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EARTH SCIENCE INVESTIGATIONS OF THE 216-Z-20 CRIB, THE UN-216-W-20 SPOIL TRENCH, AND THE STORM SEWER POND

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July 1982

Prepared for the United States
Department of Energy under
Contract DE-AC06-77RL01030

Rockwell International
Rockwell Hanford Operations
Energy Systems Group
Richland, Washington 99352

200-UP-1
200-ZP-1

Document Number RHO-HS-VS-4

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Issue Approval:

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Rockwell International

Rockwell Hanford Operations
Energy Systems Group

A-6000-054 (R-12-80)

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CHAPTER 1
INTRODUCTION
By K. R. Fecht

This document summarizes the earth science investigations to evaluate and assess the hydrology, geology and radioactive contaminants of the near-surface environment at three waste disposal facilities southeast of Z-Plant (Figures 1-1 and 1-2). The assessments were conducted to support the design, construction and operation of the 216-Z-20 crib and storm sewer pond, and the stabilization of the UN-216-W-20 spoil trench. The earth science investigations were conducted by the Environmental Technologies Group of Health, Safety and Environment Function for the Z-Plant and Radiation Area Reduction programs.

The objectives of the earth science investigations were to:

- Assess the radiological conditions at the 216-Z-20 crib site from waste discharges to the 216-Z-1, -11, and -19 ditches
- Assess the radiological conditions at the storm sewer pond
- Define the location and extent of radiological contamination at the UN-216-W-20 spoil trench
- Determine percolation rates to be used in the design of the 216-Z-20 crib and storm sewer pond
- Assess the impact of the storm sewer pond on adjacent facilities
- Construct ground-water monitoring boreholes for the 216-Z-20 crib
- Prepare a permanent record (document) of the field studies and site assessments.

The field investigations conducted to meet the aforementioned objectives are reported in the following chapters. Chapters 2 through 5 contain the basic field data and interpretations of the tasks performed during the investigations. Chapter 6, the final chapter, is a summary of the field investigations and an integration of the field studies in an assessment of site conditions at the 216-Z-20 crib, the storm sewer pond and the UN-216-W-20 spoil trench.

