA	W93-0-0667#47
B09330	30'-32'	SOIL	"	09-08-93	09-09-93	TMA	W93-0-0667#47
B09333	50'-52.5'	SOIL	"	09-10-93	09-13-93	TMA	W93-0-0764#2
B09335	N/A	TRIP	SS	09-13-93	09-13-93	TMA	W93-0-0764#2
B09339	70'-72.5'	SOIL	"	09-13-93	09-16-93	TMA	W93-0-0764#10
B09341	101'-103.3'	SOIL	"	09-15-93	09-16-93	TMA	W93-0-0764#10
B09342	101'-103.3'	SPLT	S	09-15-93	09-16-93	WESTON	W93-0-0764#11
B09347	N/A	TRIP	"	09-16-93	09-16-93	TMA	W93-0-0764#10
B09346	130'-132.5'	SOIL	"	09-16-93	09-20-93	TMA	W93-0-0764#16
B09348	N/A	TRIP	SS	09-16-93	09-16-93	WESTON	W93-0-0764#11
B09350	N/A	EQTBLK	"	09-17-93	09-20-93	TMA	W93-0-0764#16
B09351	146'-148.5'	SOIL	"	09-17-93	09-20-93	TMA	W93-0-0764#16
B09352	146'-148.5'	DUPE	"	09-17-93	09-20-93	TMA	W93-0-0764#16
B09353	N/A	FLDBLK	"	09-17-93	09-20-93	TMA	W93-0-0764#16
B09354	156'-158.5'	SOIL	"	09-17-93	09-20-93	TMA	W93-0-0764#16
B09355	167.5'-170'	SOIL	"	09-20-93	09-23-93	TMA	W93-0-0764#23
B09362	175.7'-177'	SOIL	"	09-21-93	09-23-93	TMA	W93-0-0764#23
B098Y6	N/A	TRIP	SS	09-21-93	09-23-93	TMA	W93-0-0764#23

299-W19-97 TD at 177 ft.

"ANALYSIS-G,1000ml;Gross alpha/beta,Gama Spec to include, Cs-134,Cs-137,Co-60,Eu-152,Eu-154,Eu-155,
K-40,Ru-106,Na-22;Total Uranium, U-235,U-234,U-238,Np-237,Pu-238,Pu-239/240,I-129,
Sr-90,Tc-99,Am-241,Cm-244,Se-79
Gs,125ml;Kerosene
G,125ml;Cyanide
G,125ml;Anions (NO2,NO3)
G,125ml;Anions (F,Cl,SO4)
aG,250ml;Semi-VOA CLP
aGs,250ml; VOA CLP
aG,250ml;Metals TAL CLP ; Hg Ti

$ANALYSIS-G,1000ml;Gross alpha/beta,Gamma Spec to include, Cs-134,Cs-137,Co-60,Eu-152,Eu-154,Eu-155,
K-40,Ru-106,Na-22; U-235,U-234,U-238,Np-237,Pu-238,Pu-239/240,
Sr-90,Tc-99,Am-241,Cm-244,Se-79
G,250ml;Cyanide
G,125,ml:Anions (NO2,NO3)
G,250ml;Anions (F,Cl,SO4)
aG,500ml;Semi-VOA CLP
Gs,125ml;VOA CLP
aG,500ml;Metals TAL CLP ; Hg,Ti

$$ANALYSIS-aGs,250ml;VOA CLP

Table 5. Borehole Sampling Summary. (9 sheets)

Sample Number	Interval Sampled	Sample Type	ANALY	Sample Date	Ship Date	Lab	Offsite Number
			299-W19-98				
B09WF3	4.4'-5.4'	SOIL	*	01-13-94	01-17-94	TMA	ORSR-17394
B09WF8	11'-13.5'	SOIL	*	03-02-94	03-04-94	TMA	ORSR-17896
B09WF9	15-17.25'	SOIL	*	03-03-94	03-04-94	IT	ORSR-17897
B09WG0	24'-26.5'	SOIL	*	03-04-94	03-10-94	IT	W94-0-0369-14
B09WG1	N/A	TRIP	**	03-04-94	03-04-94	TMA	ORSR-17896
B09WG2	N/A	TRIP	**	03-04-94	03-04-94	IT	ORSR-17897
B09WG3	54.5'	TOTAL ACTIVITY	!	03-08-94		222-S	
B09WG4	47'-49	SOIL	*	03-08-94	03-14-94	IT	ORSR-18107
B09WG5	60'-62.2'	SOIL	*	03-09-94	03-11-94	IT	ORSR-18105
B09WG6	34.5'-36.8'	SOIL	*	03-07-94	DISCARDED		
B09WG7	80'-82.1'	SOIL	*	03-10-94	03-14-94	IT	W94-0-0369-16
B09WH0	100'-102.5'	SOIL	*	03-14-94	03-17-94	IT	W94-0-0369-23
B09WH1	130'-132'	SOIL	*	03-15-94	03-17-94	IT	W94-0-0369-23
B09WH2	173'-175.3'	SOIL	*	03-17-94	03-21-94	IT	W94-0-0369-29
B09WH3	173'-175.3'	DUPE	*	03-17-94	03-21-94	IT	W94-0-0369-29
B09WJ8	N/A	TRIP	**	03-16-94	03-17-94	IT	W94-0-0369-23
B09WH4	183.5'-185.5'	SOIL	*	03-17-94	03-21-94	IT	W94-0-0369-29
B09WH5	183.5'-185.5'	SPLT	*	03-17-94	03-21-94	TMA	W94-0-0369-30
B09WH6	N/A	TRIP	**	03-21-94	03-21-94	IT	W94-0-0369-29
B09WH7	N/A	TRIP	**	03-21-94	03-21-94	TMA	W94-0-0369-30
B09WI0	191.1'-193'	SOIL	*	03-22-94	03-23-94	IT	W94-0-0369-34
B09WI1	N/A	TRIP	**	03-22-94	03-23-94	IT	W94-0-0369-34

299-W19-98 TD 194.5 ft.
*ANALYSIS-G,1000ml;Gross alpha/beta,Gamma Spec to include, Cs-134,Cs-137,Co-60,Eu-152,Eu-154,Eu-155,
K-40,Ru-106,Na-22;Total Uranium, U-235,U-234,U-238,Np-237,Pu-238,Pu-239/240,I-129,
Sr-90,Tc-99,Am-241,Cm-244,Se-79
Gs,125ml;Kerosene
G,125ml;Cyanide
G,125ml;Anions (NO2,NO3)
G,125ml;Anions (F,Cl,SO4)
aG,250ml;Semi-VOA CLP
aGs,250ml;VOA CLP
aG,250ml;Metals TAL CLP ; Hg,Ti
**ANALYSIS-G,1000ml;Gross alpha/beta,Gamma Spec to include, Cs-134,Cs-137,Co-60,Eu-152,Eu-154,Eu-155,
K-40,Ru-106,Na-22;Total Uranium, U-235,U-234,U-238,Np-237,Pu-238,Pu-239/240,
Sr-90,Tc-99,Am-241,Cm-244,Se-79
G,250ml;Cyanide
G,125ml;Anions (NO2,NO3)
G,250ml;Anions (F,Cl,SO4)
aG,500ml;Semi-VOA CLP
aGs,125ml;VOA CLP
aG,500ml;Metals TAL CLP ; Hg,Ti
!ANALYSIS-Gs,125ml;Kerosene
aG,250ml;Semi-VOA CLP
aGs,250ml;VOA CLP
!!ANALYSIS-G,125ml;Cyanide
G,125ml;Anions (NO2,NO3)
G,125ml;Anions (F,Cl,SO4)
aG,250ml;Metals TAL CLP ; Hg,Ti
!!!ANALYSIS-G,1000ml;Gross alpha/beta,Gamma Spec to include, Cs-134,Cs-137,Co-60,Eu-152,Eu-154,Eu-155,
K-40,Ru-106,Na-22;Total Uranium, U-235,U-234,U-238,Np-237,Pu-238,Pu-239/240,I-129,
Sr-90,Tc-99,Am-241,Cm-244,Se-79
$$ANALYSIS-aGs,250ml;VOA CLP

Table 5. Borehole Sampling Summary. (9 sheets)

Sample Number	Interval Sampled	Sample Type	ANALY	Sample Date	Ship Date	Lab	Offsite Number
299-W22-78							
B098Z0	19'-21'			10-11-93	DISCARDED		
B098Z1	21'-23'	SOIL	*	10-11-93	10-28-93	TMA	ORSR-17886
B098Z2	38'-40.6'	SOIL	*	10-12-93	10-28-93	TMA	ORSR-17886
B098Z3	49.5'-52'	SOIL	*	10-14-93	10-28-93	TMA	W94-0-0009-29
B098Z4	70'-72.5'	SOIL	*	10-15-93	10-28-93	TMA	W94-0-0009-29
B098Z5	90'-92.5'	SOIL	*	10-19-93	10-28-93	TMA	W94-0-0009-29
B098Z6	109.5'-112'	SOIL	*	10-21-93	10-28-93	TMA	W94-0-0009-29
B098Z7	129.75'-132.25'	SOIL	*	10-21-93	10-28-93	TMA	W94-0-0009-29
B098Z8	150'-152'	SOIL	*	10-22-93	10-28-93	TMA	W94-0-0009-29
B098Z9	150'-152'	DUPE	*	10-22-93	10-28-93	TMA	W94-0-0009-29
B09900	150'-152'	SPLT	*	10-22-93	10-28-93	WESTON	W94-0-0009-30
B09901	170'-172.5'	SOIL	*	10-25-93	10-28-93	TMA	W94-0-0009-29
B09902	182.5'-185'			10-25-93	DISCARDED		
B09903	185'-187.5'	SOIL	*	10-25-93	10-28-93	TMA	W94-0-0009-29
B09904	194'-196.5'	SOIL	*	10-29-93	11-08-93	TMA	W94-0-0009-41
B09905	198.5'-200.0'	SOIL	*	11-01-93	11-08-93	TMA	W94-0-0009-41
B09906	209.5'-212'	SOIL	*	11-01-93	11-08-93	TMA	W94-0-0009-41
B09907	222'-224.5'	SOIL	*	11-02-93	11-08-93	TMA	W94-0-0009-41
B09908	230'-232.5'	SOIL	*	11-02-93	11-08-93	TMA	W94-0-0009-41

299-W22-78 TD at 234 ft.
*ANALYSIS-G,1000ml;Gross beta,Total Uranium, U-235,U-234,U-238,Tc-99
G,125ml;Anions (NO2,NO3)

Table 5. Borehole Sampling Summary. (9 sheets)

Sample Number	Interval Sampled	Sample Type	ANALY	Sample Date	Ship Date	Lab	Offsite Number
			299-W23-231				
B09W18	2'-4'	SOIL	*	03-10-94	03-14-94	IT	ORSR-18107
B09W19	4'-6'	SOIL	*	03-10-94	03-14-94	IT	W94-0-0369-16
B09WJ0	6'-8'	SOIL	*	03-11-94	03-14-94	IT	W94-0-0369-16
B09WJ1	N/A	TRIP	**	03-10-94	03-14-94	IT	ORSR-18107
B09WJ2	N/A	TRIP	**	03-10-94	03-14-94	IT	W94-0-0369-16
B09WJ3	15'-17'	SOIL	*	03-14-94	03-17-94	IT	W94-0-0369-23
B09WJ4	40'-42'	SOIL	*	03-15-94	03-17-94	IT	W94-0-0369-23
B09WJ5	50'-52'	SOIL	*	03-15-94	03-17-94	IT	W94-0-0369-23
B09WJ6	N/A	TRIP	**	03-16-94	03-17-94	IT	W94-0-0269-23
B09WJ7	60'-62'	SOIL	*	03-16-94	03-17-94	IT	W94-0-0369-23
B09WJ9	110'-112'	SOIL	*	03-21-94	03-24-94	IT	W94-0-0369-42
B09WK0	135'-137'	SOIL	*	03-22-94	03-24-94	IT	W94-0-0369-42
B09WK1	135'-137'	DUPE	*	03-22-94	03-24-94	IT	W94-0-0369-42
B09WK2	138'-140'	SOIL	*	03-22-94	03-24-94	IT	W94-0-0369-42
B09WK3	138'-140'	SPLT	*	03-22-94	03-24-94	TMA	W94-0-0369-43
B09WK4	N/A	FLDBLK	*	03-23-94	03-24-94	IT	W94-0-0369-42
B09WK5	N/A	EQTBLK	*	03-23-94	03-23-94	IT	W94-0-0369-42
B09WK6	N/A	TRIP	**	03-23-94	03-24-94	IT	W94-0-0369-42
B09WK7	N/A	TRIP	**	03-24-94	03-24-94	TMA	W94-0-0369-43

299-W23-231 TD at 141.5 ft.

*ANALYSIS-G,1000ml;Gross alpha/beta,Gamma Spec to include, Cs-134,Cs-137,Co-60,Eu-152,Eu-154,Eu-155,
K-40,Ru-106,Na-22;Total Uranium, U-235,U-234,U-238,Np-237,Pu-238,Pu-239/240,I-129,
Sr-90,Tc-99,Am-241,Cm-244,Se-79
Gs,125ml;Kerosene
G,125ml;Cyanide
G,125ml;Anions (NO2,NO3)
G,125ml;Anions (F,Cl,SO4)
aG,250ml;Semi-VOA CLP
aGs,250ml;VOA CLP
aG,250ml;Metals TAL CLP ; hG tl

**ANALYSIS-AgS,250ML; VOA CLP

Table 5. Borehole Sampling Summary. (9 sheets)

Sample Number	Interval Sampled	Sample Type	ANALY	Sample Date	Ship Date	Lab	Offsite Number
216-U-10-TP-2							
B09338	N/A	EQPTBLK	*	08-21-93	08-23-93	TMA	ORSR#16171
B09313	6.5'-7.5'	SOIL	*	08-21-93	08-23-93	TMA	ORSR#16171
B09316	6.5'	SOIL	*	08-21-93	08-23-93	TMA	ORSR#17593
B09317	9'-10'	SOIL	*	08-22-93	08-23-93	TMA	ORSR#16171
B09314	9'-10'	SPLT	$	08-22-93	08-23-93	WESTON	ORSR#17864
B09315	9'-10'	DUPE	*	08-22-93	08-23-93	TMA	ORSR#16171
B09318	15'-17'	SOIL	*	08-22-93	08-23-93	TMA	ORSR#16171
B09319	25'-26'	SOIL	*	08-22-93	08-23-93	TMA	ORSR#16171
B09320	N/A	FLDBLK	*	08-22-93	08-23-93	TMA	ORSR#16171
B09321	N/A	TRIP	$$	08-22-93	08-23-93	TMA	ORSR#16171
B09322	N/A	TRIP	$$	08-22-93	08-23-93	WESTON	ORSR#17864

*ANALYSIS-G,1000ml;Gross alpha/beta,Gamma Spec to include, Cs-134,Cs-137,Co-60,Eu-152,Eu-154,Eu-155,
K-40,Ru-106,Na-22;Total Uranium, U-235,U-234,U-238,Np-237,Pu-238,Pu-239/240,I-129,
Sr-90,Tc-99,Am-241,Cm-244,Se-79
Gs,125ml;Kerosene
G,125ml;Cyanide
G,125ml;Anions (NO2,NO3)
G,125ml;Anions (F,Cl,SO4)
aG,250ml;Semi-VOA CLP
aGs,250ml;VOA CLP
aG,250ml;Metals TAL CLP ; Hg, Ti

$ANALYSIS-G,1000ml;Gross alpha/beta, Gamma Spec to include, Cs-134,Cs-137,Co-60,Eu-152,Eu-154,Eu-155,
K-40,Ru-106,Na-22; U-235,U-234,U-238,Np-237,Pu-238,Pu-239/240,
Sr-90,Tc-99,Am-241,Cm-244,Se-79
G,250ml;Cyanide
G,125ml;Anions (NO2,NO3)
G,250ml;Anions (F,Cl,SO4)
aG,500ml;Semi-VOA CLP
Gs,125ml;VOA CLP
aG,500ml;Metals TAL CLP ; Hg Ti

$$ANALYSIS -aGs,250ml;VOA CLPS

Table 6. Borehole Geophysical Survey Summary.

Well Number	Date Survey Completed	Disposal Site	Maximum Survey Depth (ft)	^{137}Cs	^{60}Co	^{152}Eu	^{154}Eu	^{235}U	^{238}U
299-W19-2	Feb 09, 1994	U-8	239.5	X					
299-W19-70	Feb 07, 1994	U-8	81.5	X			X		X
299-W19-71	Feb 02, 1994	U-8	79.5	X				X	X
299-W19-94	Dec 10, 1993	U-8	197.0	X			X	X	X
299-W19-95	Sep 21, 1994	U-1	179.5	X					
299-W19-96	Jan 12, 1994	U-1	175.5	X	X	X	X	X	X
299-W19-97	Sep 23, 1993	U-1	176.5	X					
299-W19-98	Mar 23, 1994	U-4A	192.5	X	X		X		
299-W22-78	Nov 04, 1993	U-12	233.5	X				X	X
299-W23-231	Mar 23, 1994	U-10	140.0	X					

APPENDIX A

BOREHOLE LITHOLOGY, GEOPHYSICAL AND SAMPLING SUMMARY

Soil Symbols	Sampler and Well Symbols
SILT	CH Split spoon chemical sample
Sandy SILT	PH Split spoon physical sample
Silty SAND	Split spoon chemical and physical
Slightly Silty SAND	Bentonite crumbles
SAND	
Gravelly SILT	
Gravelly Sandy Silt	
Gravelly Silty SAND	
Slightly Silty Gravelly SAND	
Gravelly SAND	
Silty GRAVEL	
Silty Sandy Gravel	
Sandy GRAVEL	
GRAVEL	

LOG LEGEND

Project: 200-UP-2 Operable Unit		Test Pit No: 216-U-10-TP2	Page 1 of 1
Date Started: 6-24-93	Date Completed: 6-25-93	Total Depth: 26.00	Water Level:
Logged By: M. Melhorn	Checked By: G. Kelty	Surface Elevation: 656.90	Facility: 216-U-10 Pond
Company: Kaiser	Operator: D. Riley	Northing: 134672.00	Easting: 566277.10
Method: Backhoe		Equipment:	
Comments:			

Elev'n (Feet) / Depth (Feet)	Lithology	Sample	Interval	Remarks	Sieve Analysis (clay, silt, sand, gravel, fines)	% CaCO3 / % Moist	Rad Cnt cpm
	0-6.5' Slighlty Silty SAND. Clean stabilization material.						
			6.0				
			6.5	Area of highest radiological contamination.		7.1 / 8.8	2500
650	6.5-7.0' SILT Area of former pond bottom.		7.0			1 / 1	15K
	7.0-9.0' Gravelly SAND						
	9.0-16.0' SAND						
10			10.0			5 / 1	2000
			11.0				
			15.0			4.7 / 1	100
640	16-26.0' Sandy GRAVEL		17.0				
20							
			25.0			4.6 / 1	200
	Bottom of test pit 26'		26.0				
630							
30							

CZ S P/C B

10 90

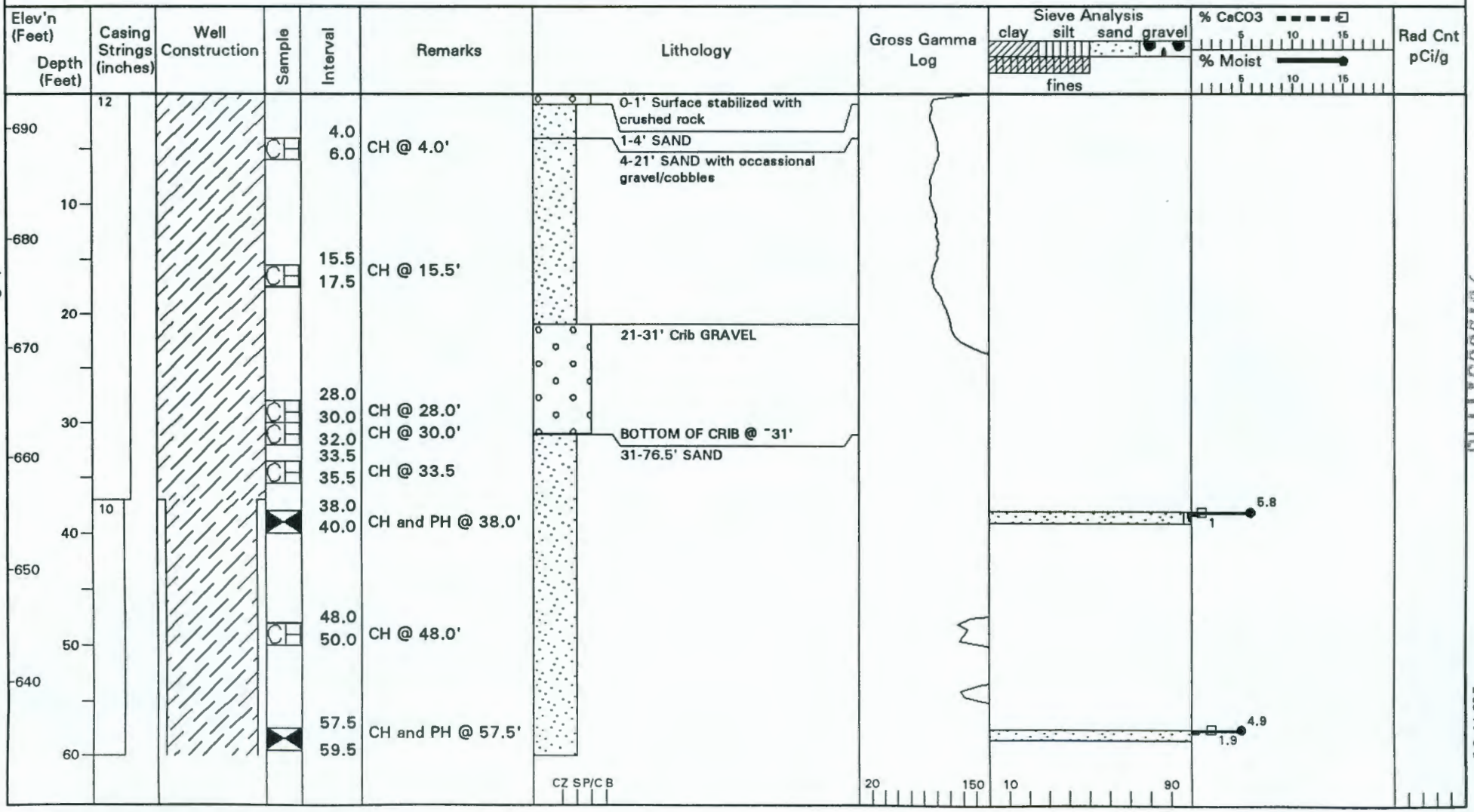
5 10 15

A-2

Rev. 01

Project: 200-UP-2 Operable Unit		Well No: 299-W19-94	Page 1 of 3
Date Started: 12-3-93	Date Completed: 1-27-94	Total Depth: 199.00	Static Water Level:
Logged By: V. Johnson	Checked By: G. Kelty	Surface Elevation: 693.18	Casing Elevation: NA
Drilling Co: Kaiser	Driller: C. Wamsley	Northing: 134706.80	Easting: 567614.16
Drilling Method: Cable Tool		Drilling Equipment: Bucyrus Erie	
Screen: NA			
Filter Pack: NA			
Permanent Casing: NA		Temporary Casing: 12" 0-37.02'; 10" 0-95.62'; 8" 0-196.92'.	

Comments: Vadose boring abandoned with bentonite crumbles after reaching target depth. Radiological screening results presented in text. Location: 216-U-8 Crib.



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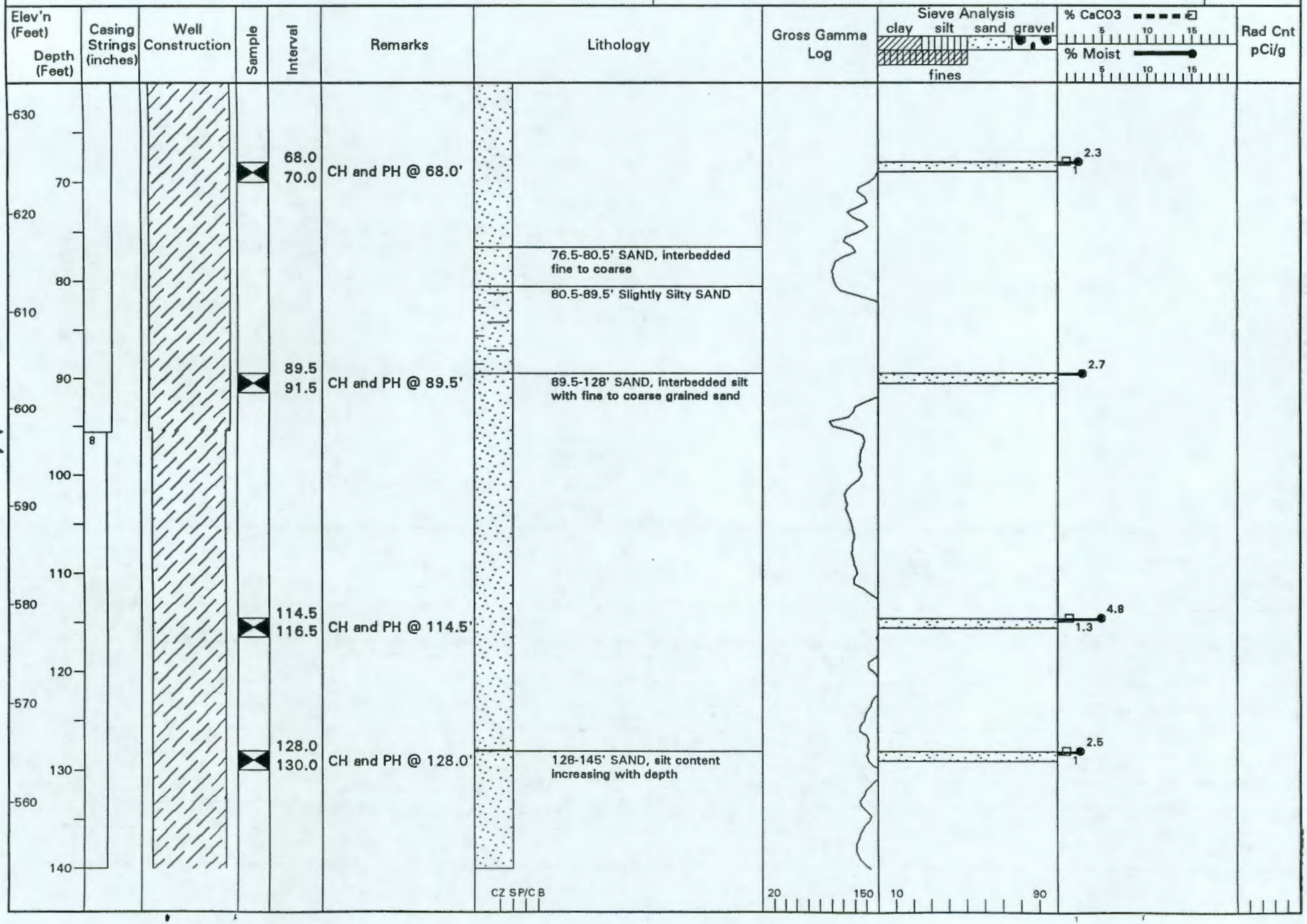
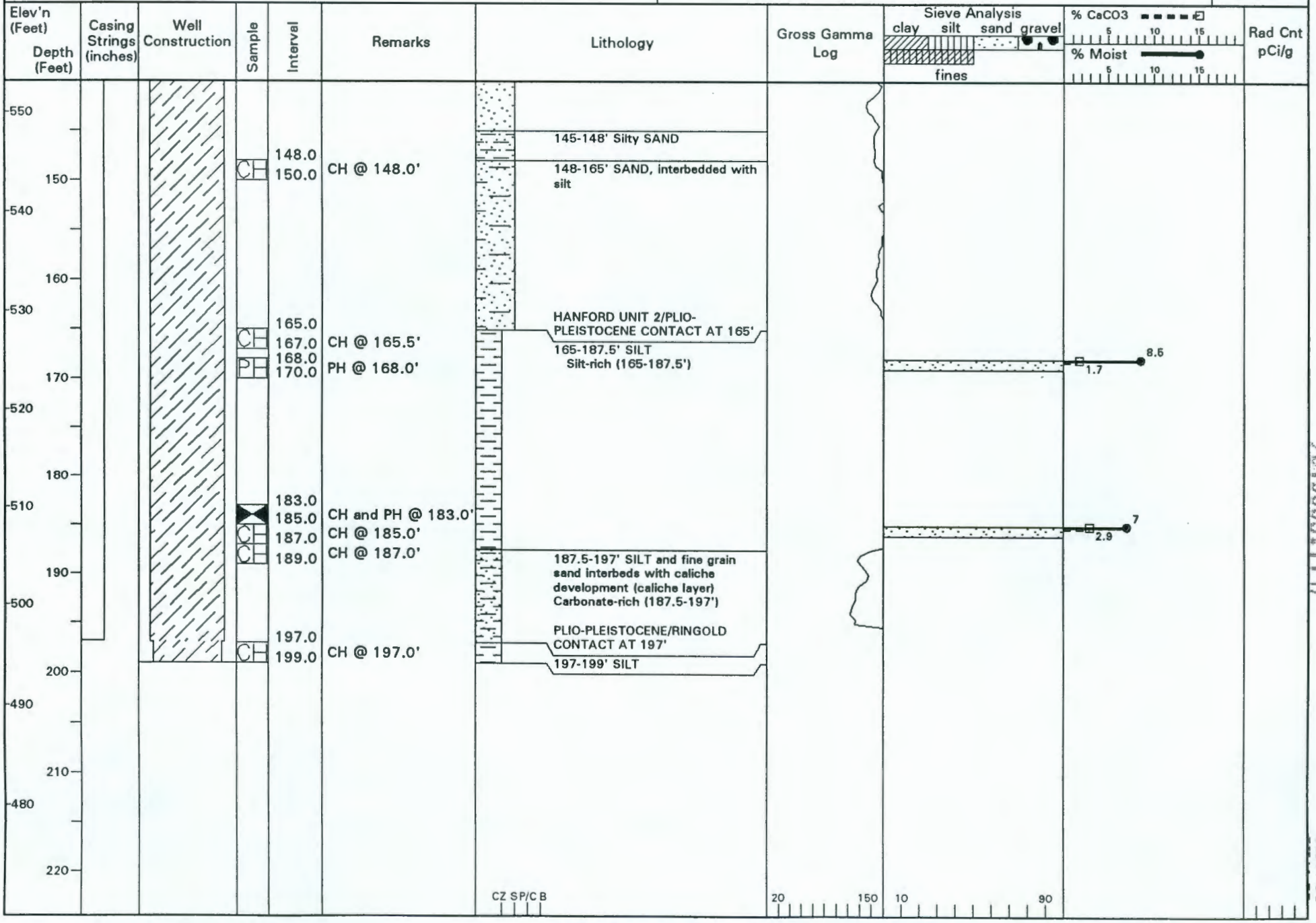
Rev. 01

Project: 200-UP-2 Operable Unit | Well No: 299-W19-94 | Page 2 of 3



Project: 200-UP-2 Operable Unit | Well No: 299-W19-94 | Page 3 of 3



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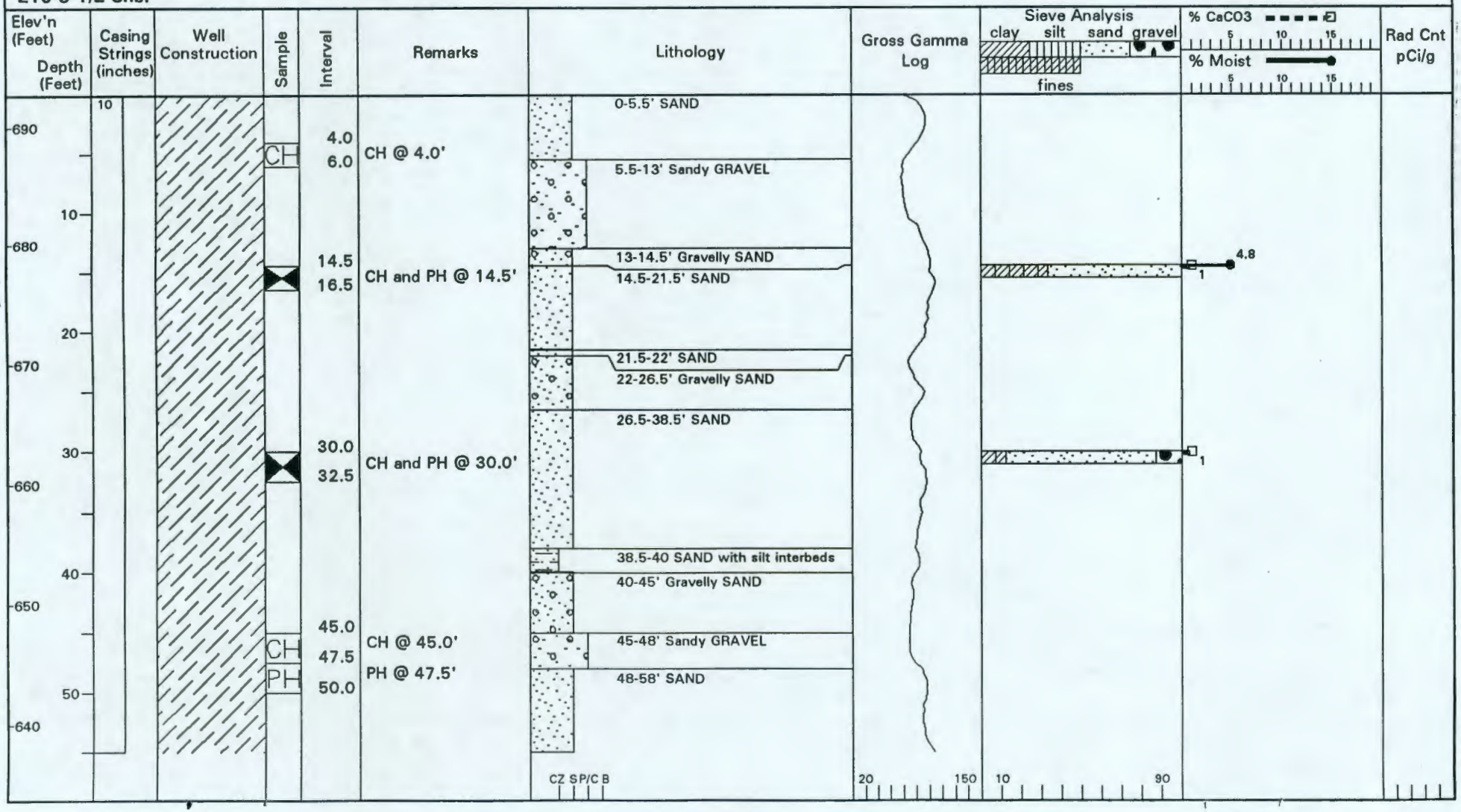
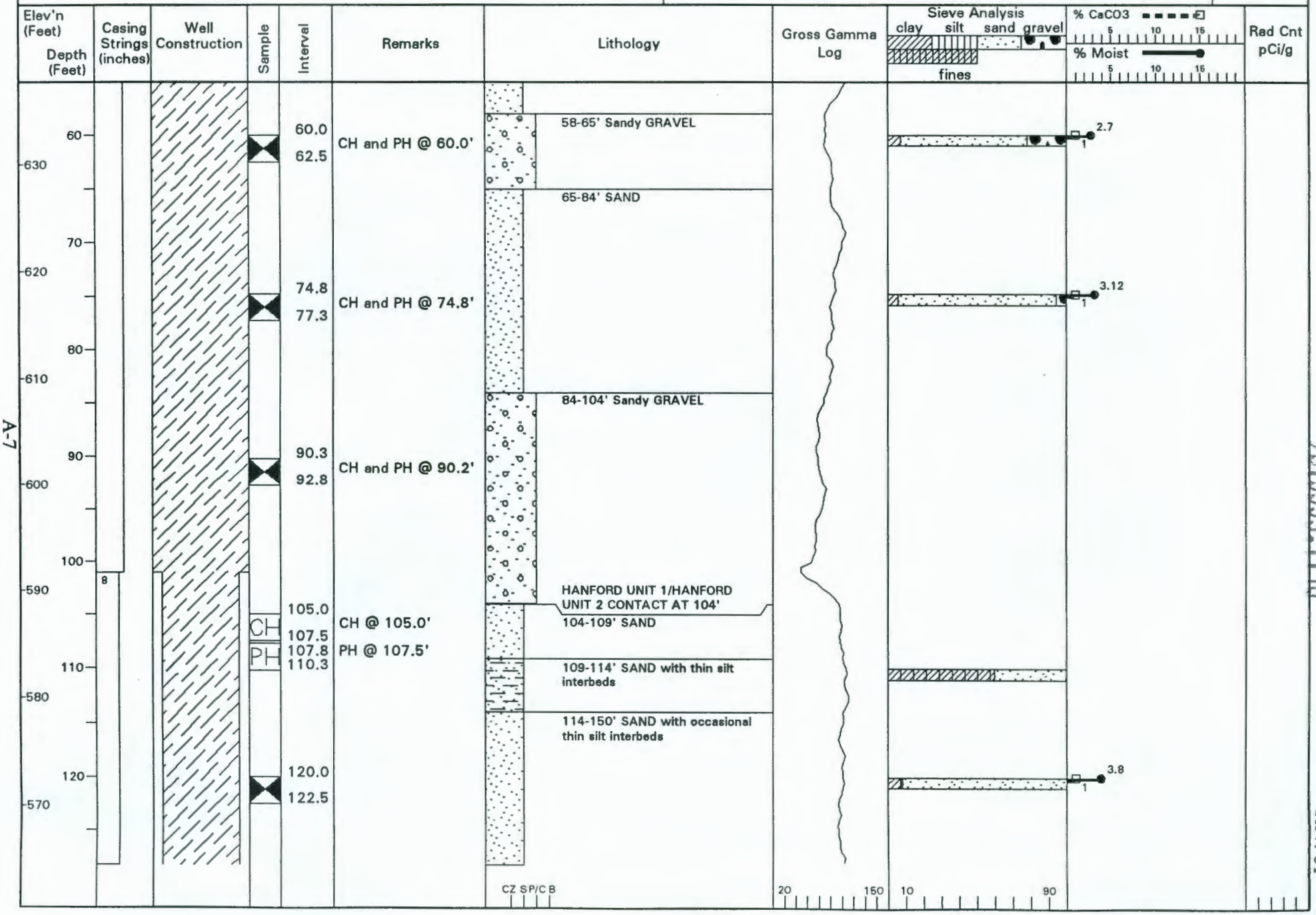
Rev. 01

Project: 200-UP-2 Operable Unit		Well No: 299-W19-95	Page 1 of 3
Date Started: 9-2-93	Date Completed: 9-23-93	Total Depth: 182.00	Static Water Level:
Logged By: M. Melhorn	Checked By: G. Kelty	Surface Elevation: 692.71	Casing Elevation: NA
Drilling Co: Kaiser	Driller: M. Wraspir	Northing: 134937.83	Easting: 567275.32
Drilling Method: Cable Tool		Drilling Equipment: Bucyrus Erie	
Screen: NA			
Filter Pack: NA			
Permanent Casing: NA		Temporary Casing: 10" 0-101.11'; 8" 0-180.15'.	

Comments: Vadose boring abandoned with bentonite crumbles after reaching target depth. Radiological screening results presented in text. Location: South of 216-U-1/2 Crib.



Project: 200-UP-2 Operable Unit | Well No: 299-W19-95 | Page 2 of 3



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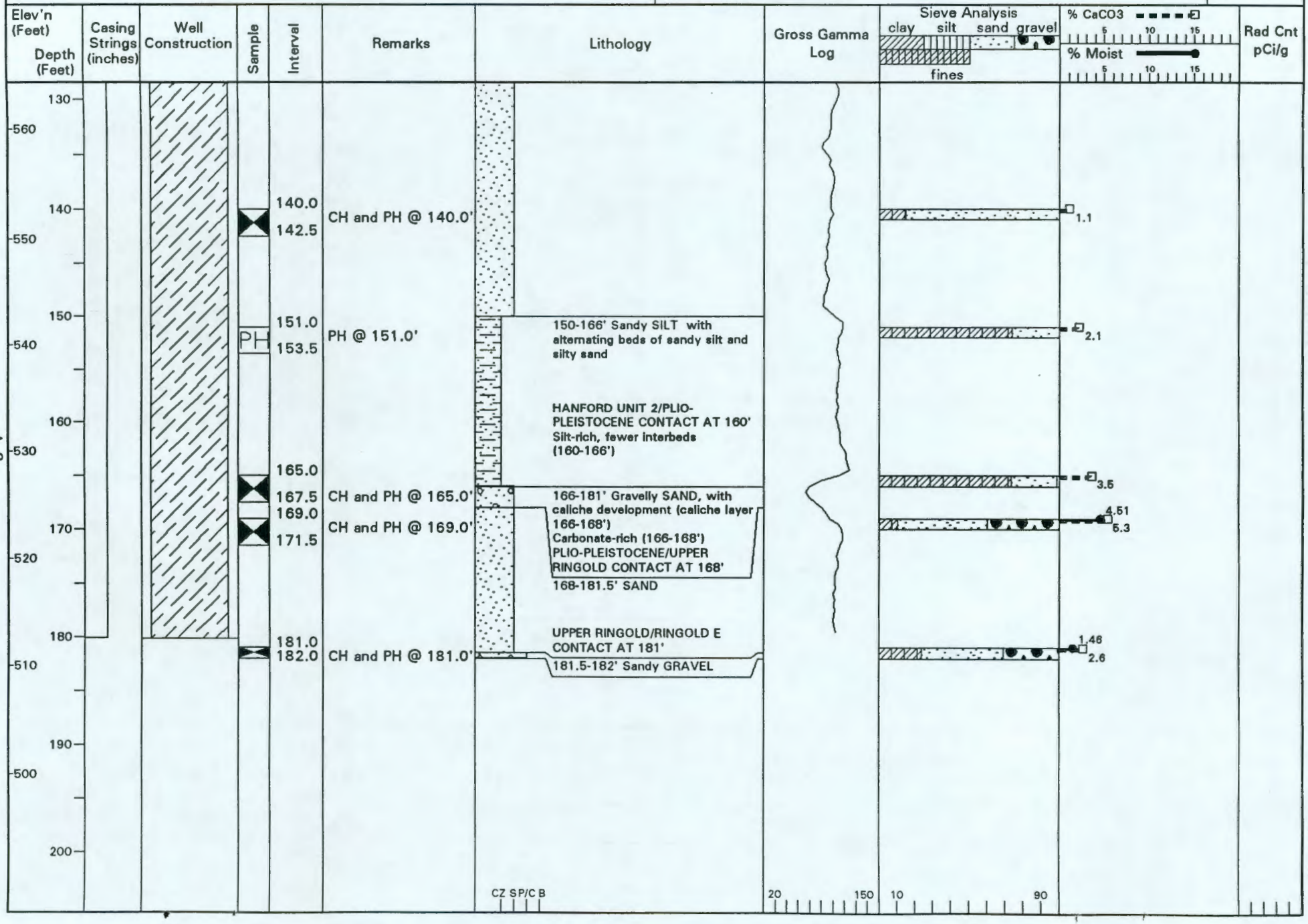
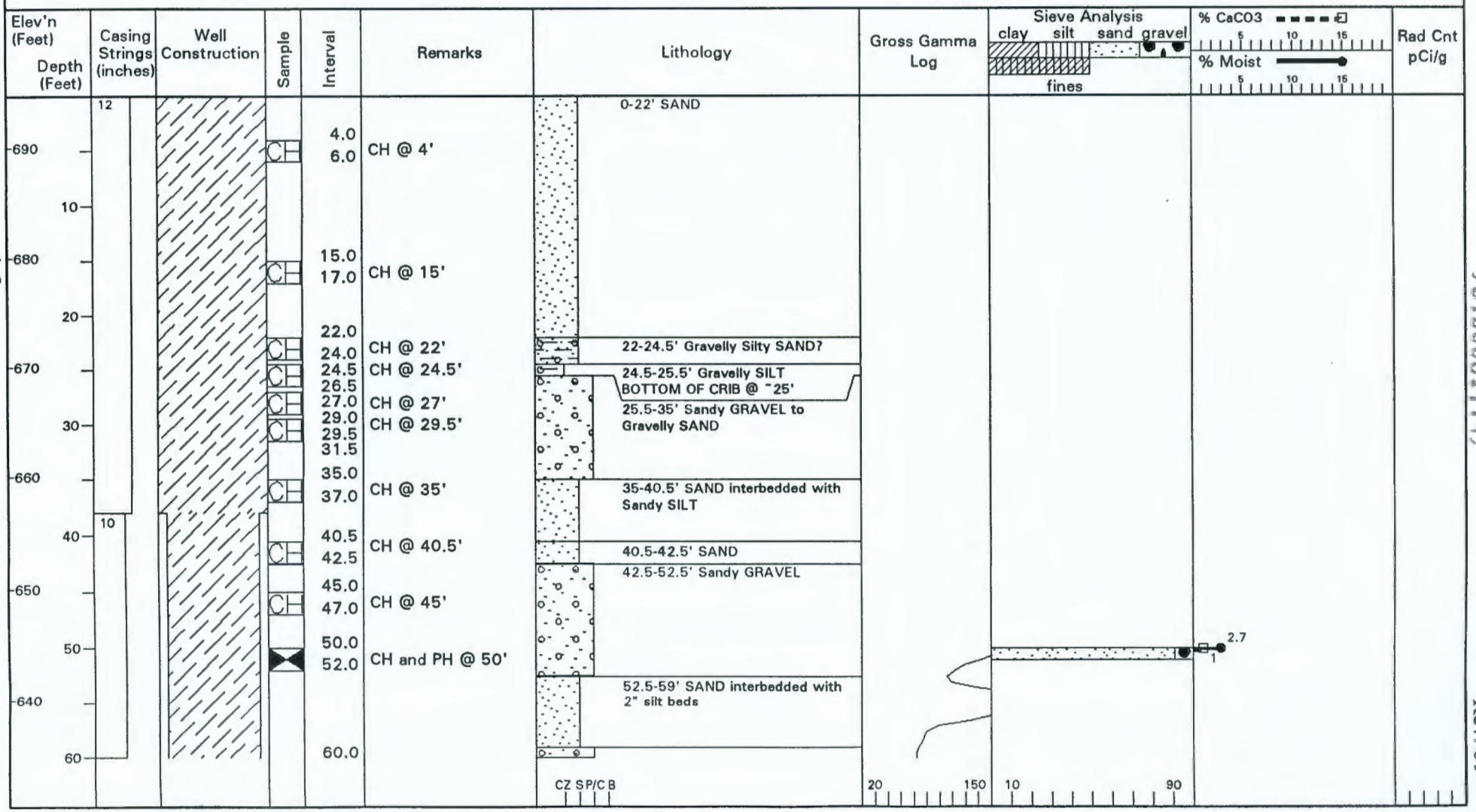
Project: 200-UP-2 Operable Unit | Well No: 299-W19-95 | Page 3 of 3



Project: 200-UP-2 Operable Unit		Well No: 299-W19-96	Page 1 of 3
Date Started: 11-5-93	Date Completed: 1-21-94	Total Depth: 179.00	Static Water Level:
Logged By: M. Faroute	Checked By: G. Kelty	Surface Elevation: 694.74	Casing Elevation: NA
Drilling Co: Kaiser	Driller: G. Howell	Northing: 135003.79	Easting: 567263.16
Drilling Method: Cable Tool		Drilling Equipment: Bucyrus Erie	
Screen: NA			
Filter Pack: NA			
Permanent Casing: NA		Temporary Casing: 12" 0-38'; 10" 0-99.5'; 8" 0-175'.	
Comments: Vadose boring abandoned with bentonite crumbles after reaching target depth. Radiological screening results presented in text. Location: 216-U-1/2 Crib.			