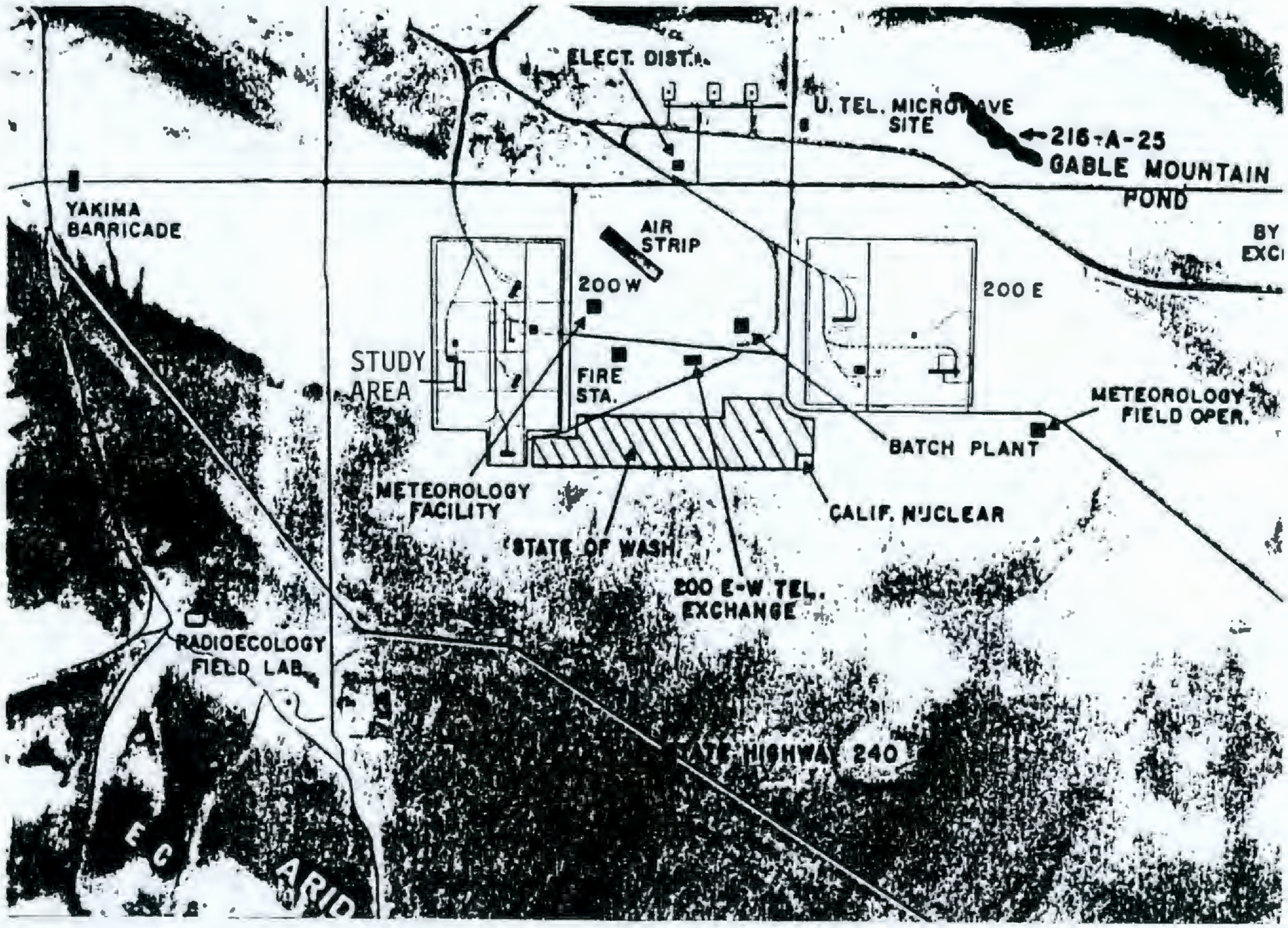


FIGURE 1-1. Study Area Location Map.

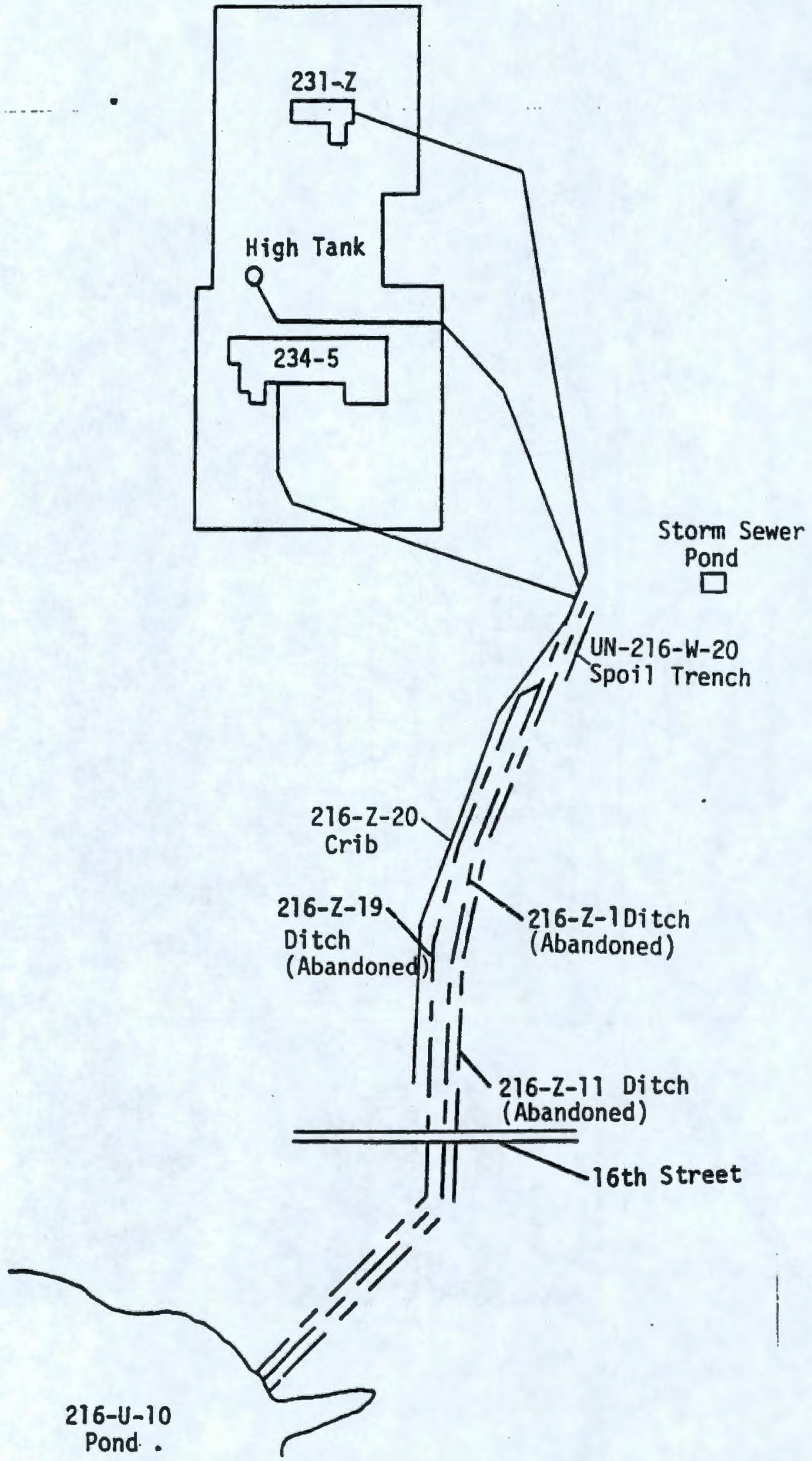


FIGURE 1-2. 216-Z-20, UN-216-W-20 and Storm Sewer Pond Site Area.

CHAPTER 2

DRILLING AND SAMPLING ACTIVITIES

By G. L. Wagenaar and T. J. Wood

Boreholes were drilled by the Hatch Drilling Company* and Environmental Technologies Group's drilling engineers to conduct radiological, geological, and hydrological investigations in support of the design, construction and operation of the 216-Z-20 crib and storm sewer pond and the stabilization of the UN-216-W-20 spoil trench.

A total of 44 boreholes were drilled to support various tasks (Figures 2-1 and 2-2). Four shallow boreholes were drilled at 400-foot intervals along the center line of the 216-Z-20 crib site and one shallow borehole at the storm sewer pond to support percolation tests. Sixteen shallow boreholes were drilled at 100-foot intervals along the west side of the 216-Z-19 ditch to determine the extent of lateral migration of radiocontaminants and the existance of perched water in the 216-Z-20 crib area from waste discharges to the 216-Z-19 ditch. Ten shallow, closely spaced boreholes were drilled across the buried 216-Z-1 ditch at the location where the storm sewer line was projected across to determine levels of radiocontaminants present. Two shallow boreholes were drilled along the center line at the south end of the 216-Z-20 crib to support additional radiocontaminant distribution studies. Nine shallow boreholes were drilled in and around the UN-216-W-20 spoil trench to determine the location of the trench and associated radiocontaminants. Finally two ground-water monitoring boreholes were drilled immediately to the east of the crib to support ground-water surveillance operations upon startup of the 216-Z-20 crib.

The boreholes were drilled using a Johnson Prospector MR-24 auger owned by Hatch Drilling Company in conjunction with Rockwell Hanford Operation's (Rockwell) drive hammer and split-tube sampler and a Bucyrus Erie 22W Cable-Tool Percussion drilling rig owned by Rockwell.

*Hatch Drilling Company of Pasco, Washington was under subcontract to J. A. Jones Construction Company.