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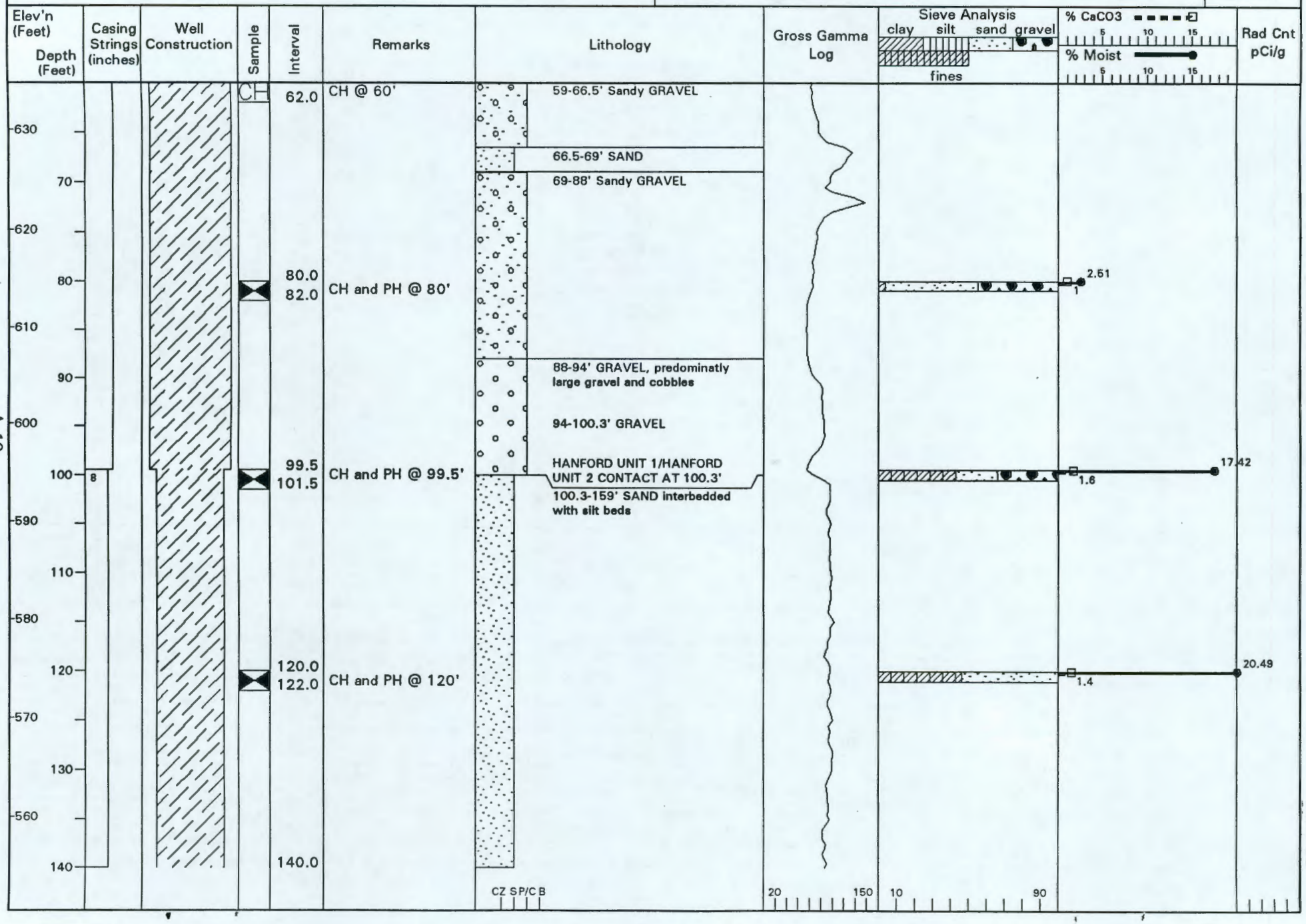
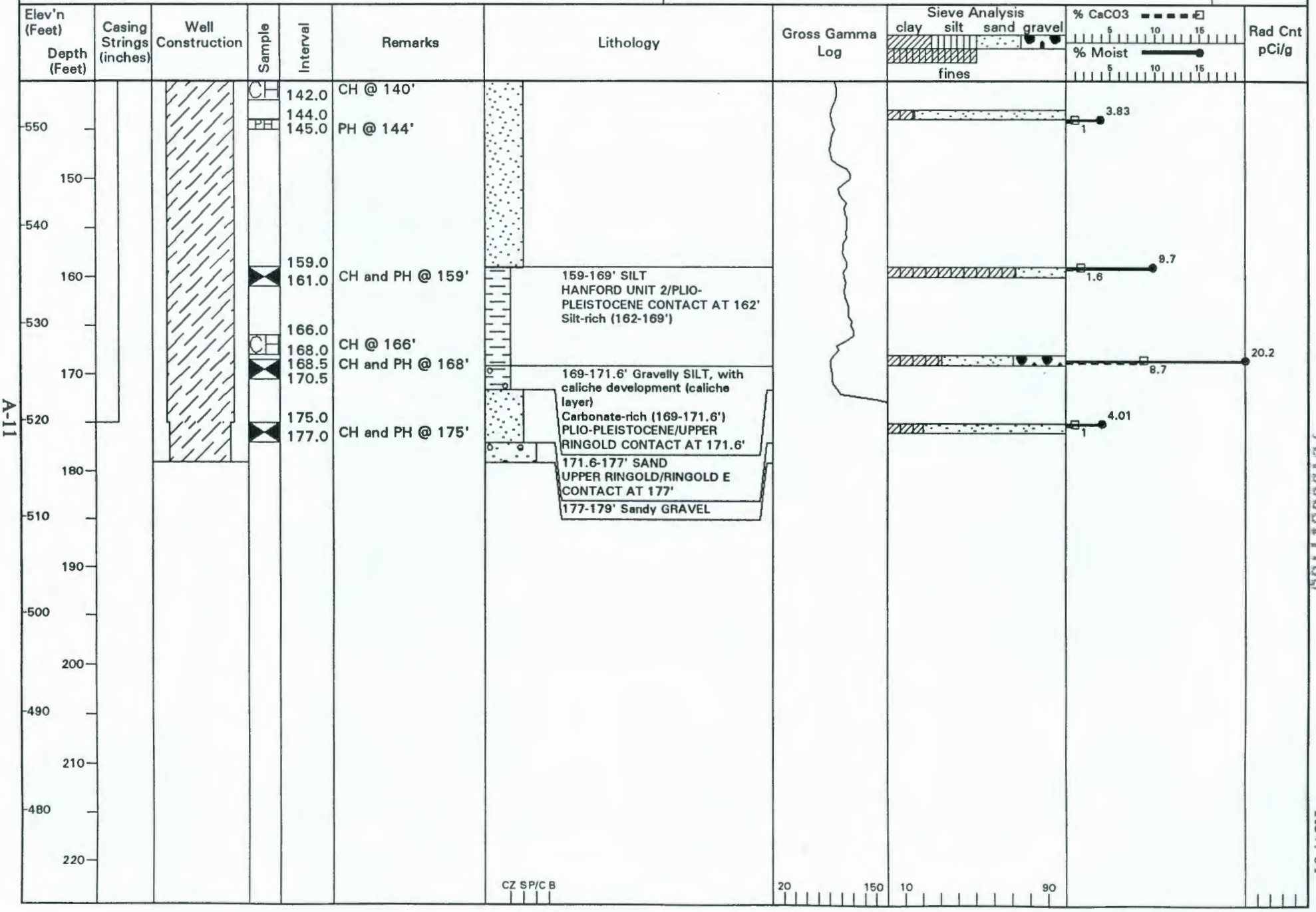
Rev. 01

Project: 200-UP-2 Operable Unit | Well No: 299-W19-96 | Page 2 of 3



Project: 200-UP-2 Operable Unit | Well No: 299-W19-96 | Page 3 of 3



A-11

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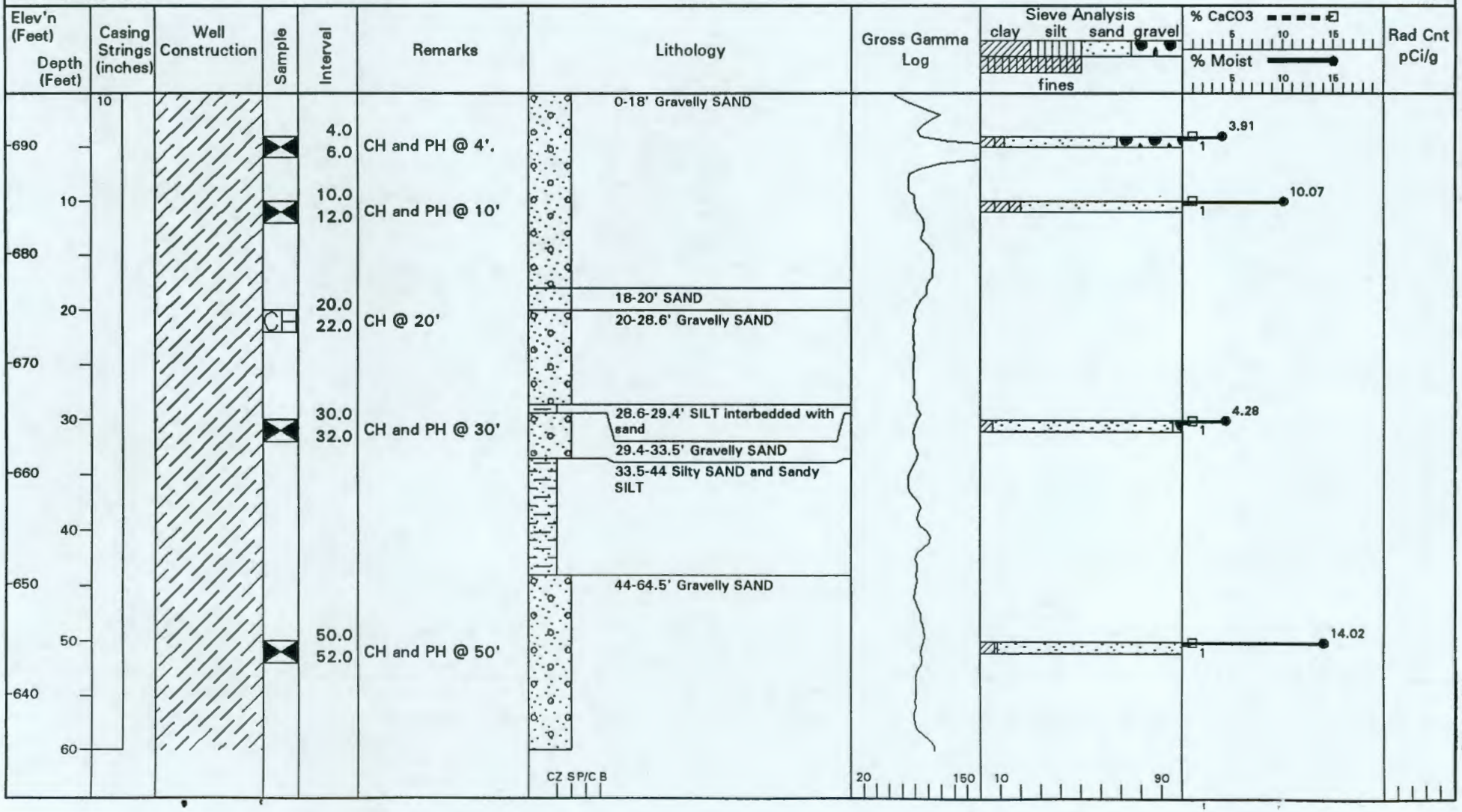
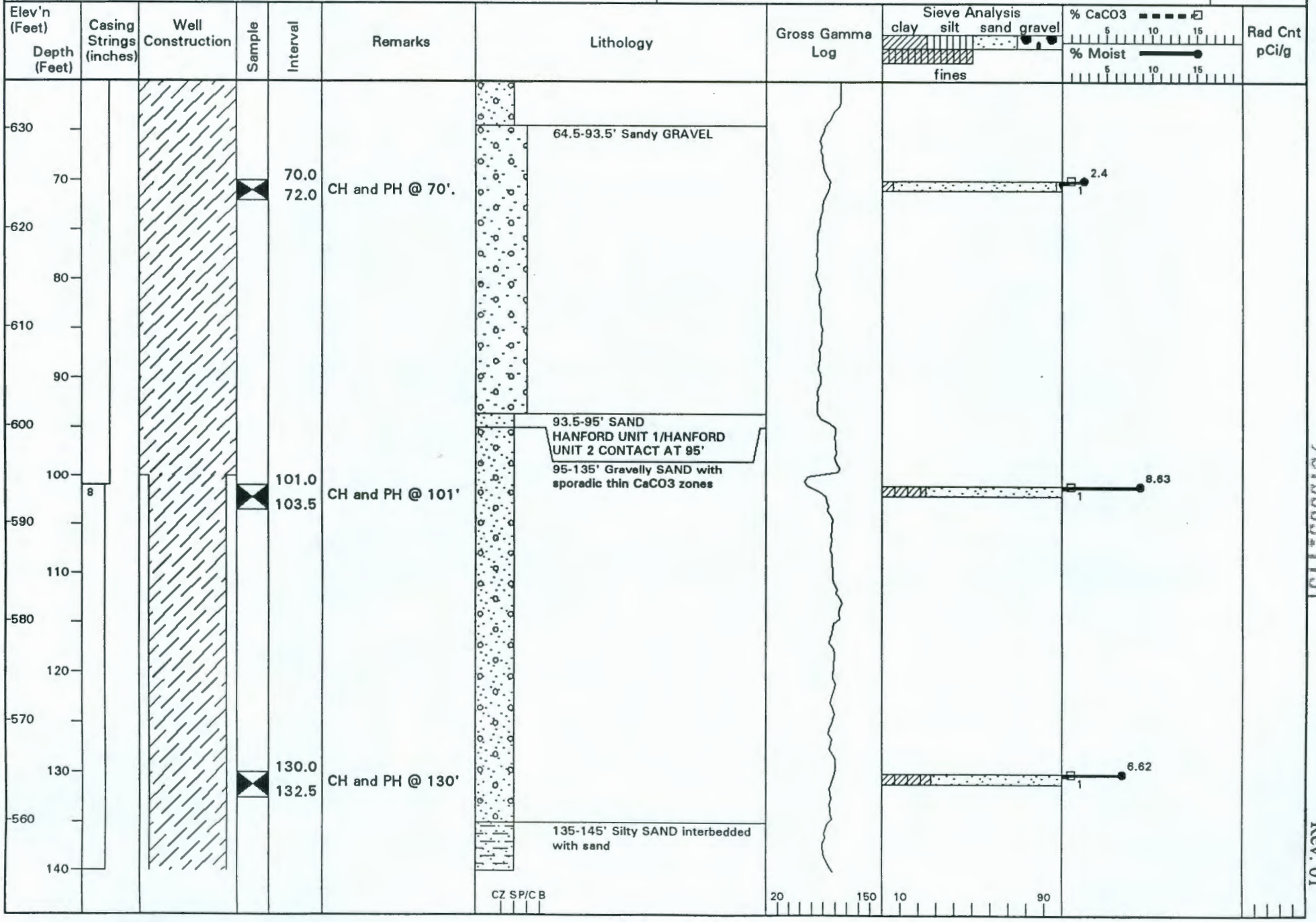
Rev. 01

Project: 200-UP-2 Operable Unit		Well No: 299-W19-97	Page 1 of 3
Date Started: 9-7-93	Date Completed: 9-28-93	Total Depth: 177.00	Static Water Level:
Logged By: M. Faurote	Checked By: G. Kelty	Surface Elevation: 694.81	Casing Elevation: NA
Drilling Co: Kaiser	Driller: G.M. Howell	Northing: 135044.06	Easting: 567283.78
Drilling Method: Cable Tool		Drilling Equipment: Bucyrus Erie-22	
Screen: NA			
Filter Pack: NA			
Permanent Casing:		Temporary Casing: 10" 0-101'; 8" 0-175'.	

Comments: Vadose boring abandoned with bentonite crumbles after reaching target depth. Radiological screening results presented in text. Location: North of 216-U-1/2 Crib.



Project: 200-UP-2 Operable Unit | Well No: 299-W19-97 | Page 2 of 3



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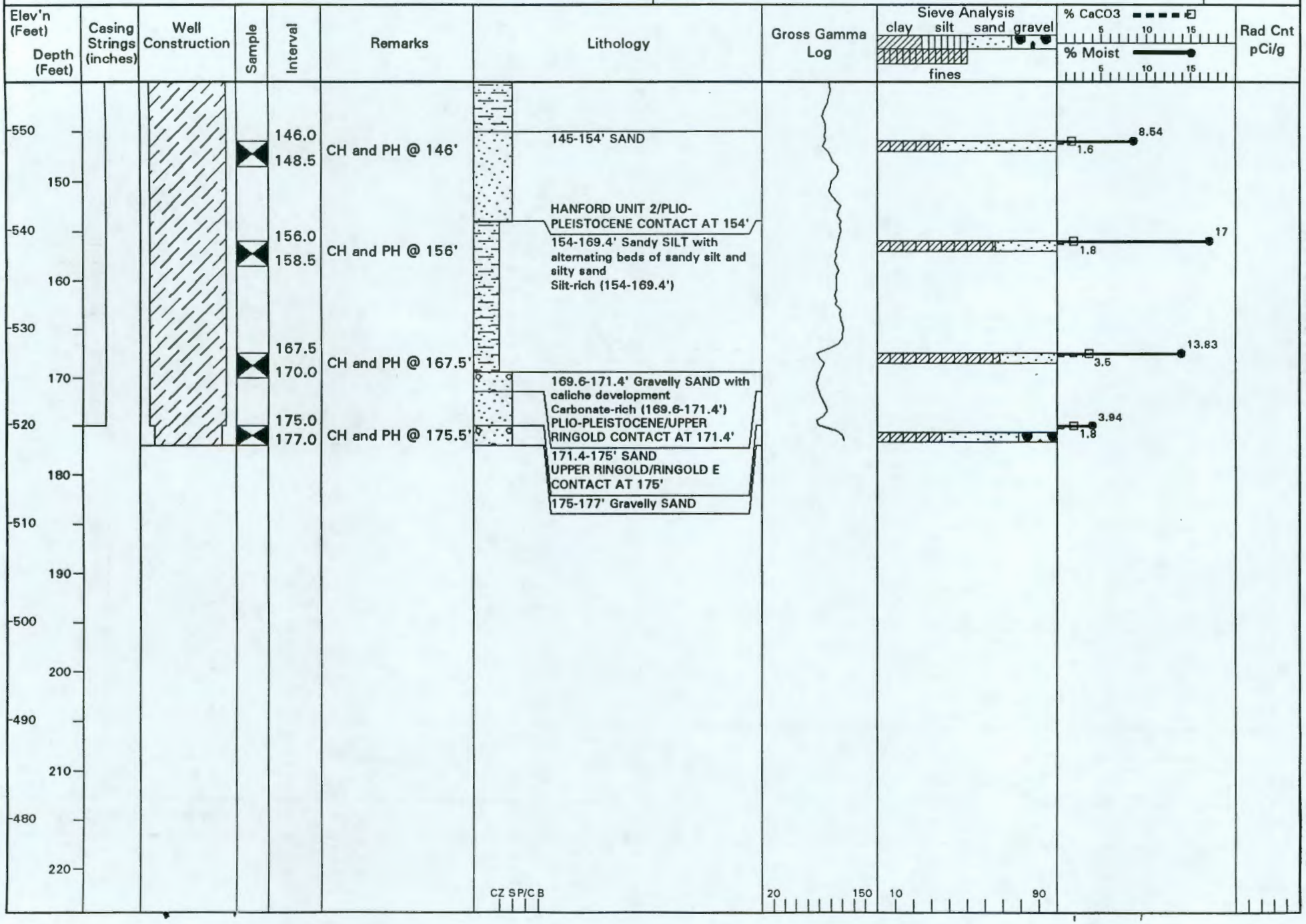
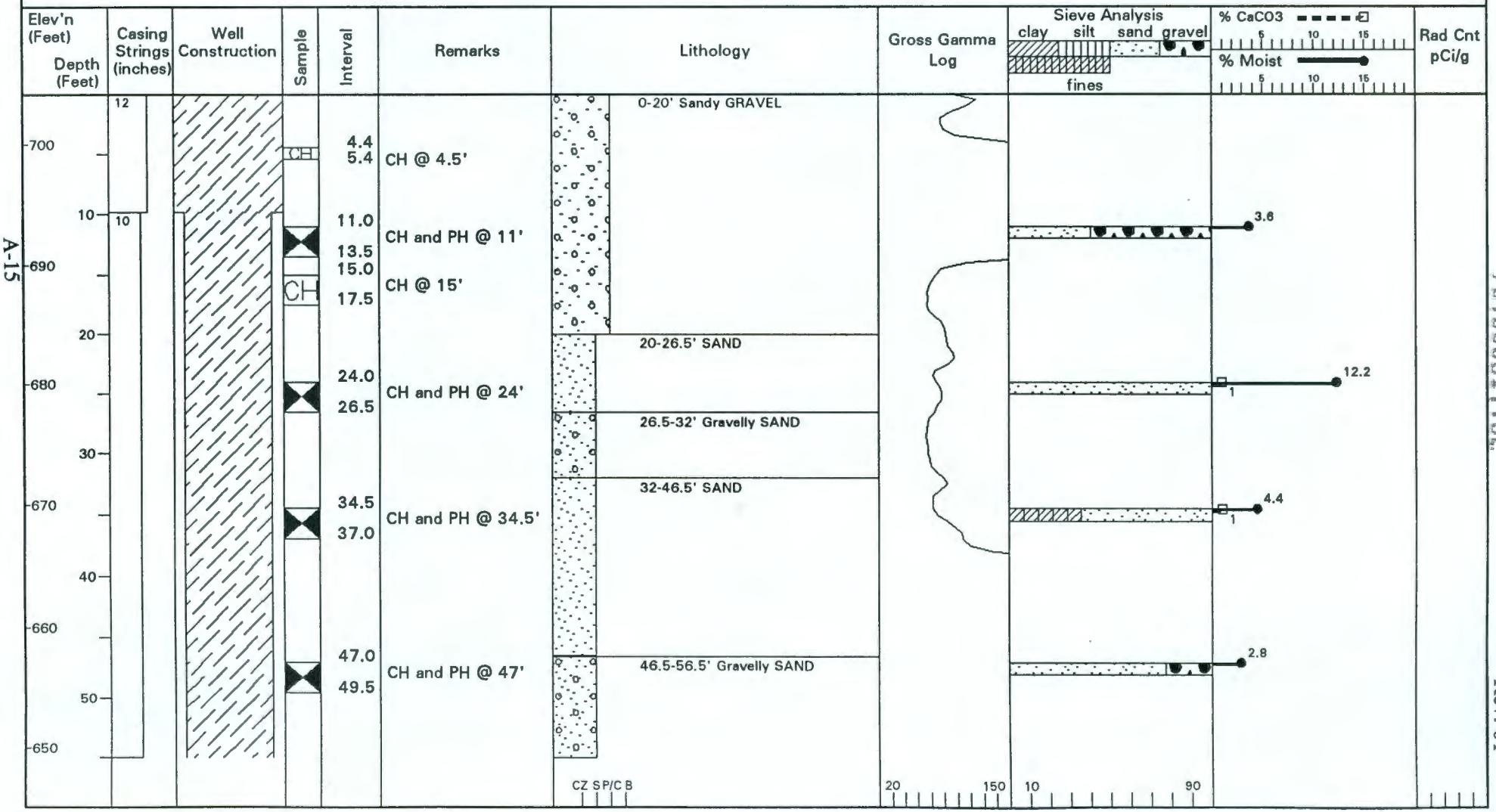
Rev. 01

Project: 200-UP-2 Operable Unit | Well No: 299-W19-97 | Page 3 of 3



Project: 200-UP-2 Operable Unit		Well No: 299-W19-98	Page 1 of 3
Date Started: 3-2-94	Date Completed: 3-29-94	Total Depth: 195.00	Static Water Level:
Logged By: M. Melhorn	Checked By: G. Howell	Surface Elevation: 704.20	Casing Elevation: NA
Drilling Co: Kaiser	Driller: G. Howell	Northing: 135109.57	Easting: 567578.43
Drilling Method: Cable Tool		Drilling Equipment: Bucyrus Erie-22	
Screen: NA			
Filter Pack: NA			
Permanent Casing: NA		Temporary Casing: 12" 0-9.85'; 10" 0-96.56'; 8" 0-191.95'	
Comments: Vadose boring abandoned wtih bentonite crumbles after reaching target depth. Radiological screening results presented in text. Location: 216-U-4/4A.			



A-15

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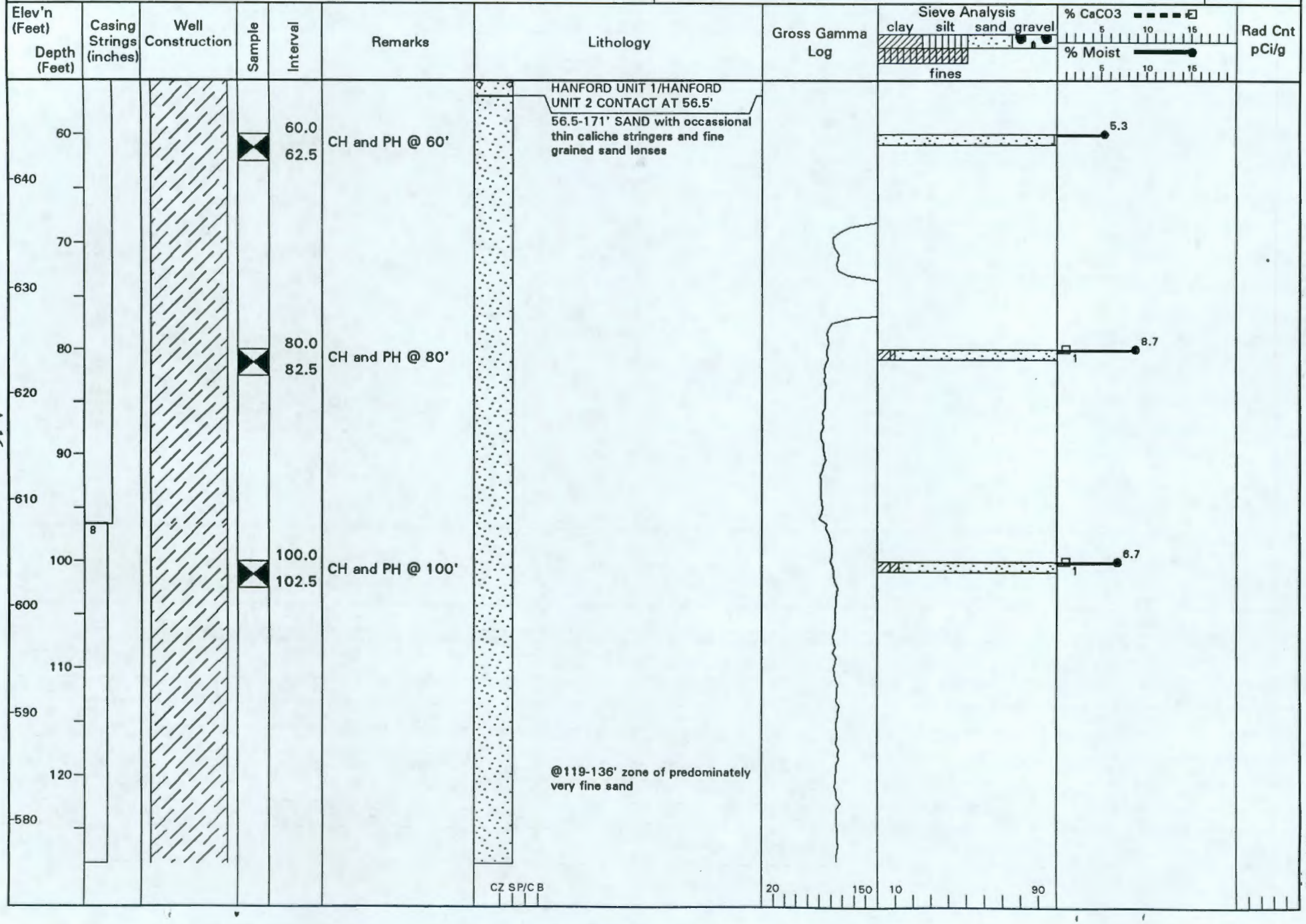
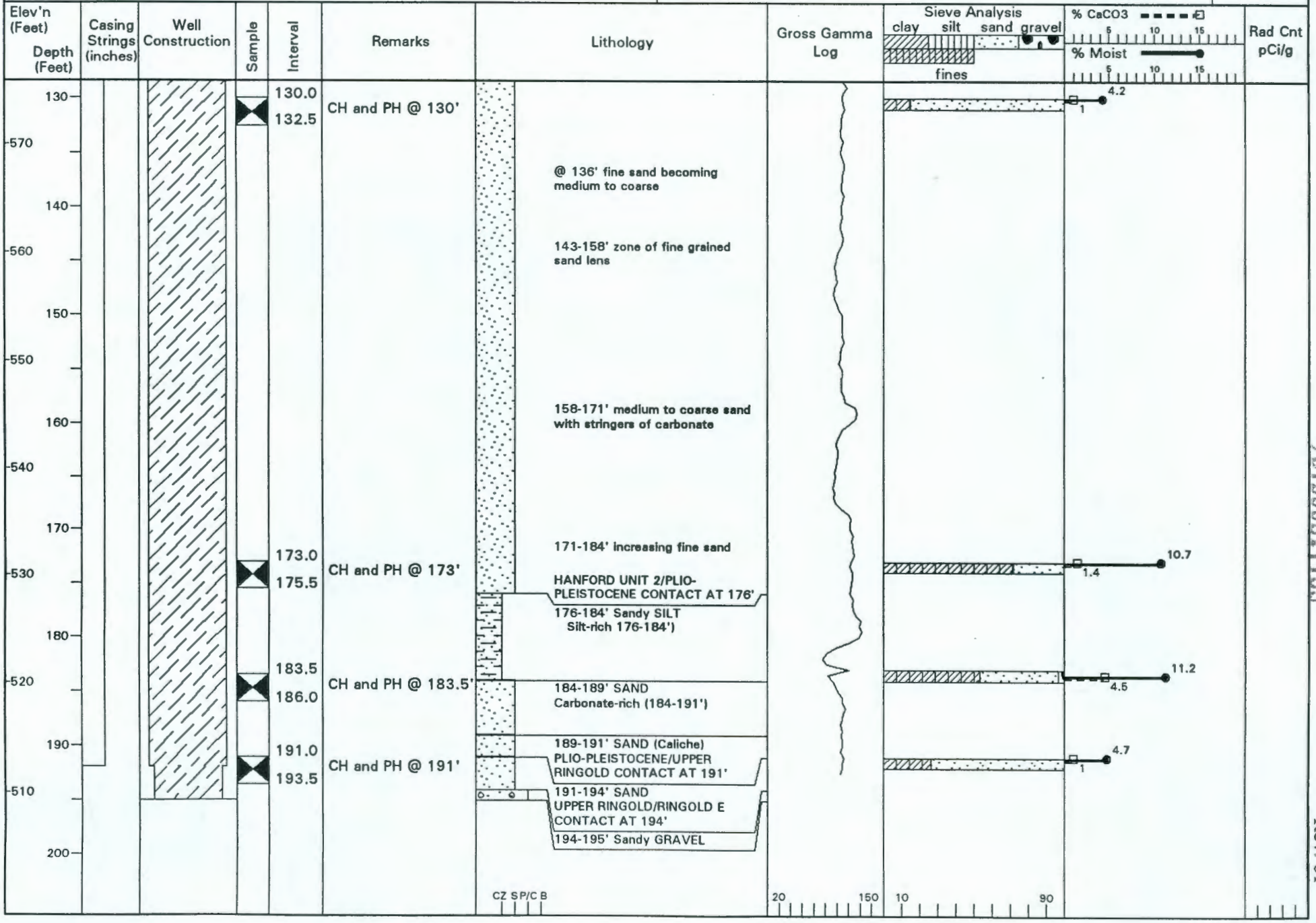
Rev. 01

Project: 200-UP-2 Operable Unit | Well No: 299-W19-98 | Page 2 of 3



Project: 200-UP-2 Operable Unit | Well No: 299-W19-98 | Page 3 of 3



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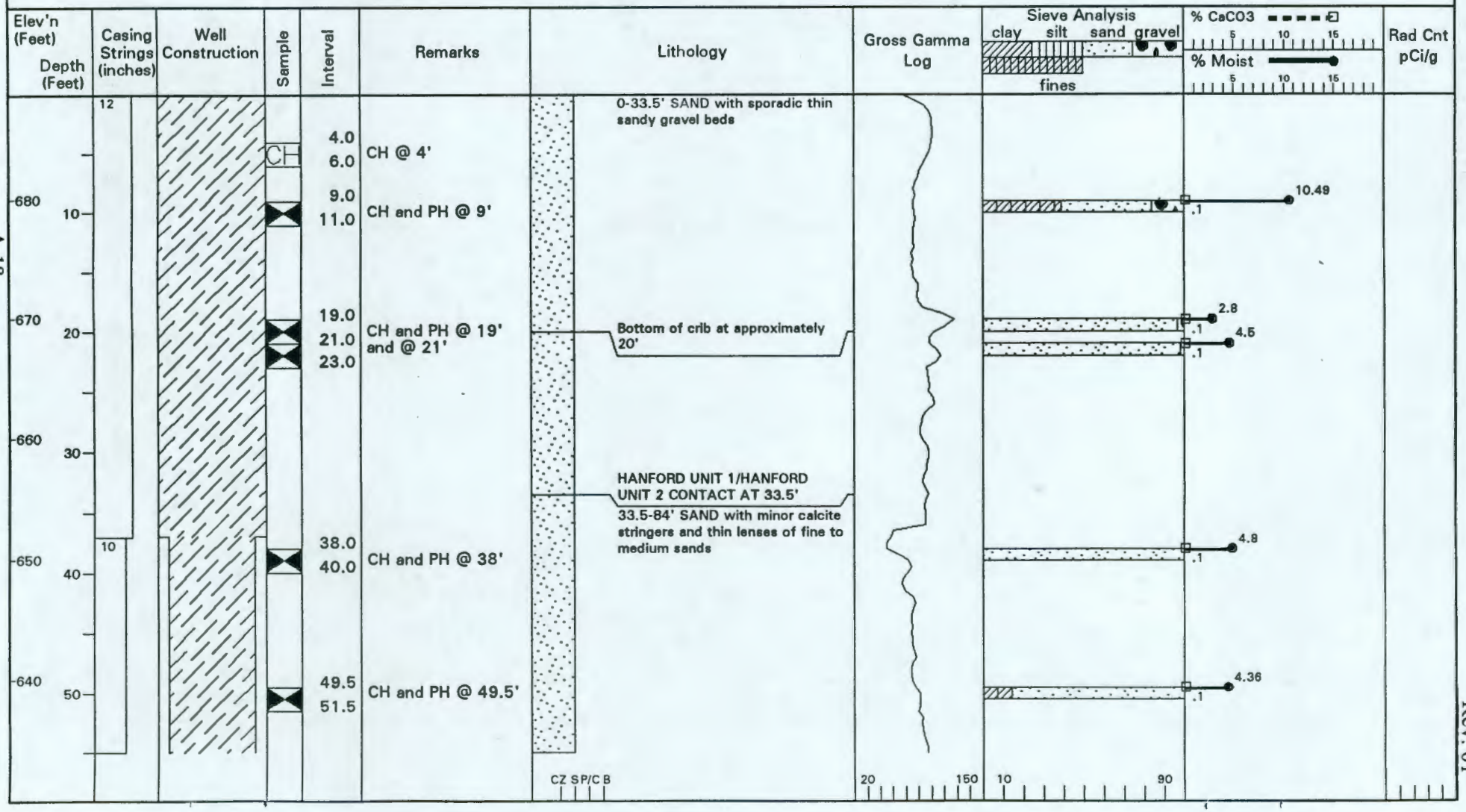
Rev. 01

Project: 200-UP-2 Operable Unit		Well No: 299-W22-78	Page 1 of 4
Date Started: 10-7-93	Date Completed: 11-17-94	Total Depth: 234.00	Static Water Level: 230.60
Logged By: M. Mehlhorn	Checked By: G. Kelty	Surface Elevation: 688.86	Casing Elevation: NA
Drilling Co: Kaiser	Driller: C. Wamsly	Northing: 134499.76	Easting: 567606.03
Drilling Method: Cable Tool		Drilling Equipment: Bucyrus Erie-22	
Screen: NA			
Filter Pack: NA			
Permanent Casing: NA		Temporary Casing: 12" 0-37.01'; 10" 0-91.24'; 8" 0-189.45'; 6" 0-233.36'.	
Comments: Vadose boring abandoned with bentonite crumbles after reaching target depth. Radiological screening results presented in text. Location: 216-U-12 Crib.			



Project: 200-UP-2 Operable Unit | Well No: 299-W22-78 | Page 2 of 4

Elev'n (Feet) / Depth (Feet)	Casing Strings (inches)	Well Construction	Sample	Interval	Remarks	Lithology	Gross Gamma Log	Sieve Analysis (clay, silt, sand, gravel, fines)	% CaCO3 / % Moist	Rad Cnt pCi/g
630 / 60										
620 / 70				70.0 – 72.0	CH and PH @ 70'				2.06 / .1	
610 / 80										
600 / 90	8			90.0 – 92.0	CH and PH @ 90'	84-97.5' SAND			5.82 / .1	
590 / 100						97.5-107' SAND with thin laminations?				
580 / 110				109.0 – 111.0	CH and PH @ 109.5'	107-124' SAND, thinly laminated with lenses of silty sand; strong reaction to HCL			3.96 / .1	
570 / 120						124-132' SAND, weak reaction with HCL				

CZ SP/C B

Gross Gamma Log: 20 – 150

Sieve Analysis: 10 – 90

% CaCO3: 5 10 15

% Moist: 5 10 15

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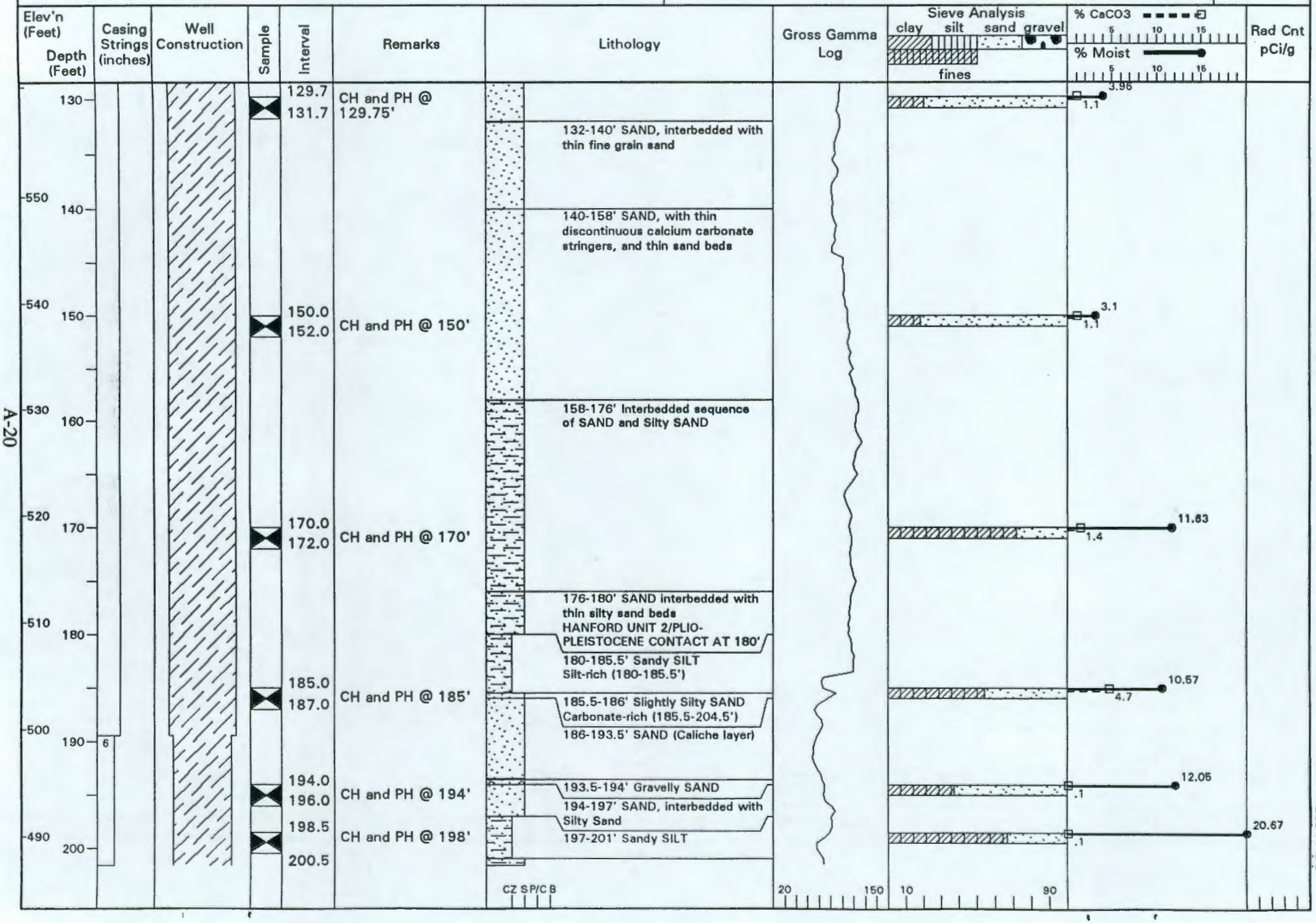
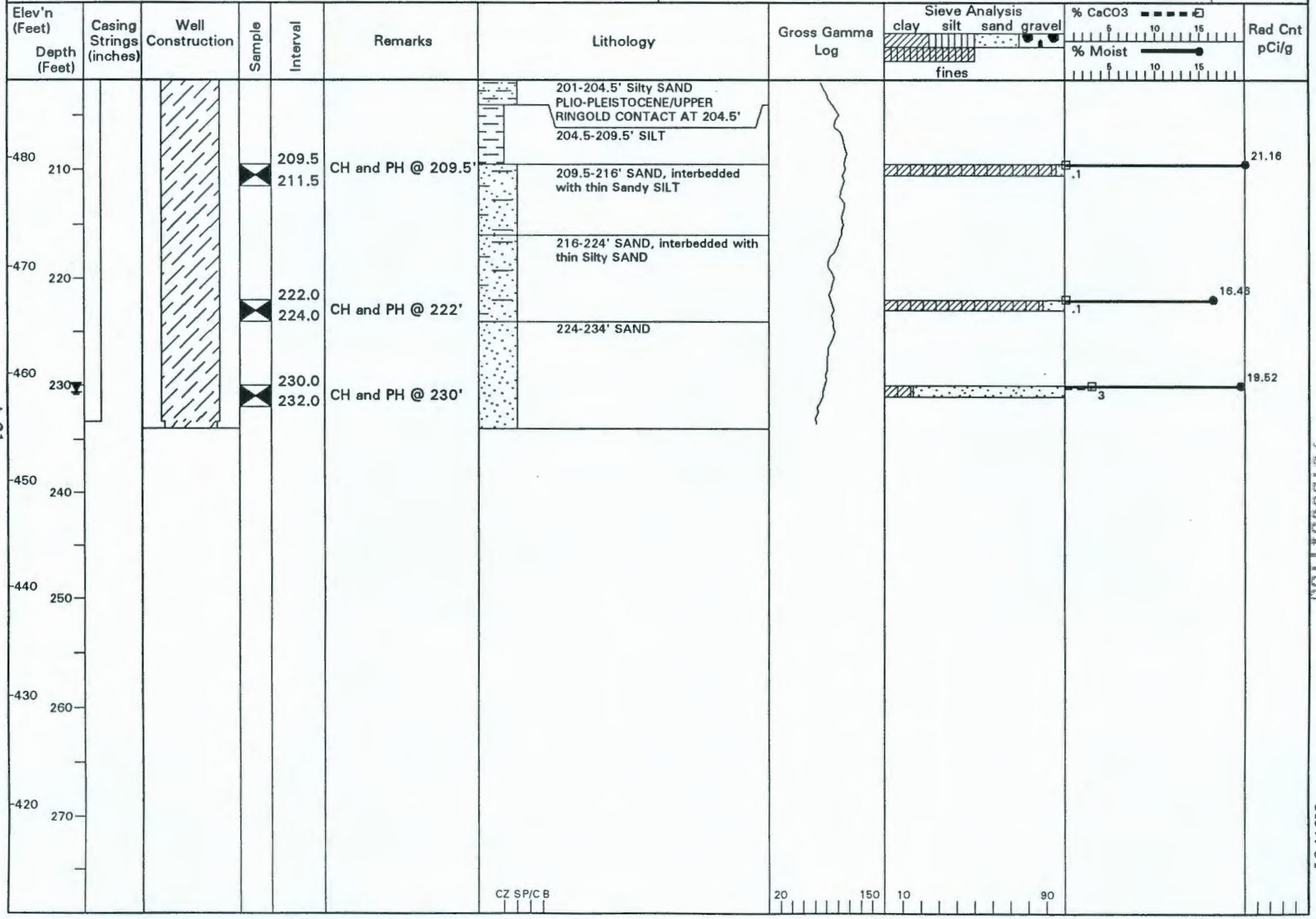
Rev. 01

Project: 200-UP-2 Operable Unit | Well No: 299-W22-78 | Page 3 of 4



Project: 200-UP-2 Operable Unit | Well No: 299-W22-78 | Page 4 of 4



A-21

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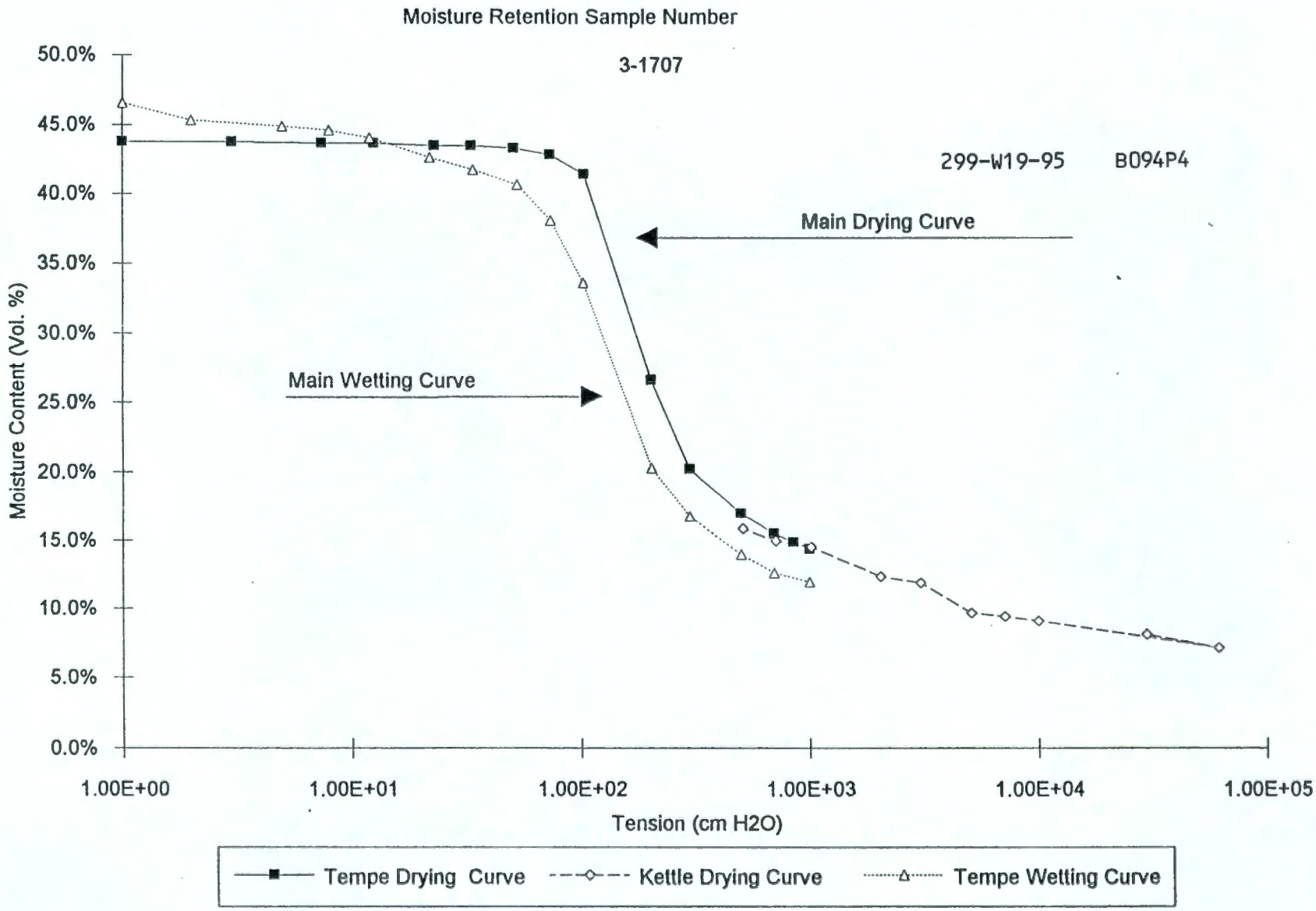
Rev. 01