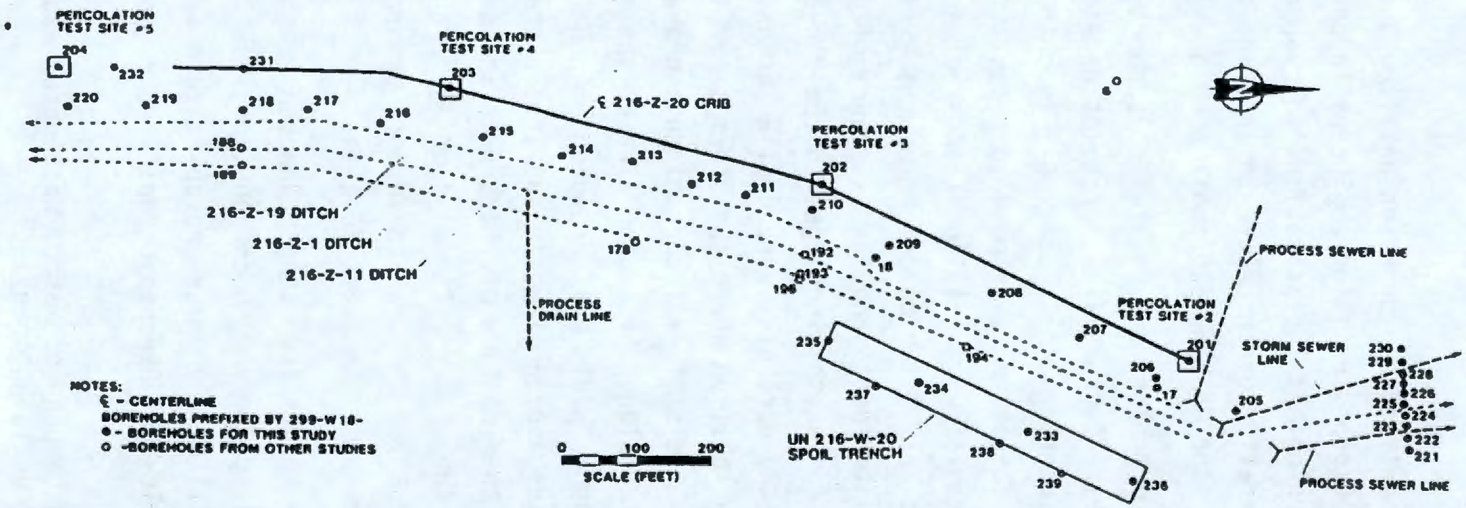


FIGURE 2-1. 216-Z-20 Crib and UN-216-W-20 Spoil Trench Borehole Location Map.

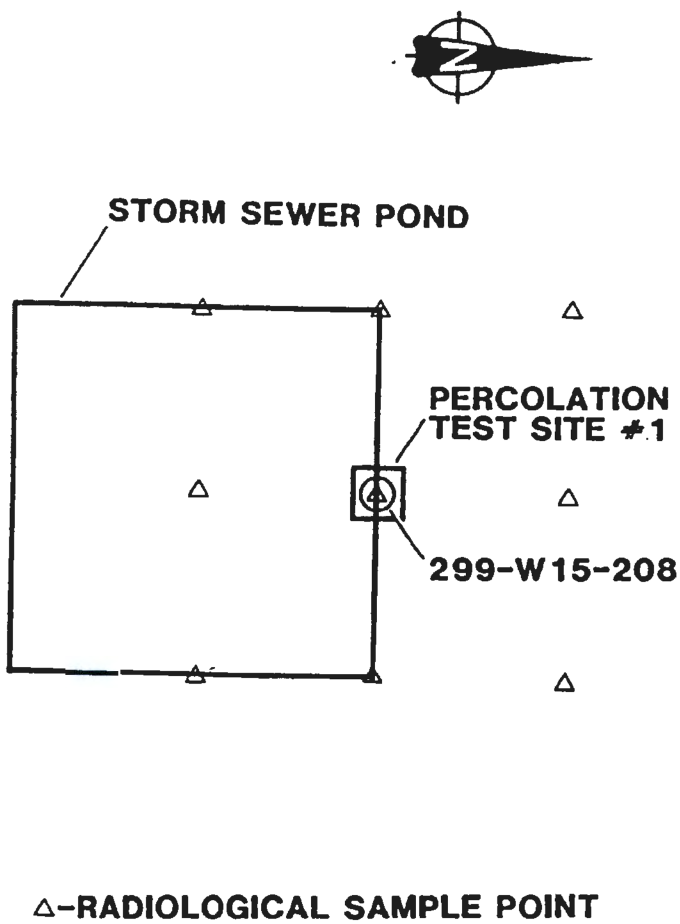


FIGURE 2-2. Storm Sewer Pond Borehole and In Situ Sample Location Map.

All boreholes were backfilled upon completion of the drilling, except boreholes 299-W18-17 and 299-W18-18 which are permanent ground-water monitoring structures.

Borehole summary textural logs and pertinent borehole data are summarized in Table 2-1 and Figures 2-3 through 2-46. The original borehole logs and borehole completion reports are on file with the Environmental Technologies Group.

Sediments recovered from the borehole during drilling were surveyed with field instruments for radioactivity and visually inspected for zones of high moisture content and areas of backfilling. The sediment samples were collected from discrete intervals by the Environmental Technologies Group during drilling. The sample intervals are designated on the textural logs in Figures 2-3 through 2-46. Approximately 200 of these sediments were selected for radiological analysis. Results of the radiological analyses of the samples are reported in Chapter 5. Clean sediment samples have been stored in the Rockwell Sediment Respository in 2101-M Building, 200 East Area to provide a permanent record of the sediments beneath the 216-Z-20 crib the UN-216-W-20 spoil trench and the storm sewer pond.

TABLE 2-1. Borehole Data Chart.

Borehole Number[a]	Coordinates[b]		Drill Depth (ft)	Drill Method	Borehole Status
	Northerly	Westerly			
W15-208	39600	75650	20	cable tool	backfilled and casing pulled
W18-17	39256	76091	265	cable tool	monitoring structure
W18-18	38903	76270	265	cable tool	monitoring structure
W18-201	39280	76130	25	cable tool	backfilled and casing pulled
W18-202	38810	76355	20	cable tool	backfilled and casing pulled
W18-203	38327	76482	20	cable tool	backfilled and casing pulled
W18-204	37830	76523	20	cable tool	backfilled and casing pulled
W18-205	39348	76051	18.5	auger	backfilled
W18-206	39256	76096	15.5	auger	backfilled
W18-207	39145	76148	17	auger	backfilled
W18-208	39032	76207	20	cable tool	backfilled and casing pulled
W18-209	38898	76270	16	auger	backfilled
W18-210	38798	76319	20	cable tool	backfilled and casing pulled
W18-211	38715	76338	17	auger	backfilled
W18-212	38645	76355	16.5	auger	backfilled
W18-213	38564	76358	20	cable tool	backfilled and casing pulled
W18-214	38473	76395	17.5	auger	backfilled
W18-215	38370	76422	17	auger	backfilled
W18-216	38235	76440	17	auger	backfilled
W18-217	38140	76459	17	auger	backfilled
W18-218	38058	76462	20	cable tool	backfilled and casing pulled
W18-219	37940	76470	16	auger	backfilled
W18-220	37840	76471	20	cable tool	backfilled and casing pulled
W18-221	39525	76006	15	auger	backfilled
W18-222	39525	76020	15	auger	backfilled
W18-223	39525	76030	15	auger	backfilled
W18-224	39525	76040	15	auger	backfilled
W18-225	39525	76050	15	auger	backfilled
W18-226	39525	76060	15	auger	backfilled
W18-227	39525	76070	15	auger	backfilled
W18-228	39525	76080	15	auger	backfilled
W18-229	39525	76086	15	auger	backfilled
W18-230	39525	76096	11.5	auger	backfilled
W18-231	37830	76522	12	auger	backfilled
W18-232	38060	76512	12	auger	backfilled
W18-233	39080	76023	12.5	auger	backfilled
W18-234	38942	76095	15	auger	backfilled
W18-235	38830	76155	12.5	auger	backfilled
W18-236	39213	75954	15	auger	backfilled
W18-237	38875	76090	12.5	auger	backfilled
W18-238	39036	76008	15	auger	backfilled
W18-239	39115	75965	15	auger	backfilled
W18-240	39282	75918	15	auger	backfilled
W18-241	38915	76116	15	auger	backfilled

[a]Boreholes prefixed by 299.