APPENDIX B

HYDRAULIC CONDUCTIVITY DATA



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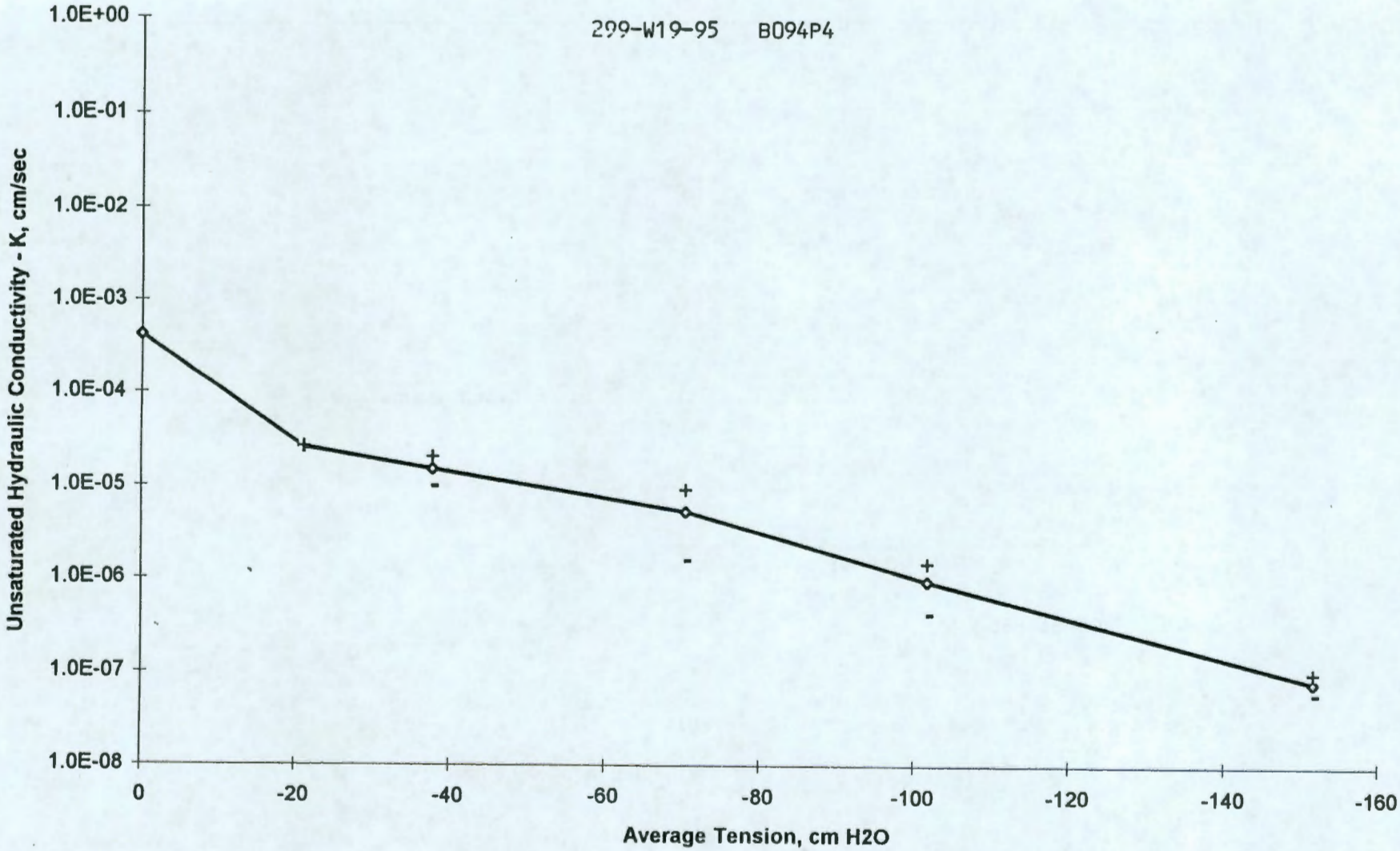
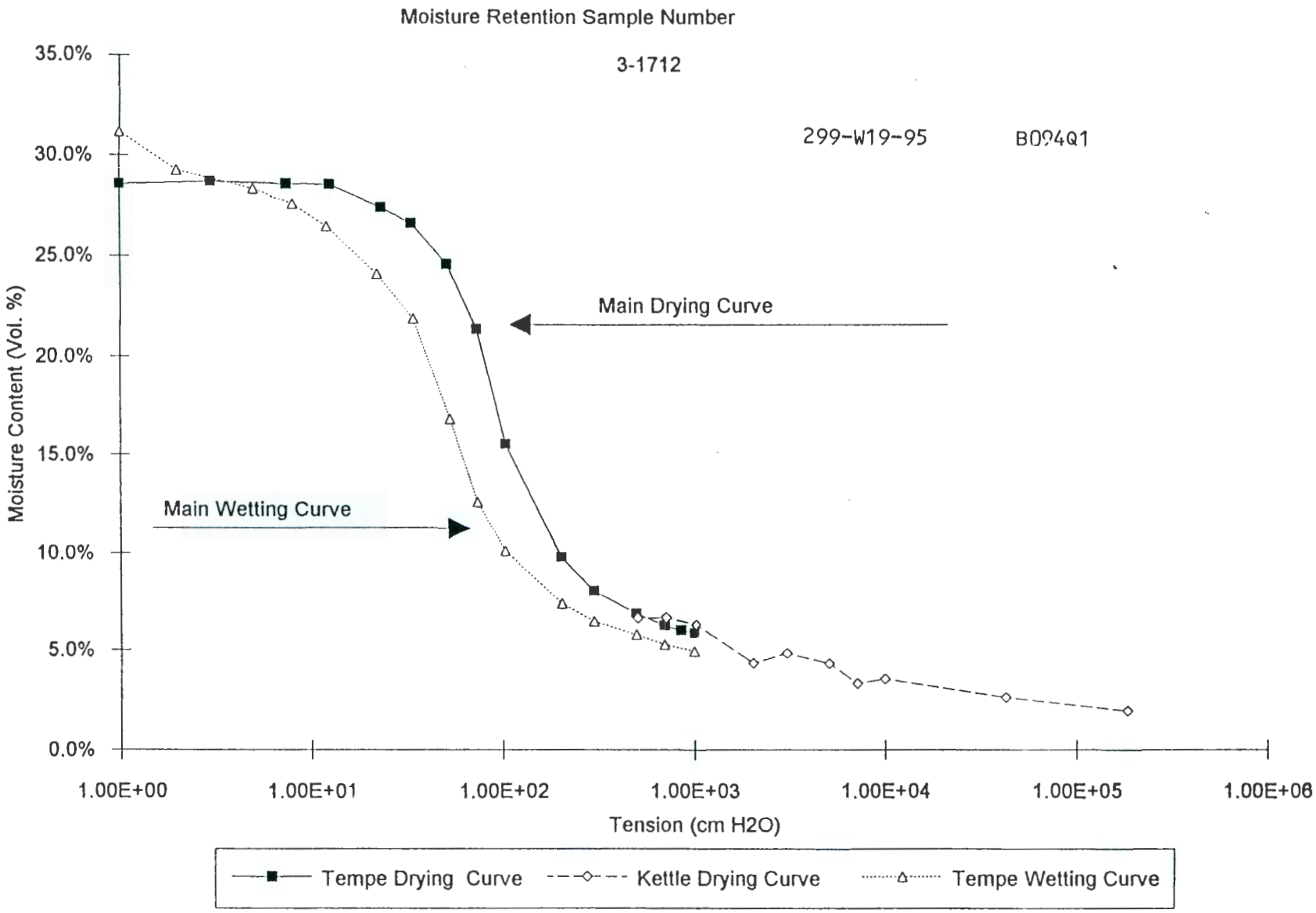
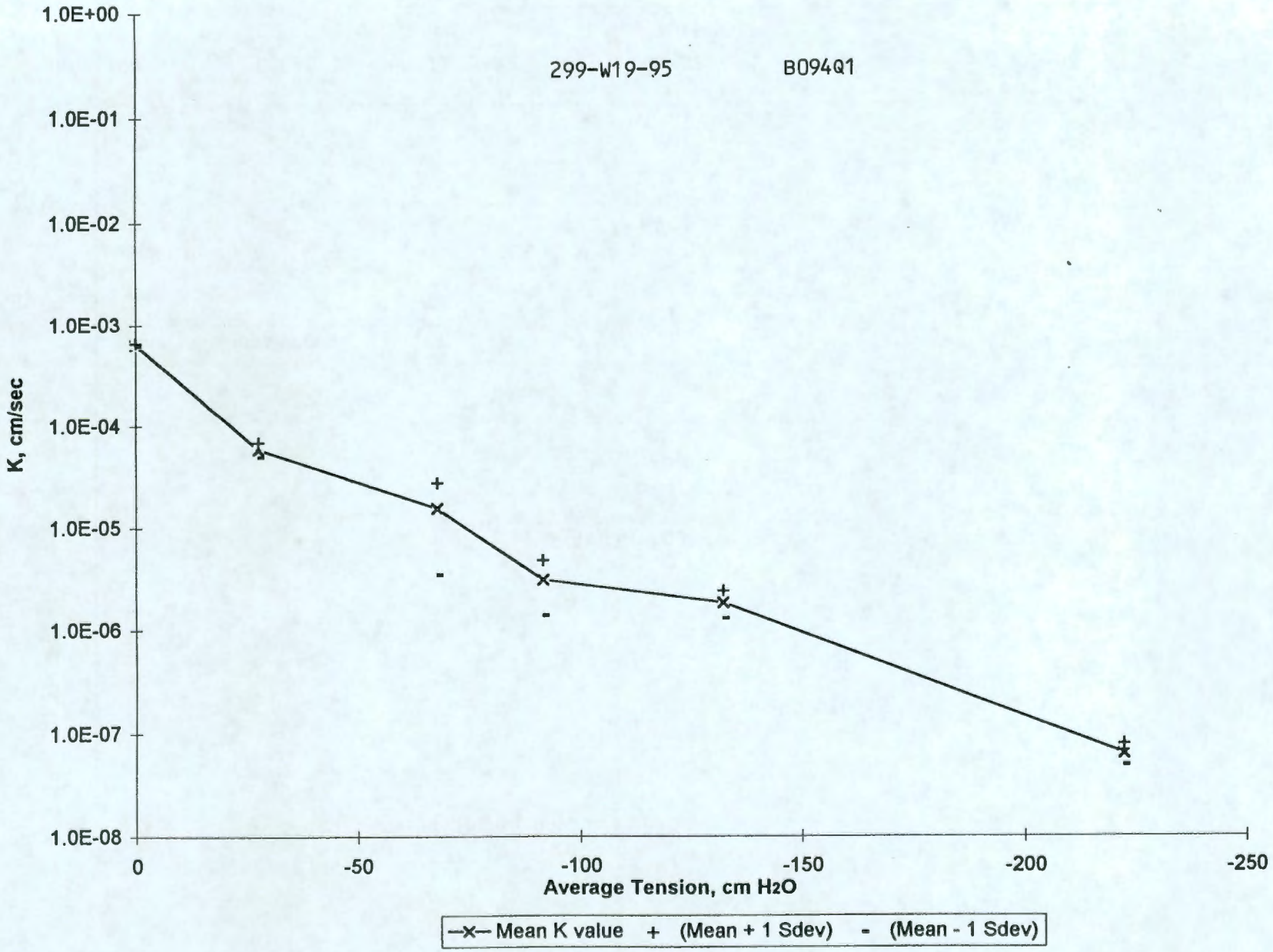
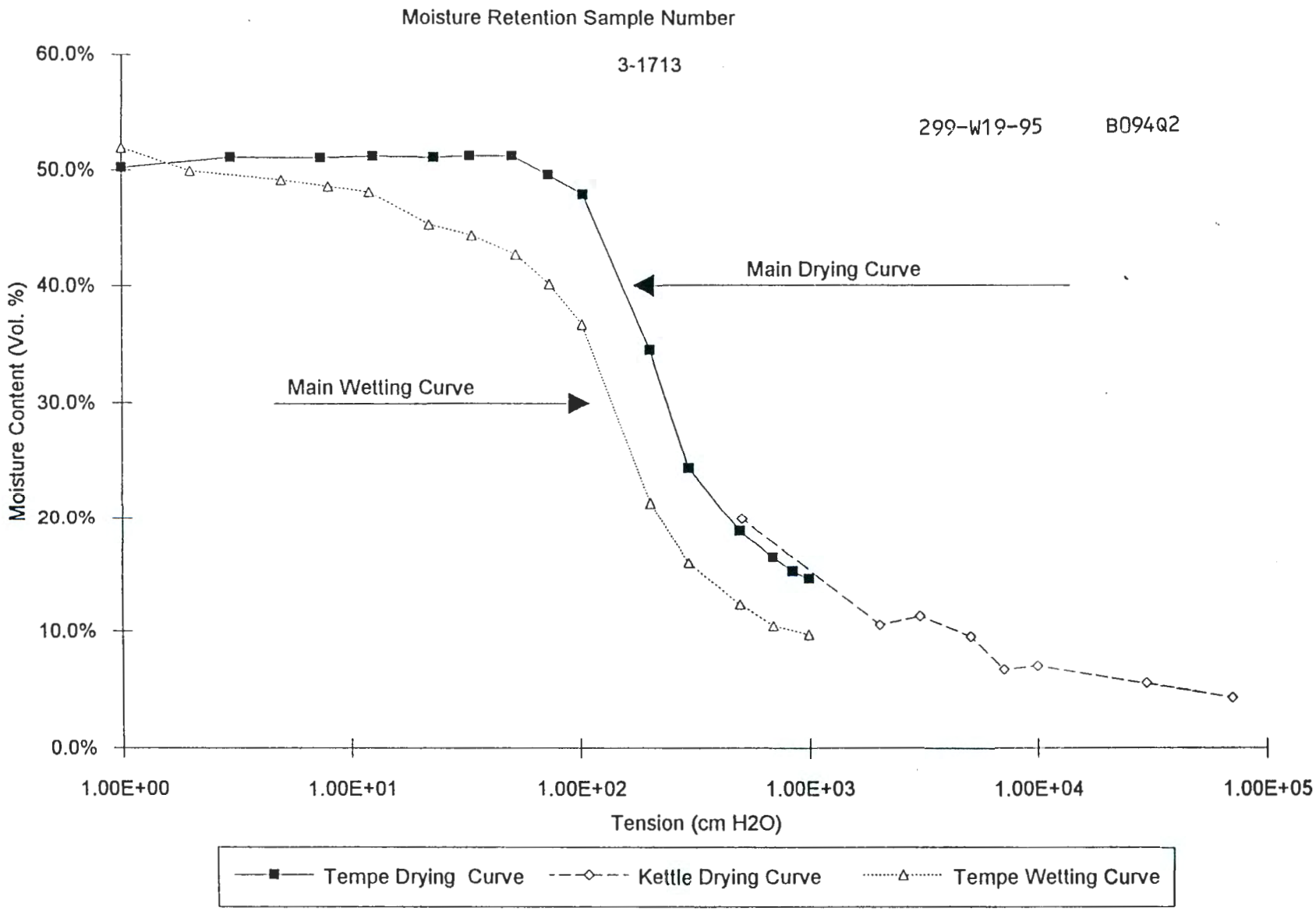
Unsaturated Hydraulic Conductivity Data for Sample 3-1707




Moisture Retention Sample Number
3-1712
299-W19-95
B094Q1
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
Moisture Content (Vol. %)
Main Drying Curve
Main Wetting Curve
1.00E+00
1.00E+01
1.00E+02
1.00E+03
1.00E+04
1.00E+05
1.00E+06
Tension (cm H2O)
Tempe Drying Curve
Kettle Drying Curve
Tempe Wetting Curve

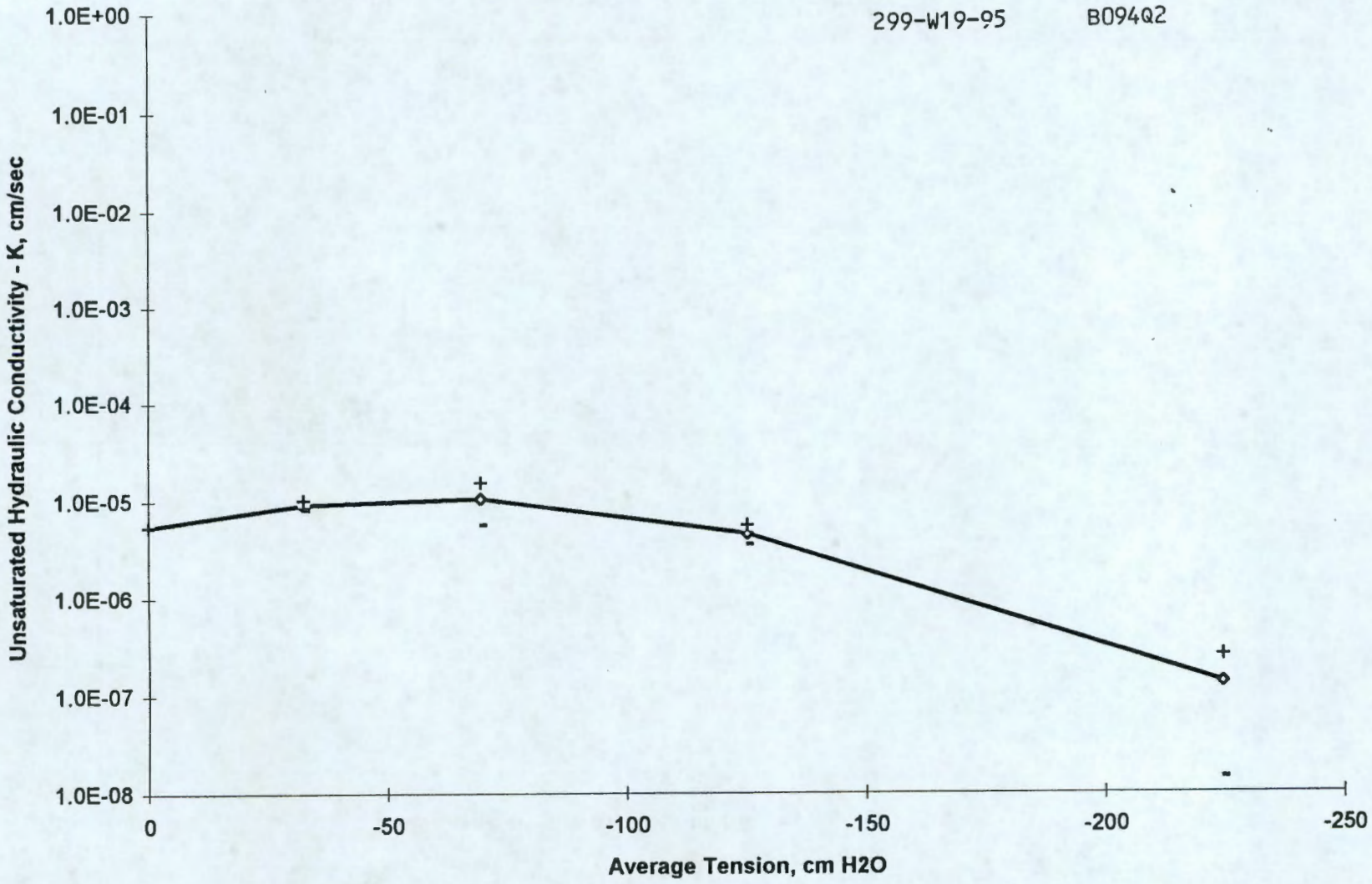
Unsaturated Hydraulic Conductivity Values for Test Sample 3-1712

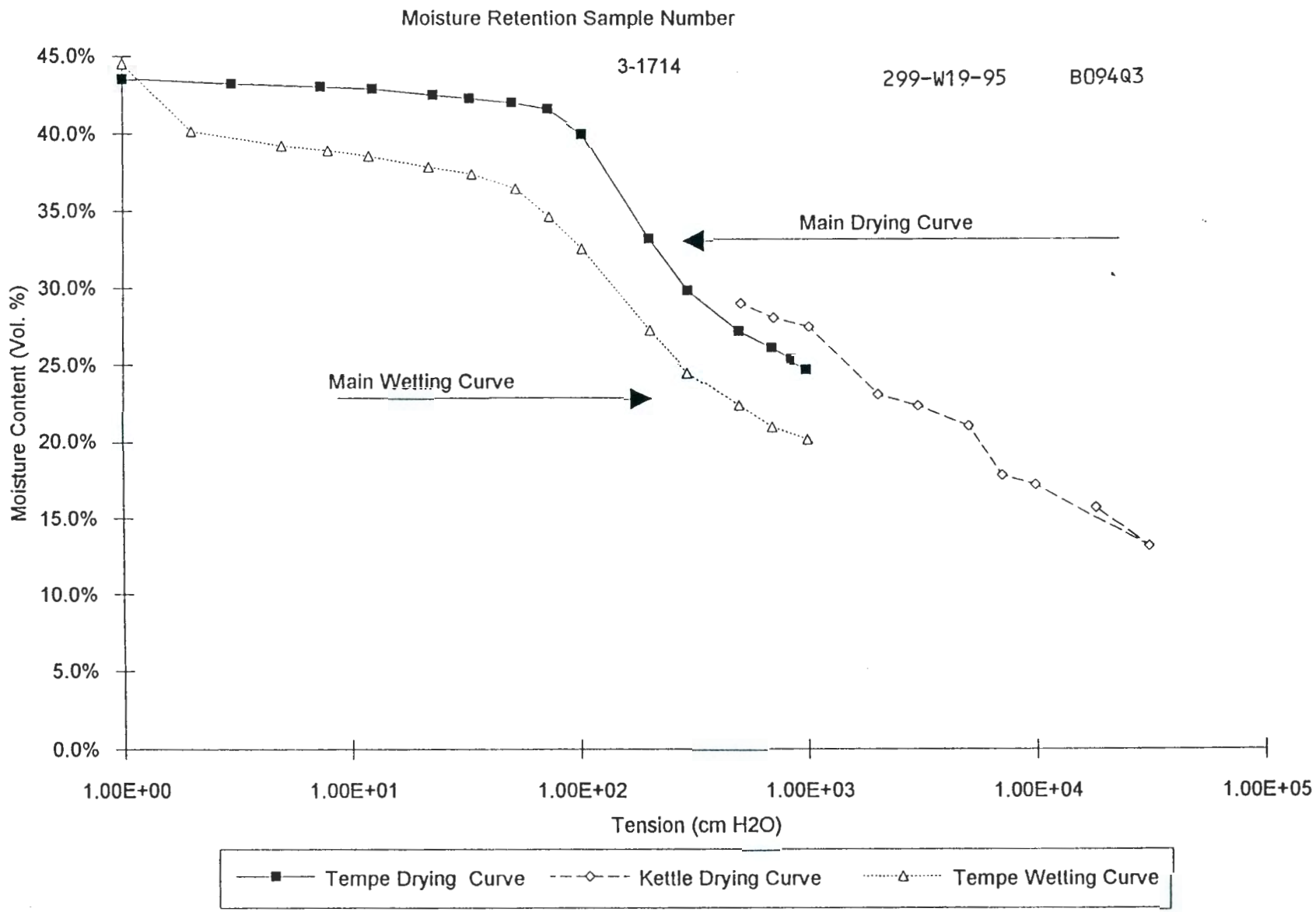




9513335.1159

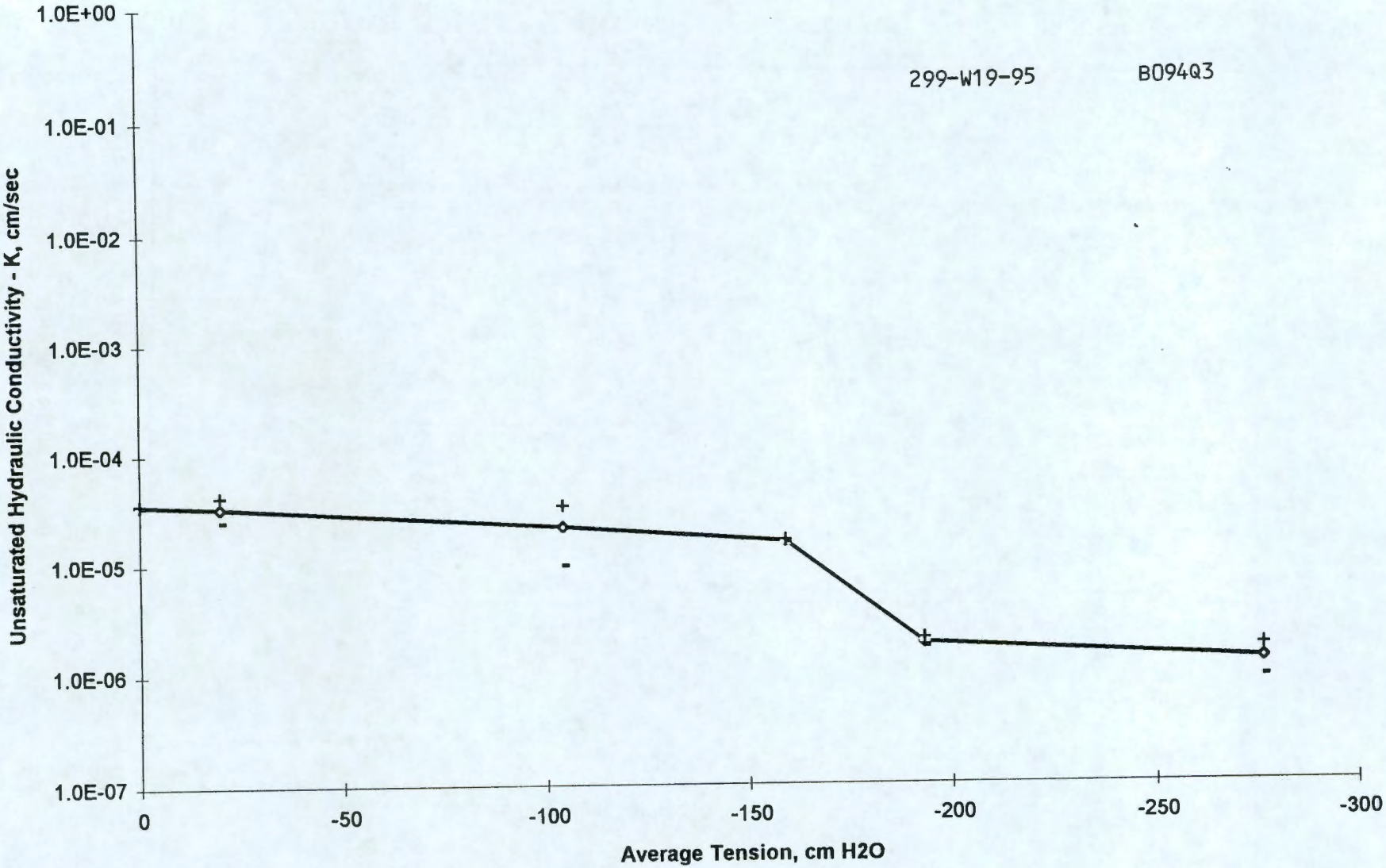
Unsaturated Hydraulic Conductivity Data for Sample 3-1713





9513351.1601

Unsaturated Hydraulic Conductivity Data for Sample 3-1714



APPENDIX C

RLS SPECTRAL GAMMA-RAY BOREHOLE SURVEY REPORTS

APPENDIX C.1

RLS System Description

The WHC Radionuclide Logging System(RLS) utilizes a high-purity germanium (HPGe) passive gamma-ray detector. Gamma-ray interactions with the HPGe crystal yield very sharp electrical charge pulses corresponding to energies of the impinging gamma ray resulting in excellent energy resolution. Precise energy resolution permits absolute identification of the gamma-emitting radionuclides and, with proper calibration, an accurate assay of their decay activity.

The HPGe detector is housed in the logging tool along with the high voltage power supply, preamplifiers, and a cryogenic system to maintain the detector at liquid nitrogen temperatures. The nitrogen is vented to the atmosphere through a conduit in the logging cable.

The surface components of the system include gamma-ray spectroscopy amplifiers and counting electronics interfaced with a computer. The computer controls the hydraulic winch during logging and maintains accurate positioning and movement of the detector in the borehole.

System and Radioelement Analyses Limitations

Several limitations of the borehole survey equipment, calibration, and data acquisition objectives are described below.

The logging cable equipped on the RLS was specifically designed for the system. It suspends the detector in the well, conducts power to the detector, receives electrical signals from the detector, and provides the conduit for venting the liquid nitrogen component of the detector. Errors in the depth measuring system of the RLS are mainly related to cable stretch, cable and sheave wheel contact, and electronic encoding components. The recorded depth of the detector is estimated to be accurate to 98.5 percent, with a precision (repeatability) of 99 percent. Comparisons with drilling measurements, other logging equipment, and secondary measurement systems have verified the accuracy.

Borehole environment correction factors have been determined for steel casing and water in the borehole. Correction factors for other borehole configurations have not been determined. Other configurations for which correction factors have not been determined, but which may be encountered at the Hanford site include: (1) grout between multiple casing strings, (2) formation seals containing grout, bentonite, or sand behind the casing, and (3) drilling mud present in the borehole while logging. The calculated decay activities will be underestimated with these configurations.

Energy-dependent casing corrections have been established for steel casing thicknesses up to 0.40 inch. Corrections for casings of different materials and/or cumulative thicknesses of greater than 0.40 inch have not been determined and therefore cannot be used in the data reduction process.

The calibration data were recorded with the detector centered in calibration zones that are uniform in density, water content, and gamma-ray source material. The dimensions of each zone are large enough that the detector always responded as though surrounded by a medium of infinite extent. Therefore, the use of the calibration results to calculate nuclide activity carries the assumption that the nuclide in the logged formation are also distributed in thick uniform layers.

Gamma-ray sources are not normally distributed in the earth in thick uniform layers. Source inhomogeneities are reflected to some degree by the fluctuations in the amplitudes of the log traces. A factor called the vertical spacial resolution quantifies the correlation between (1) the intensity of the log fluctuation and the depth interval over which it extends, and (2) the intensity of the corresponding gamma-ray source and the thickness of the zone in which the source is embedded. The vertical spatial resolution of the RLS HPGe logging system is scheduled for investigation.

Radionuclide decay activities are determined from the net area of the gamma-ray peaks. Radionuclides such as strontium-90, which do not emit a gamma ray when they decay, will not be identified or quantified by the spectral analyses process. However, the decay of strontium-90 results in a high-energy beta particle that can excite surrounding elements to emit gamma-ray radiation that can be identified by the HPGe detector. This type of radiation is called "bremsstrahlung" radiation. A method to obtain estimates of the concentration of strontium-90 is under consideration.

APPENDIX C.2

Borehole Survey Reports

The report for each borehole survey by the RLS contains three types of information. The contents are described as follows:

1. Log header

This form is titled "RLS Spectral Gamma-Ray Borehole Survey Log Header" and summarizes the borehole and survey information.

The form contains the project name, borehole number, coordinates, and elevation.

The borehole environment is described including casing size, wall thickness, depths, and water level (if present). This information is used during data reduction.

RLS survey information is presented and includes logging engineer(s) names, survey dates, file names, logging mode, and survey depths.

Data reduction information is provided including calibration date and report number, analyst name and analysis date. A line is included for notes and man-made radionuclide identification.

2. Radionuclide plots

The individual radionuclide activity responses versus depth plots are titled "RLS Spectral Gamma-Ray Borehole Survey".

The plots are contained on one or more pages depending on the number of radionuclide species encountered and/or depth of the borehole.

A uniform depth scale of 20 feet per inch is used for all plots. Four plot tracks are usually presented for uniformity, however improvements in plotting capabilities are forthcoming.

The "Total Gamma" is the count rate for all gamma rays detected by the RLS detector with no discrimination of the gamma-ray energy. The total gamma is equivalent to the gross gamma log used at Hanford for many years. The count rate data values are plotted on two linear scales. The scale of the narrow line is usually 0 to 1000 counts per second (cps): the scale of the wide line is 0 to 100,000 c/s. An expanded total gamma plot is provided with the 200-UP-2 data that has a single scale of 0 to 200 c/s.

Generally the natural radionuclides, potassium, uranium, and thorium will be plotted on a separate plot.

The remaining plot tracks contain the results of the spectra analyses. The computed activity values are generally plotted on two linear scales,

and similar to the total gamma, the thin-line scale is indicated at the top of the plot, the wide-line scale at the bottom.

3.RLS Borehole Survey Report

The RLS Borehole Survey Report contains a description of the borehole conditions, unusual logging conditions, and possible limitations with the data and/or results. The species of radionuclides encountered as well as their depth ranges and maximum activities are reported.

Westinghouse Hanford Company
RLS Spectral Gamma-Ray Borehole Survey Log Header

Project: 200-UP-2

Borehole	299-W19-02			
Coordinates	36849.0 N	-73000.0W	Feet	(Hanford System)
Elevation	694.04 ft	Top of casing		

Borehole Environment Information

Borehole liquid depth None (ft) from zero (0.0) depth reference of log

Casing size (in.)	Casing thickness (in.)	Top depth (ft)	Base depth (ft)
8	0.375	0.0	285

RLS Passive Spectral Gamma Survey Information

Logging Engineers R. V. Cram J. P. Kiesler
Log depth reference at zero (0.0) depth is ground level

Log Date	Archive file names	Log mode	speed	Depth interval (ft) Top	Base	Incr
Feb 08, 1994	H2W19002\A518	MSA	80sec RT	0.0	119.5	0.5
Feb 09, 1994	H2W19002\A519	MSA	80sec RT	118.5	239.5	0.5

MSA: Move-Stop-Acquire
RT: Real time

Calibration and Analysis Information

RLS Calibration Date: Nov. 21, 1991
Calibration Report: WHC-SD-EN-TRP-001

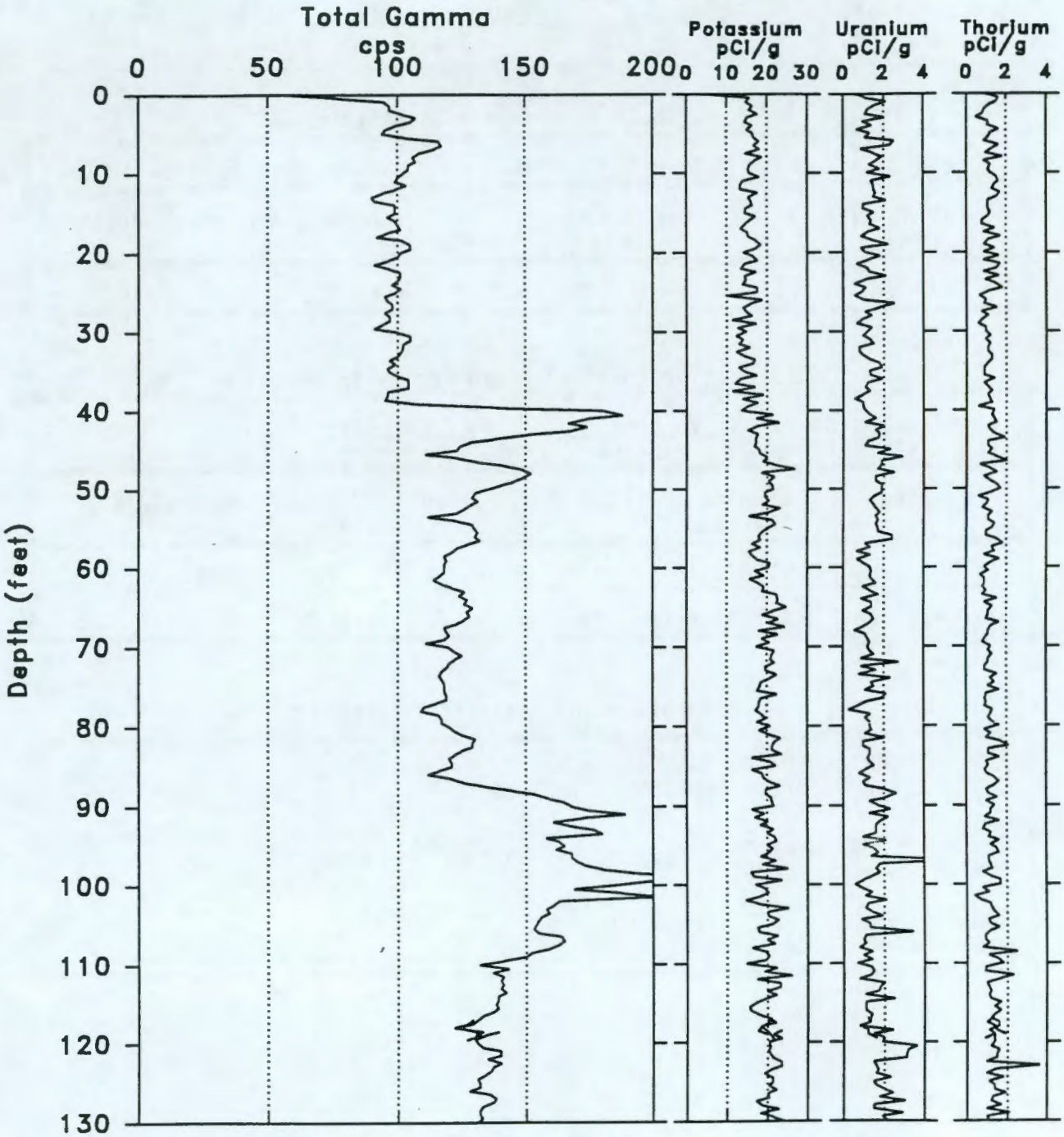
Analyst Names: S. E. Kos R. K. Price
Analysis Date: Dec 09, 1993

Analysis Notes: Single casing
Radionuclides Identified: Cs-137

RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-2
Borehole: 299-W19-2

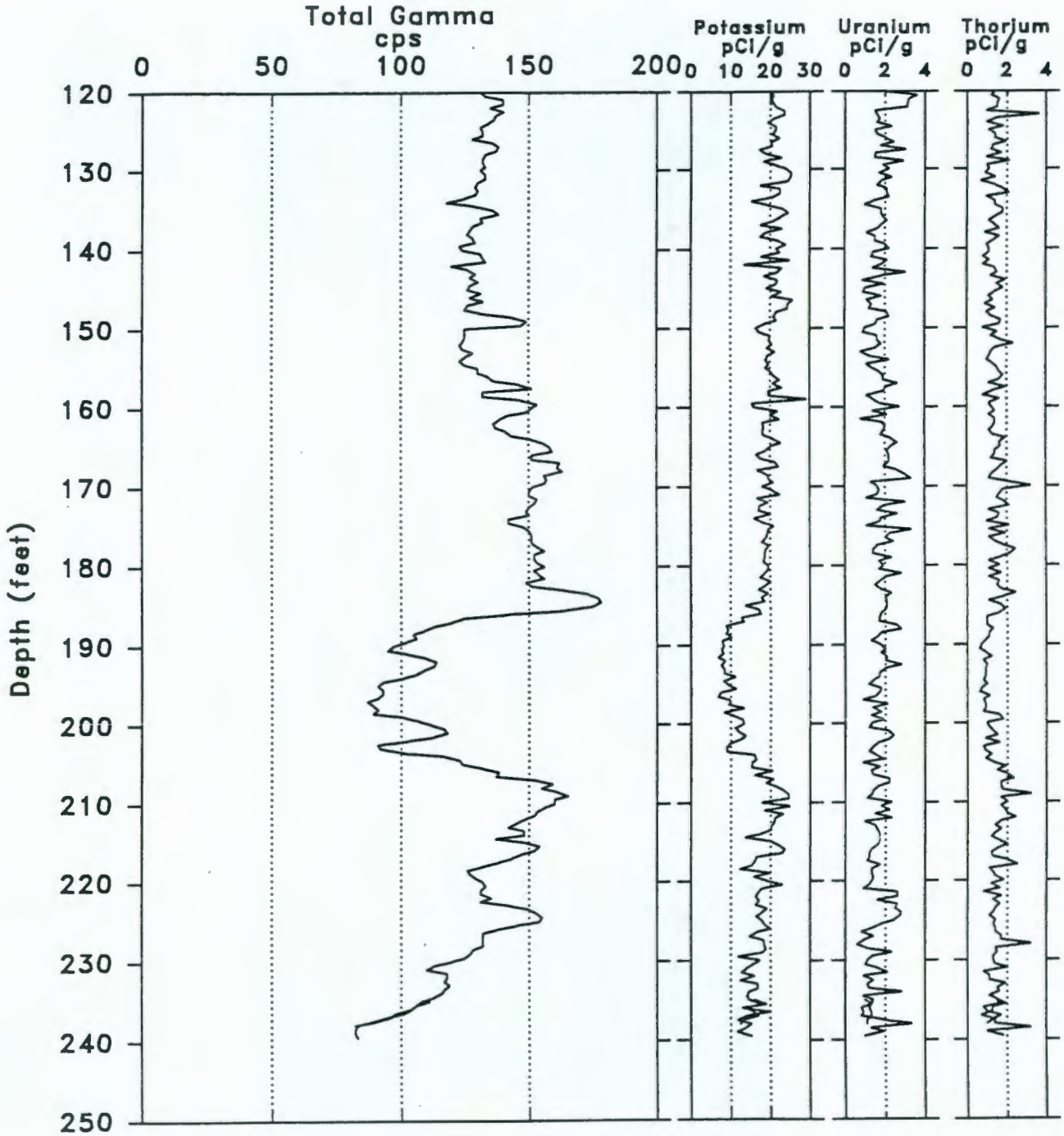
Log Date: Feb 09, 1994
Anal Date: Feb 16, 1994



RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-2
Borehole: 299-W19-2

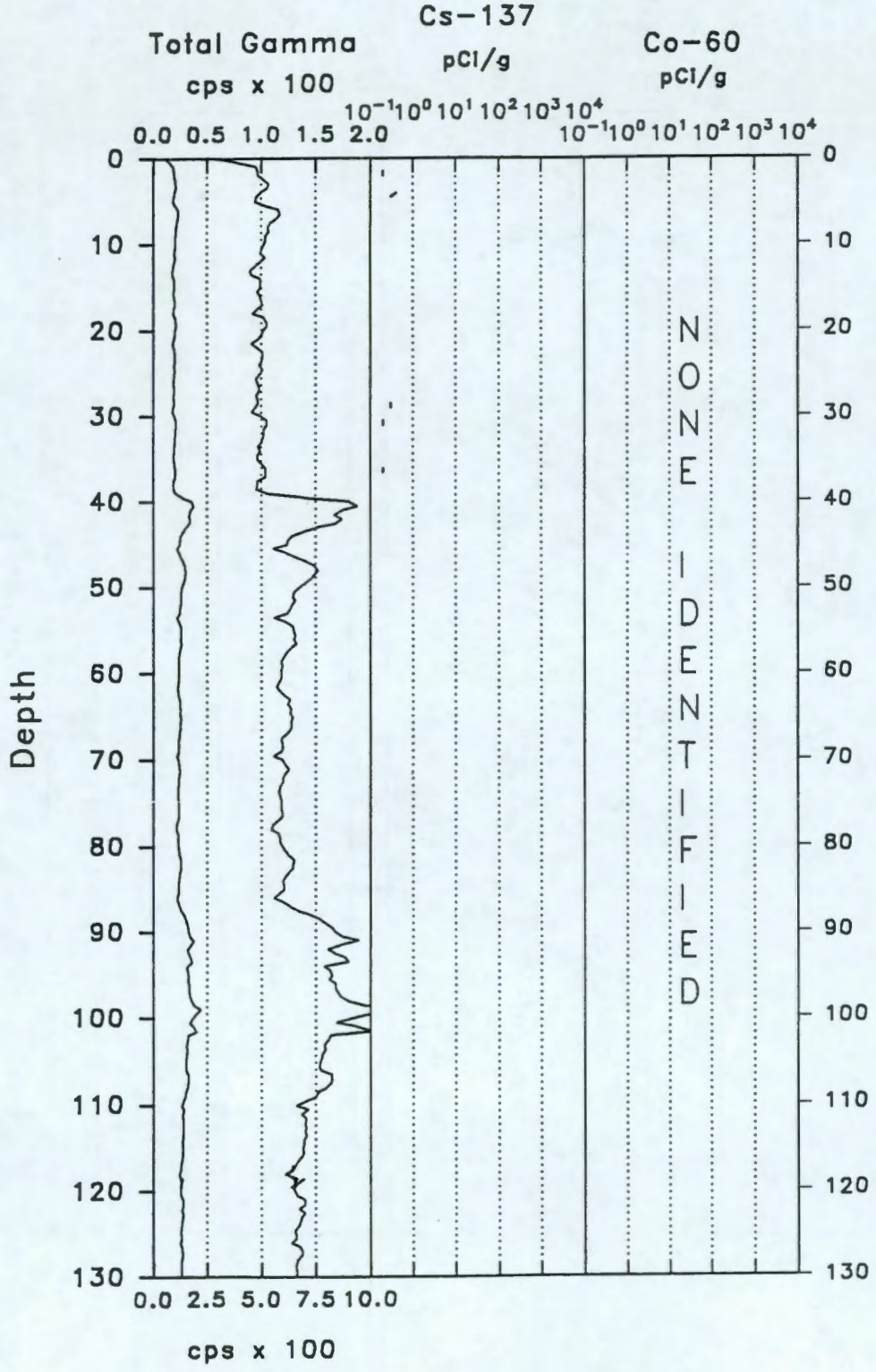
Log Date: Feb 09, 1994
Anal Date: Feb 16, 1994



RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-2 Log Date:Feb 09, 1994

Borehole: 299-W19-2 Analysis Date: Feb 16, 1994



RLS Borehole Survey Report

Borehole: 299-W19-2

Casing	Depth: 0.0'- 285'	Size: 8"	Thickness: 0.375"
Water	237.6'		
Survey	Interval: 0.0'- 119.5'	Date: Feb 08, 1994	
	118.5'- 239.5'	Feb 09, 1994	

General Notes:
The RLS survey of well 299-W19-2 was acquired in single 8-inch-diameter casing at an acquisition time of 80 seconds RT. The well is located at the U-8 crib in the 200-W area.

The plot of the naturally occurring radionuclides potassium, uranium and thorium shows normal Hanford sediment concentrations throughout the surveyed interval. Repeat sections were conducted in each survey and are included on the plots.

Man-made Radionuclides:
Cs-137 was identified intermittently from 1.5'-41.0', and at 115.0'. The maximum thickness observed was 1.0'; all activity was less than 1 piCi/g.

Westinghouse Hanford Company
RLS Spectral Gamma-Ray Borehole Survey Log Header

Project: 200-UP-2

Borehole	299-W19-70			
Coordinates	36860.0 N	-73100.0 W	Feet	(Hanford System)
Elevation	692.0 ft	Top of casing		

Borehole Environment Information

Borehole liquid depth None (ft) from zero (0.0) depth reference of log

Casing size (in.)	Casing thickness (in.)	Top depth (ft)	Base depth (ft)
8	0.375	0.0	105.0

RLS Passive Spectral Gamma Survey Information

Logging Engineers R. Cram J. Kiesler
Log depth reference at zero (0.0) depth is ground level

Log Date	Archive file names	Log mode	speed	Depth interval (ft) Top	Base	Incr
Feb 07, 1994	H2W19070\A517	MSA	80sec RT	0.0	81.5	0.5

MSA: Move Stop Acquire
RT: Real Time

Calibration and Analysis Information

RLS Calibration Date: Nov. 21, 1991
Calibration Report: WHC-SD-EN-TRP-001

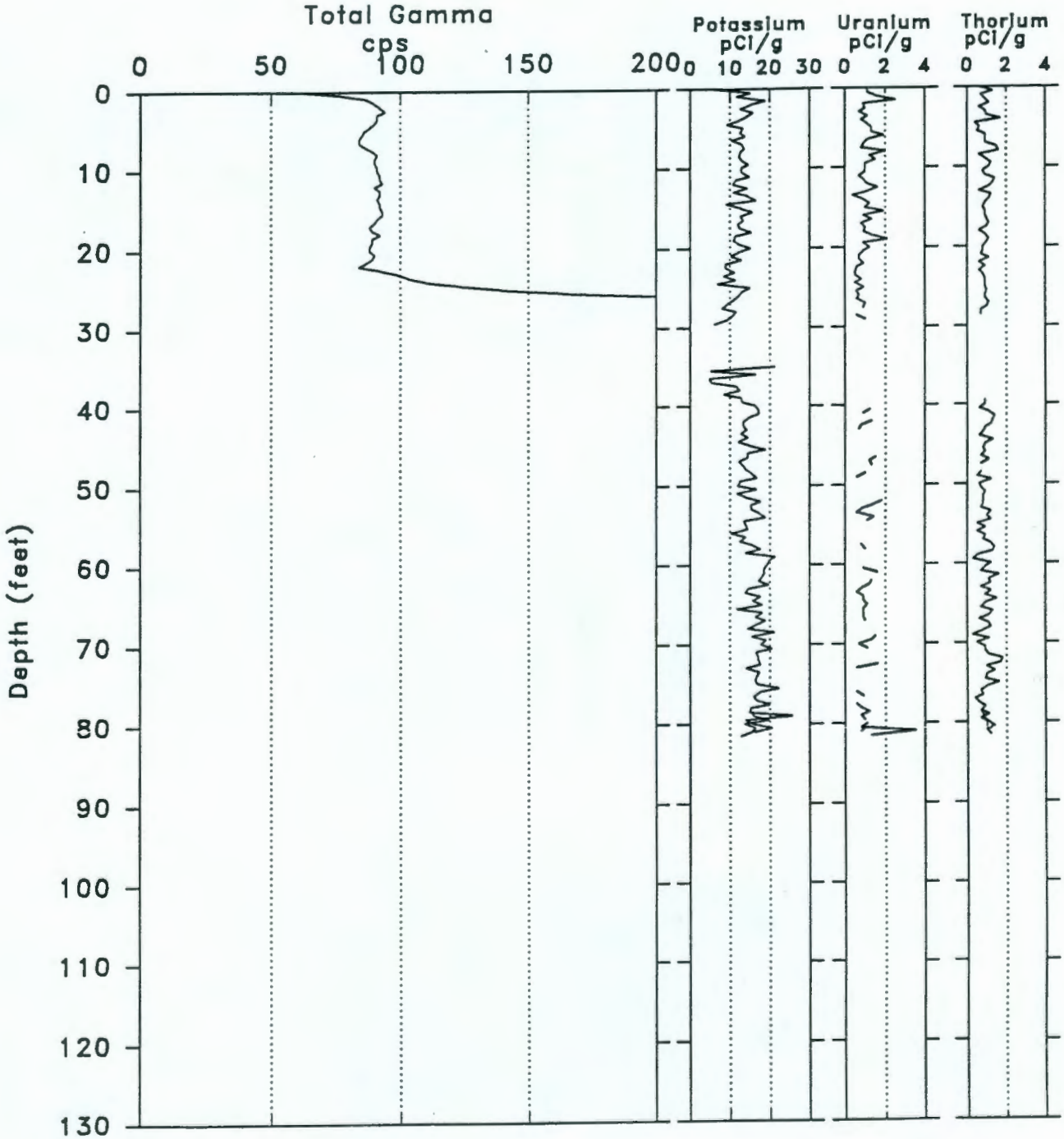
Analyst Names: S. E. Kos R. K. Price
Analysis Date: Feb 10, 1994

Analysis Notes: Detector saturated 30.0 to 35.5 feet
Radionuclides Identified: Cs-137, U-238, EU-154

RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-2
Borehole: 299-W19-70

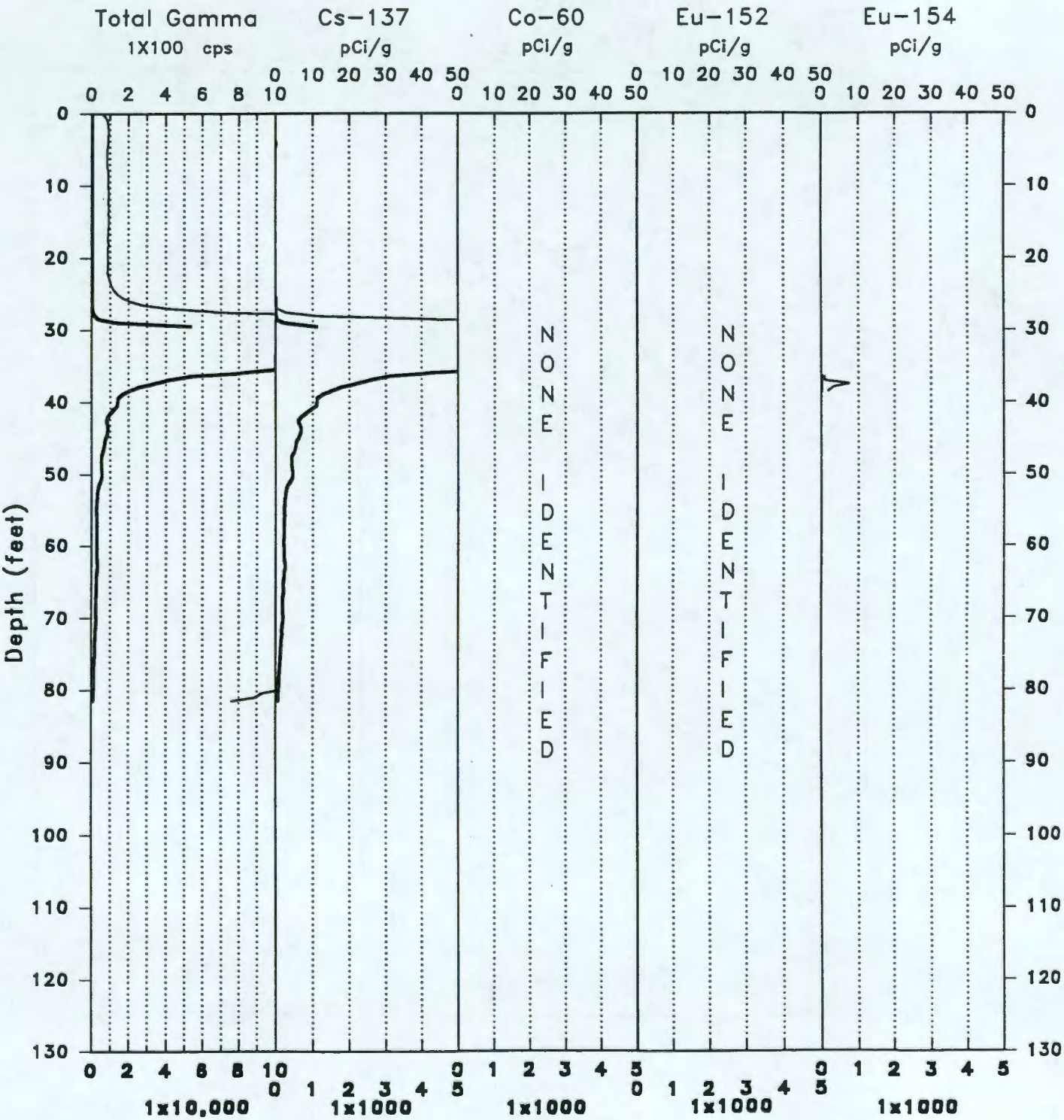
Log Date : Feb 07, 1994
Anal Date: Feb 10, 1994



RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-2 Log Date: Feb 07, 1994

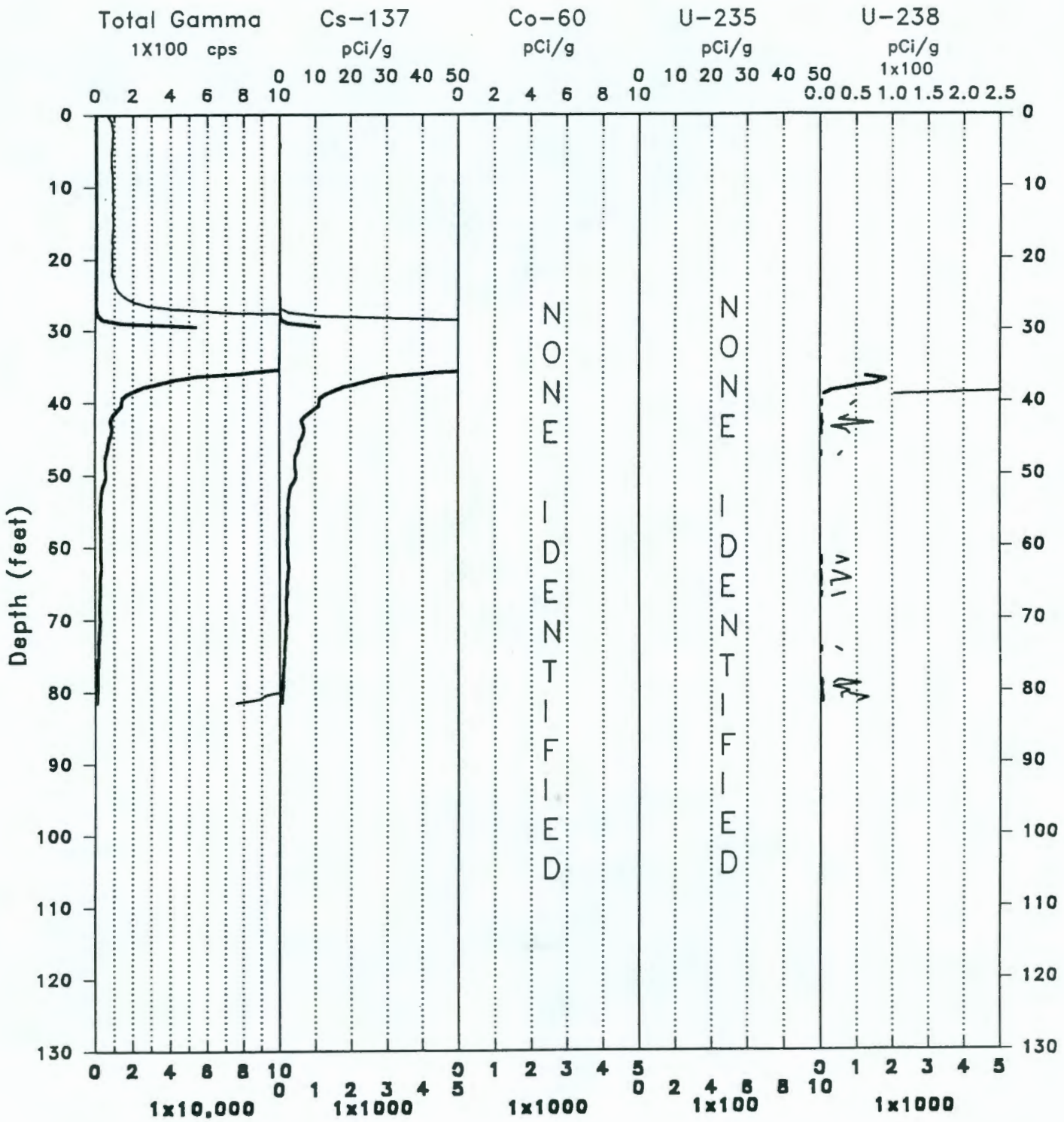
Borehole: 299-W19-70 Anal. Date: Feb 10, 1994



RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-2 Log Date: Feb 07, 1994

Borehole: 299-W19-70 Anal. Date: Feb 10, 1994



RLS Borehole Survey Report

Borehole: 299-W19-70

Casing Depth: 0.0′- 105′ Size: 8" Thickness: 0.375"

Water None

Survey Interval: 0.0′- 81.5′ Date: Feb 10, 1994

General Notes:
The RLS survey of well 299-W19-71 was acquired in single 8-inch-diameter casing at an acquisition time of 80 seconds RT. The well is located at the U-8 crib in the 200-W area. The Hanford Wells directory reports the depth of the well at 105′, however the pre-survey swab would not pass 81.6′.

The plot of the naturally occurring radionuclides potassium, uranium and thorium shows normal Hanford sediment concentrations throughout the surveyed interval. Excessive variation in the potassium concentration between 35.0 to 37.0 feet is due to the high count rate encountered in this interval. A repeat section was conducted from 78.5′-81.0′, and is included on the plot.

The detector was saturated in the interval 30.0′-34.0′.

Man-made Radionuclides:
Cs-137 was identified in the intervals 2.5′-24.5′(intermittently), and 25.5′-81.5′, the maximum survey depth. Activity exceeded 200 pCi/g from 29.0′-66.5′, and from 69.5′-70.0′. The maximum activity of 16156 pCi/g was observed at 34.0′ at the base of the saturation zone.

Co-60 was included in the analyses but was not identified. The Co-60 plot track is included on the plot for uniformity in presentation.

U-235 was included in the analyses but was not identified. The most prominent energy peak for U-235 at 186 KeV is unidentifiable in the spectrum when the Cs-137 concentration is greater than 20 pCi/g. The U-235 plot track is included on the plot for uniformity in presentation.

U-238 was identified in the interval 36.5′-44.5′,intermittently from 47.0-59.5′, from 61.5′-67.0′, intermittently from 72.0′-77.5′, and from 78.5′-81.5′, the maximum survey depth. Activity exceeded 200 pCi/g from 36.5′-38.5′. The maximum activity of 1806 pCi/g was observed at 37.0′.

Eu-154 was identified at 34.5′, and from 36.5′-39.5′. The maximum activity detected was 12.1 pCi/g at 34.5′, immediately below the base of the zone of saturation.

Eu-152 was included in the analysis but was not identified. The Eu-152 plot track is included on the plot for uniformity in presentation.

Westinghouse Hanford Company
RLS Spectral Gamma-Ray Borehole Survey Log Header

Project: 200-UP-2

Borehole	299-W19-71			
Coordinates	36800 N	73100 W	Feet	(Hanford System)
Elevation	692 ft	Top of casing		

Borehole Environment Information

Borehole liquid depth None (ft) from zero (0.0) depth reference of log

Casing size (in.)	Casing thickness (in.)	Top depth (ft)	Base depth (ft)
8	0.375	0.0	107.0

RLS Passive Spectral Gamma Survey Information

Logging Engineers R. Cram J. Kiesler
Log depth reference at zero (0.0) depth is ground level

Log Date	Archive file names	Log mode	speed	Depth interval (ft) Top	Base	Incr
Feb 02, 1994	H2W19071\A514	MSA	80sec RT	0.0	79.5	0.5

MSA: Move Stop Acquire
RT: Real Time

Calibration and Analysis Information

RLS Calibration Date: Nov. 21, 1991
Calibration Report: WHC-SD-EN-TRP-001

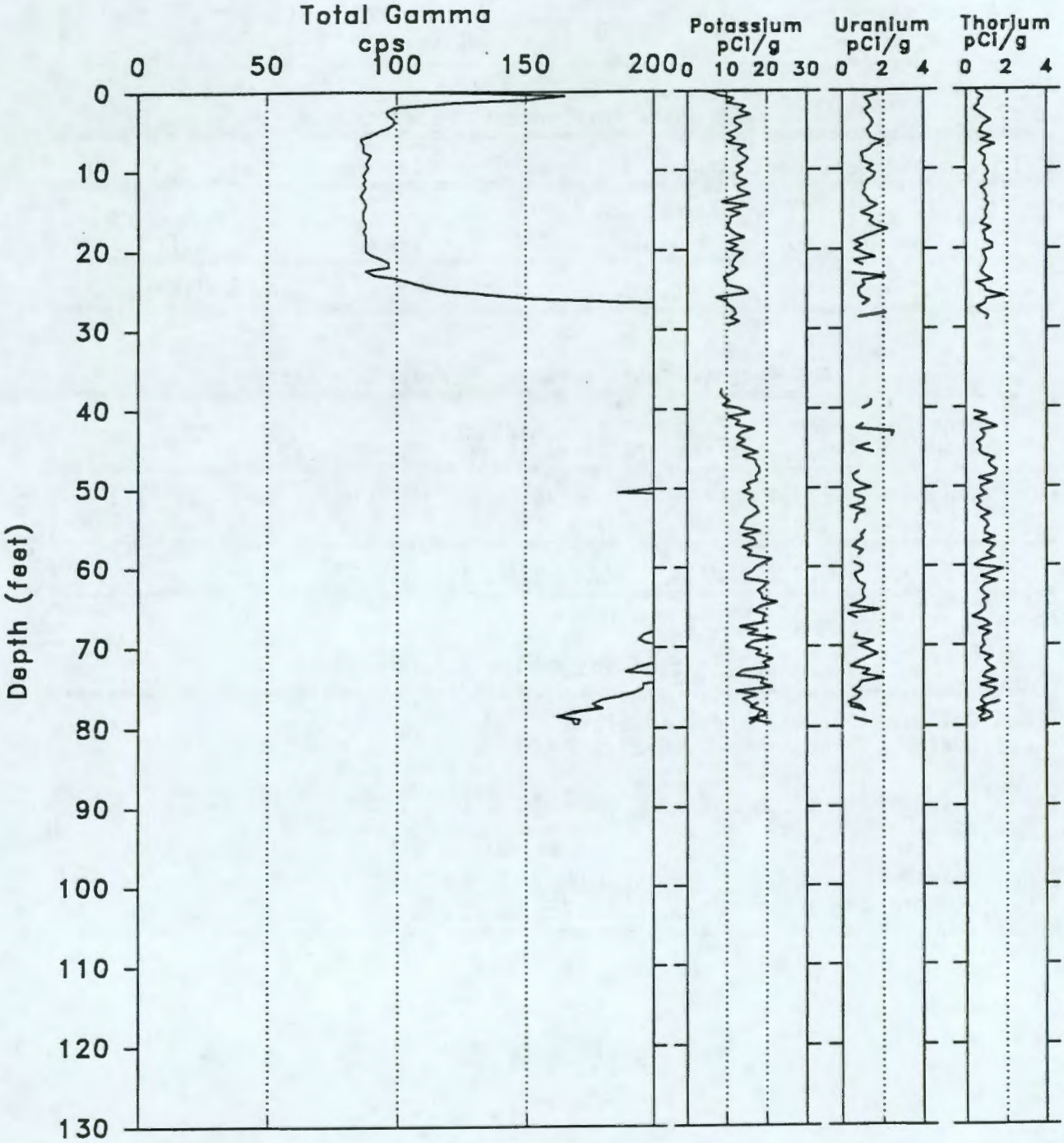
Analyst Names: S. E. Kos R. K. Price
Analysis Date: Feb 04, 1994

Analysis Notes: Detector saturated 30.0-37.0 feet
Radionuclides Identified: Cs-137, U-235, U-238

RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-2
Borehole: 299-W19-71

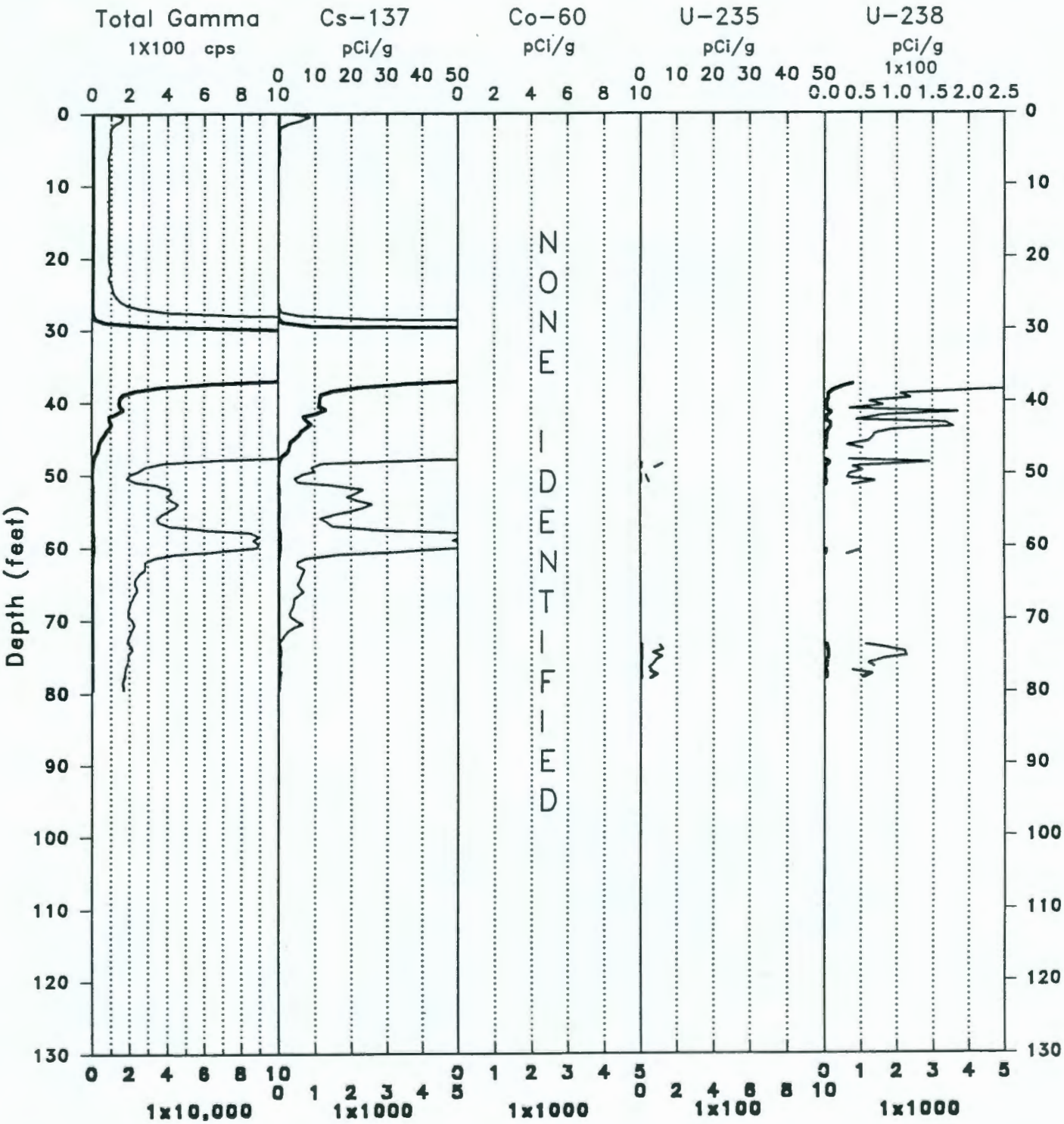
Log Date : Feb 02, 1994
Anal Date: Feb 04, 1994



RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-2 Log Date: Feb 02, 1994

Borehole: 299-W19-71 Anal. Date: Feb 04, 1994



RLS Borehole Survey Report

Borehole: 299-W19-71

Casing Depth: 0.0′- 107′ Size: 8" Thickness: 0.375"

Water None

Survey Interval: 0.0′- 79.5′ Date: Feb 02, 1994

General Notes:
The RLS survey of well 299-W19-71 was acquired in single 8-inch-diameter casing at an acquisition time of 80 seconds RT. The well is located at the U-8 crib in the 200-W area.

The Hanford Wells directory reports the depth of the well at 107′, however the pre-survey swab would not pass 78.6′. The plot of the naturally occurring radionuclides potassium, uranium and thorium shows normal Hanford sediment concentrations throughout the surveyed interval. A repeat section was conducted from 77.0′-79.5′, and is included on the plot.

The detector was saturated in the interval 30.0′-37.0′.

Man-made Radionuclides:
Cs-137 was identified in the intervals 0′-7.0′, 26.5′-30.0′, and 36.5′-79.5′, the maximum survey depth. Activity exceeded 200 pCi/g from 29.5′-30.0′, and from 36.5′-47.0′. The maximum activity of >5000 pCi/g was observed at 30.0′, and from 36.5′ to 37.0′.

Co-60 was included in the analyses but was not identified. The Co-60 track is included on the plot for uniformity in presentation.

U-235 was identified in the intervals 48.5′-51.0′, 73.5′-78.0′, and at 79.0′. The maximum activity of 6.2 pCi/g was observed at 74.0′. The most prominent energy peak for U-235 at 186 KeV is unidentifiable when the CS-137 concentration is >20 pCi/g.

U-238 was identified in the intervals 37.5′-46.5′, 48.0′-51.5′,intermittently from 58.0′-61.0′, and 73.5′-78.0′. Activity exceeded 200 pCi/g at 37.5′-38.5′. The maximum activity of 779 pCi/g was observed at 37.5′, the bottom of the detector saturation zone. Detector saturation prevented observation of the initial occurrence of U-238.

Westinghouse Hanford Company
RLS Spectral Gamma-Ray Borehole Survey Log Header

Project: 200-UP-2

Borehole	299-W19-94			
Coordinates	NA N	NA W	Feet	(Hanford System)
Elevation	NA ft	Top of casing		

Borehole Environment Information

Borehole liquid depth None (ft) from zero (0.0) depth reference of log

Casing size (in.)	Casing thickness (in.)	Top depth (ft)	Base depth (ft)
12	0.500	0	37.62
10	0.500	0	97.56
8	0.500	0	195.42

RLS Passive Spectral Gamma Survey Information

Logging Engineers R. V. Cram J. P. Kiesler
Log depth reference at zero (0.0) depth is ground level

Log Date	Archive file names	Log mode speed	Depth interval (ft) Top	Base	Incr
Dec 10, 1993	H2W19094\A485	MSA 180sec RT Stat. 500sec RT	0.0 36.0	36.0	0.5
Dec 17, 1993	H2W19094\A489	MSA 180sec RT Stat. 500sec RT	35.0 94.5	94.5	0.5
Jan 18, 1994	H2W19094\A505	MSA 180sec RT	93.5	194.0	0.5
Jan 19, 1994	H2W19094\A506	MSA 180sec RT Stat. 300sec RT	190.0 197.0	197.0	0.5

MSA: Move-Stop-Acquire
RT: Real time

Calibration and Analysis Information

RLS Calibration Date: Nov. 21, 1991
Calibration Report: WHC-SD-EN-TRP-001

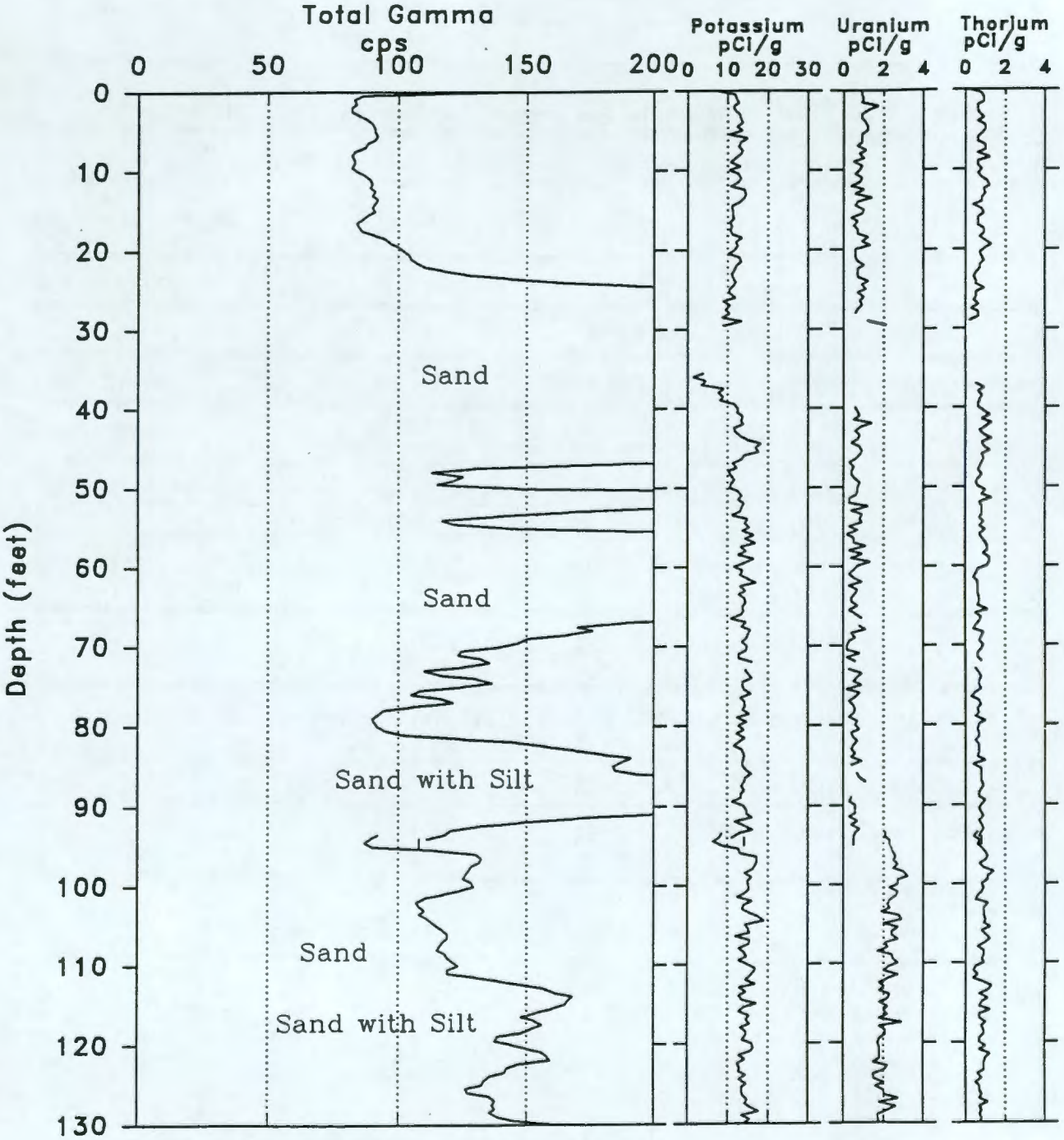
Analyst Names: S. E. Kos R. K. Price
Analysis Date: Feb 03, 1994

Analysis Notes: Exceeded maximum casing correction factor
Radionuclides Identified: Cs-137, U-235, U-238, Eu-154

RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-2
Borehole: 299-W19-94

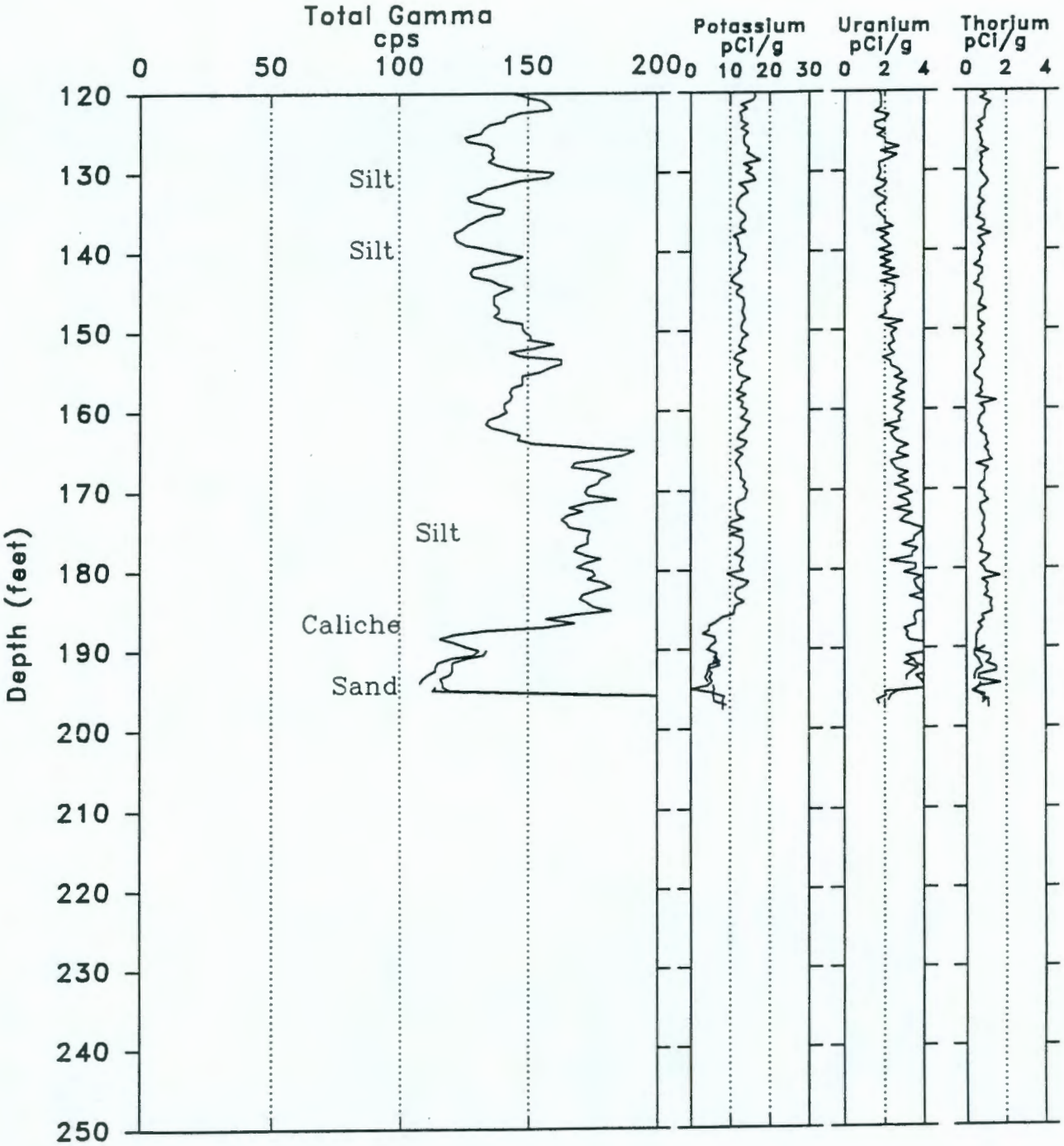
Log Date : Jan 19, 1994
Anal Date: Feb 02, 1994



RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-2
Borehole: 299-W19-94

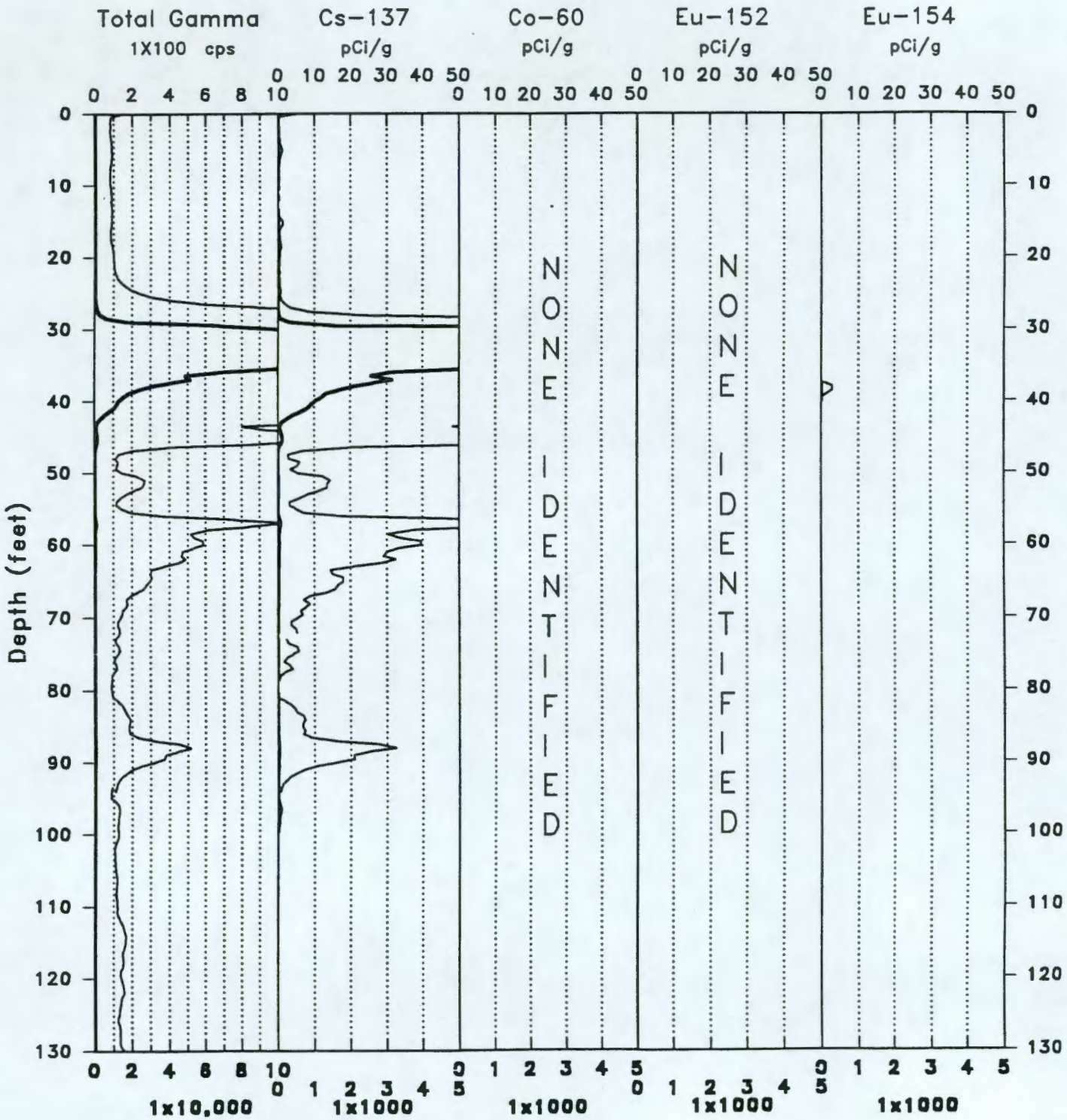
Log Date : Jan 19, 1994
Anal Date: Feb 02, 1994



RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-2 Log Date: Jan 19, 1994

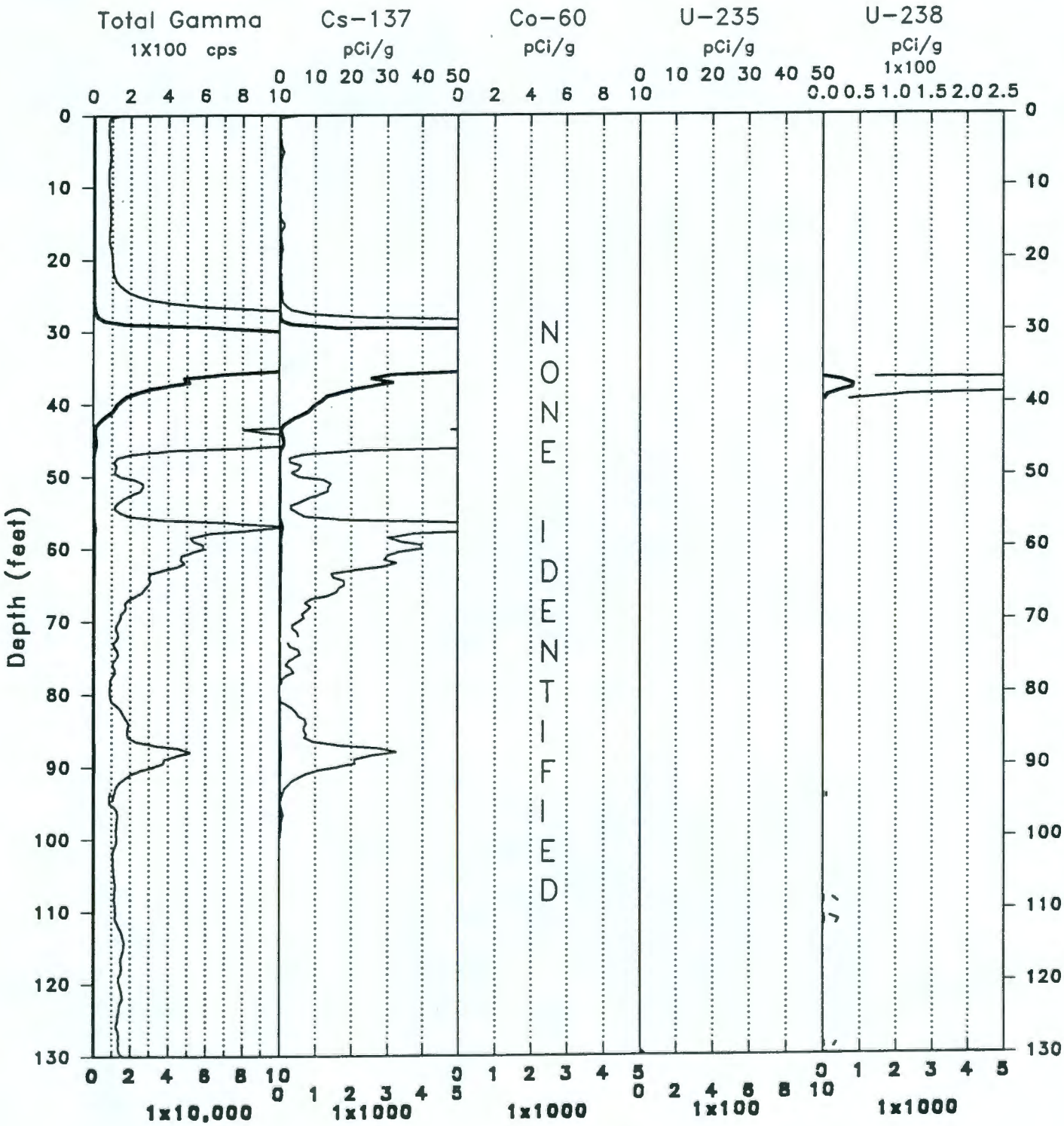
Borehole: 299-W19-94 Anal. Date: Feb 03, 1994



RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-2 Log Date: Jan 19, 1994

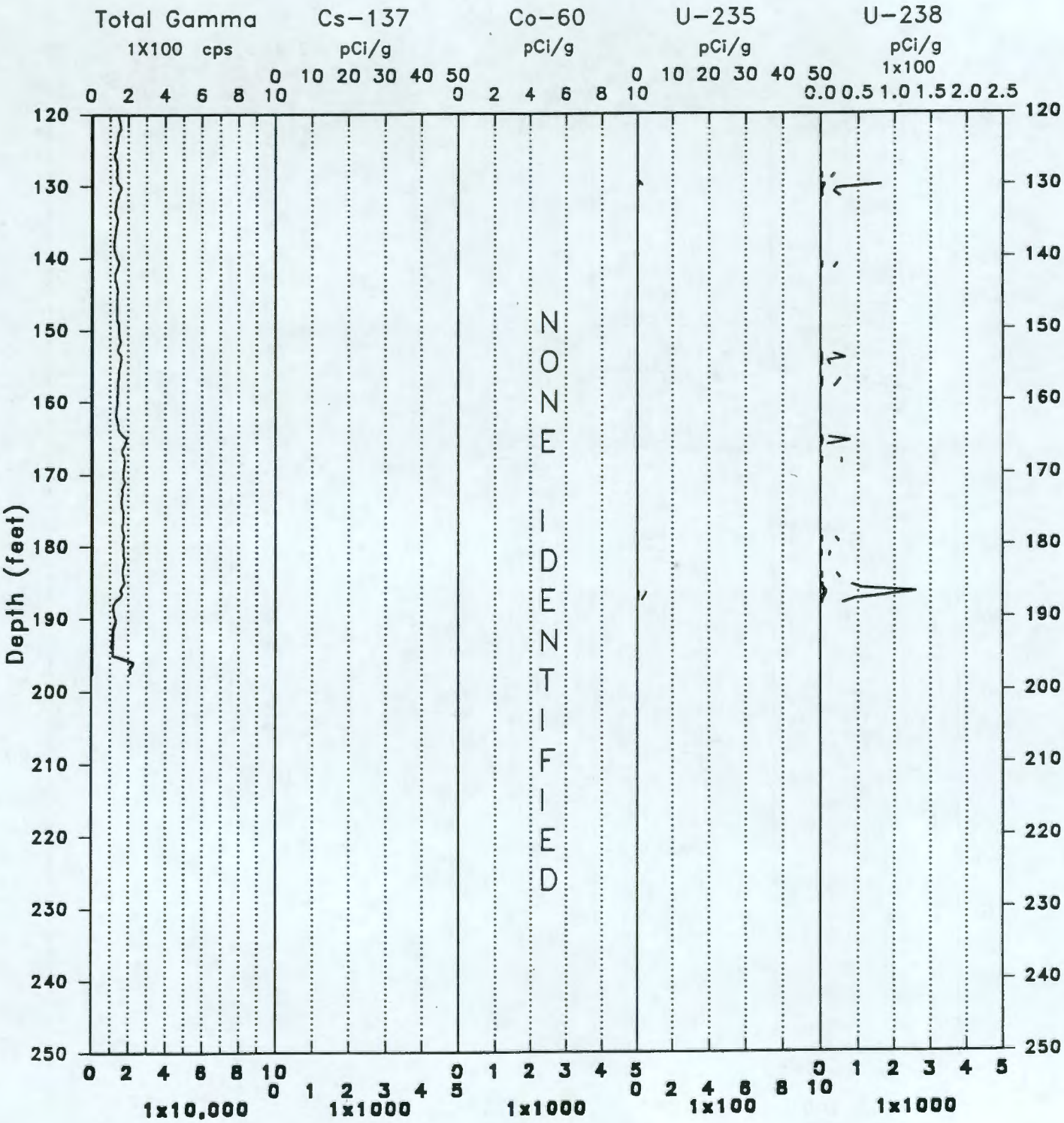
Borehole: 299-W 19-94 Anal. Date: Feb 03, 1994



RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-2 Log Date: Jan 19, 1994

Borehole: 299-W19-94 Anal. Date: Feb 03, 1994



RLS Borehole Survey Report

Borehole: 299-W19-94

Casing	Depth: 0.0′- 37.62′	Size: 12"	Thickness: 0.50"	
Casing	Depth: 0.0′- 97.56′	Size: 10"	Thickness: 0.50"	
	Depth: 0.0′-195.42′	Size: 8"	Thickness: 0.50"	
Water	None			
Survey	Depth: 0.0′- 36.0′	Date: Dec 10, 1993		
	Depth: 35.0′- 94.5′	Date: Dec 17, 1993		
	Depth: 93.5′-194.0′	Date: Jan 18, 1994		
	Depth: 190.0′-197.0′	Date: Jan 19, 1994		

General Notes:
The well was surveyed four times during drilling; each survey was conducted in a single-casing zone. The first survey spanned the interval 0.0′ to 36.0′ in 12-inch-diameter carbon steel casing. The second survey spanned the interval 35.0′ to 94.5′ in 10-inch-diameter threaded-joint carbon steel casing. The third survey spanned the interval 93.5′ to 194.0′ in 8-inch-diameter threaded-joint carbon steel casing. A fourth survey was necessary because the liquid nitrogen became depleted at the end of the third survey, and the equipment had to be shut down. All surveys were performed at an acquisition time of 180 seconds real time at a .5′ sample interval. Stationary measurements were also acquired at 300 and 500-second acquisition times. The location of stationary measurements are noted on the log header. The detector was saturated from 30.0′ to 35.5′

The plot tracks for the naturally occurring radionuclides show the depth profile for the total gamma count rate and the radionuclides potassium, uranium and thorium. The calculated activities for the naturally occurring radionuclides for all intervals surveyed are typical for Hanford sediments.

Man-made Radionuclides:
Cesium (Cs-137) was identified from 0.0′ to 99.5′, and at 132.0′. The Cs-137 activity exceeded 200 pCi/g from 29.0′ to 30.0′, and from 35.5′ to 42.5′. Cs-137 was observed immediately above and below the interval of detector saturation.

Uranium-235 was identified from 129.5′ to 130.5′, at 143.0′ and 155.0′, from 186.0′ to 188.0′, and at 189.5′. The maximum observed activity of 2.6 pCi/g occurred at 186.5′.

Uranium-238 was identified at 10.5′, from 36.5′ to 41.0′, intermittently from 43.0′ to 182.0′, and from 184.0′ to 188.5′. The maximum activity of 831 pCi/g was observed at 37.5.

Co-60 was analyzed but was not identified. The Co-60 plot track is included for uniformity in plot presentation.

Eu-152 was analyzed but was not identified. The Eu-152 plot track is included for uniformity in plot presentation.

Eu-154 was identified from 37.5′to 40.5′. The maximum activity of 2.9 pCi/g occurred at 38.0′.

Westinghouse Hanford Company
RLS Spectral Gamma-Ray Borehole Survey Log Header

Project: 200-UP-2

Borehole	299-W19-95				
Coordinates	NA	N	NA	W	Feet (Hanford System)
Elevation	NA	ft	Top of casing		

Borehole Environment Information

Borehole liquid depth None (ft) from zero (0.0) depth reference of log

Casing size (in.)	Casing thickness (in.)	Top depth (ft)	Base depth (ft)
10	0.50	0	101.0
8	0.50	0	180.2

RLS Passive Spectral Gamma Survey Information

Logging Engineers R. V. Cram S. E. Kos J. P. Kiesler
Log depth reference at zero (0.0) depth is ground level

Log Date	Archive file names	Log mode	speed	Depth interval (ft) Top	Base	Incr
Sep 13, 1993	H2W1995\A434	MSA	120sec RT	0	100.0	0.5
Sep 21, 1993	H2W1995\A436	MSA	120sec RT	99.0	179.5	0.5

MSA: Move-Stop-Acquire
RT: Real time

Calibration and Analysis Information

RLS Calibration Date: Nov. 21, 1991
Calibration Report: WHC-SD-EN-TRP-001

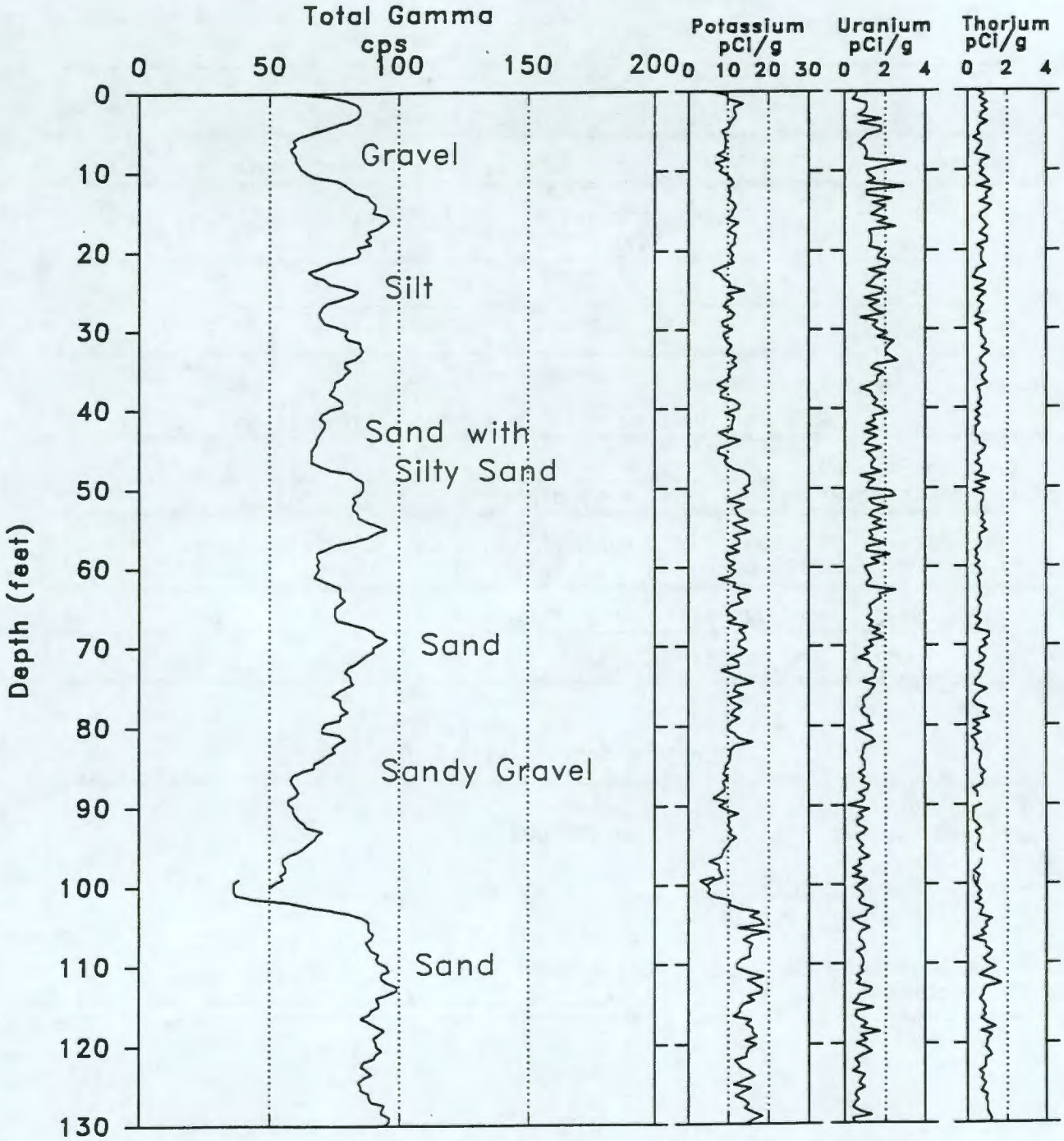
Analyst Names: S. E. Kos R. K. Price
Analysis Date: Nov 19, 1993

Analysis Notes: Double casing- exceeds max. correction factor
Radionuclides Identified: Cs-137

RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-2
Borehole: 299-W19-95

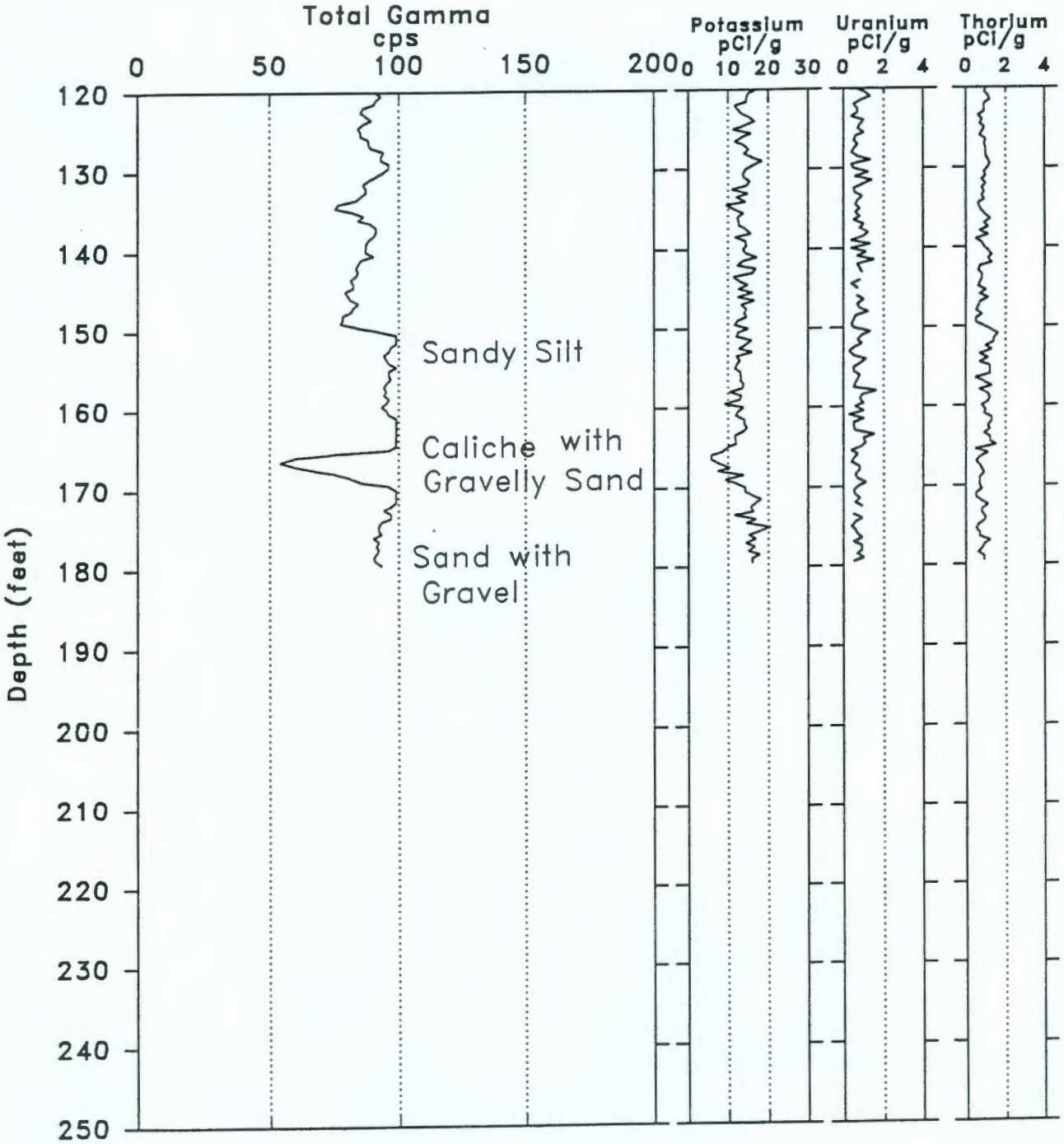
Log Date : Sep 21, 1993
Anal Date: Nov 19, 1993



RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-2
Borehole: 299-W19-95

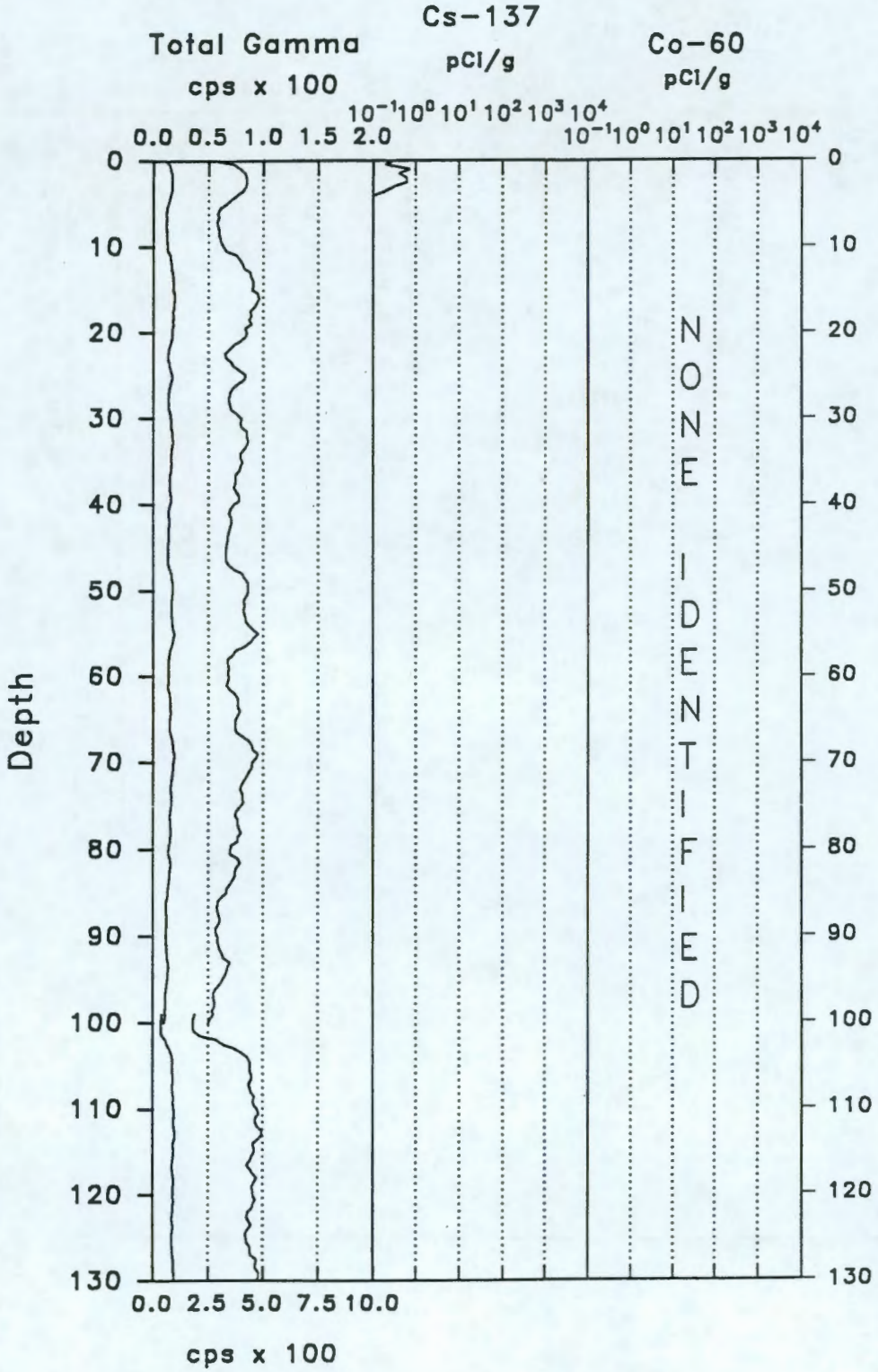
Log Date : Sep 21, 1993
Anal Date: Nov 19, 1993



RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-2 Log Date: Sep 21, 1993

Borehole: 299-W19-95 Analysis Date: Nov 19, 1993



RLS Borehole Survey Report

Borehole: 299-W19-95

Casing	Depth: 0.0′-101.0′	Size: 10"	Thickness: 0.50"
Casing	Depth: 0.0′-180.2′	Size: 8"	Thickness: 0.50"
Water	None		
Survey	Depth: 0.0′-100.0′	Date: Sep 13, 1993	
	Depth: 99.0′-179.5′	Date: Sep 21, 1993	

General Notes:
The well was surveyed twice during drilling; each survey was conducted in a single-casing zone. The first survey spanned the interval 0.0′ to 100.0′ in 10-inch-diameter threaded-joint carbon steel casing. The second survey spanned the interval 99.0′ to 179.5′ in 8-inch-diameter threaded-joint carbon steel casing. There was no fill material between the casing strings. The thickness of each casing was .500 inch, exceeding the maximum correction factor. A casing overlap during the second survey for the interval 99.0′ to 101.0′ resulted in a lower calculated activity than actually present. All measurements were acquired at 120 seconds real time.