[b]Based on Hanford Coordinate System.

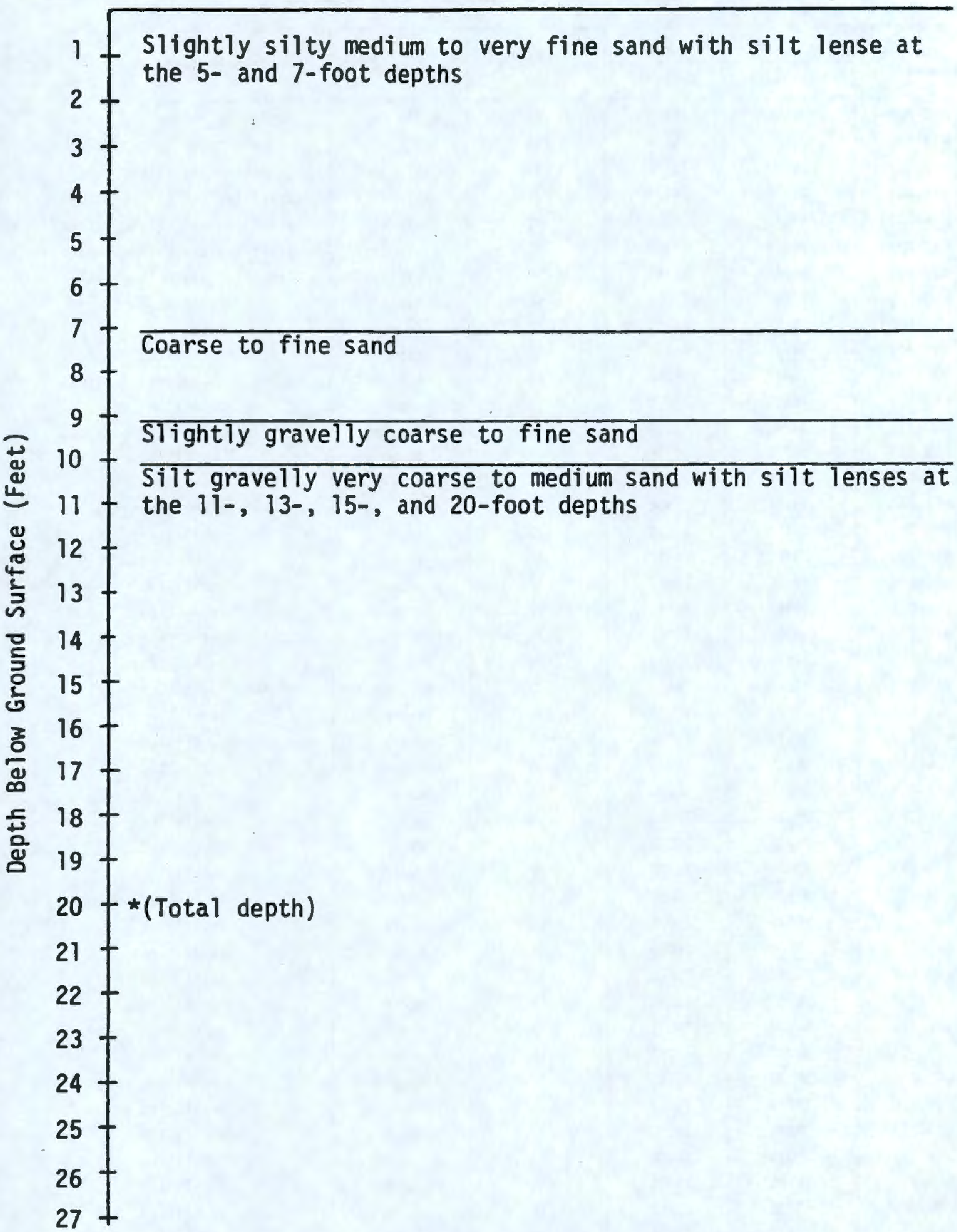


FIGURE 2-3. Borehole 299-W15-208 Summary Textural Log.