The plot tracks for the naturally occurring radionuclides shows the depth profile for the total gamma count rate and the radionuclides potassium, uranium and thorium. The maximum total gamma count rate of slightly above 100 cps (111cps at 164.5′) occurs in three zones; 150.5′-151.5′; 162.5′-164.5′;and 170.0′-171.0′. The higher count rates in these zones are consistent with the concentrations of the naturally occurring radionuclides. The calculated activities for the naturally occurring radionuclides throughout the interval surveyed are typical for Hanford soils.

Man-made Radionuclides:
Cesium (Cs-137) was detected from 0.0′ to 4.0′ with a maximum calculated activity of less than 1 pCi/g. Analyses were performed for U-235 and U-238; neither of these radionuclides was identified. The Cs-137 results are plotted along with total gamma cps; the additional tracks are plotted for plot consistency.

Westinghouse Hanford Company
RLS Spectral Gamma-Ray Borehole Survey Log Header

Project: 200-UP-2

Borehole 299-W19-96
Coordinates NA N NA W Feet (Hanford System)
Elevation NA ft Top of casing

Borehole Environment Information

Borehole liquid depth none (ft) from zero (0.0) depth reference of log

Casing size (in.)	Casing thickness (in.)	Top depth (ft)	Base depth (ft)
12	0.500	0.0	38.0
10	0.500	0.0	99.5
8	0.500	0.0	173.0

RLS Passive Spectral Gamma Survey Information

Logging Engineers R. V. Cram J. P. Kiesler
Log depth reference at zero (0.0) depth is ground level

Log Date	Archive file names	Log mode speed	Depth interval (ft) Top	Base	Incr
Nov 23, 1993	H2W19096\A476	MSA 180sec RT	0.0	26.0	0.5
		80sec RT	26.5	38.5	0.5
		Stat.300sec RT	38.52		
Dec 21, 1993	H2W19096\A490	MSA 180sec RT	37.0	99.5	0.5
		Stat.300sec RT	99.89		
Jan 06, 1994	H2W19096\A498	MSA 180sec RT	99.0	166.5	0.5
Jan 12, 1994	H2W19096\A502	MSA 180sec RT	155.0	175.5	0.5
		Stat.300sec RT	175.0		

MSA: Move-Stop-Acquire
RT: Real time

Calibration and Analysis Information

RLS Calibration Date: Nov. 21, 1991
Calibration Report: WHC-SD-EN-TRP-001

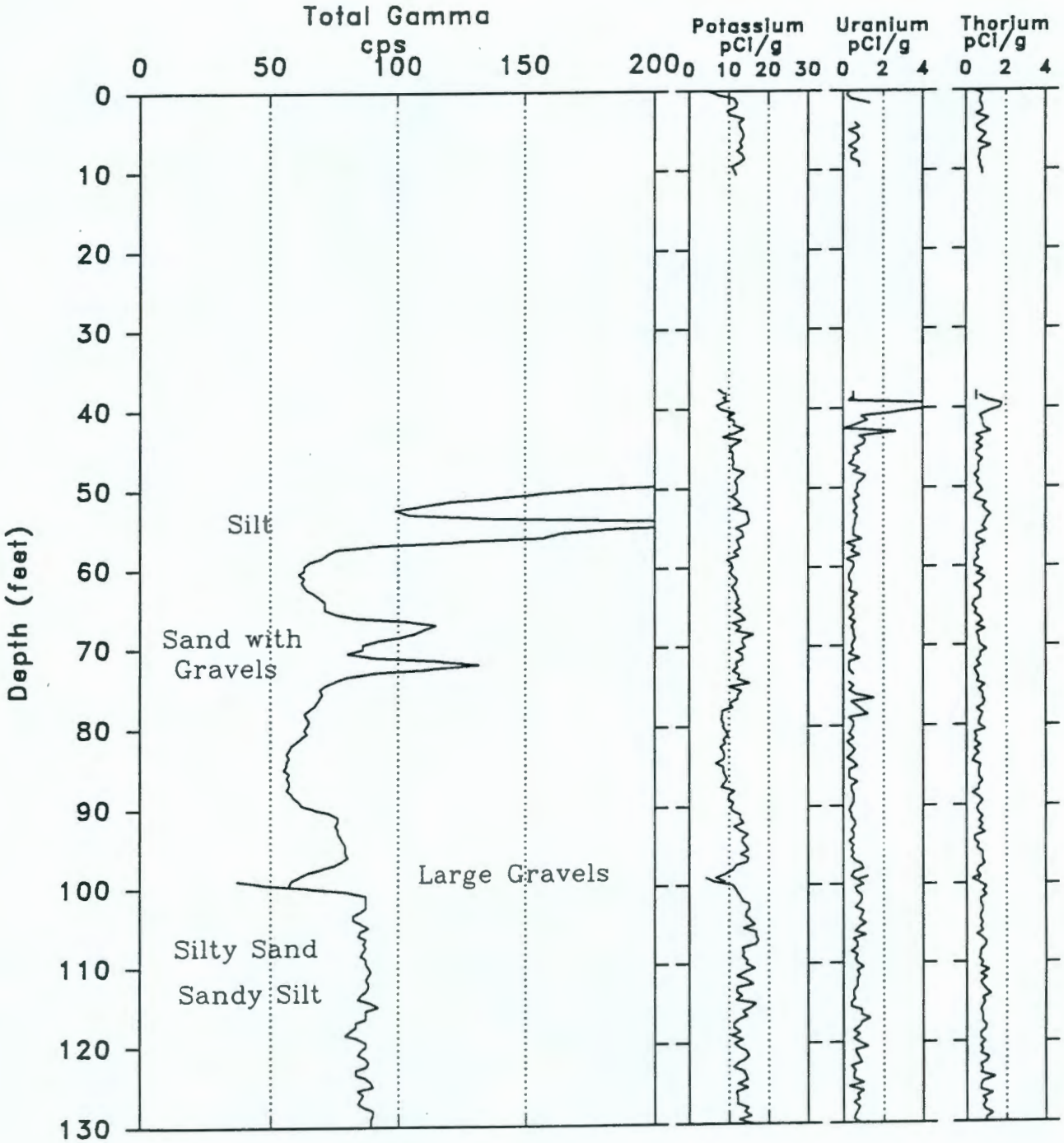
Analyst Names: S. E. Kos R. K. Price
Analysis Date: Apr 06, 1994

Analysis Notes: Casing exceeds max. correction factor
Radionuclides Identified: Cs-137, Co-60, Eu-152/154, U-235/238

RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-2
Borehole: 299-W19-96

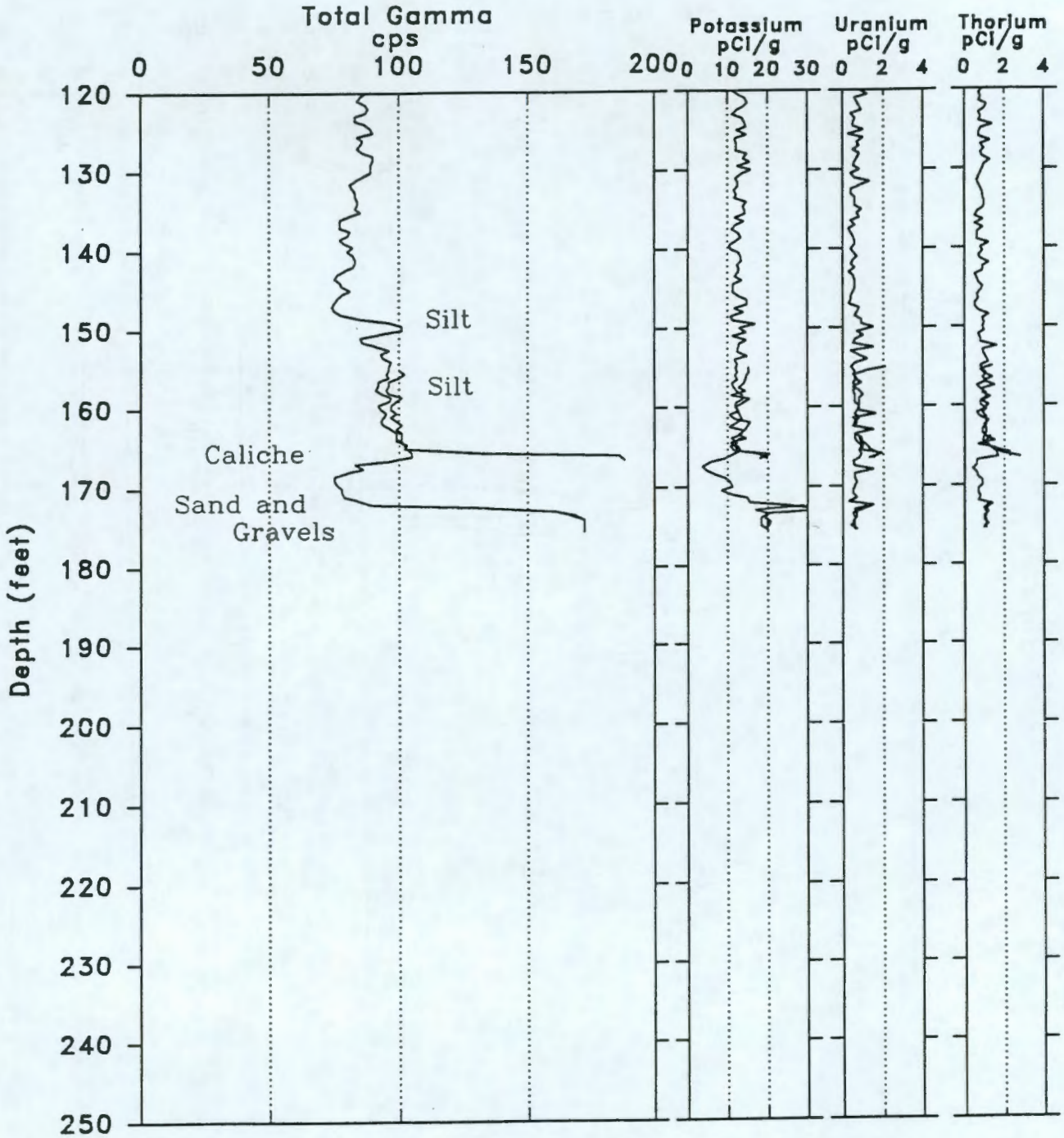
Log Date : Jan 12, 1994
Anal Date: Apr 06, 1994



RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-2
Borehole: 299-W19-96

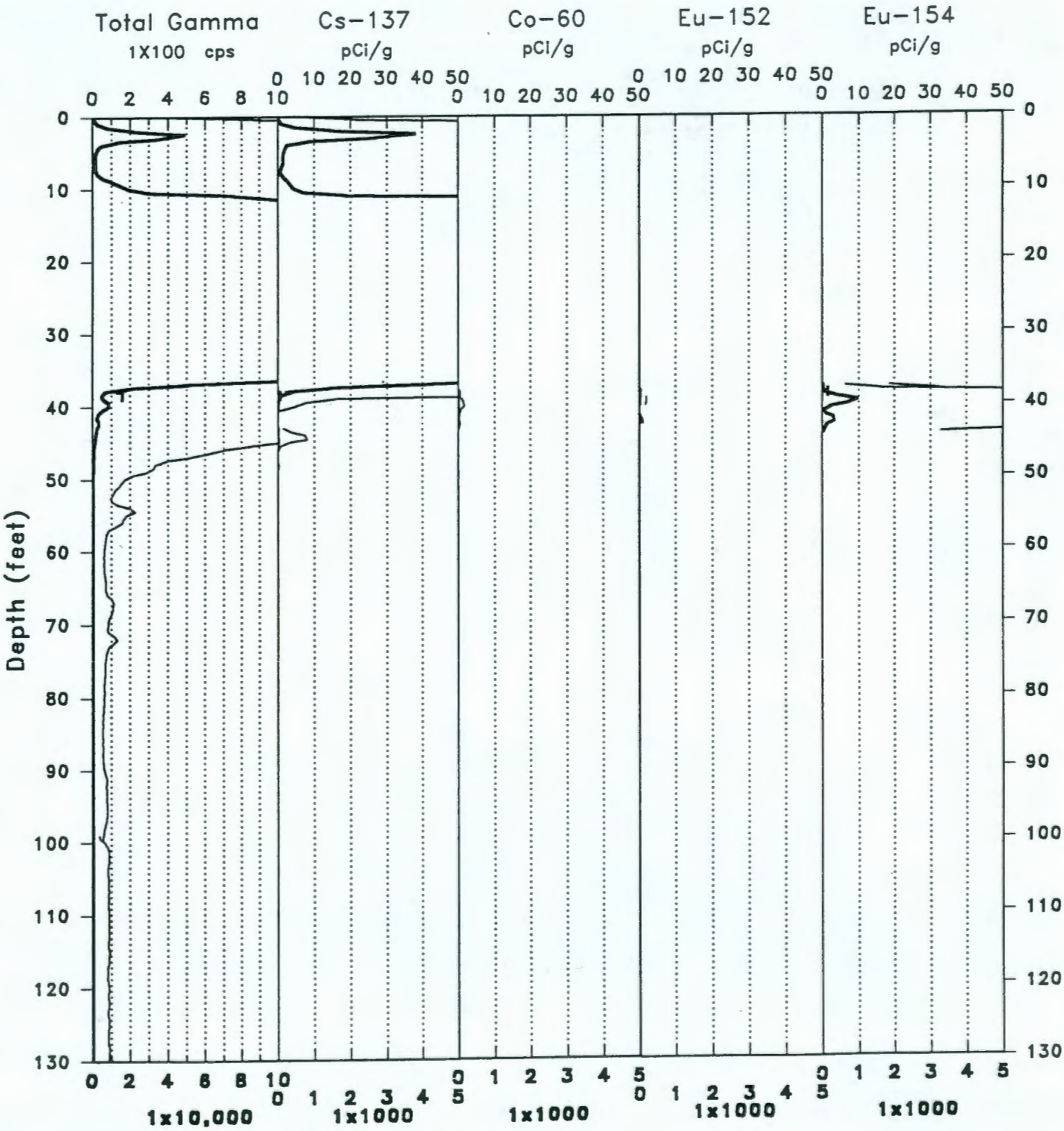
Log Date : Jan 12, 1994
Anal Date: Apr 06, 1994



RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-2 Log Date: Jan 12, 1994

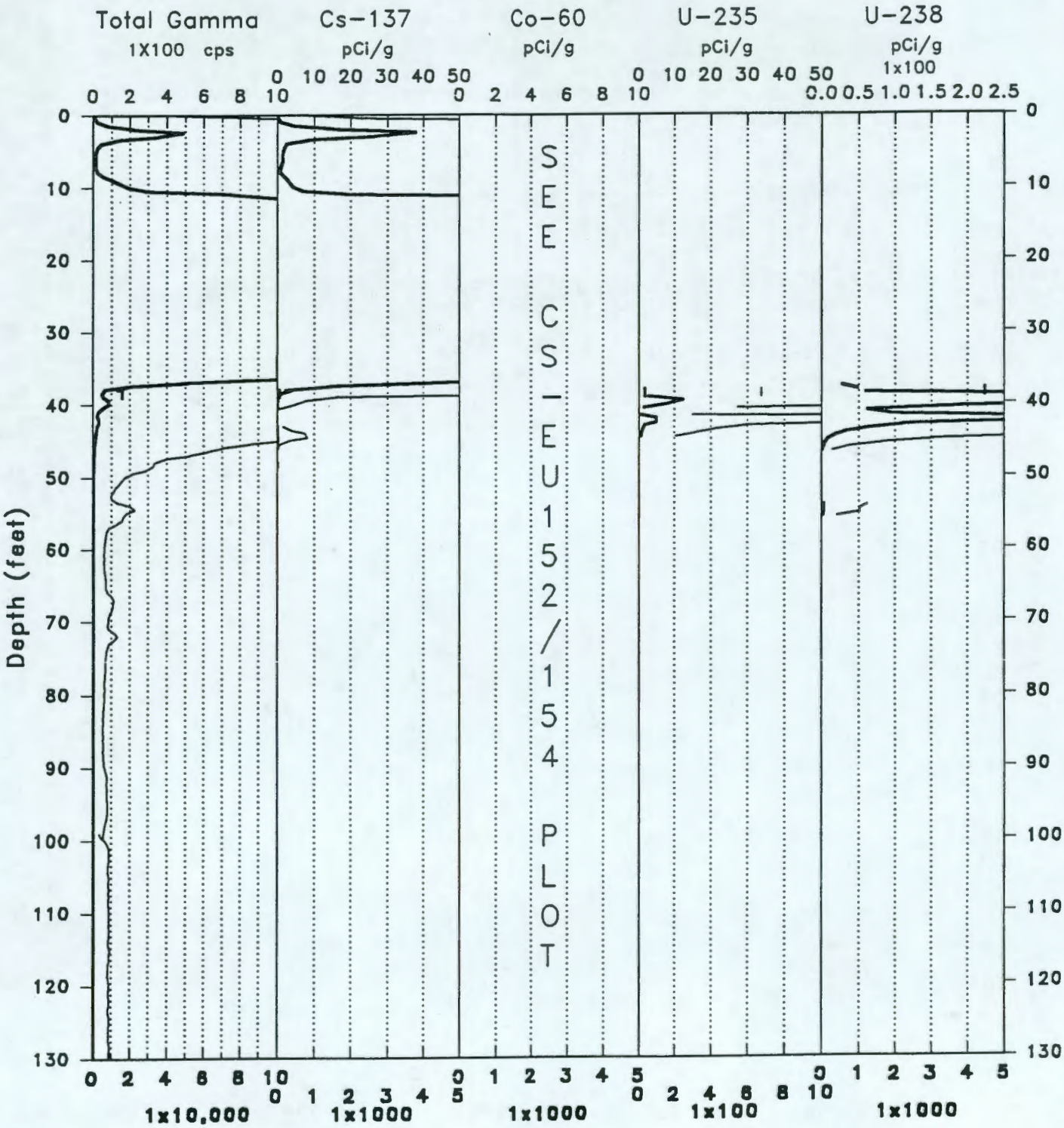
Borehole: 299-W19-96 Anal. Date: Apr 06, 1994



RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-2 Log Date: Jan 12, 1994

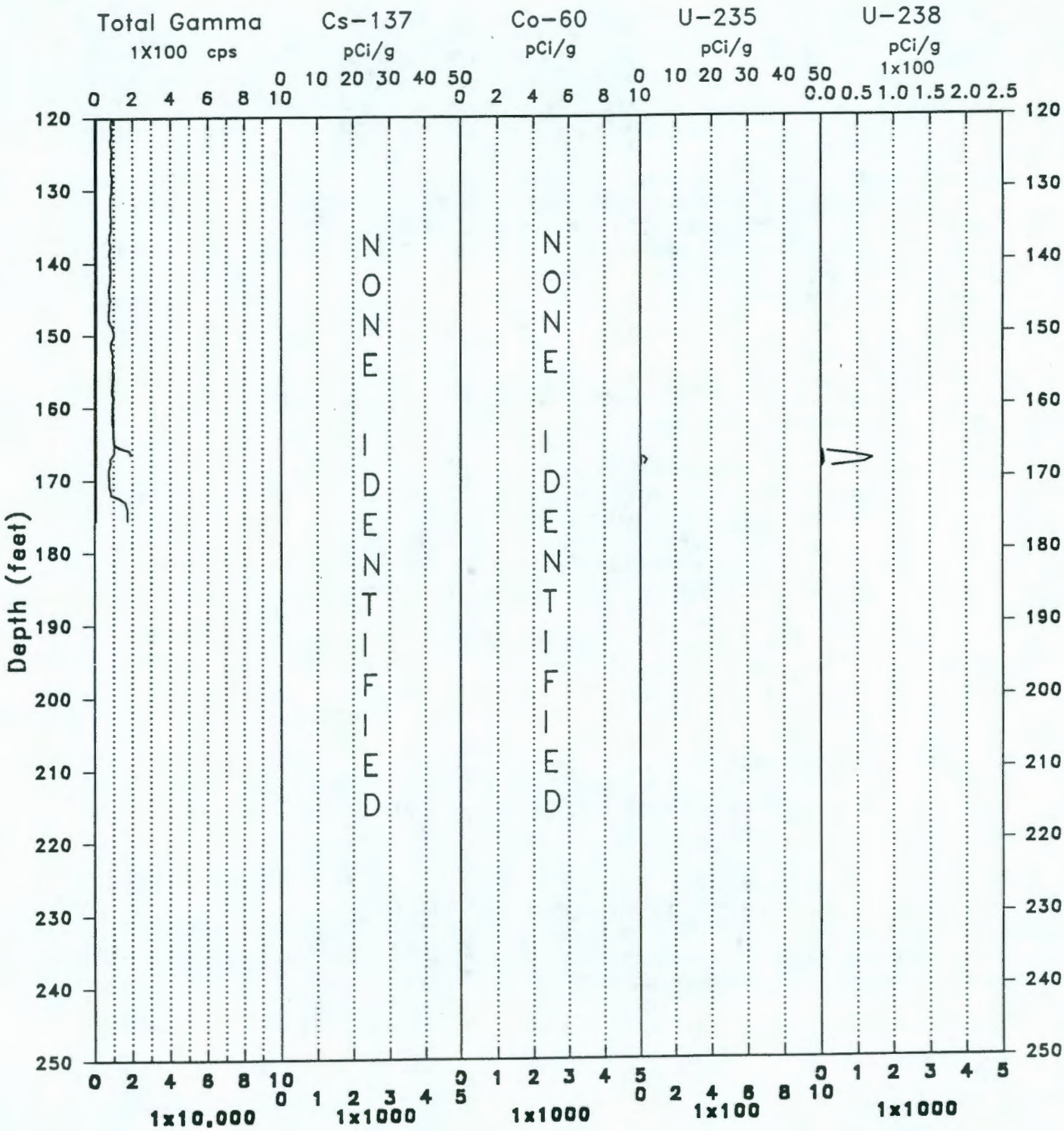
Borehole: 299-W19-96 Anal. Date: Apr 06, 1994



RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-2 Log Date: Jan 12, 1994

Borehole: 299-W19-96 Anal. Date: Apr 06, 1994



RLS Borehole Survey Report

Borehole: 299-W19-96

Casing	Depth:	0.0′- 38.0′	Size: 12"	Thickness: 0.500"
		0.0′- 99.5′	10"	0.500"
		0.0′-173.0′	8"	0.500"
Water	None			
Survey	Depth:	0.0′- 38.5′	Date: Nov 23, 1993	
		37.0′- 99.9′	Dec 21, 1993	
		99.0′-166.5′	Jan 06, 1994	
		155.0′-175.0′	Jan 12, 1994	

General Notes:

The well was surveyed four times during drilling in three different casing sizes. Essentially all of the surveys were conducted in single-casing strings. Casing overlaps occurred at 37.0 to 38.0 feet during the second survey, and from 99.0 to 99.5 feet during the third survey. The overlaps did not impair the quality of the data collected. The data was collected at an acquisition time of 180 seconds real time with the exception of the interval 26.5 to 38.5 feet which was collected at 80 seconds real time. Stationary measurements were acquired at 300 seconds real time. Repeat sections were performed at the end of the surveys to monitor equipment performance, and the data is included on the plots.

The plots of the naturally occurring radionuclides of potassium, uranium, and thorium are typical for sediments of the Hanford site. The total gamma-ray log in intervals of overlap show decreased count rate. Elevated count rate is observed where the detector is directly exposed to sediments such as at the bottom of the borehole and in open, uncased hole. In the final survey, approximately 2.5 feet of open hole was surveyed.

The detector was saturated between 11.5 and 35.5 feet. Cobalt-60, europium 152/154, and uranium 235/238 were identified at the base of the saturation zone. The first presence of these radionuclides could not be determined, as it most likely occurred within the saturated zone.

Man-made Radionuclides:

Cesium (Cs-137) was identified from 0.0 to 11.5 feet, and from 35.5 to 48.5 feet. The maximum observed cesium activity of 19534 pCi/g occurred at 35.5 feet.

Cobalt (Co-60) was identified from 38.0 to 43.0 feet. The maximum cobalt activity of 1.8 pCi/g occurred at 40.0 feet.

Europium (Eu-152) was identified from 38.0 to 42.5 feet. The maximum Eu-152 activity of 1.9 pCi/g occurred at 39.5 feet.

Europium (Eu-154) was identified from 37.5 to 44.0 feet. The maximum Eu-154 activity of 951 pCi/g occurred at 39.5 feet.

Uranium (U-235) was identified from 38.5 to 44.5 feet, and from 167.0 to 168.5 feet. The maximum U-235 activity of 246 pCi/g occurred at 39.5 feet.

Uranium (U-238) was identified from 37.5 to 47.0 feet, at 49.5 feet and 52.5 feet, from 54.0 to 56.0 feet, at 165.0 feet, and from 166.5 to 169.0 feet. The maximum activity of over 5000 pCi/g occurred at 39.5 feet.

Westinghouse Hanford Company
RLS Spectral Gamma-Ray Borehole Survey Log Header

Project: 200-UP-2

Borehole	299-W19-97				
Coordinates	NA	N	NA	W	Feet (Hanford System)
Elevation	NA	ft	Top of casing		

Borehole Environment Information

Borehole liquid depth None (ft) from zero (0.0) depth reference of log

Casing size (in.)	Casing thickness (in.)	Top depth (ft)	Base depth (ft)
10	0.50	0.0	100.0
8	0.50	0.0	175.0

RLS Passive Spectral Gamma Survey Information

Logging Engineers R. V. Cram S. E. Kos J. P. Kiesler
Log depth reference at zero (0.0) depth is ground level

Log Date	Archive file names	Log mode	speed	Depth interval (ft) Top	Base	Incr
Sep 14, 1993	H2W1997\A435	MSA	120sec RT	0.0	100.0	0.5
Sep 22, 1993	H2W1997\A437	MSA	120sec RT	99.0	146.5	0.5
Sep 23, 1993	H2W1997\A438	MSA	120sec RT	145.5	176.5	0.5

MSA: Move-Stop-Acquire
RT: Real time

Calibration and Analysis Information

RLS Calibration Date: Nov. 21, 1991
Calibration Report: WHC-SD-EN-TRP-001

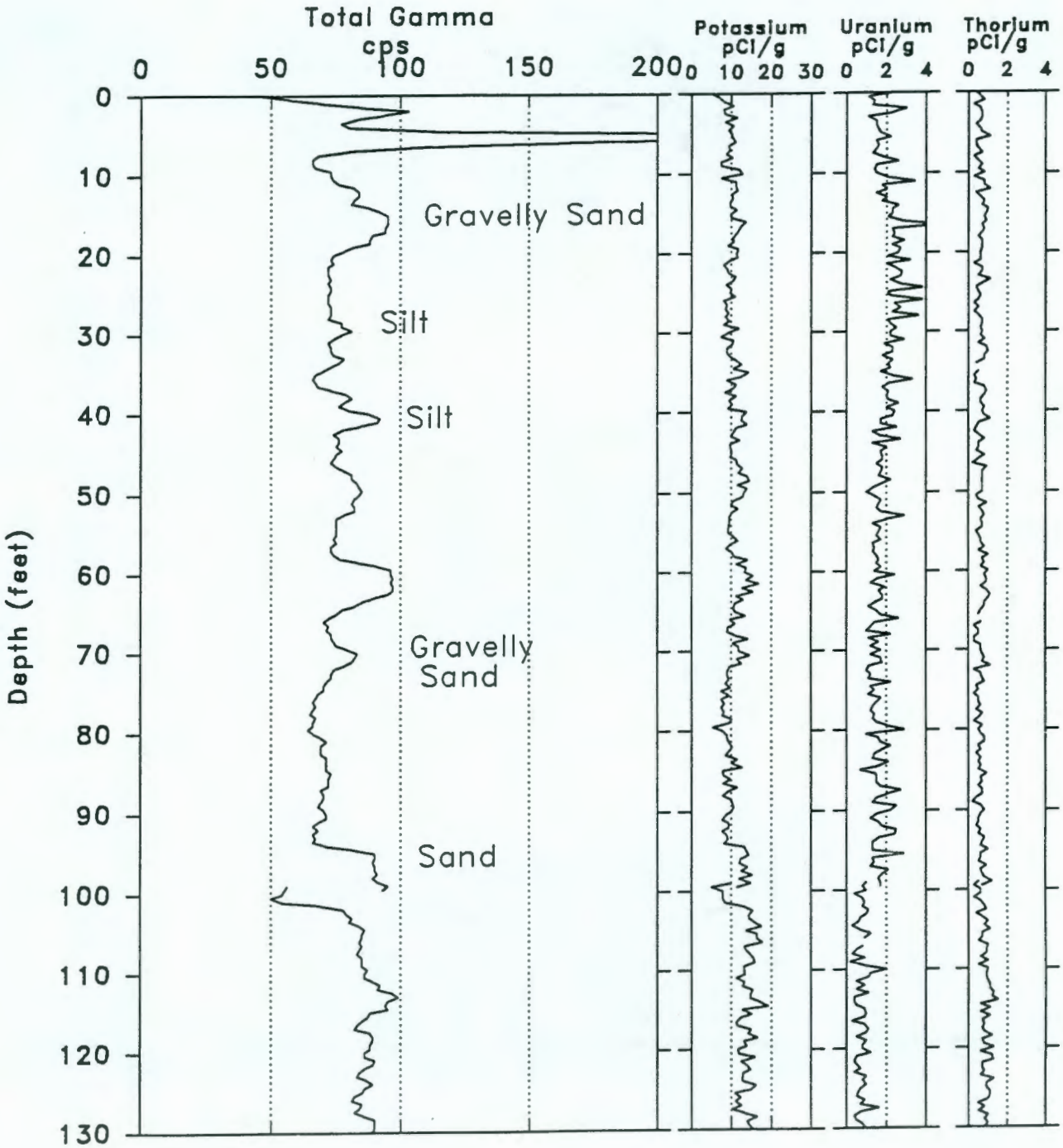
Analyst Names: S. E. Kos R. K. Price
Analysis Date: Dec 09, 1993

Analysis Notes: Double casing- exceeds max. correction factor
Radionuclides Identified: Cs-137

RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-2
Borehole: 299-W19-97

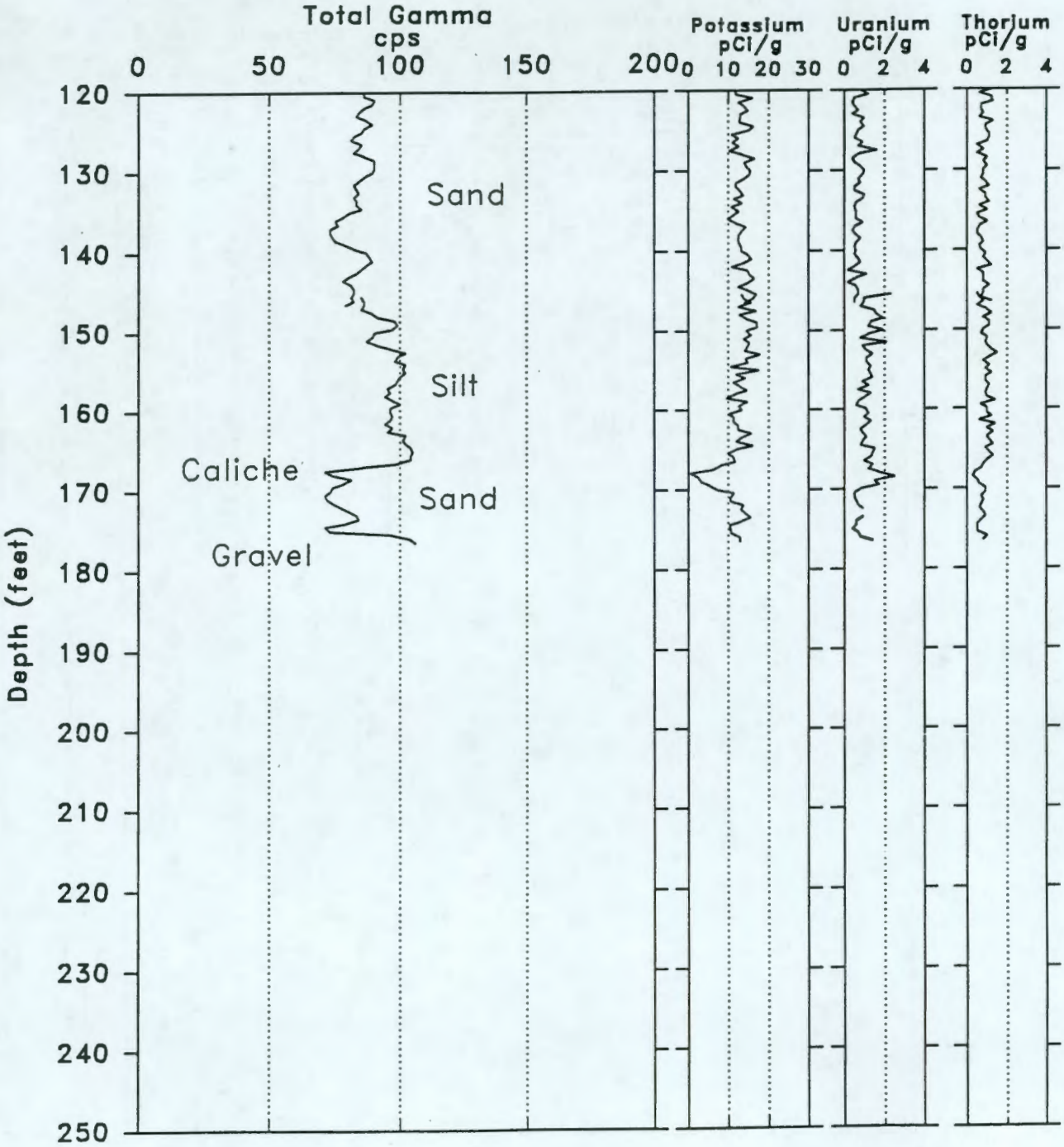
Log Date : Sep 23, 1993
Anal Date: Dec 09, 1993



RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-2
Borehole: 299-W19-97

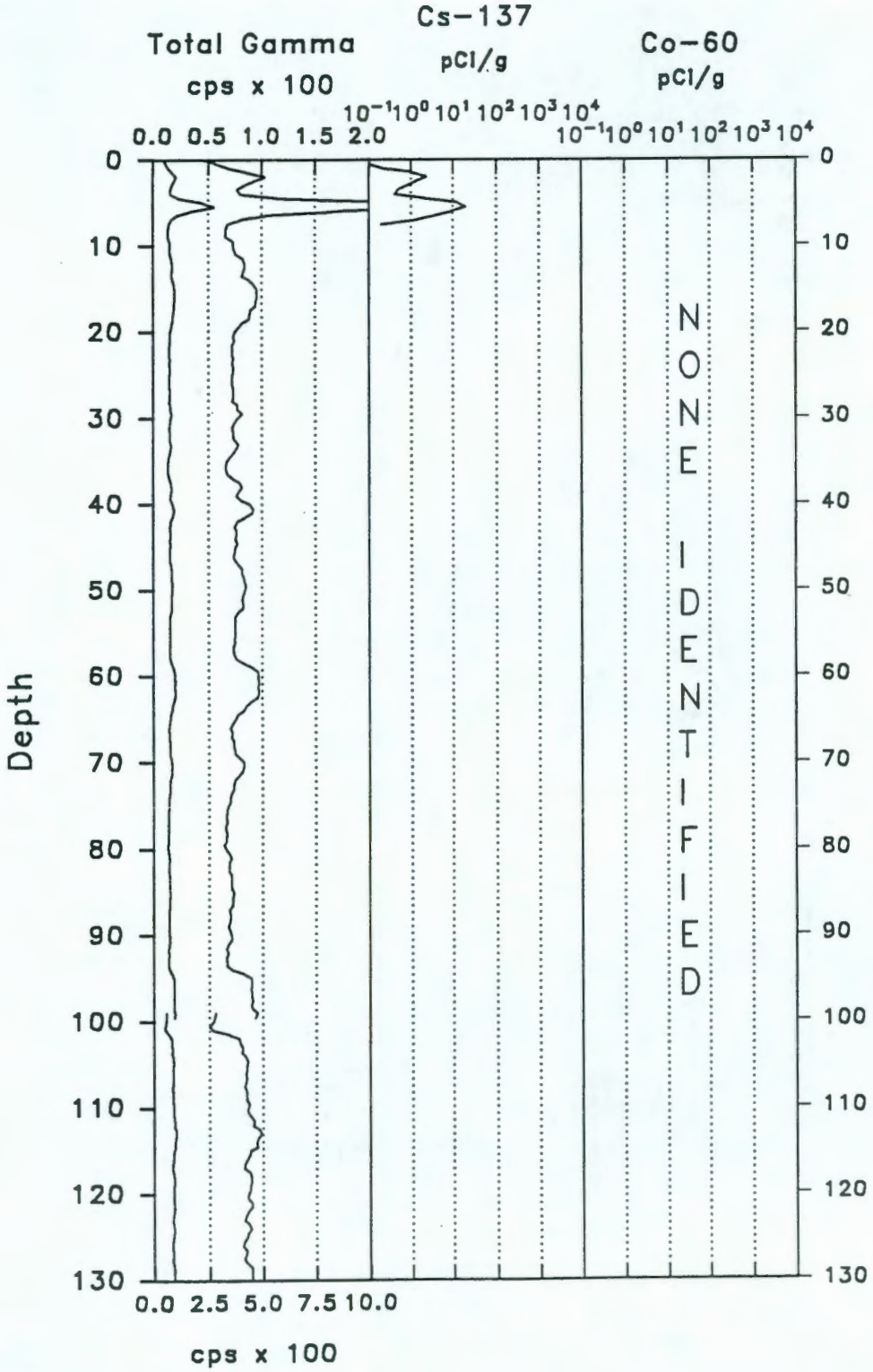
Log Date : Sep 23, 1993
Anal Date: Dec 09, 1993



RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-2 Log Date: Sep 23, 1993

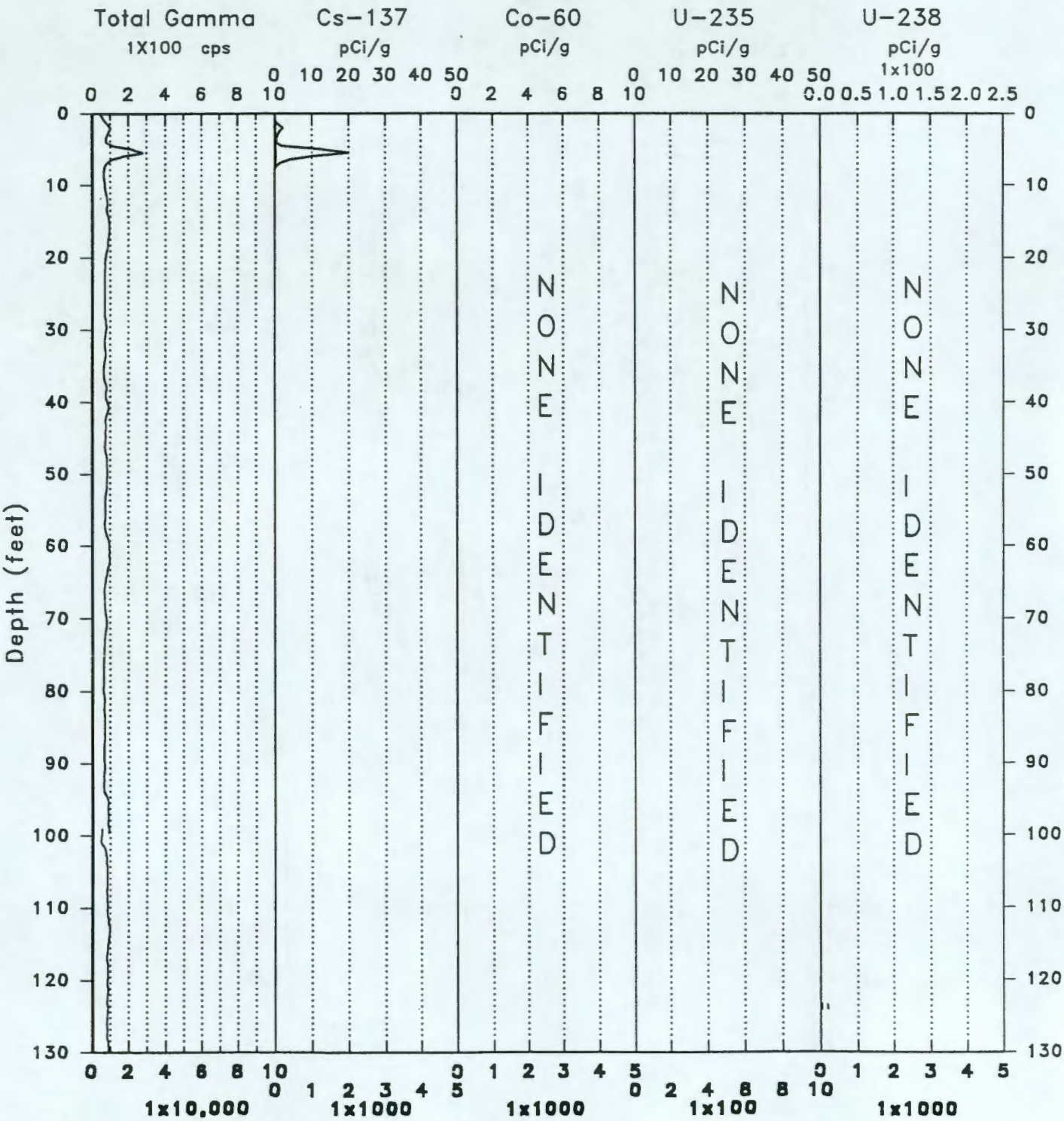
Borehole: 299-W19-97 Analysis Date: Dec 09, 1993



RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-2 Log Date: Sep 23, 1993

Borehole: 299-W19-97 Anal. Date: Dec 09, 1993



RLS Borehole Survey Report

Borehole: 299-W19-97

Casing	Depth:	0.0′-100.0′	Size: 10"	Thickness: 0.50"
Casing	Depth:	0.0′-175.0′	Size: 8"	Thickness: 0.50"
Water	None			
Survey	Depth:	0.0′-100.0′		Date: Sep 14, 1993
		99.0′-146.5′		Sep 22, 1993
		145.5′-176.5′		Sep 23, 1993

General Notes:
The well was surveyed three times during drilling; each survey was conducted in a single-casing zone. The first survey spanned the interval 0.0′ to 100.0′ in 10-inch-diameter threaded-joint carbon steel casing. The second survey spanned the interval 99.0′ to 146.5′. The survey was interrupted at 146.5′ when the liquid nitrogen cooling the detector became depleted, requiring immediate equipment shutdown. The RLS returned to the 400 Area laboratory, and the cooling system was inspected and the detector was cooled. Logging continued the following day, and the survey from 145.5′ to 176.5′ was completed. Both the second and third surveys were completed in 8-inch-diameter threaded-joint carbon steel casing. There was no fill material between the casing strings. The thickness of each casing was .500 inch, exceeding the maximum correction factor. A casing overlap during the second survey for the interval 99.0′ to 100.0′ resulted in a lower calculated activity than actually present. All measurements were acquired at 120 seconds real time.

The plot tracks for the naturally occurring radionuclides shows the depth profile for the total gamma count rate and the radionuclides potassium, uranium and thorium. The calculated activities for the naturally occurring radionuclides throughout the interval surveyed are typical for Hanford soils. The higher concentrations of naturally occurring uranium from 0.0′ to 100.0′, as compared with the data acquired from 99.0′ to 146.5′, are common for data acquired on days when low barometric pressure permits radon gas (a decay daughter of uranium) to enter the casing at the bottom of the well and migrate upward.

Man-made Radionuclides:
Cesium (Cs-137) was detected from 0.5′ to 7.5′. The maximum calculated activity of 20 pCi/g occurred at 5.5′. Analyses were performed for U235 and U238; neither of these radionuclides was identified. The Cs-137 results are plotted along with total gamma cps; the additional tracks are plotted for plot consistency.

Westinghouse Hanford Company
RLS Spectral Gamma-Ray Borehole Survey Log Header

Project: 200-UP-2

Borehole 299-W19-98
Coordinates NA N NA W Feet (Hanford System)
Elevation NA ft Top of casing

Borehole Environment Information

Borehole liquid depth none (ft) from zero (0.0) depth reference of log

Casing size (in.)	Casing thickness (in.)	Top depth (ft)	Base depth (ft)
12	0.375	0.0	9.88
10	0.500	0.0	96.56
8	0.500	0.0	191.95

RLS Passive Spectral Gamma Survey Information

Logging Engineers R. V. Cram J. P. Kiesler
Log depth reference at zero (0.0) depth is ground level

Log Date	Archive file names	Log mode speed	Depth interval (ft) Top	Base	Incr
Mar 02, 1994	H2W19098\A532	MSA 120sec RT	0.0	9.1	0.5
Mar 11, 1994	H2W19098\A539	MSA 120sec RT	8.0	96.51	0.5
Mar 18, 1994	H2W19098\A543	MSA 120sec RT	95.5	145.0	0.5
Mar 21, 1994	H2W19098\A544	MSA 120sec RT	144.0	183.0	0.5
Mar 23, 1994	H2W19098\A545	MSA 120sec RT	181.5	192.5	0.5

MSA: Move-Stop-Acquire
RT: Real time

Calibration and Analysis Information

RLS Calibration Date: Nov. 21, 1991
Calibration Report: WHC-SD-EN-TRP-001

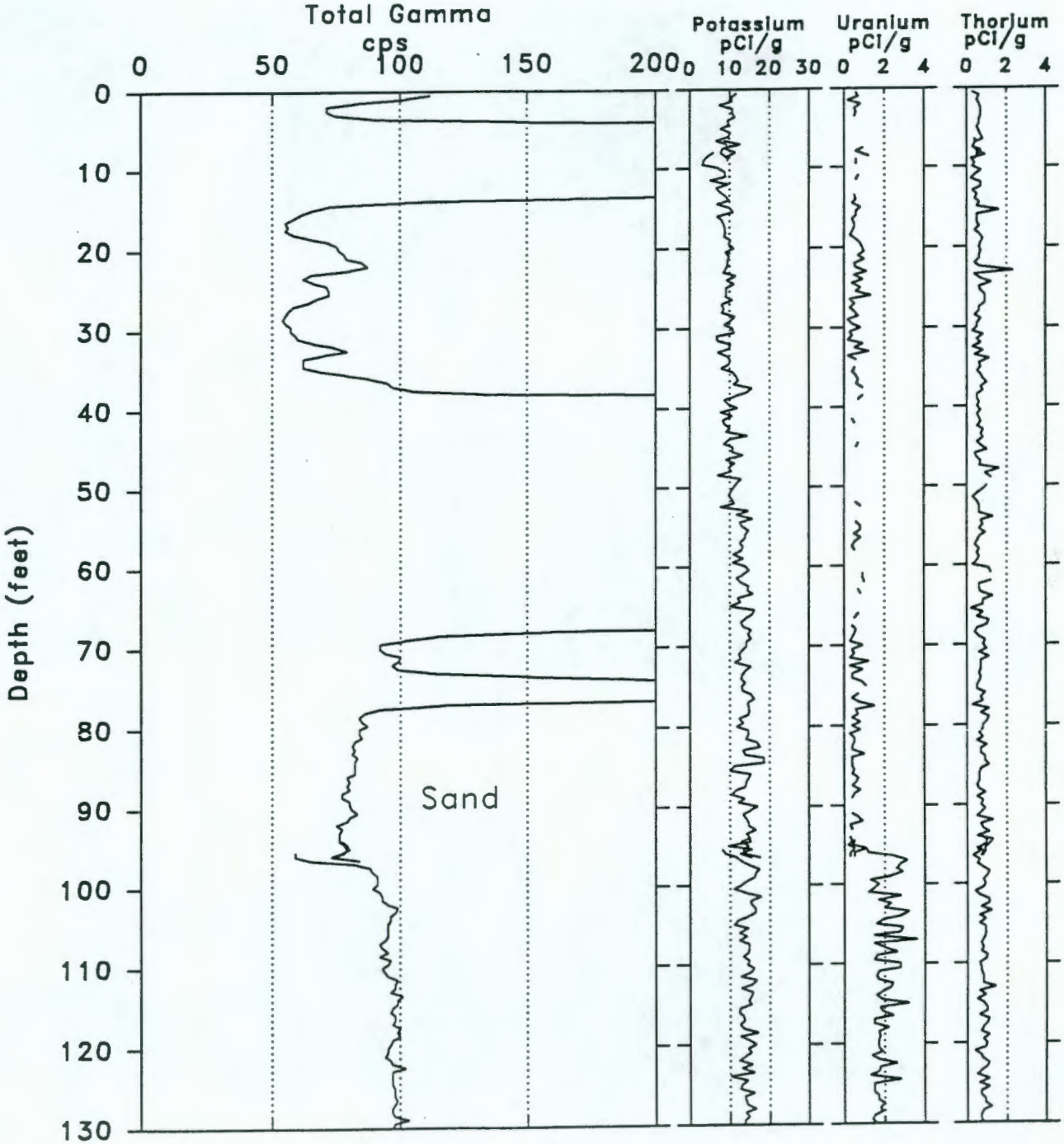
Analyst Names: S. E. Kos R. K. Price
Analysis Date: Mar 24, 1994

Analysis Notes: Casing exceeds max. correction factor
Radionuclides Identified: Cs-137, Co-60, Eu-154

RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-2
Borehole: 299-W19-98

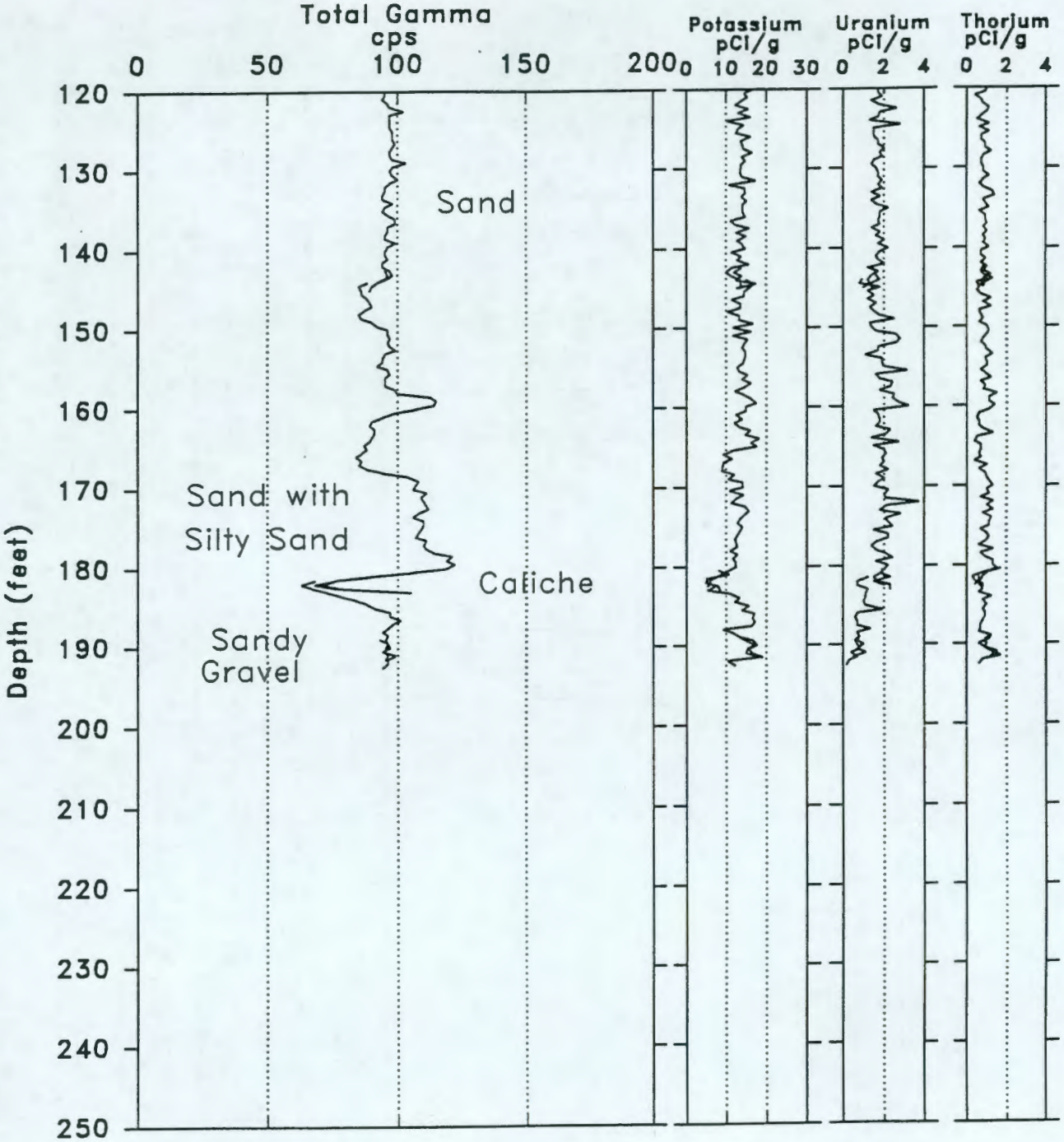
Log Date : Mar 23, 1994
Anal Date: Mar 24, 1994



RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-2
Borehole: 299-W19-98

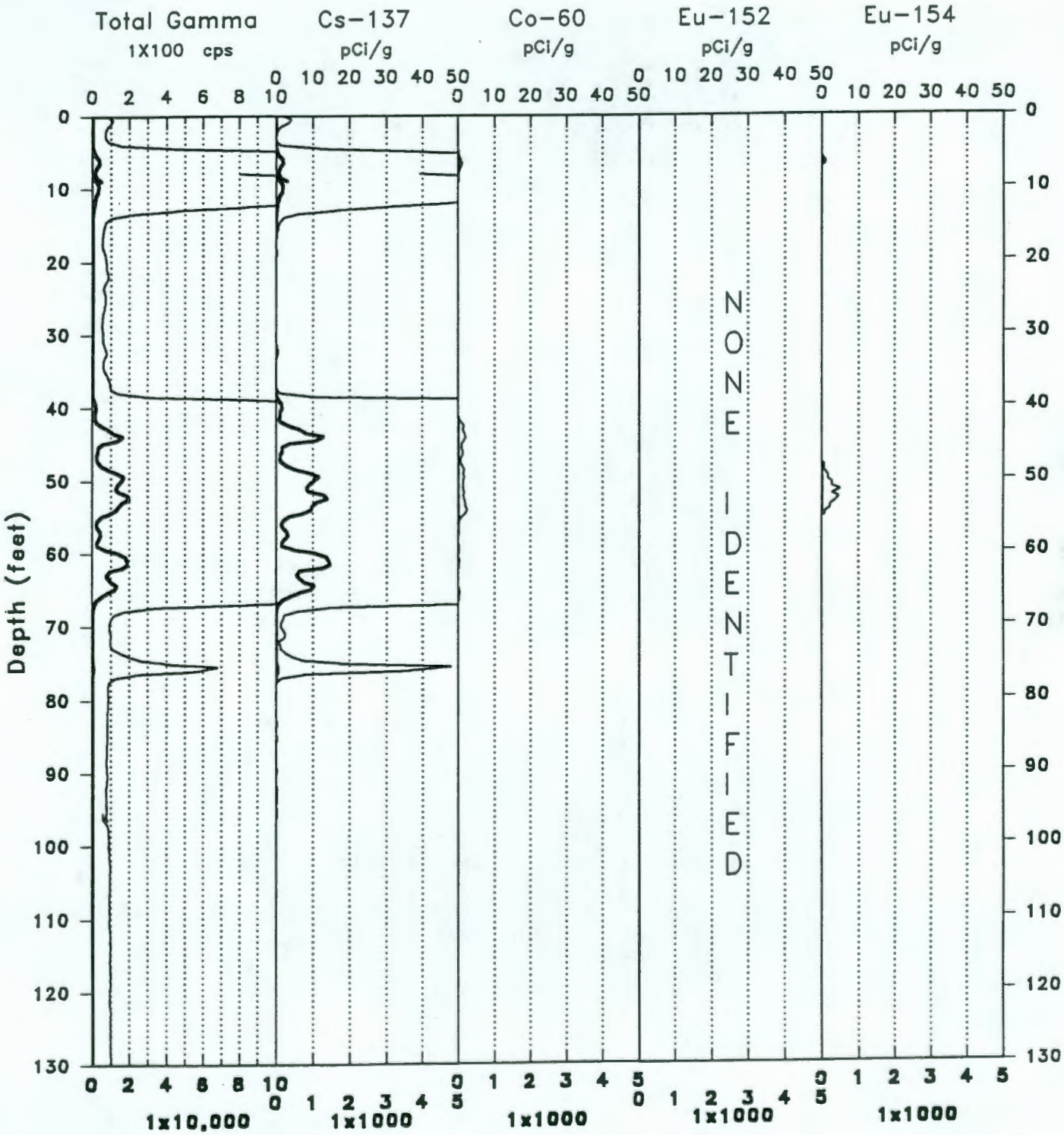
Log Date : Mar 23, 1994
Anal Date: Mar 24, 1994



RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-2 Log Date: Mar 23, 1994

Borehole: 299-W19-98 Anal. Date: Mar 24, 1994



RLS Borehole Survey Report

Borehole: 299-W19-98

Casing	Depth:	0.0′- 9.88′	Size: 12"	Thickness: 0.375"
		0.0′- 96.56′	10"	0.500"
		0.0′-191.95′	8"	0.500"
Water	None			
Survey	Depth:	0.0′- 9.1′	Date: Mar 02, 1994	
		8.0′- 96.5′	Mar 11, 1994	
		95.5′-145.0′	Mar 18, 1994	
		144.0′-183.0′	Mar 21, 1994	
		181.5′-192.5′	Mar 23, 1994	

General Notes:

The well was surveyed five times during drilling in three different casing sizes. Essentially all of the surveys were conducted in single casing strings. Casing overlaps occurred at 8.0 to 9.88 feet, and from 95.0 to 96.56 feet; the overlaps did not impair the quality of the surveys. All data were collected at an acquisition time of 120 seconds real time.

The plots of the naturally occurring radionuclides of potassium, uranium, and thorium are typical for sediments of the Hanford site. Repeat sections were conducted at the end of each survey to verify equipment performance and the data are included on the plots.

Man-made Radionuclides:

Cesium (Cs-137) was identified from 0.0 to 16.5 feet, intermittently from 18.5 to 35.5 feet, from 37.5 to 77.5 feet, and intermittently from 80.5 to 95.5 feet. The maximum observed cesium concentration of 1460 pCi/g occurred at 61.5 feet.

Cobalt (Co-60) was identified from 5.0 to 8.5 feet, from 41.5 to 57.5 feet, and from 59.0 to 66.5 feet. The maximum cobalt activity of 2.5 pCi/g occurred at 54.0 feet. The cobalt is found in conjunction with the cesium contamination.

Europium (Eu-154) was identified from 6.0 to 7.0 feet, and from 47.0 to 55.0 feet. The maximum Eu-154 activity of 5 pCi/g occurred at 51.5 feet. The Eu-154 is found in the same contamination zone with the cesium and cobalt.

Europium (Eu-152) was analyzed but was not identified. The Eu-152 plot track is included for uniformity in plot presentation.

Westinghouse Hanford Company
RLS Spectral Gamma-Ray Borehole Survey Log Header

Project: 200-UP-2

Borehole	299-W22-78				
Coordinates	NA	N	NA	W	Feet (Hanford System)
Elevation	NA	ft	Top of casing		

Borehole Environment Information

Borehole liquid depth None (ft) from zero (0.0) depth reference of log

Casing size (in.)	Casing thickness (in.)	Top depth (ft)	Base depth (ft)
12	0.50	0.0	37.01
10	0.50	0.0	91.24
8	0.50	0.0	184.63
6	0.50	0.0	233.36

RLS Passive Spectral Gamma Survey Information

Logging Engineers R. V. Cram S. E. Kos J. P. Kiesler
Log depth reference at zero (0.0) depth is ground level

Log Date	Archive file names	Log mode speed	Depth interval (ft) Top	Base	Incr
Oct 13,1993	H2W2278\A451	MSA 120sec RT	0.0	39.1	0.5
Oct 19,1993	H2W2278\A456	MSA 120sec RT	36.0	40.5	0.5
		MSA 180sec RT	40.5	51.5	0.5
		Stat.300sec RT	39.1		
Oct 20,1993	H2W2278\A457	MSA 180sec RT	50.5	93.0	0.5
		Stat.300sec RT	93.0		
Oct 26,1993	H2W2278\A461	MSA 180sec RT	92.0	144.0	0.5
Oct 27,1993	H2W2278\A462	MSA 180sec RT	143.0	184.02	0.5
Nov 04,1993	H2W2278\A465	MSA 180sec RT	184.0	233.5	0.5
		Stat.300sec RT	184.0		

MSA: Move-Stop-Acquire
RT: Real time

Westinghouse Hanford Company
RLS Spectral Gamma-Ray Borehole Survey Log Header

Calibration and Analysis Information

RLS Calibration Date: Nov. 21, 1991
Calibration Report: WHC-SD-EN-TRP-001

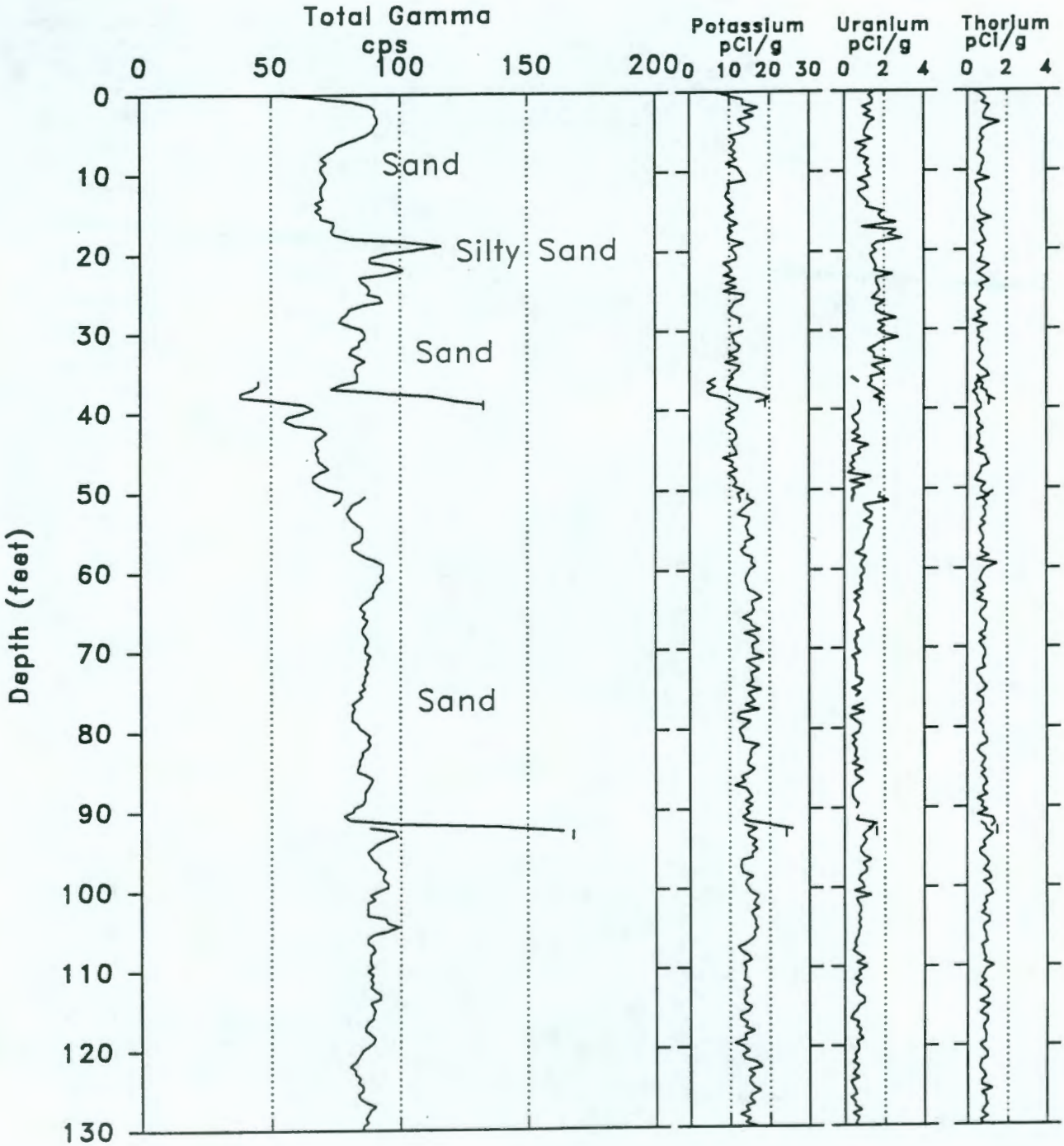
Analyst Names: S. E. Kos R. K. Price
Analysis Date: Jan 03, 1994

Analysis Notes: Casing exceeds max. correction factor
Radionuclides Identified: Cs-137, U-235, U-238

RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-2
Borehole: 299-W22-78

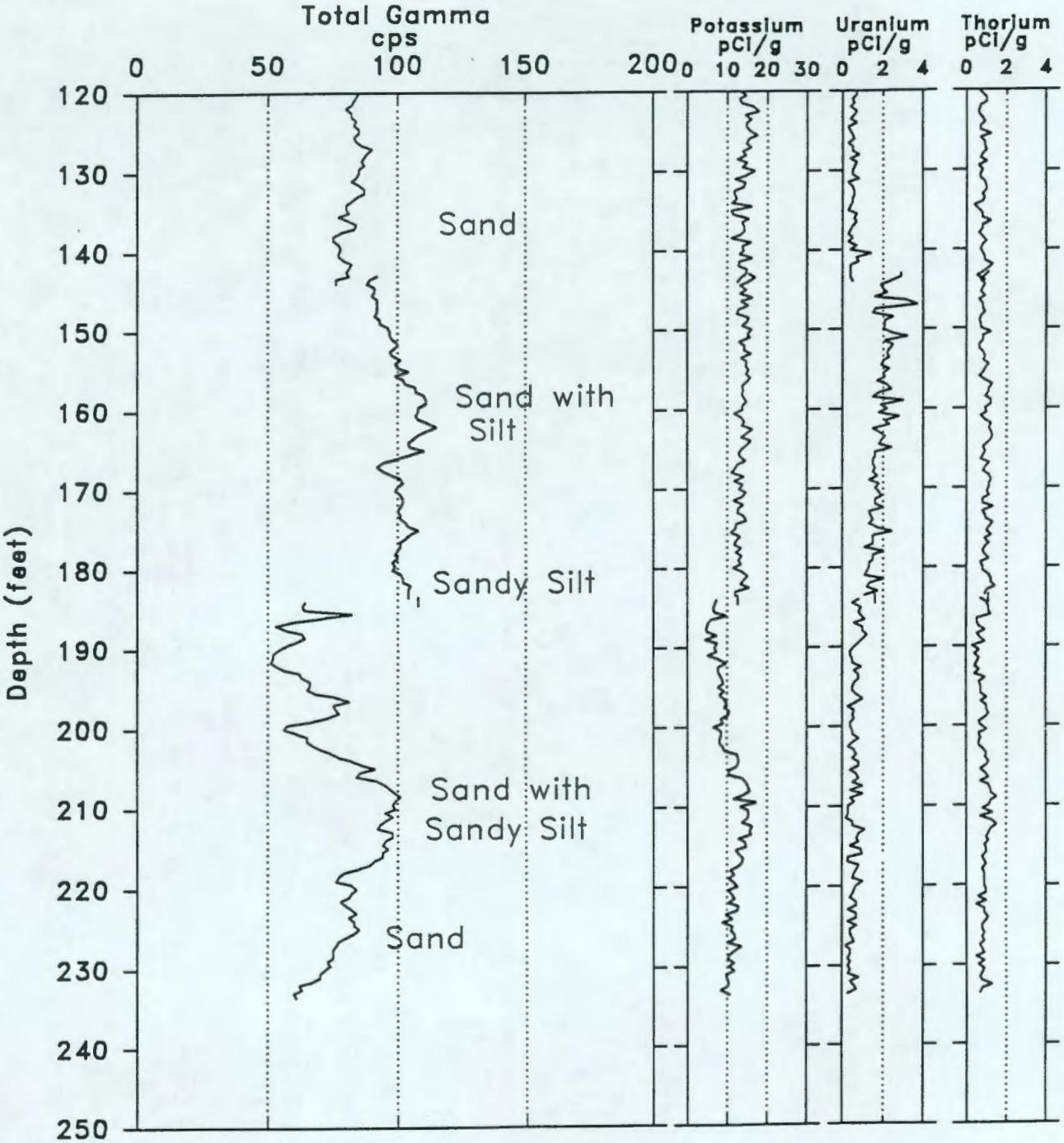
Log Date : Nov 04, 1993
Anal Date: Jan 03, 1994



RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-2
Borehole: 299-W22-78

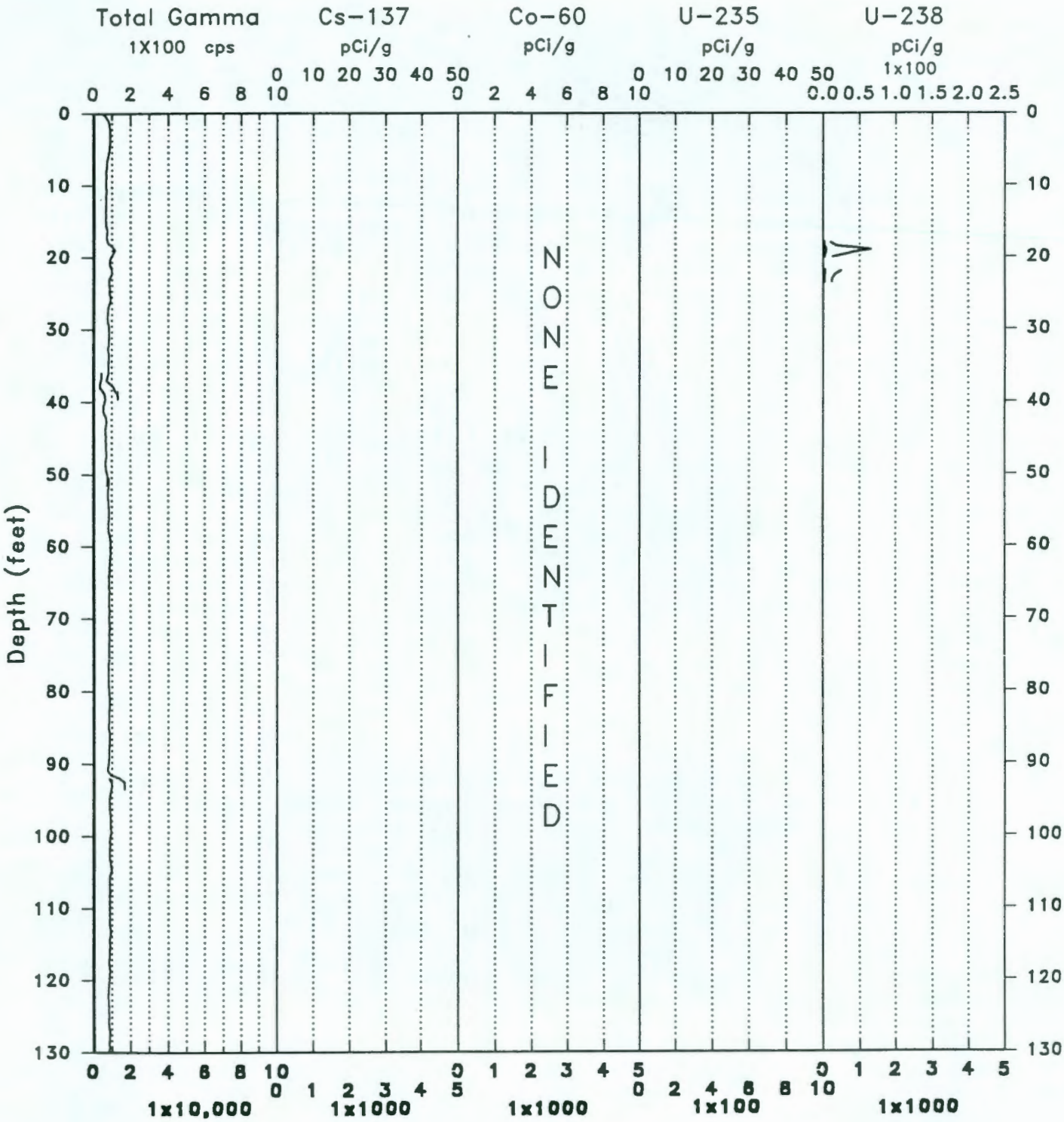
Log Date : Nov 04, 1993
Anal Date: Jan 03, 1994



RLS Spectral Gamma-Ray Borehole Survey

Project: 200- UP-2 Log Date: Nov 04, 1993

Borehole: 299-W22-78 Anal. Date: Jan 03, 1994



RLS Borehole Survey Report

Borehole: 299-W22-78

Casing	Depth:	0.0′- 37.01′	Size: 12"	Thickness: 0.50"
		0.0′- 91.24′	10"	0.50"
		0.0′-184.63′	8"	0.50"
		0.0′-233.36′	6"	0.50"
Water	None			
Survey	Interval:	0.0′- 39.1′	Date:	Oct 13,1993
		36.0′- 51.5′		Oct 19,1993
		50.5′- 93.0′		Oct 20,1993
		92.0′-144.0′		Oct 26,1993
		143.0′-184.02′		Oct 27,1993
		184.0′-233.5′		Nov 04,1993

General Notes:
The well was surveyed six times during drilling; each survey was conducted in a single-casing zone. All casings were threaded-joint carbon steel; there was no fill material between the casing strings. The wall thickness of each casing was .50 inch, exceeding the maximum correction factor. The data acquisition time was increased from 120 seconds RT to 180 seconds RT at 40.5′ to improve detection capabilities. Multiple surveys were required because of the extended acquisition time, the long survey intervals, and the limited access to the well.

The plot tracks for the naturally occurring radionuclides shows the depth profile for the total gamma count rate and the radionuclides potassium, uranium and thorium. The calculated activities for the naturally occurring radionuclides throughout the well are typical for Hanford soils. The higher calculated concentrations of naturally occurring uranium from 0.0′ to 39.1′, and from 143.0′ to 184.02′, are common for data acquired on days when low barometric pressure permits radon gas (a decay daughter of uranium) to enter the casing at the bottom of the well and migrate upward. Decreased activity is observed at 36.0′ where the second survey was conducted for 3′ in an overlap of 12-inch-diameter and 10-inch-diameter casings. Increased total gamma activity is observed at approximately 40.0′ and 93.0′ where open (uncased) borehole was logged.

Man-made Radionuclides:
Cesium (Cs-137) was detected at 0.5′ at a concentration of less than 1 pCi/g. Because of the low concentration, the data were not plotted on the Cs-137 plot. The plot is included for uniformity in presentation.

Uranium-235(U-235) was detected at 19.0′ at a concentration of 3 pCi/g. The U-235 data did not plot since each occurrence was a single data point. The U-235 plot is included for uniformity in presentation.

Uranium-238(U-238) was detected in two intervals, 18.0′ to 20.0′, and 22.0′ to 23.5′. The maximum calculated activity of 66 pCi/g occurred at 19.0′.

Cobalt (Co-60) was not detected in the well. The Co-60 plot is included for uniformity in presentation.

Westinghouse Hanford Company
RLS Spectral Gamma-Ray Borehole Survey Log Header

Project: 200-UP-2

Borehole	299-W23-231			
Coordinates	NA N	NA W	Feet	(Hanford System)
Elevation	NA ft	Top of casing		

Borehole Environment Information

Borehole liquid depth None (ft) from zero (0.0) depth reference of log

Casing size (in.)	Casing thickness (in.)	Top depth (ft)	Base depth (ft)
12	0.375	0	13.3
10	0.500	0	82.3
8	0.500	0	140.5

RLS Passive Spectral Gamma Survey Information

Logging Engineers R. V. Cram J. P. Kiesler

Log depth reference at zero (0.0) depth is ground level

Log Date	Archive file names	Log mode	speed	Depth interval (ft) Top	Base	Incr
Mar 14, 1994	H2W23231\A540	MSA	120sec RT	0.0	11.5	0.5
Mar 17, 1994	H2W23231\A542	MSA	120sec RT	10.5	79.0	0.5
Mar 24, 1994	H2W23231\A547	MSA	80sec RT	78.0	140.0	0.5

MSA: Move-Stop-Acquire
RT: Real time

Calibration and Analysis Information

RLS Calibration Date: Nov. 21, 1991
Calibration Report: WHC-SD-EN-TRP-001

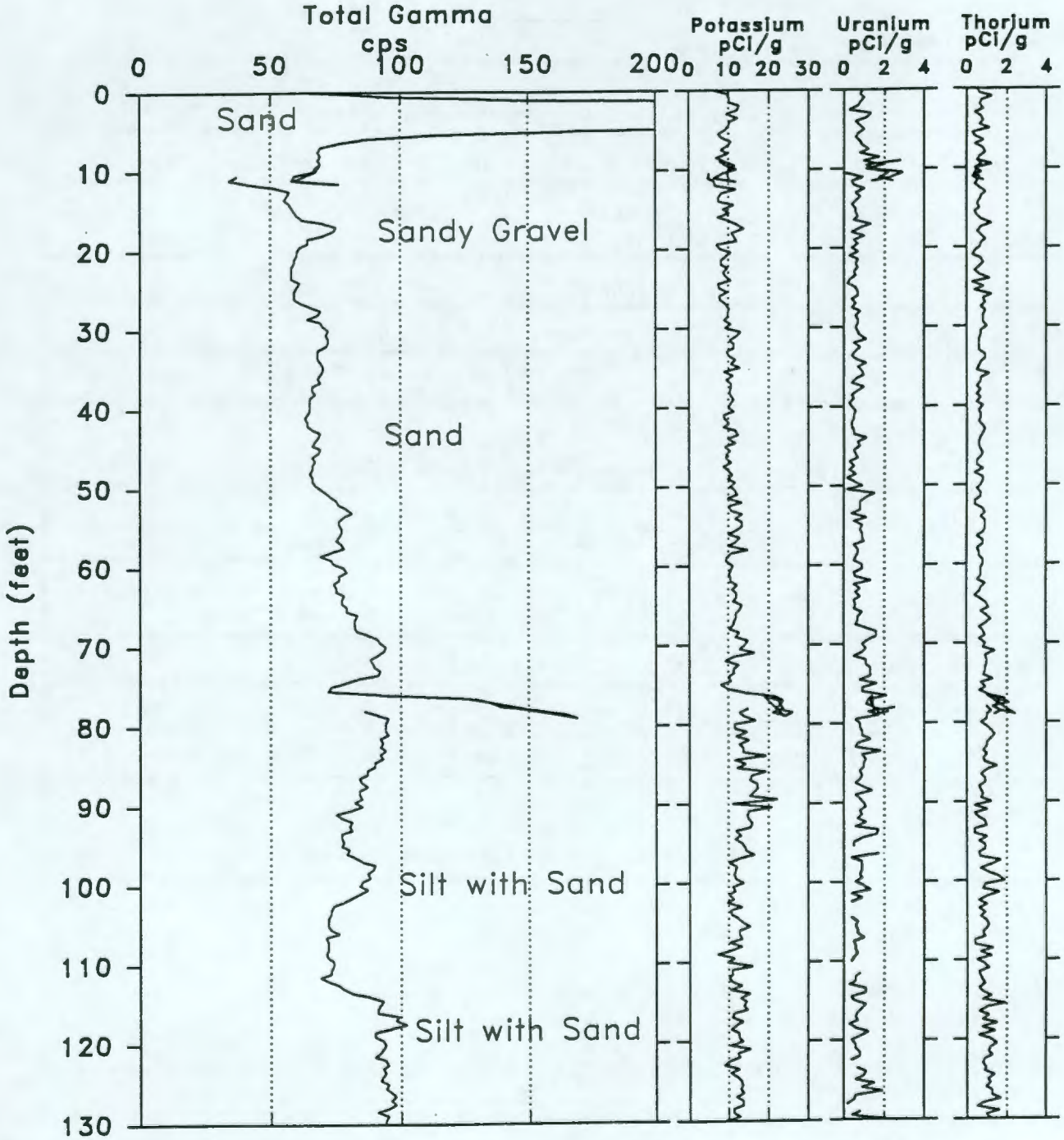
Analyst Names: S. E. Kos R. K. Price
Analysis Date: Mar 25, 1994

Analysis Notes: Casing exceeds max. correction factor
Radionuclides Identified: Cs-137

RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-2
Borehole: 299-W23-231

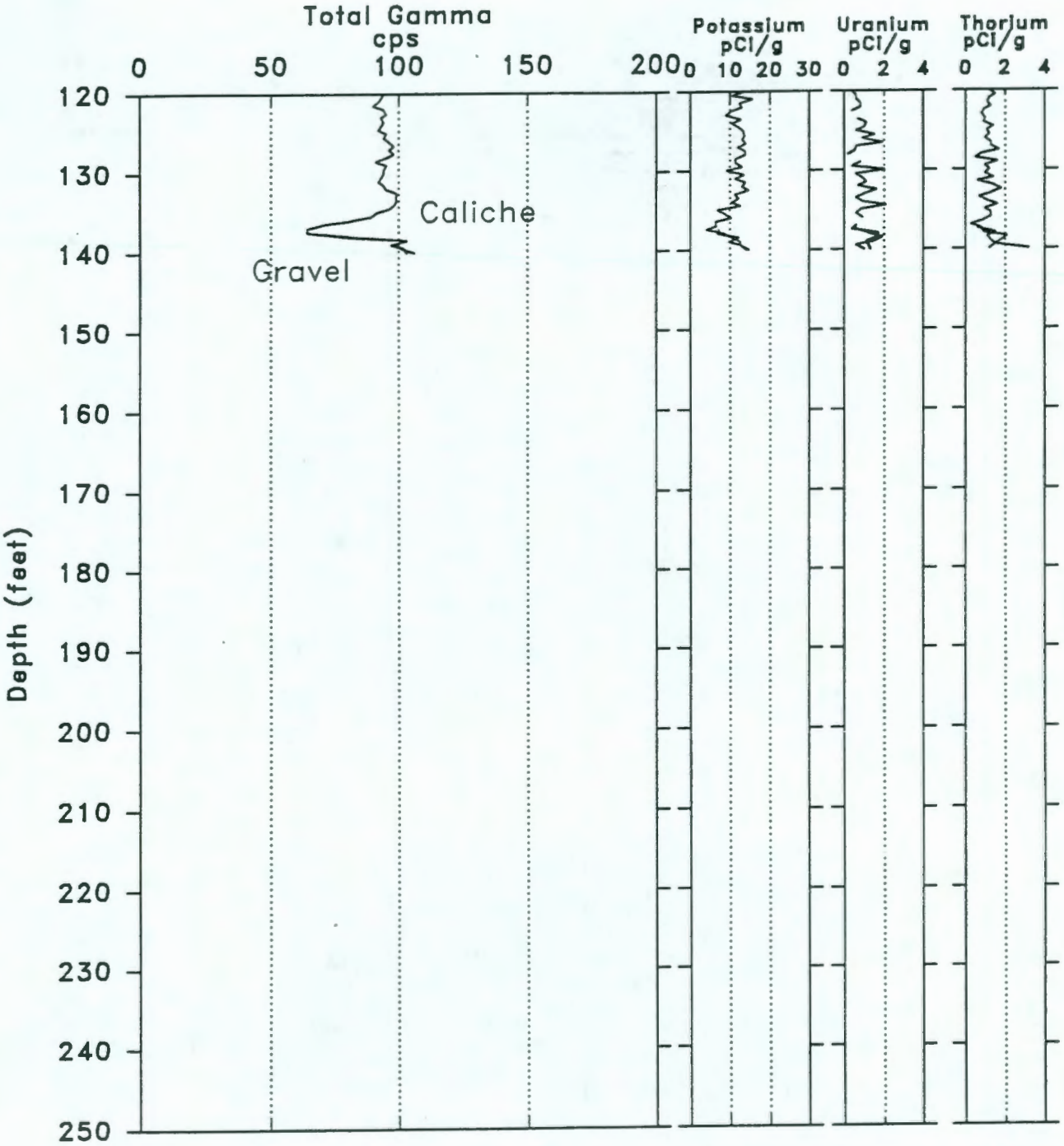
Log Date : Mar 24, 1994
Anal Date: Mar 25, 1994



RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-2
Borehole: 299-W23-231

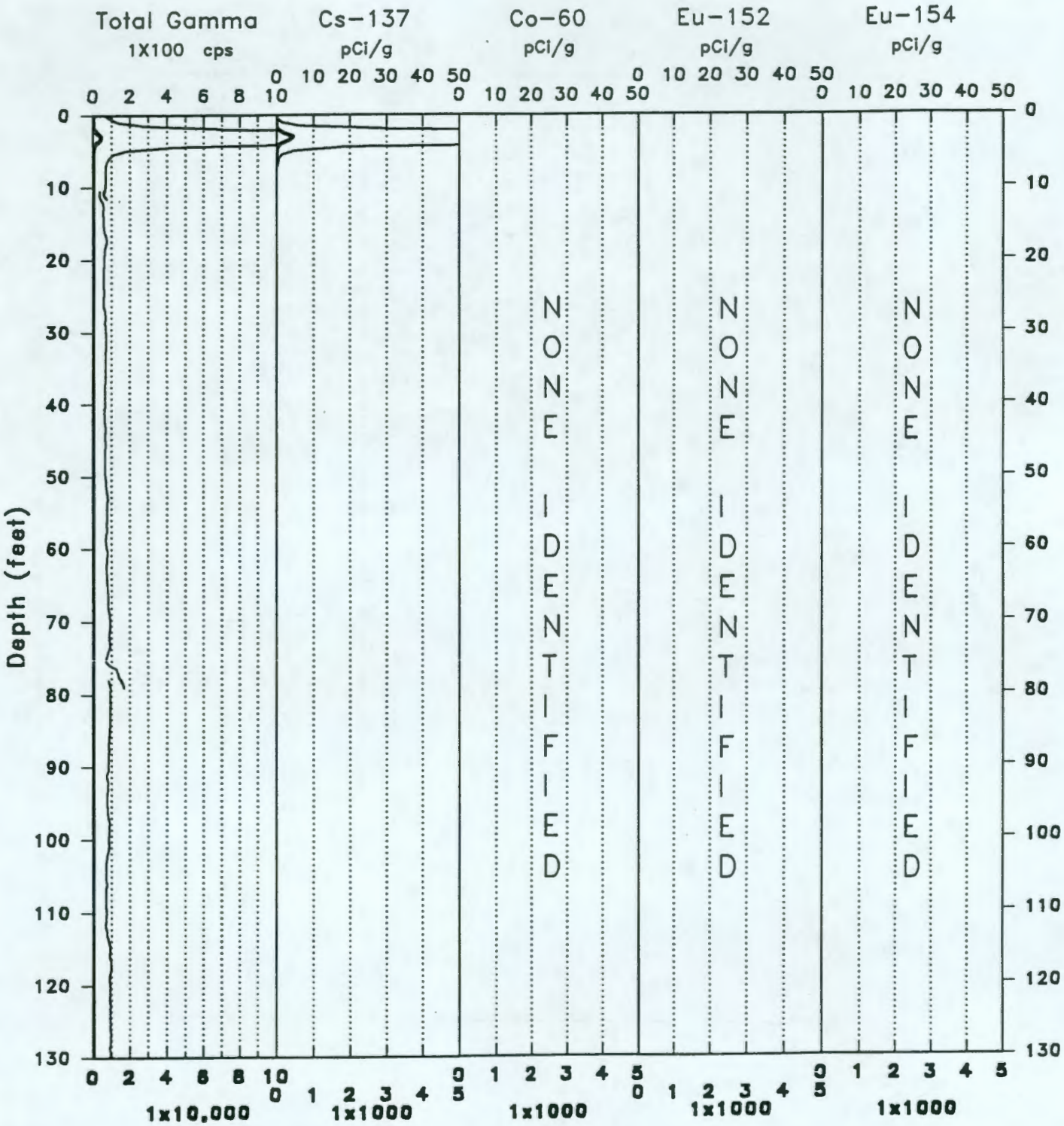
Log Date : Mar 24, 1994
Anal Date: Mar 25, 1994



RLS Spectral Gamma-Ray Borehole Survey

Project: 200-UP-2 Log Date: Mar 24, 1994

Borehole: 299-W23-231 Anal. Date: Mar 25, 1994



RLS Borehole Survey Report

Borehole: 299-W23-231

Casing	Depth:	0.0′- 13.3′	Size: 12"	Thickness: 0.375"
		0.0′- 82.3′	10"	0.500"
		0.0′-140.5′	8"	0.500"
Water	None			
Survey	Depth:	0.0′- 11.5′	Date: Mar 14, 1994	
		10.5′- 79.0′	Mar 17, 1994	
		78.0′-140.0′	Mar 24, 1994	

General Notes:

The well was surveyed three times during drilling in three casing sizes. Essentially all of the surveys were conducted in single casing strings. Casing overlap occurred from 10.5 to 13.3 feet during the second survey, and from 78.0 to 82.3 feet during the third survey; the overlaps did not impair the quality of the surveys. The data were collected at an acquisition time of 120 seconds real time for the first and second surveys, and at 80 seconds real time for the third survey.

The plots of the naturally occurring radionuclides of potassium, uranium, and thorium are typical for sediments of the Hanford site. Zones of increased count rate are observed at 11.0 feet and 75.0 feet where the detector encountered uncased sediments, either in open hole or at the bottom of the borehole. Repeat sections were conducted at the end of each survey to verify equipment performance, and the repeat data are included on the plots.

Man-made Radionuclides:

Cesium (Cs-137) was identified from 0.0 to 10.0 feet. The maximum observed activity of 440 pCi/g occurred at 3.0 feet.

Cobalt (Co-60) was analyzed but was not identified. The cobalt plot track is presented for uniformity in presentation.

Europium (Eu-152 and Eu-154) was not analyzed. The europium plot tracks are included for uniformity in plot presentation.

Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-94** |

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks	Total Gross Spectral Log (1x1000 c/s)	Cs 137 Log (1x1000 pCi/g)	Co 60 Log (pCi/g)	U 235 Log (pCi/g)	U 238 Log (1x100 pCi/g)	Depth (Feet)
		0-1' Surface stabilized with crushed rock 1-4' SAND		Boring abandoned with bentonite crumbles						
	SS	4-21' SAND with occassional gravel/cobbles		CH @ 4.0'						
10										10
	SS			CH @ 15.5'						
20		21-31' Crib GRAVEL								20
	SS			CH @ 28.0'						
30	SS	BOTTOM OF CRIB @ ~31' 31-76.5' SAND		CH @ 30.0'						30
	SS			CH @ 33.5						
				12" casing set at 37.02'						
	SS			CH and PH @ 38.0'						
40										40
	SS			CH @ 48.0'						
50										50
	SS			CH and PH @ 57.5'						
60										60
	SS			CH and PH @ 68.0'						
70		CZ SP/C B	6 4 2 0 2 4 6		10 90	10 90	0.5 4.5	0.5 4.5	1 9	70

Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-94** |

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks	Total Gross Spectral Log (1x1000 c/s)	Cs 137 Log (1x1000 pCi/g)	Co 60 Log (pCi/g)	U 235 Log (pCi/g)	U 238 Log (1x100 pCi/g)	Depth (Feet)
		76.5-80.5' SAND, interbedded fine to coarse								
80		80.5-89.5' Slightly Silty SAND								80
90	SS	89.5-128' SAND, interbedded silt with fine to coarse grained sand		CH and PH @ 89.5'						90
				10" casing set at 95.62'						
100										100
110										110
	SS			CH and PH @ 114.5'						
120										120
	SS	128-145' SAND, silt content increasing with depth		CH and PH @ 128.0'						
130										130
140		CZ SP/CB	6 4 2 0 2 4 6		10 90	10 90	0.5 4.5	0.5 4.5	1 9	140

Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-94** |

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks	Total Gross Spectral Log (1x1000 c/s)	Cs 137 Log (1x1000 pCi/g)	Co 60 Log (pCi/g)	U 235 Log (pCi/g)	U 238 Log (1x100 pCi/g)	Depth (Feet)
		145-148' Silty SAND								
150	SS	148-165' SAND, interbedded with silt		CH and PH @ 148.0'						150
160										160
		HANFORD UNIT 2/PLIO-PLEISTOCENE CONTACT AT 165'								
	SS	165-187.5' SILT Silt-rich (165-187.5')		CH @ 165.5'						
170	SS			PH @ 168.0'						170
180										180
	SS			CH and PH @ 183.0'						
	SS			CH @ 185.0'						
	SS	187.5-197' SILT and fine grain sand interbeds with caliche development (caliche layer) Carbonate-rich (187.5-187')		CH @ 187.0'						
190										190
		PLIO-PLEISTOCENE/RINGOLD CONTACT AT 197'		8" casing set at 196.82'						
	SS	197-199' SILT		CH @ 197.0'						
200				Total Depth = 199'						200
210		CZ SP/C B	6 4 2 0 2 4 6		10 90	10 90	0.5 4.5	0.5 4.5	1 9	210

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Rev. 01

Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-96** |

Depth (Feet)	Sample	Lithology	Remarks
		0-22' SAND	Boring abandoned with bentonite crumbles
	SS		CH @ 4'
10			
	SS		CH @ 15'
20			
	SS	22-24.5' Gravelly Silty SAND?	CH @ 22'
	SS	24.5-25.5' Gravelly SILT	CH @ 24.5'
		BOTTOM OF CRIB @ ~26'	
	SS	25.5-35' Sandy GRAVEL to Gravelly SAND	CH @ 27'
30	SS		CH @ 29.5'
	SS	35-40.5' SAND interbedded with Sandy SILT	CH @ 35'
			12" casing set at 38'
40	SS	40.5-42.5' SAND	CH @ 40.5'
		42.5-52.5' Sandy GRAVEL	
	SS		CH @ 45'
50	SS		CH and PH @ 50'
		52.5-59' SAND interbedded with 2" silt beds	
60	SS	59-66.5' Sandy GRAVEL	CH @ 60'
		66.5-69' SAND	
70		69-88' Sandy GRAVEL	
		CZ SP/C B	

Well Construction (inches): 6 4 2 0 2 4 6

Total Gross Spectral Log (1x1000 c/s): 10 – 90

Cs 137 Log (1x1000 pCi/g): 10 – 90

Co 60 Log (pCi/g): 0.5 – 4.5

U 235 Log (pCi/g): 0.5 – 4.5

U 238 Log (1x1000 pCi/g): 2 – 18

Depth (Feet): 10, 20, 30, 40, 50, 60, 70

Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-96** |

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks	Total Gross Spectral Log (1x1000 c/s)	Cs 137 Log (1x1000 pCi/g)	Co 60 Log (pCi/g)	U 235 Log (pCi/g)	U 238 Log (1x1000 pCi/g)	Depth (Feet)
80	SS			CH and PH @ 80'						80
90		88-94' GRAVEL, predominatly large gravel and cobbles 94-100.3' GRAVEL								90
100	SS	HANFORD UNIT 1/HANFORD UNIT 2 CONTACT AT 100.3' 100.3-159' SAND interbedded with silt beds		10" casing set at 99.5' CH and PH @ 99.5'						100
110										110
120	SS			CH and PH @ 120'						120
130										130
140		CZ SP/CB	6 4 2 0 2 4 6		10 90	10 90	0.5 4.5	0.5 4.5	2 18	140

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Rev. 01

Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-96** |

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks	Total Gross Spectral Log (1x1000 c/s)	Cs 137 Log (1x1000 pCi/g)	Co 60 Log (pCi/g)	U 235 Log (pCi/g)	U 238 Log (1x1000 pCi/g)	Depth (Feet)
	SS			CH @ 140'						
	SS			PH @ 144'						
150										150
160	SS	159-169' SILT HANFORD UNIT 2/PLIO-PLEISTOCENE CONTACT AT 162' Silt-rich (162-169')		CH and PH @ 159'						160
	SS			CH @ 166'						
	SS			CH and PH @ 168'						
170		169-171.6' Gravelly SILT, with caliche development (caliche layer) Carbonate-rich (169-171.6') PLIO-PLEISTOCENE/UPPER RINGOLD CONTACT AT 171.6'								170
	SS	171.6-177' SAND UPPER RINGOLD/RINGOLD E CONTACT AT 177'		8" casing set at 175' CH and PH @ 175'						
		177-179' Sandy GRAVEL								
180				Total Depth = 179'						180
190										190
200										200
210		CZ SP/C B	6 4 2 0 2 4 6		10 90	10 90	0.5 4.5	0.5 4.5	2 18	210

Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W22-78** |

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks	Total Gross Spectral Log (1x100 c/s)	Cs 137 Log (pCi/g)	Co 60 Log (pCi/g)	U 235 Log (pCi/g)	U 238 Log (pCi/g)	Depth (Feet)
		0-33.5' SAND with sporadic thin sandy gravel beds		Boring abandoned with bentonite crumbles						
				CH @ 4'						
	SS									
10				CH and PH @ 9'						10
	SS									
20		Bottom of crib at approximately 20'		CH and PH @ 19' and @ 21'						20
	SS									
	SS									
30										30
		HANFORD UNIT 1/HANFORD UNIT 2 CONTACT AT 33.5'								
		33.5-84' SAND with minor calcite stringers and thin lenses of fine to medium sands		12" casing set at 37.01'						
				CH and PH @ 38'						
40	SS									40
50				CH and PH @ 49.5'						50
	SS									
60										60
70		CZ SP/CB	6 4 2 0 2 4 6		0.5 4.5	0.5 4.5	0.5 4.5	0.5 4.5	10 90	70

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Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W22-78** |

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks	Total Gross Spectral Log (1x100 c/s)	Cs 137 Log (pCi/g)	Co 60 Log (pCi/g)	U 235 Log (pCi/g)	U 238 Log (pCi/g)	Depth (Feet)
	SS			CH and PH @ 70'						
80										80
		84-97.5' SAND								
90	SS			CH and PH @ 90' 10" casing set at 91.24'						90
		97.5-107' SAND with thin laminations?								
100										100
		107-124' SAND, thinly laminated with lenses of silty sand; strong reaction to HCL								
110	SS			CH and PH @ 109.5'						110
120										120
		124-132' SAND, weak reaction with HCL								
130				CH and PH @ 129.75'						130
	SS	132-140' SAND, interbedded with thin fine grain sand								
140		CZ SP/CB	6 4 2 0 2 4 6		0.5 4.5	0.5 4.5	0.5 4.5	0.5 4.5	10 90	140

Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W22-78** |

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks	Total Gross Spectral Log (1x100 c/s)	Cs 137 Log (pCi/g)	Co 60 Log (pCi/g)	U 235 Log (pCi/g)	U 238 Log (pCi/g)	Depth (Feet)
150	SS	140-158' SAND, with thin discontinuous calcium carbonate stringers, and thin sand beds		CH and PH @ 150'						150
160		158-176' Interbedded sequence of SAND and Silty SAND								160
170	SS			CH and PH @ 170'						170
180		176-180' SAND interbedded with thin silty sand beds HANFORD UNIT 2/PLIO-PLEISTOCENE CONTACT AT 180' 180-185.5' Sandy SILT Silt-rich (180-185.5')								180
190	SS	185.5-186' Slightly Silty SAND Carbonate-rich (185.5-204.5') 186-193.5' SAND (Caliche layer)		CH and PH @ 185' 8" casing set at 189.45'						190
200	SS	193.5-194' Gravelly SAND 194-197' SAND, interbedded with Silty Sand 197-201' Sandy SILT		CH and PH @ 194' CH and PH @ 198'						200
210	SS	201-204.5' Silty SAND PLIO-PLEISTOCENE/UPPER RINGOLD CONTACT AT 204.5' 204.5-209.5' SILT CZ SP/C B	6 4 2 0 2 4 6	CH and PH @ 209.5'	0.5 4.5	0.5 4.5	0.5 4.5	0.5 4.5	10 80	210

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Rev. 01

Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W22-78** |

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks	Total Gross Spectral Log (1x100 c/s)	Cs 137 Log (pCi/g)	Co 60 Log (pCi/g)	U 235 Log (pCi/g)	U 238 Log (pCi/g)	Depth (Feet)
	SS	209.5-216' SAND, interbedded with thin Sandy SILT								
		216-224' SAND, interbedded with thin Silty SAND								
220				CH and PH @ 222'						220
	SS	224-234' SAND								
230	SS			CH and PH @ 230' Static Water Level at 230.6' 6" casing set at 233.36' Total Depth = 234'						230
240										240
250										250
260										260
270										270
280		CZ SP/C B	6 4 2 0 2 4 6		0.5 4.5	0.5 4.5	0.5 4.5	0.5 4.5	10 90	280

Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-94** | Page 1 of 3

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks	Total Gross Spectral Log (1x1000 c/s)	Cs 137 Log (1x1000 pCi/g)	Co 60 Log (pCi/g)	Eu 152 Log (pCi/g)	Eu 154 Log (pCi/g)	Depth (Feet)
		0-1' Surface stabilized with crushed rock 1-4' SAND		Boring abandoned with bentonite crumbles						
	SS	4-21' SAND with occassional gravel/cobbles		CH @ 4.0'						
10										10
	SS			CH @ 15.5'						
20										20
		21-31' Crib GRAVEL								
	SS			CH @ 28.0'						
30	SS	BOTTOM OF CRIB @ ~31'		CH @ 30.0'						30
		31-76.5' SAND								
	SS			CH @ 33.5						
				12" casing set at 37.02'						
	SS			CH and PH @ 38.0'						
40										40
	SS			CH @ 48.0'						
50										50
	SS			CH and PH @ 57.5'						
60										60
	SS			CH and PH @ 68.0'						
70		CZ SP/CB	6 4 2 0 2 4 6		10 90	10 90	0.5 4.5	0.5 4.5	0.5 4.5	70

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Rev. 01

Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-94** |

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks	Total Gross Spectral Log (1x1000 c/s)	Cs 137 Log (1x1000 pCi/g)	Co 60 Log (pCi/g)	Eu 152 Log (pCi/g)	Eu 154 Log (pCi/g)	Depth (Feet)
		76.5-80.5' SAND, interbedded fine to coarse								
80		80.5-89.5' Slightly Silty SAND								80
90	SS	89.5-128' SAND, interbedded silt with fine to coarse grained sand		CH and PH @ 89.5'						90
				10" casing set at 95.62'						
100										100
110										110
	SS			CH and PH @ 114.5'						
120										120
	SS	128-145' SAND, silt content increasing with depth		CH and PH @ 128.0'						
130										130
140		CZ SP/C B	6 4 2 0 2 4 6		10 90	10 90	0.5 4.5	0.5 4.5	0.5 4.5	140

Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-94** |

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks	Total Gross Spectral Log (1x1000 c/s)	Cs 137 Log (1x1000 pCi/g)	Co 60 Log (pCi/g)	Eu 152 Log (pCi/g)	Eu 154 Log (pCi/g)	Depth (Feet)
		145-148' Silty SAND								
150	SS	148-165' SAND, interbedded with silt		CH and PH @ 148.0'						150
160										160
		HANFORD UNIT 2/PLIO-PLEISTOCENE CONTACT AT 165'								
	SS	165-187.5' SILT Silt-rich (165-187.5')		CH @ 165.5'						
170	SS			PH @ 168.0'						170
180										180
	SS			CH and PH @ 183.0'						
	SS			CH @ 185.0'						
	SS	187.5-197' SILT and fine grain sand interbeds with caliche development (caliche layer) Carbonate-rich (187.5-197')		CH @ 187.0'						
190										190
		PLIO-PLEISTOCENE/RINGOLD CONTACT AT 197'		8" casing set at 196.82'						
	SS	197-199' SILT		CH @ 197.0'						
200				Total Depth = 199'						200
210		CZ SP/CB	6 4 2 0 2 4 6		10 90	10 90	0.5 4.5	0.5 4.5	0.5 4.5	210

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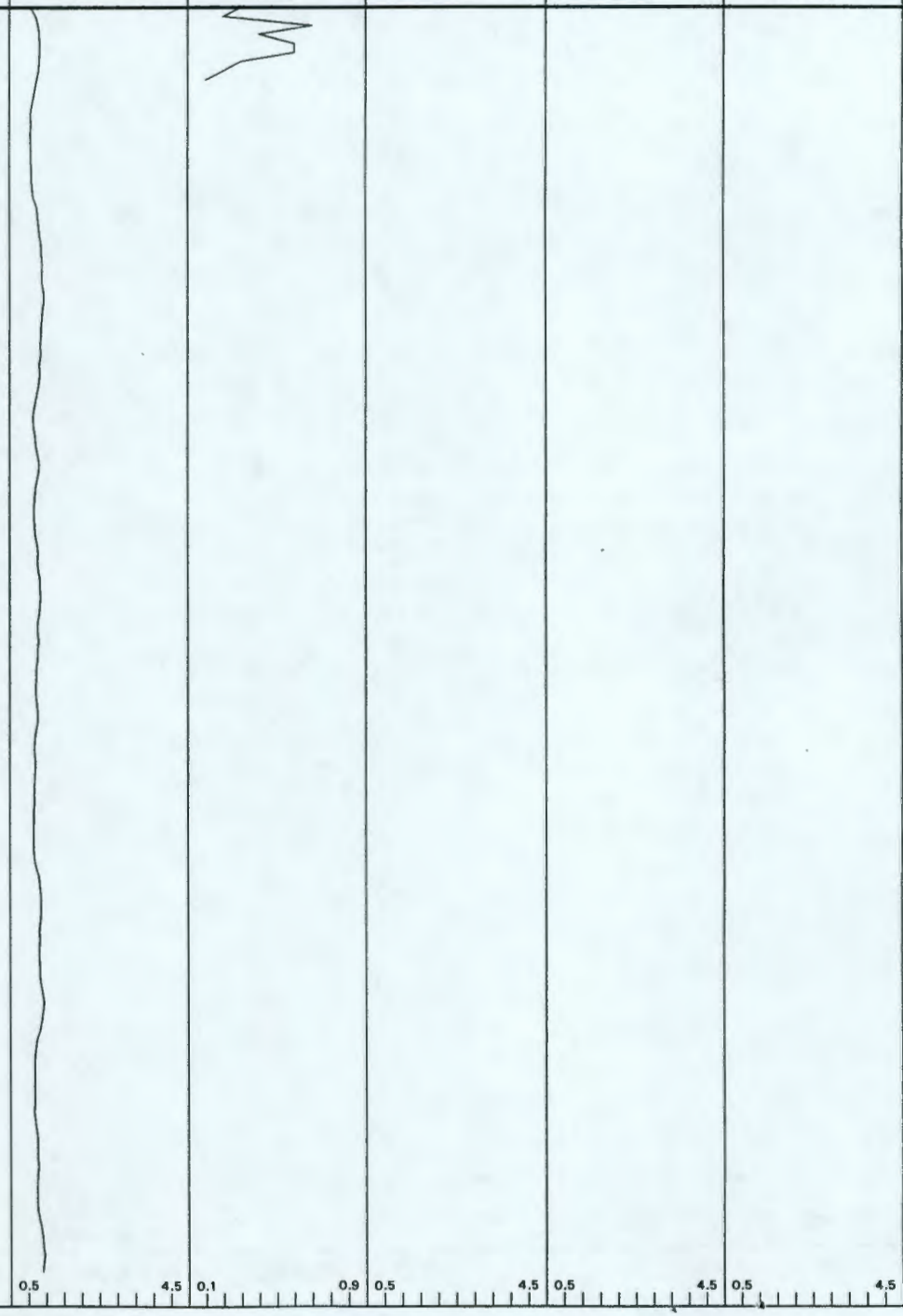
Rev. 01

Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-95** |

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks
		0-5.5' SAND		Boring abandoned with bentonite crumbles
	SS			CH @ 4.0'
		5.5-13' Sandy GRAVEL		
10				
		13-14.5' Gravelly SAND		
	SS	14.5-21.5' SAND		CH and PH @ 14.5'
20				
		21.5-22' SAND		
		22-26.5' Gravelly SAND		
		26.5-38.5' SAND		
30	SS			CH and PH @ 30.0'
		38.5-40 SAND with silt interbeds		
40		40-45' Gravelly SAND		
	SS	45-48' Sandy GRAVEL		CH @ 45.0'
	SS	48-58' SAND		PH @ 47.5'
50				
		58-65' Sandy GRAVEL		
60	SS			CH and PH @ 60.0'
		65-84' SAND		
70		CZ SP/CB	6 4 2 0 2 4 6	



Depth (Feet): 10, 20, 30, 40, 50, 60, 70

Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-95** |

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks	Total Gross Spectral Log (1x100 c/s)	Cs 137 Log (pCi/g)	Co 60 Log (pCi/g)	Eu 152 Log (pCi/g)	Eu 154 Log (pCi/g)	Depth (Feet)
80	SS			CH and PH @ 74.8'						80
		84-104' Sandy GRAVEL								
90	SS			CH and PH @ 90.2'						90
100		HANFORD UNIT 1/HANFORD UNIT 2 CONTACT AT 104'		10" casing set at 101.1'						100
	SS	104-109' SAND		CH @ 105.0'						
	SS			PH @ 107.5'						
110		109-114' SAND with thin silt interbeds								110
		114-150' SAND with occasional thin silt interbeds								
120	SS									120
130										130
140		CZ SP/CB	6 4 2 0 2 4 6		0.5 4.5	0.1 0.9	0.5 4.5	0.5 4.5	0.5 4.5	140

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Rev. 01

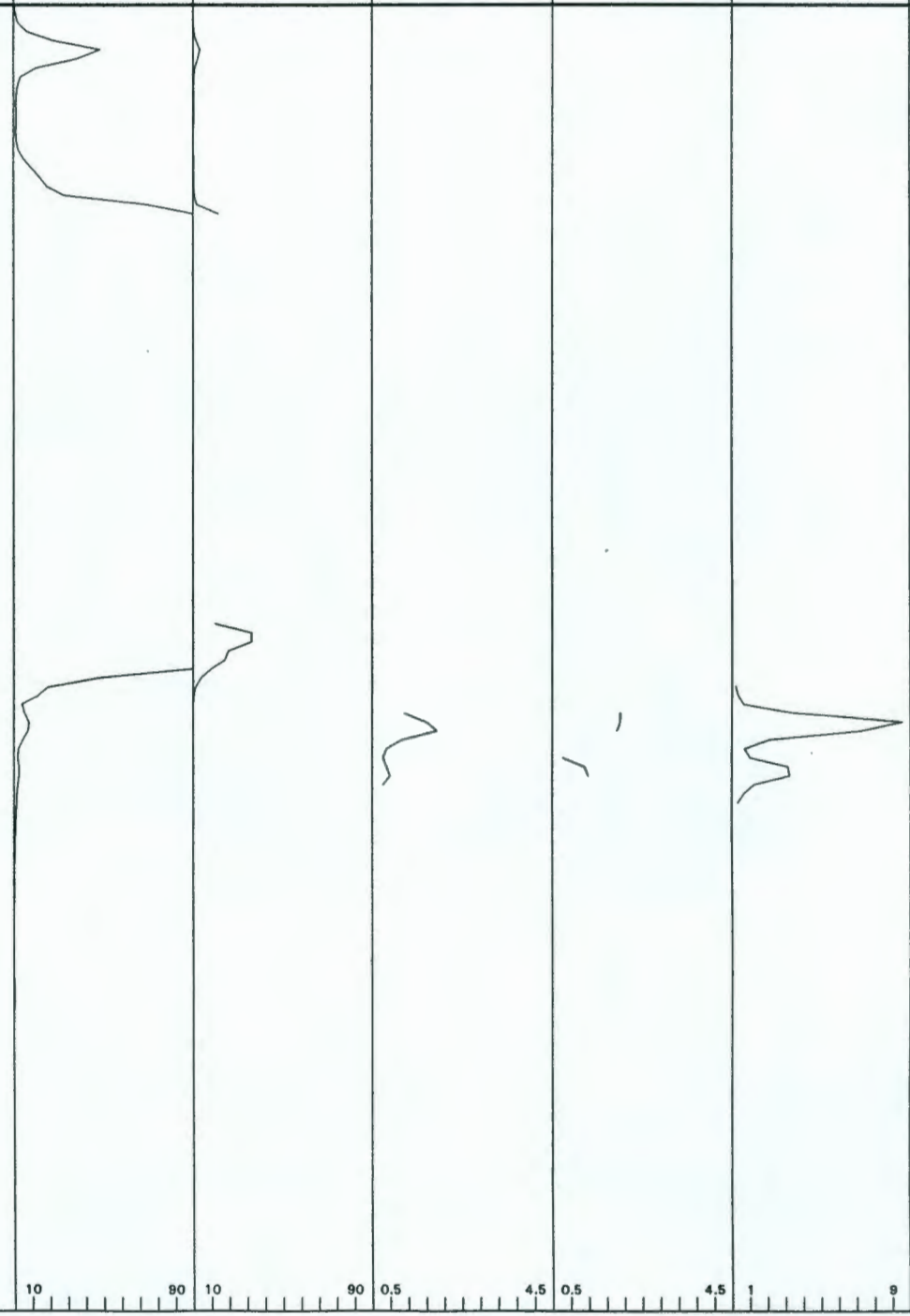
Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-95** |

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks	Total Gross Spectral Log (1x100 c/s)	Cs 137 Log (pCi/g)	Co 60 Log (pCi/g)	Eu 152 Log (pCi/g)	Eu 154 Log (pCi/g)	Depth (Feet)
	SS			CH and PH @ 140.0'						
150	SS	150-166' Sandy SILT with alternating beds of sandy silt and silty sand		PH @ 151.0'						150
160		HANFORD UNIT 2/PLIO-PLEISTOCENE CONTACT AT 160' Silt-rich, fewer interbeds (160-166')								160
	SS	166-181' Gravelly SAND, with caliche development (caliche layer 166-168') Carbonate-rich (166-168') PLIO-PLEISTOCENE/UPPER RINGOLD CONTACT AT 168'		CH and PH @ 165.0'						
170	SS	168-181.5' SAND		CH and PH @ 169.0'						170
180		UPPER RINGOLD/RINGOLD E CONTACT AT 181'		8" casing set at 180.1'						180
	SS	181.5-182' Sandy GRAVEL		CH and PH @ 181.0' Total Depth = 182'						
190										190
200										200
210		CZ SP/CB	6 4 2 0 2 4 6		0.5 4.5	0.1 0.9	0.5 4.5	0.5 4.5	0.5 4.5	210

Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-96** |

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks
		0-22' SAND		Boring abandoned with bentonite crumbles
	SS			CH @ 4'
10				
	SS			CH @ 15'
20				
	SS	22-24.5' Gravelly Silty SAND?		CH @ 22'
	SS	24.5-25.5' Gravelly SILT		CH @ 24.5'
		BOTTOM OF CRIB @ ~25'		
	SS	25.5-35' Sandy GRAVEL to Gravelly SAND		CH @ 27'
30	SS			CH @ 29.5'
	SS	35-40.5' SAND interbedded with Sandy SILT		CH @ 35'
				12" casing set at 38'
40	SS	40.5-42.5' SAND		CH @ 40.5'
		42.5-52.5' Sandy GRAVEL		
	SS			CH @ 45'
50	SS			CH and PH @ 50'
		52.5-59' SAND interbedded with 2" silt beds		
60	SS	59-66.5' Sandy GRAVEL		CH @ 60'
		66.5-69' SAND		
70		69-88' Sandy GRAVEL		
		CZ SP/CB	6 4 2 0 2 4 6	

Total Gross Spectral Log (1x1000 c/s)	Cs 137 Log (1x1000 pCi/g)	Co 60 Log (pCi/g)	Eu 152 Log (pCi/g)	Eu 154 Log (1x100 pCi/g)	Depth (Feet)
10 — 90	10 — 90	0.5 — 4.5	0.5 — 4.5	1 — 9	70



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Rev. 01

Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-96** |

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks	Total Gross Spectral Log (1x1000 c/s)	Cs 137 Log (1x1000 pCi/g)	Co 60 Log (pCi/g)	Eu 152 Log (pCi/g)	Eu 154 Log (1x100 pCi/g)	Depth (Feet)
80	SS			CH and PH @ 80'						80
90		88-94' GRAVEL, predominatly large gravel and cobbles 94-100.3' GRAVEL								90
100	SS	HANFORD UNIT 1/HANFORD UNIT 2 CONTACT AT 100.3' 100.3-159' SAND interbedded with silt beds		10" casing set at 99.5' CH and PH @ 99.5'						100
110										110
120	SS			CH and PH @ 120'						120
130										130
140		CZ SP/C B	6 4 2 0 2 4 6		10 90	10 90	0.5 4.5	0.5 4.5	1 9	140

Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-96** |

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks	Total Gross Spectral Log (1x1000 c/s)	Cs 137 Log (1x1000 pCi/g)	Co 60 Log (pCi/g)	Eu 152 Log (pCi/g)	Eu 154 Log (1x100 pCi/g)	Depth (Feet)
	SS			CH @ 140'						
	SS			PH @ 144'						
150										150
160	SS	159-169' SILT HANFORD UNIT 2/PLIO-PLEISTOCENE CONTACT AT 162' Silt-rich (162-169')		CH and PH @ 159'						160
	SS			CH @ 166'						
	SS			CH and PH @ 168'						
170		169-171.6' Gravelly SILT, with caliche development (caliche layer) Carbonate-rich (169-171.6') PLIO-PLEISTOCENE/UPPER RINGOLD CONTACT AT 171.6'								170
	SS	171.6-177' SAND UPPER RINGOLD/RINGOLD E CONTACT AT 177'		8" casing set at 175' CH and PH @ 175'						
		177-179' Sandy GRAVEL		Total Depth = 179'						
180										180
190										190
200										200
210		CZ SP/C B	6 4 2 0 2 4 6		10 90	10 90	0.5 4.5	0.5 4.5	1 9	210

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Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-97** |

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks	Total Gross Spectral Log (1x100 c/s)	Cs 137 Log (pCi/g)	Co 60 Log (pCi/g)	Eu 152 Log (pCi/g)	Eu 154 Log (pCi/g)	Depth (Feet)
	SS	0-18' Gravelly SAND		Boring abandoned with bentonite crumbles						
				CH and PH @ 4'						
10	SS			CH and PH @ 10'						10
		18-20' SAND								
20	SS	20-28.6' Gravelly SAND		CH @ 20'						20
		28.6-29.4' SILT interbedded with sand								
30	SS	29.4-33.5' Gravelly SAND		CH and PH @ 30'						30
		33.5-44 Silty SAND and Sandy SILT								
40										40
		44-64.5' Gravelly SAND								
50	SS			CH and PH @ 50'						50
60										60
		64.5-93.5' Sandy GRAVEL								
70		CZ SP/CB	6 4 2 0 2 4 6		0.5 4.5	2 18	0.5 4.5	0.5 4.5	0.5 4.5	70

Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-97** |

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks	Total Gross Spectral Log (1x100 c/s)	Cs 137 Log (pCi/g)	Co 60 Log (pCi/g)	Eu 152 Log (pCi/g)	Eu 154 Log (pCi/g)	Depth (Feet)
	SS			CH and PH @ 70'						
80										80
90										90
		93.5-95' SAND HANFORD UNIT 1/HANFORD UNIT 2 CONTACT AT 95'								
		95-135' Gravelly SAND with sporadic thin CaCO3 zones								
100	SS			10" casing set at 101' CH and PH @ 101'						100
110										110
120										120
130	SS			CH and PH @ 130'						130
		135-145' Silty SAND interbedded with sand								
140		CZ SP/CB	6 4 2 0 2 4 6		0.5 4.5	2 18	0.5 4.5	0.5 4.5	0.5 4.5	140

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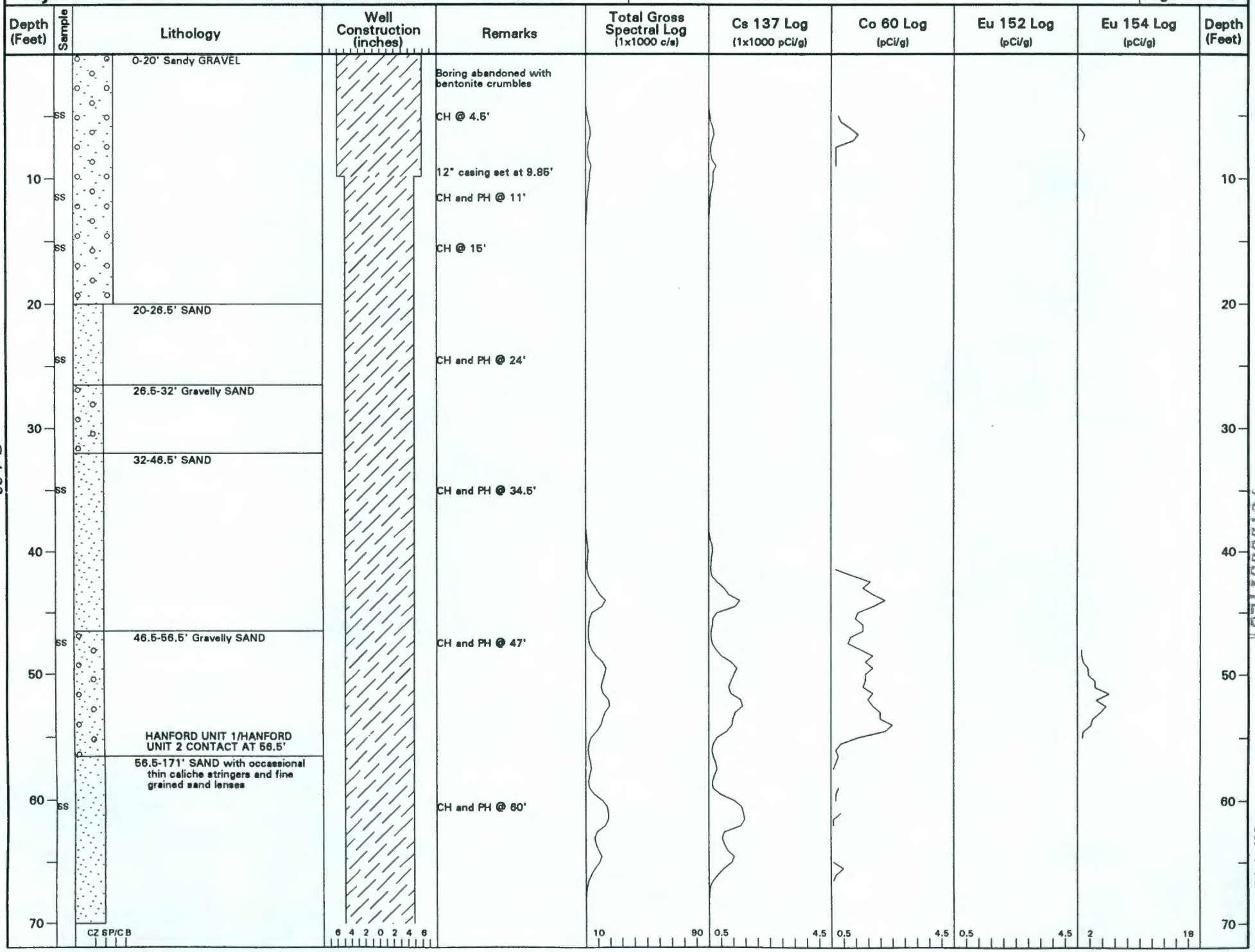
Rev. 01

Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-97** |

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks	Total Gross Spectral Log (1x100 c/s)	Cs 137 Log (pCi/g)	Co 60 Log (pCi/g)	Eu 152 Log (pCi/g)	Eu 154 Log (pCi/g)	Depth (Feet)
		145-154' SAND								
	SS			CH and PH @ 146'						
150										150
		HANFORD UNIT 2/PLIO-PLEISTOCENE CONTACT AT 154'								
		154-169.4' Sandy SILT with alternating beds of sandy silt and silty sand Silt-rich (154-169.4')								
	SS			CH and PH @ 156'						
160										160
	SS			CH and PH @ 167.5'						
170		169.6-171.4' Gravelly SAND with caliche development Carbonate-rich (169.6-171.4') PLIO-PLEISTOCENE/UPPER RINGOLD CONTACT AT 171.4'								170
		171.4-175' SAND UPPER RINGOLD/RINGOLD E CONTACT AT 175'		8" casing set at 175' CH and PH @ 175.5'						
	SS	175-177' Gravelly SAND		Total Depth = 177'						
180										180
190										190
200										200
210		CZ SP/CB	6 4 2 0 2 4 6		0.5 4.5	2 18	0.5 4.5	0.5 4.5	0.5 4.5	210

Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-98** |



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Rev. 01

Project: 200 UP2 VADOSE ZONE CHARACTERIZATION	Well No.: 299-W19-98	Page 2 of 3

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks	Total Gross Spectral Log (1x1000 c/s)	Cs 137 Log (1x1000 pCi/g)	Co 60 Log (pCi/g)	Eu 152 Log (pCi/g)	Eu 154 Log (pCi/g)	Depth (Feet)
80	SS			CH and PH @ 80'						80
90										90
				10" casing set at 96.56'						
100	SS			CH and PH @ 100'						100
110										110
120		@119-136' zone of predominately very fine sand								120
130	SS			CH and PH @ 130'						130
140		@ 136' fine sand becoming medium to coarse								140
		CZ SP/CB	6 4 2 0 2 4 6		10 90	0.5 4.5	0.5 4.5	0.5 4.5	2 18	

Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-98** |

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks	Total Gross Spectral Log (1x1000 c/s)	Cs 137 Log (1x1000 pCi/g)	Co 60 Log (pCi/g)	Eu 152 Log (pCi/g)	Eu 154 Log (pCi/g)	Depth (Feet)
150		143-158' zone of fine grained sand lens								150
160		158-171' medium to coarse sand with stringers of carbonate								160
170		171-184' increasing fine sand								170
	SS	HANFORD UNIT 2/PLIO-PLEISTOCENE CONTACT AT 176'		CH and PH @ 173'						
180		176-184' Sandy SILT Silt-rich 176-184')								180
	SS	184-189' SAND Carbonate-rich (184-191')		CH and PH @ 183.5'						
190		189-191' SAND (Caliche) PLIO-PLEISTOCENE/UPPER RINGOLD CONTACT AT 191'		8" casing set at 191.89' CH and PH @ 191'						190
	SS	191-194' SAND UPPER RINGOLD/RINGOLD E CONTACT AT 194'								
		194-195' Sandy GRAVEL		Total Depth = 195'						
200										200
210		CZ SP/C B	6 4 2 0 2 4 6		10 90	0.5 4.5	0.5 4.5	0.5 4.5	2 18	210

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Rev. 01

Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W23-231** |

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks	Total Gross Spectral Log (1x1000 c/s)	Cs 137 Log (1x100 pCi/g)	Co 60 Log (pCi/g)	Eu 152 Log (pCi/g)	Eu 154 Log (pCi/g)	Depth (Feet)
	SS	0-4.3' Sand fill		Boring abandoned with bentonite crumbles						
	SS			CH @ 2'						
	SS	Pond bottom @ 4.3' with abundant organic material		CH @ 4'						
	SS	4.3-6' SAND		CH @ 6'						
		6-28' Sandy GRAVEL								
10				12" casing set at 11.49'						10
	SS			CH @ 15'						
20										20
	SS	HANFORD UNIT 1/HANFORD UNIT 2 CONTACT AT 28'		CH @ Ph						
		28-33' SAND and interbedded SILT								
30										30
		33-98' SAND								
40	SS			CH and PH @ 40'						40
50	SS			CH @ 50'						50
60	SS			CH and PH @ 60'						60
70		CZ SP/C B	6 4 2 0 2 4 6		0.5 4.5	0.5 4.5	0.5 4.5	0.5 4.5	0.5 4.5	70

Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W23-231** |

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks	Total Gross Spectral Log (1x1000 c/s)	Cs 137 Log (1x100 pCi/g)	Co 60 Log (pCi/g)	Eu 152 Log (pCi/g)	Eu 154 Log (pCi/g)	Depth (Feet)
				There is a data gap in the RLS log from 76' to 78'						
80				10" casing set at 81.38'						80
90										90
100		98-137.5' Interbedded SAND and SILT								100
110	SS			CH and PH @ 110'						110
120										120
130										130
	SS	HANFORD UNIT 2/PLIO-PLEISTOCENE CONTACT AT 137.5'		CH and PH @ 135'						
	SS	137.5-139.5' SILT Caliche layer @ 137.5'		8" casing set at 138.21' CH @ 138'						
140		CZ SP/CB	6 4 2 0 2 4 6		0.5 4.5	0.5 4.5	0.5 4.5	0.5 4.5	0.5 4.5	140

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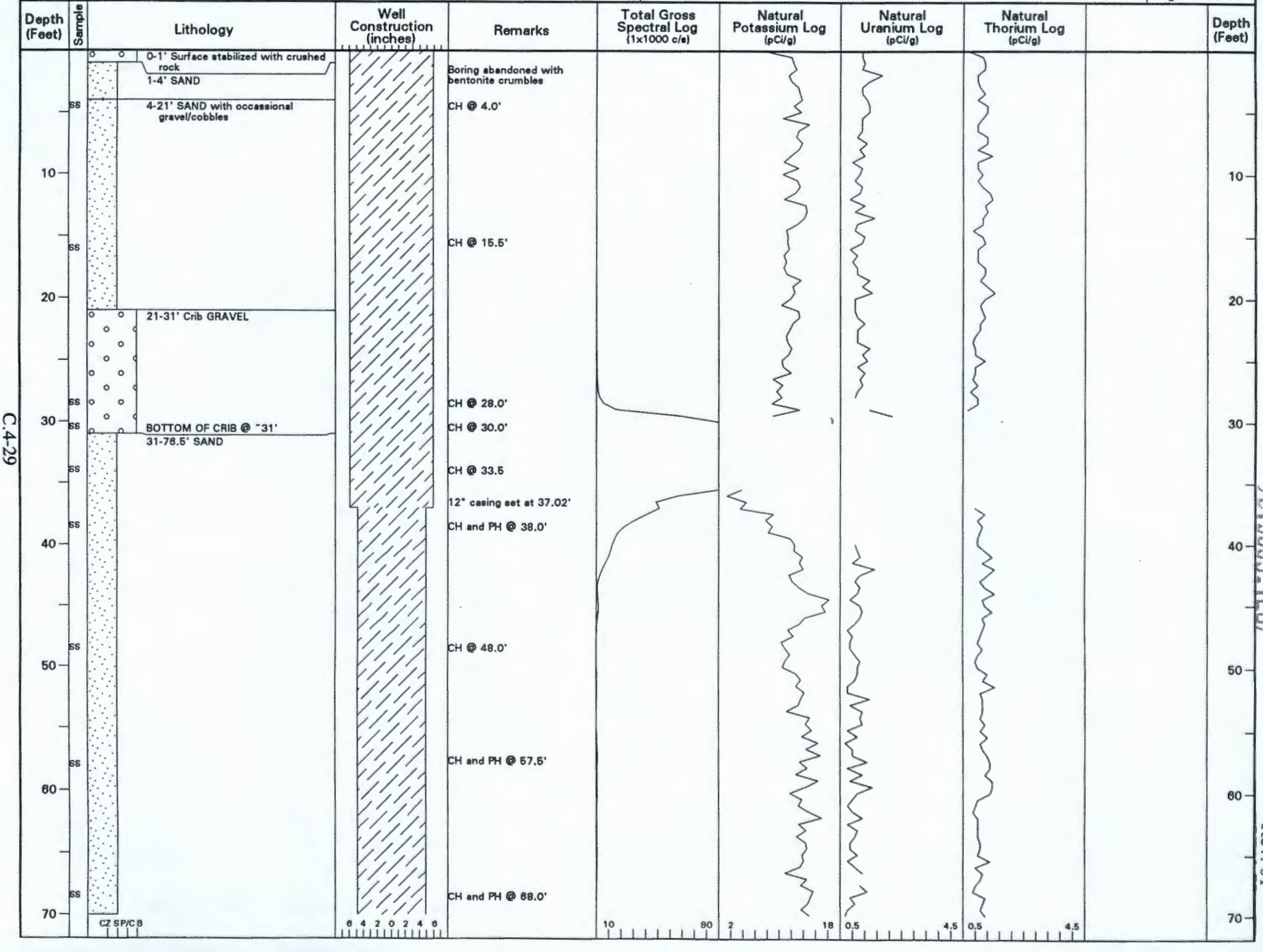
Rev. 01

Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W23-231** |

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks	Total Gross Spectral Log (1x1000 c/s)	Cs 137 Log (1x100 pCi/g)	Co 60 Log (pCi/g)	Eu 152 Log (pCi/g)	Eu 154 Log (pCi/g)	Depth (Feet)
		Carbonate-rich (137.5-139.5') PLIO-PLEISTOCENE/RINGOLD E CONTACT AT 139.5'		Total Depth = 141.4'						
		139.5-141.4' GRAVEL								
150										150
160										160
170										170
180										180
190										190
200										200
210		CZ SP/C B	6 4 2 0 2 4 6		0.5 4.5	0.5 4.5	0.5 4.5	0.5 4.5	0.5 4.5	210

Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-94** |



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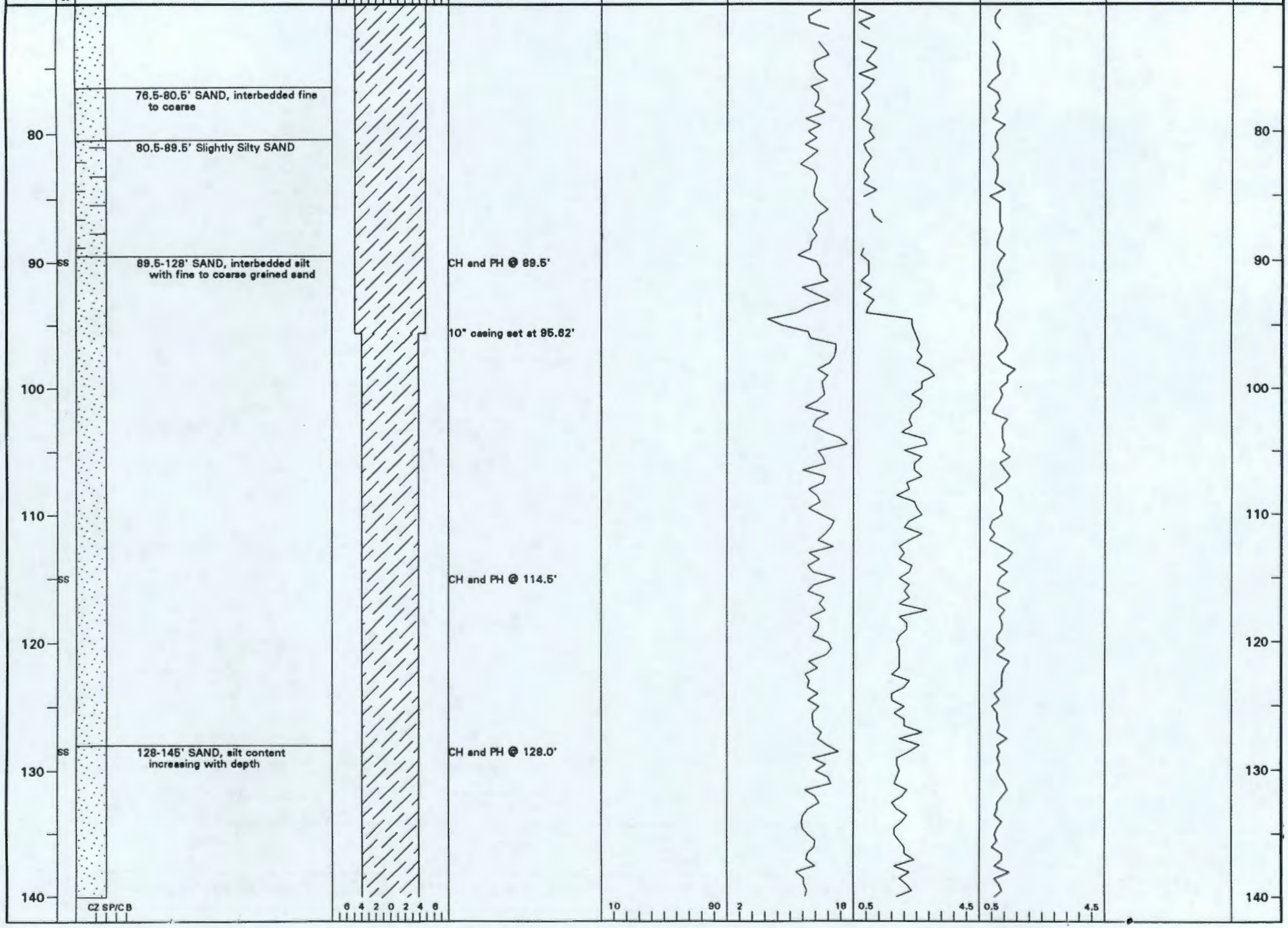
Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-94** |



Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-94** |

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks
		145-148' Silty SAND		
150	SS	148-165' SAND, interbedded with silt		CH and PH @ 148.0'
160				
		HANFORD UNIT 2/PLIO-PLEISTOCENE CONTACT AT 165'		
	SS	165-187.5' SILT Silt-rich (165-187.5')		CH @ 165.5'
170	SS			PH @ 168.0'
180				
	SS			CH and PH @ 183.0'
	SS			CH @ 185.0'
	SS	187.5-197' SILT and fine grain sand interbeds with caliche development (caliche layer) Carbonate-rich (187.5-197')		CH @ 187.0'
190				
		PLIO-PLEISTOCENE/RINGOLD CONTACT AT 197'		8" casing set at 196.82'
	SS	197-199' SILT		CH @ 197.0'
200				Total Depth = 198'
210		CZ SP/CB	6 4 2 0 2 4 6	

Total Gross Spectral Log (1x1000 c/s)	Natural Potassium Log (pCi/g)	Natural Uranium Log (pCi/g)	Natural Thorium Log (pCi/g)		Depth (Feet)
					150
					160
					170
					180
					190
					200
					210
10 — 90	2 — 18	0.5 — 4.5	0.5 — 4.5		

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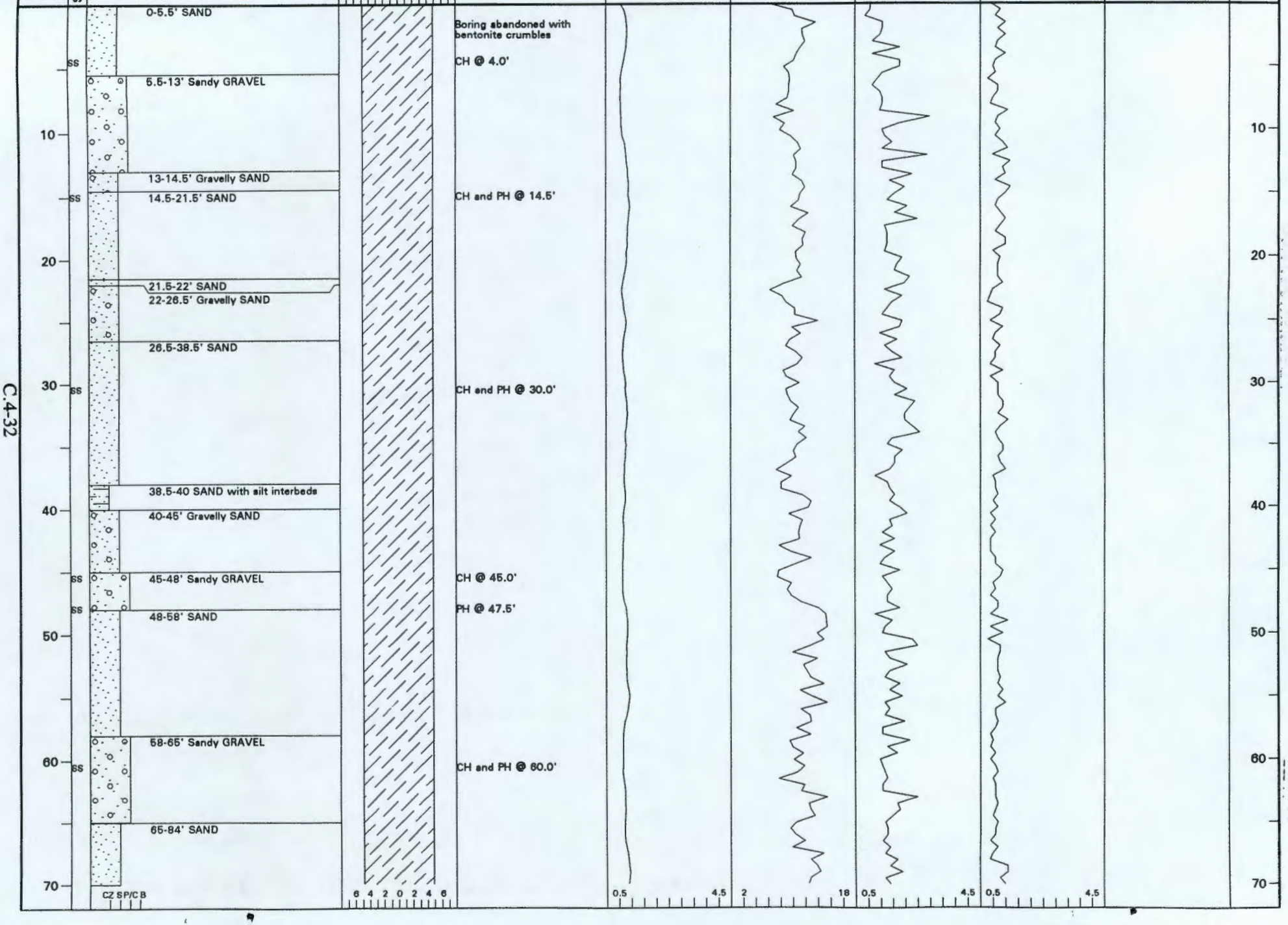
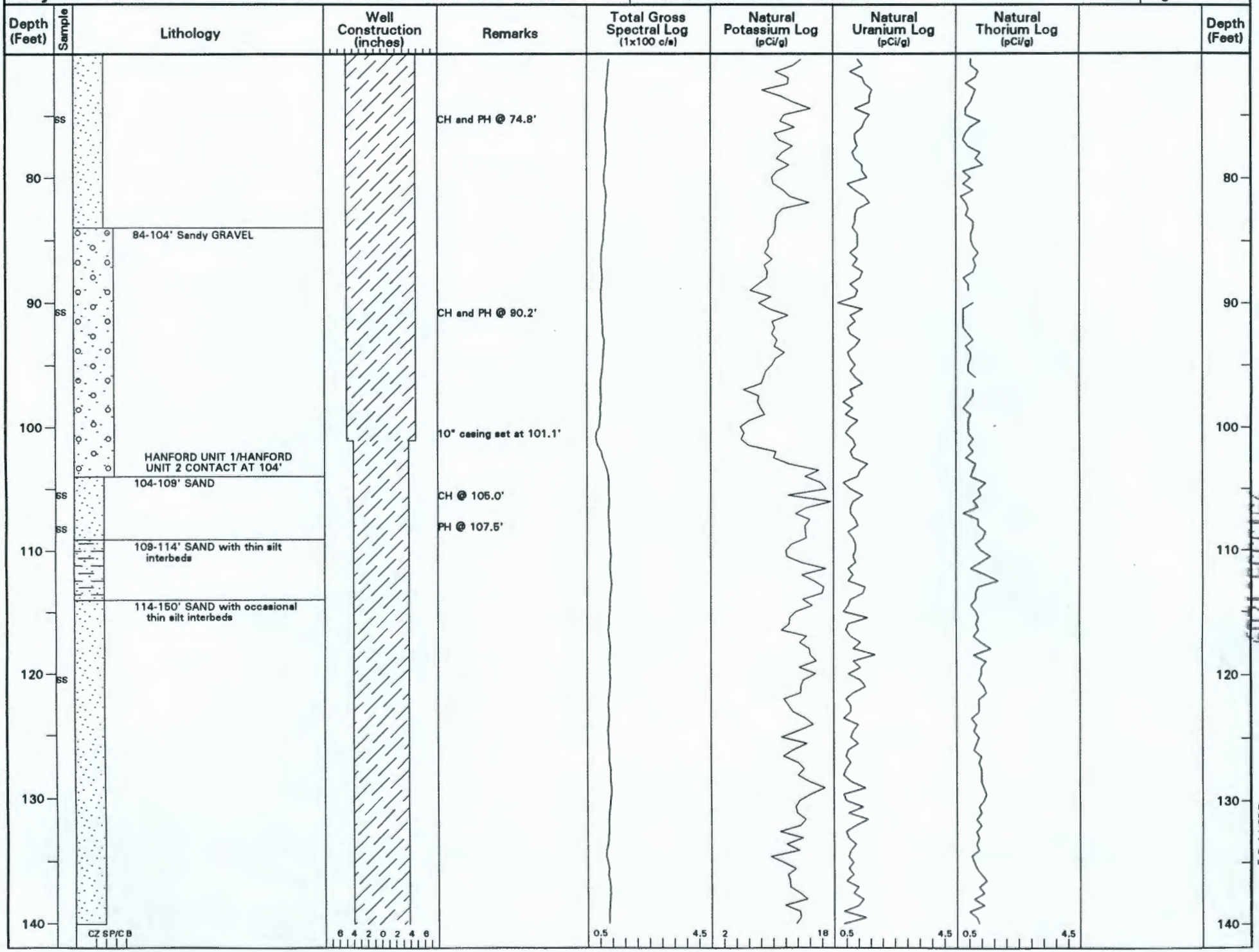
Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-95** |



Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-95** |



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Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-95** |

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks	Total Gross Spectral Log (1x100 c/s)	Natural Potassium Log (pCi/g)	Natural Uranium Log (pCi/g)	Natural Thorium Log (pCi/g)	Depth (Feet)
	SS			CH and PH @ 140.0'					
150	SS	150-166' Sandy SILT with alternating beds of sandy silt and silty sand		PH @ 151.0'					150
160		HANFORD UNIT 2/PLIO-PLEISTOCENE CONTACT AT 160' Silt-rich, fewer interbeds (160-166')							160
	SS	166-181' Gravelly SAND, with caliche development (caliche layer 166-168')		CH and PH @ 165.0'					
170	SS	Carbonate-rich (166-168') PLIO-PLEISTOCENE/UPPER RINGOLD CONTACT AT 168' 168-181.5' SAND		CH and PH @ 169.0'					170
180		UPPER RINGOLD/RINGOLD E CONTACT AT 181'		8" casing set at 180.1'					180
	SS	181.5-182' Sandy GRAVEL		CH and PH @ 181.0' Total Depth = 182'					
190									190
200									200
210		CZ SP/CB	6 4 2 0 2 4 6		0.5 4.5	2 18	0.5 4.5	0.5 4.5	210

Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-96** |

Depth (Feet)	Sample	Lithology	Remarks
		0-22' SAND	Boring abandoned with bentonite crumbles
	SS		CH @ 4'
10			
	SS		CH @ 15'
20			
	SS	22-24.5' Gravelly Silty SAND?	CH @ 22'
	SS	24.5-25.5' Gravelly SILT	CH @ 24.5'
		BOTTOM OF CRIB @ ~25'	
	SS	25.5-35' Sandy GRAVEL to Gravelly SAND	CH @ 27'
30	SS		CH @ 29.5'
	SS	35-40.5' SAND interbedded with Sandy SILT	CH @ 35'
			12" casing set at 38'
40	SS	40.5-42.5' SAND	CH @ 40.5'
		42.5-52.5' Sandy GRAVEL	
	SS		CH @ 45'
50	SS		CH and PH @ 50'
		52.5-59' SAND interbedded with 2" silt beds	
60	SS	59-66.5' Sandy GRAVEL	CH @ 60'
		66.5-69' SAND	
70		69-88' Sandy GRAVEL	
		CZ SP/CB	

Well Construction (inches): 6 4 2 0 2 4 6

Total Gross Spectral Log (1x1000 c/s): 10 – 90

Natural Potassium Log (pCi/g): 2 – 18

Natural Uranium Log (pCi/g): 0.5 – 4.5

Natural Thorium Log (pCi/g): 0.5 – 4.5

Depth (Feet): 10, 20, 30, 40, 50, 60, 70

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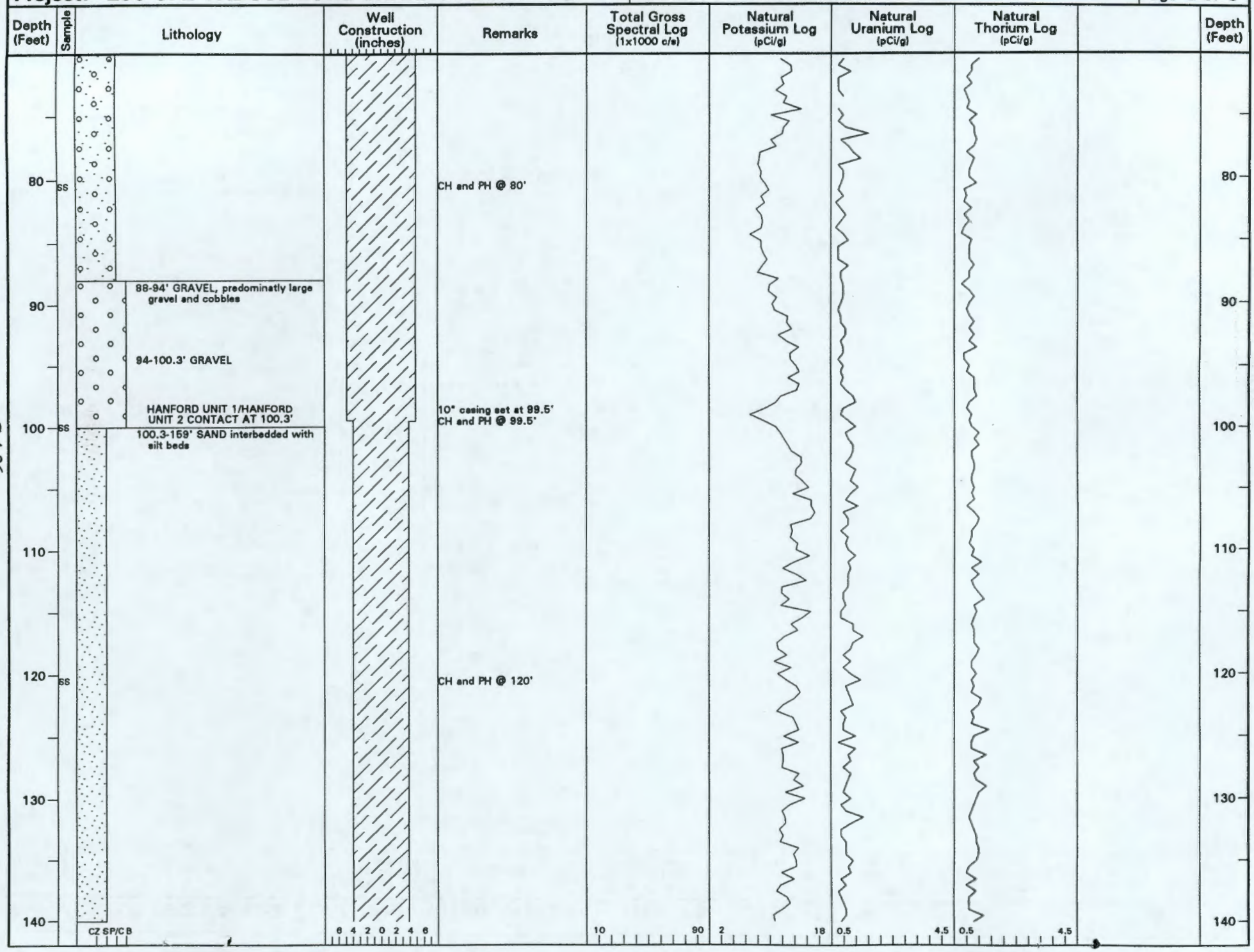
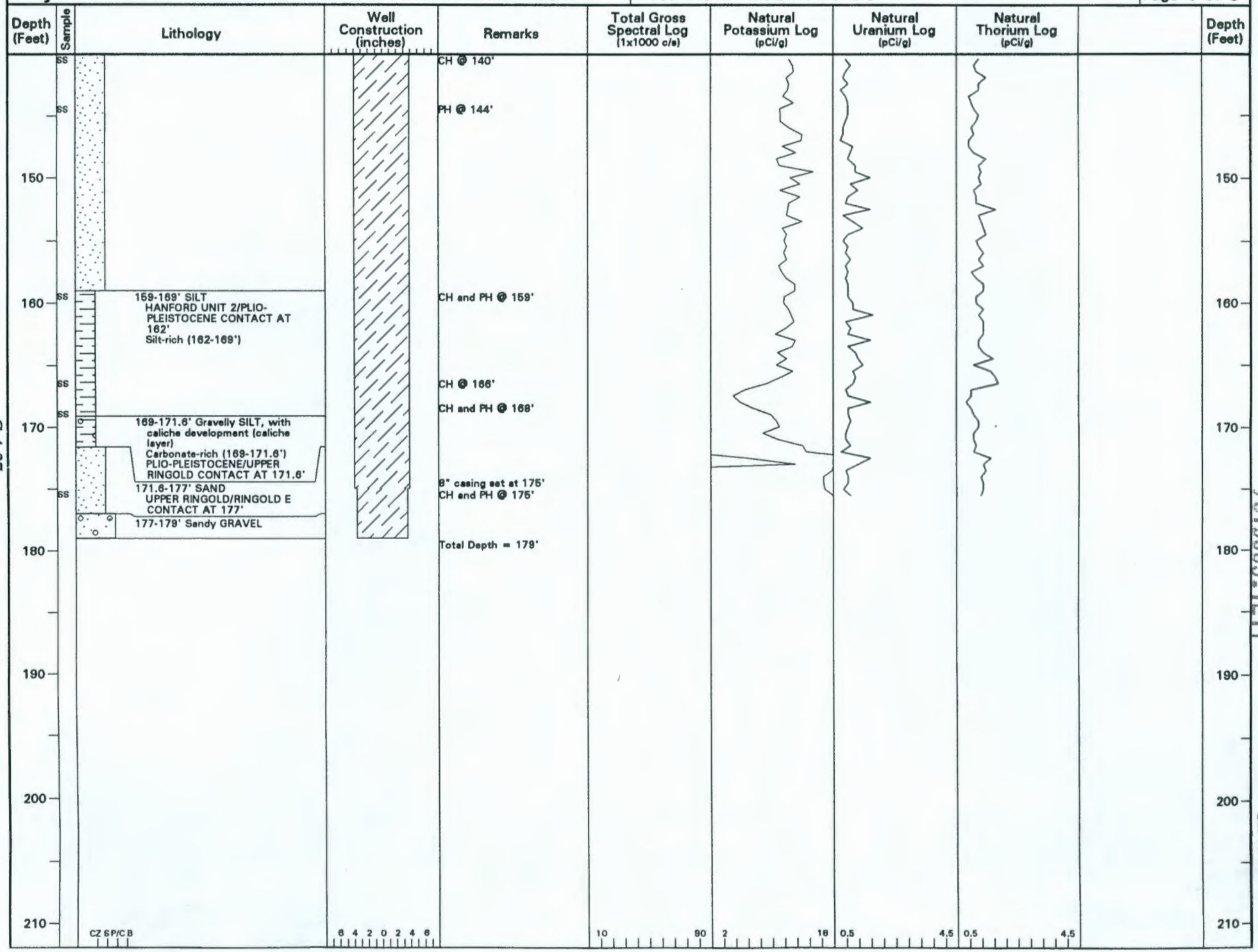
Rev. 01

Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-96** |



Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-96** |



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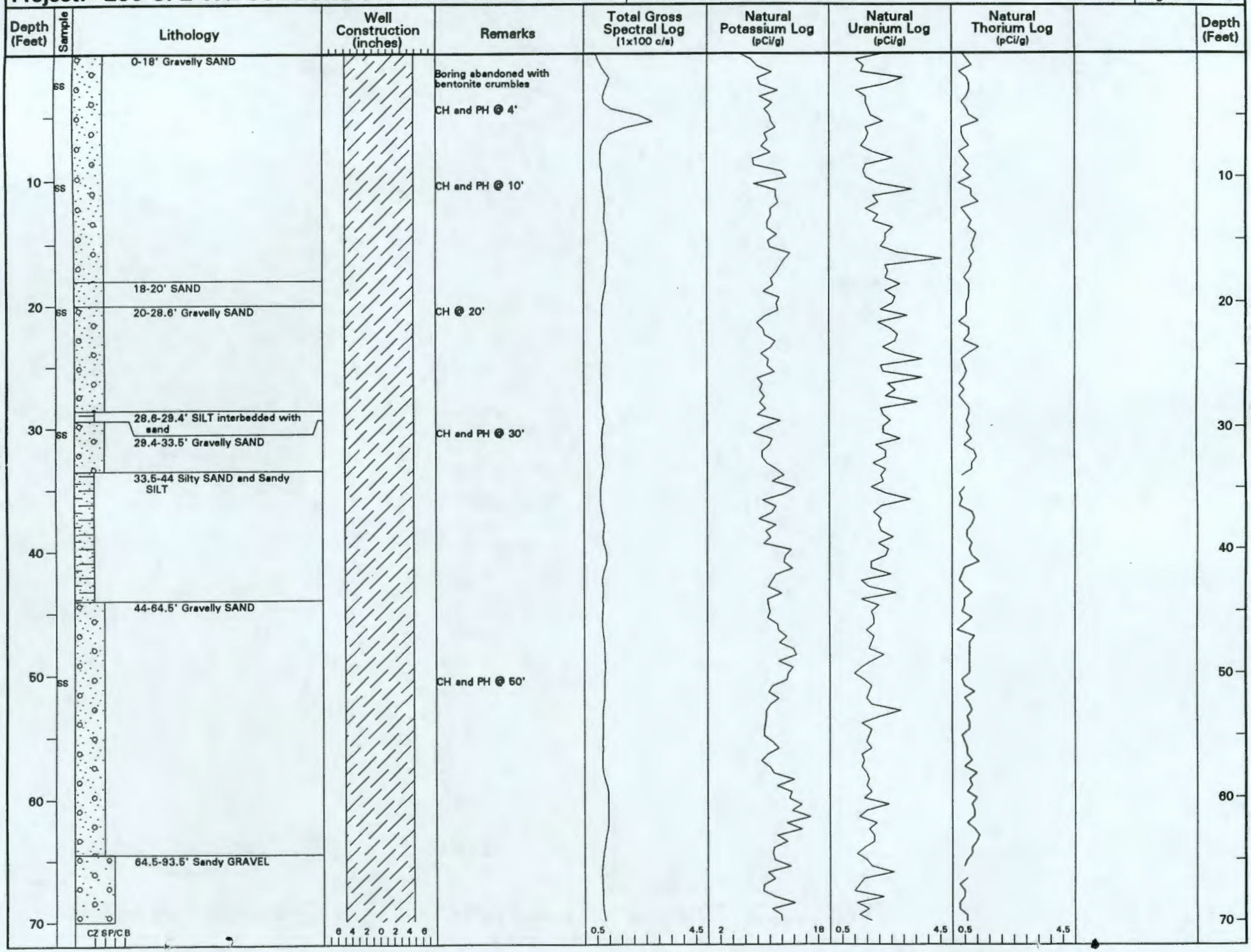
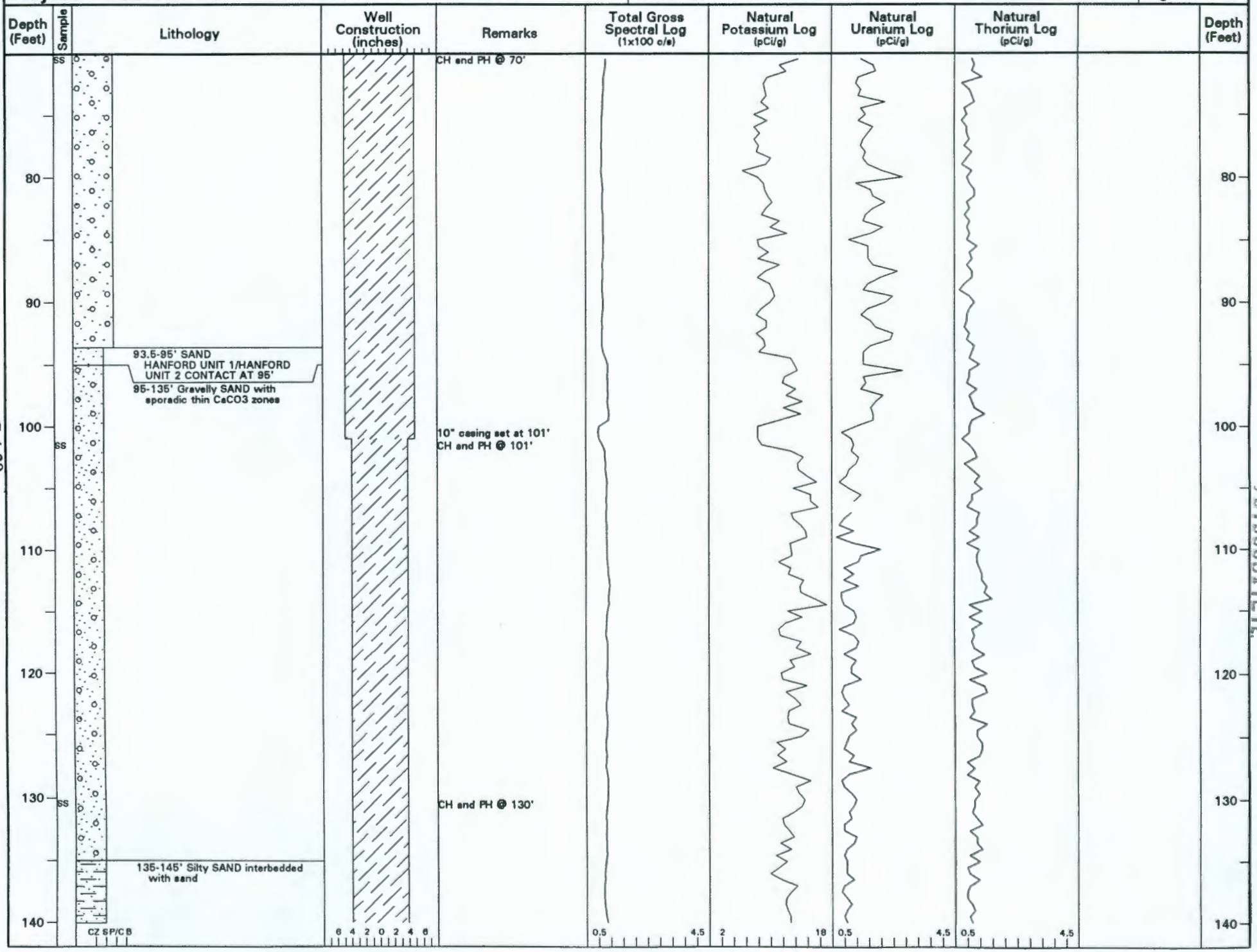
Rev. 01

Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-97** |



Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-97** |



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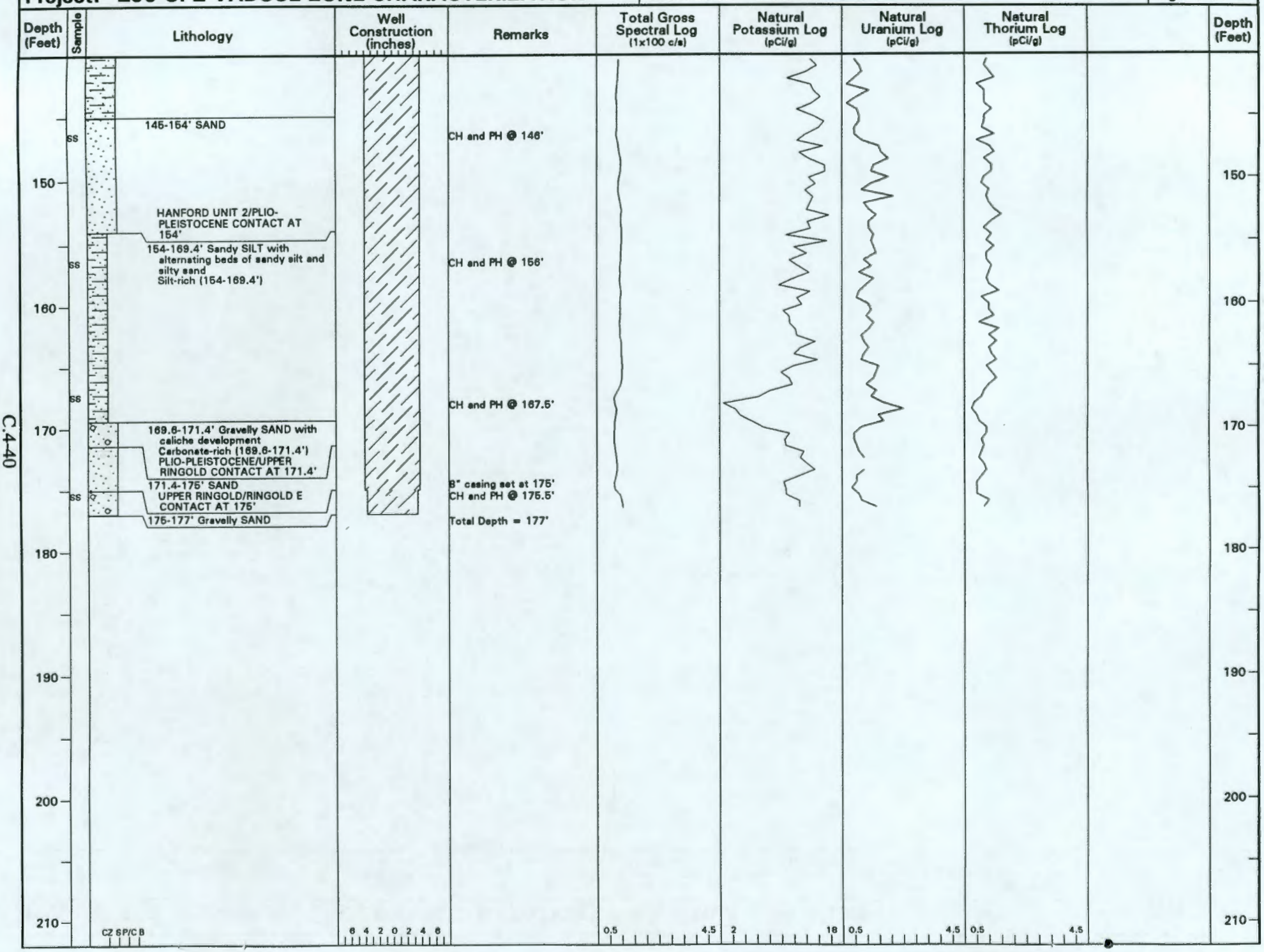
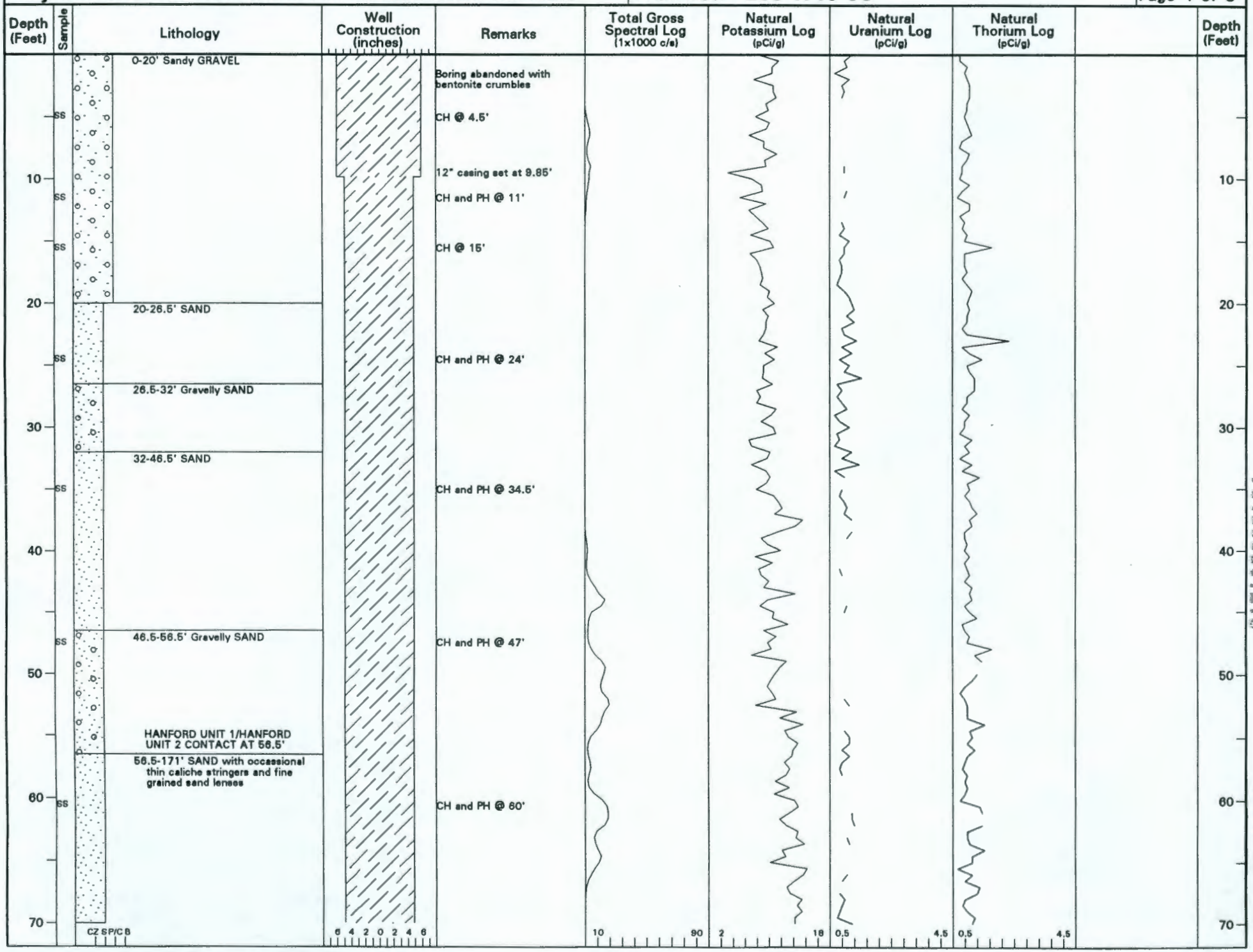
Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-97** |



Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-98** |



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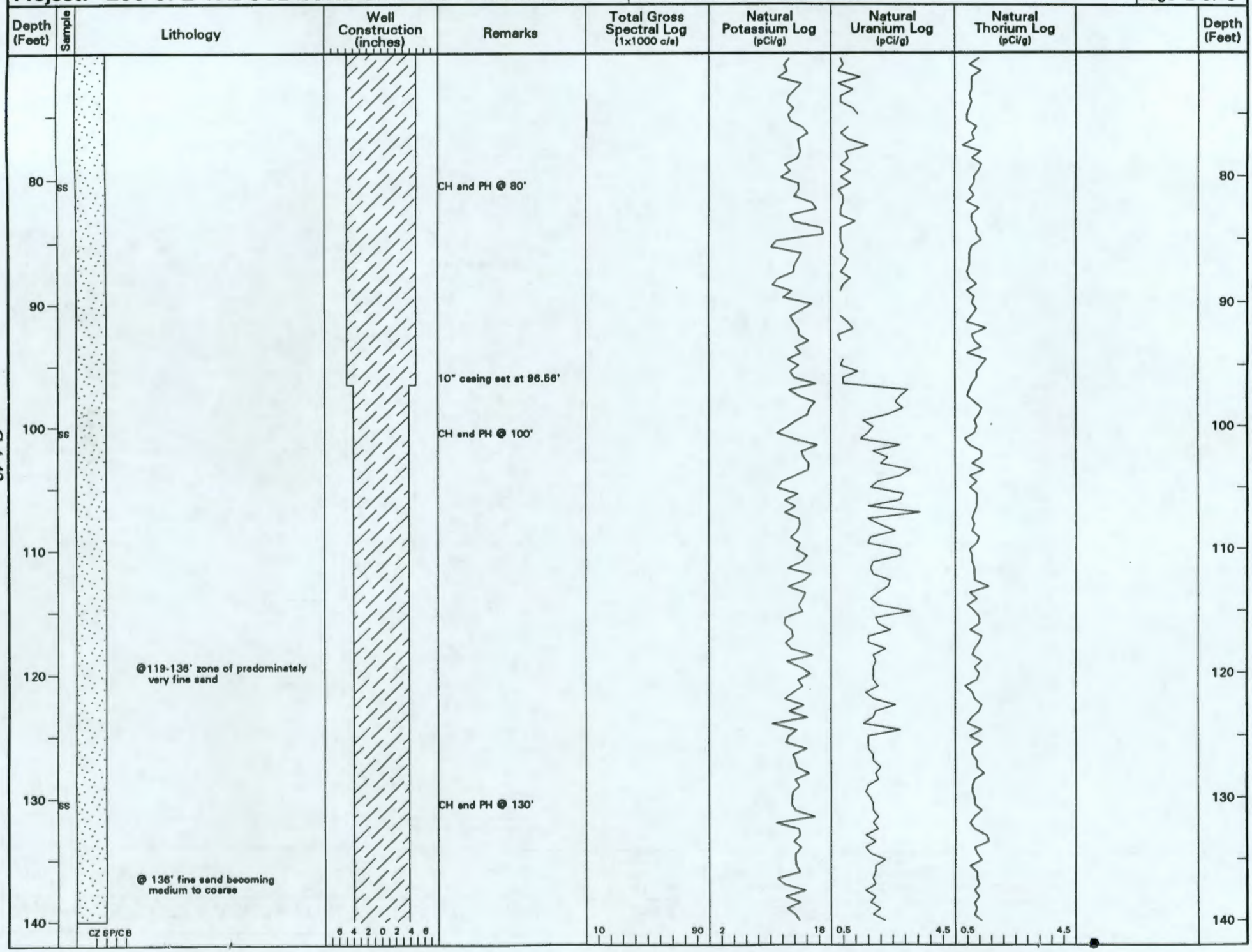
Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-98** |



Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W19-98** |

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks	Total Gross Spectral Log (1x1000 c/s)	Natural Potassium Log (pCi/g)	Natural Uranium Log (pCi/g)	Natural Thorium Log (pCi/g)		Depth (Feet)
		143-158' zone of fine grained sand lens								
150										150
		158-171' medium to coarse sand with stringers of carbonate								
160										160
170		171-184' increasing fine sand								170
	SS	HANFORD UNIT 2/PLIO-PLEISTOCENE CONTACT AT 176'		CH and PH @ 173'						
		176-184' Sandy SILT Silt-rich 176-184')								
180										180
	SS	184-189' SAND Carbonate-rich (184-191')		CH and PH @ 183.5'						
190		189-191' SAND (Caliche) PLIO-PLEISTOCENE/UPPER RINGOLD CONTACT AT 191'		8" casing set at 191.89' CH and PH @ 191'						190
	SS	191-194' SAND UPPER RINGOLD/RINGOLD E CONTACT AT 194'								
		194-195' Sandy GRAVEL		Total Depth = 195'						
200										200
210		CZ SP/CB	6 4 2 0 2 4 6		10 90	2 18	0.5 4.5	0.5 4.5		210

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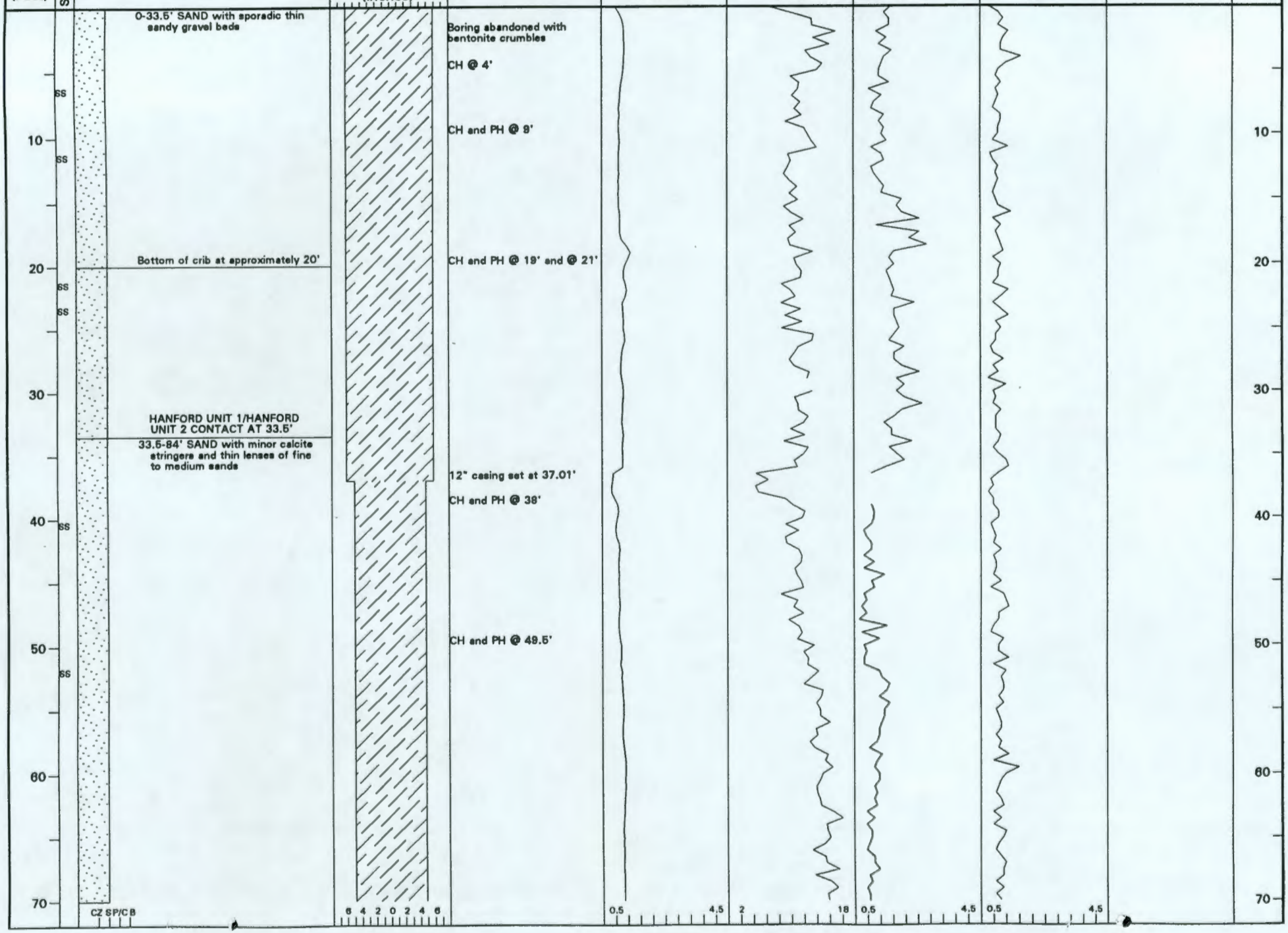
Rev. 01

Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W22-78** |

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks	Total Gross Spectral Log (1x100 c/s)	Natural Potassium Log (pCi/g)	Natural Uranium Log (pCi/g)	Natural Thorium Log (pCi/g)	Depth (Feet)



Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W22-78** |

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks	Total Gross Spectral Log (1x100 c/s)	Natural Potassium Log (pCi/g)	Natural Uranium Log (pCi/g)	Natural Thorium Log (pCi/g)		Depth (Feet)
	SS			CH and PH @ 70'						
80										80
		84-97.5' SAND								
90	SS			CH and PH @ 90' 10" casing set at 91.24'						90
		97.5-107' SAND with thin laminations?								
100										100
		107-124' SAND, thinly laminated with lenses of silty sand; strong reaction to HCL								
110	SS			CH and PH @ 109.5'						110
120										120
		124-132' SAND, weak reaction with HCL								
130				CH and PH @ 129.75'						130
	SS	132-140' SAND, interbedded with thin fine grain sand								
140		CZ SP/CB	6 4 2 0 2 4 6		0.5 4.5	2 18	0.5 4.5	0.5 4.5		140

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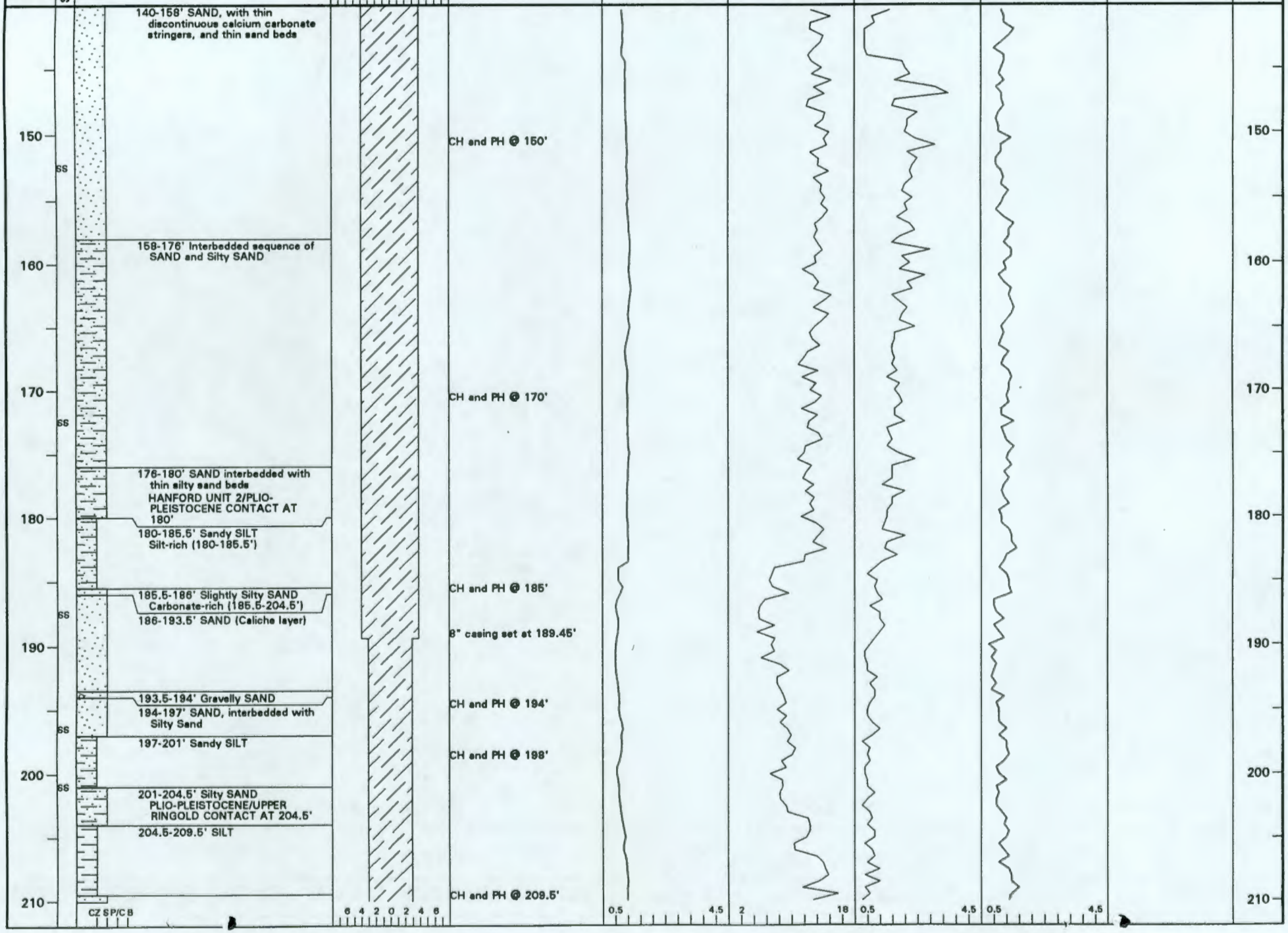
Depth (Feet)
Sample
Lithology
Well Construction (inches)
Remarks
Total Gross Spectral Log (1x100 c/s)
Natural Potassium Log (pCi/g)
Natural Uranium Log (pCi/g)
Natural Thorium Log (pCi/g)
Depth (Feet)
140-158' SAND, with thin discontinuous calcium carbonate stringers, and thin sand beds
158-176' Interbedded sequence of SAND and Silty SAND
176-180' SAND interbedded with thin silty sand beds
HANFORD UNIT 2/PLIO-PLEISTOCENE CONTACT AT 180'
180-185.5' Sandy SILT
Silt-rich (180-185.5')
185.5-186' Slightly Silty SAND
Carbonate-rich (185.5-204.5')
186-193.5' SAND (Caliche layer)
193.5-194' Gravelly SAND
194-197' SAND, interbedded with Silty Sand
197-201' Sandy SILT
201-204.5' Silty SAND
PLIO-PLEISTOCENE/UPPER RINGOLD CONTACT AT 204.5'
204.5-209.5' SILT
SS
CZ SP/CB
6 4 2 0 2 4 6
CH and PH @ 150'
CH and PH @ 170'
CH and PH @ 185'
8" casing set at 189.45'
CH and PH @ 194'
CH and PH @ 198'
CH and PH @ 209.5'
0.5 4.5
2 18
0.5 4.5
0.5 4.5
150
160
170
180
190
200
210

Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W22-78** |

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks	Total Gross Spectral Log (1x100 c/s)	Natural Potassium Log (pCi/g)	Natural Uranium Log (pCi/g)	Natural Thorium Log (pCi/g)		Depth (Feet)
	SS	209.5-216' SAND, interbedded with thin Sandy SILT								
		216-224' SAND, interbedded with thin Silty SAND								
220				CH and PH @ 222'						220
	SS	224-234' SAND								
230				CH and PH @ 230' Static Water Level at 230.6' 6" casing set at 233.36'						230
	SS			Total Depth = 234'						
240										240
250										250
260										260
270										270
280		CZ SP/C B	6 4 2 0 2 4 6		0.5 4.5	2 18	0.5 4.5	0.5 4.5		280

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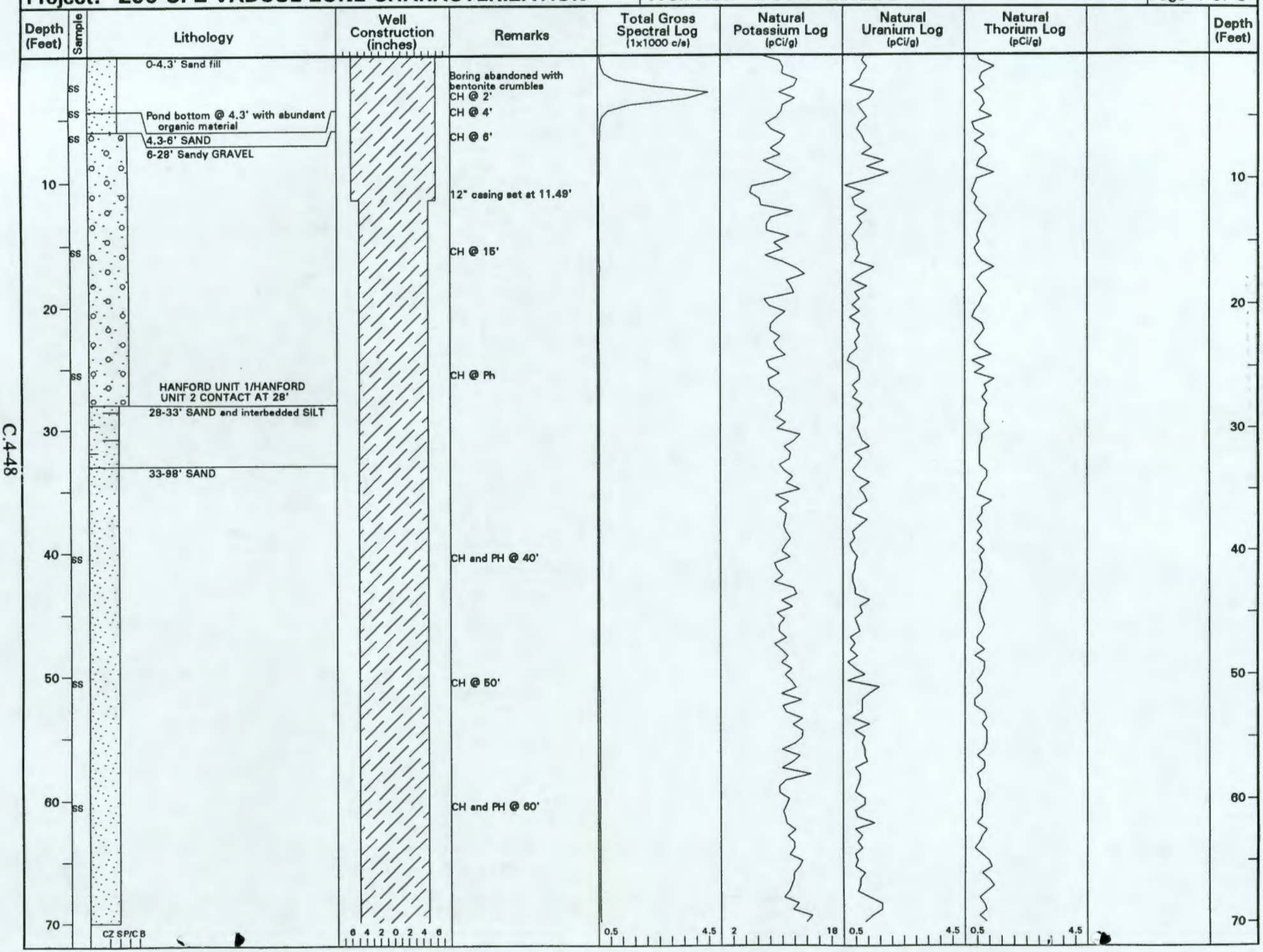
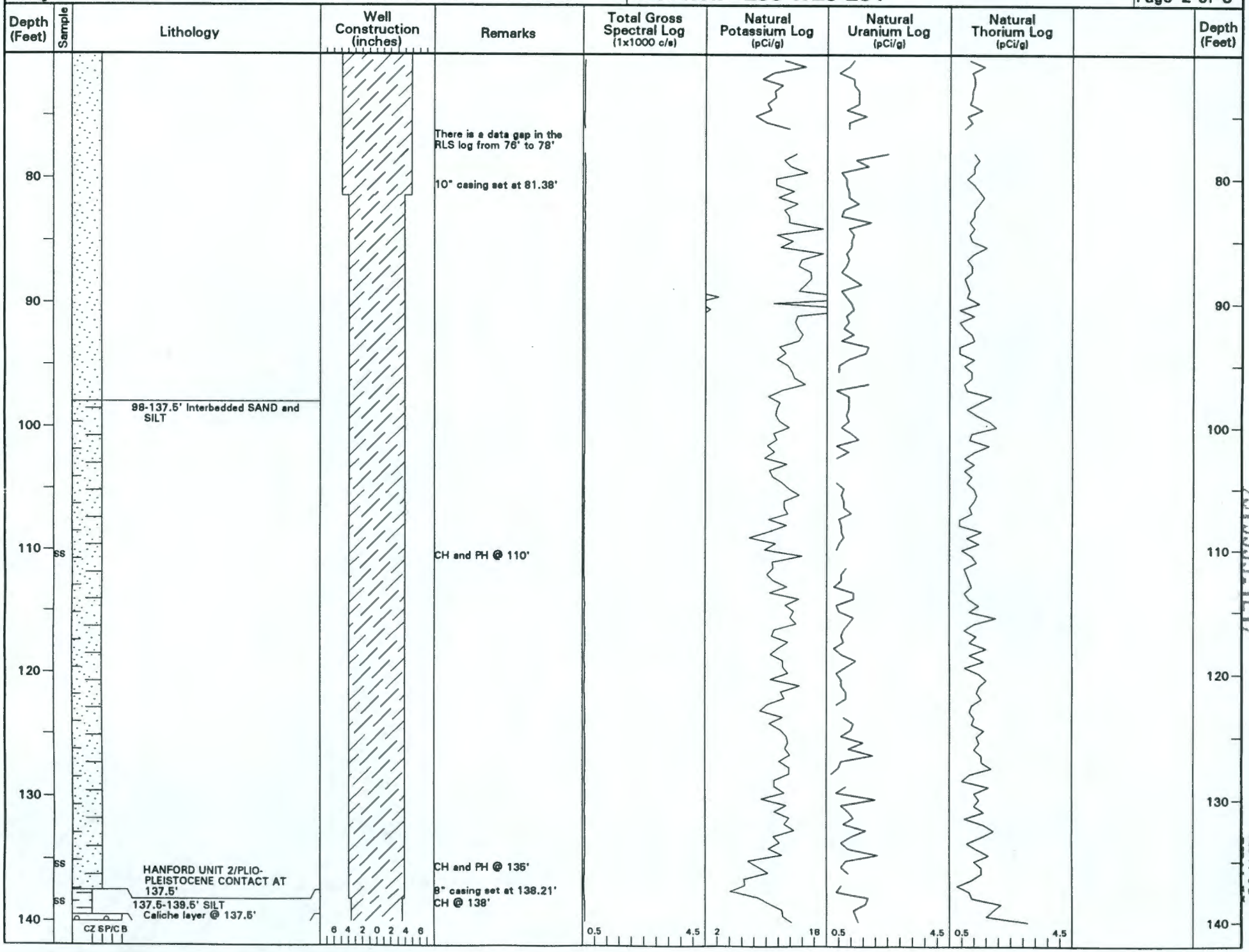
Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W23-231** |



Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W23-231** |



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Project: 200 UP2 VADOSE ZONE CHARACTERIZATION | **Well No.: 299-W23-231** |

Depth (Feet)	Sample	Lithology	Well Construction (inches)	Remarks	Total Gross Spectral Log (1x1000 c/s)	Natural Potassium Log (pCi/g)	Natural Uranium Log (pCi/g)	Natural Thorium Log (pCi/g)		Depth (Feet)
		Carbonate-rich (137.5-139.5') PLIO-PLEISTOCENE/RINGOLD E CONTACT AT 139.5' 139.5-141.4' GRAVEL		Total Depth = 141.4'						
150										150
160										160
170										170
180										180
190										190
200										200
210		CZ SP/CB	6 4 2 0 2 4 6		0.5 4.5	2 18	0.5 4.5	0.5 4.5		210

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