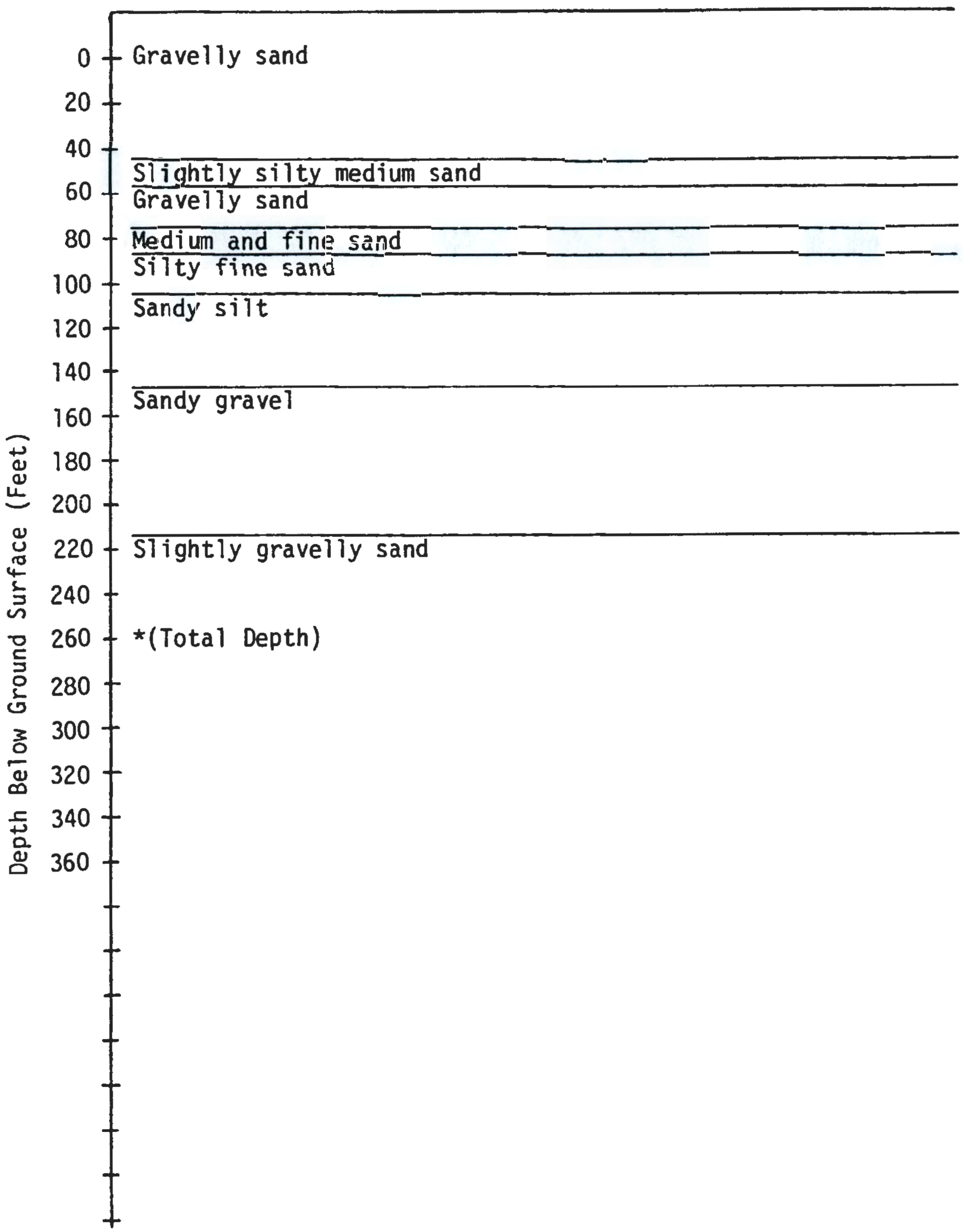


FIGURE 2-4. Borehole 299-W18-17 Summary Textural Log.

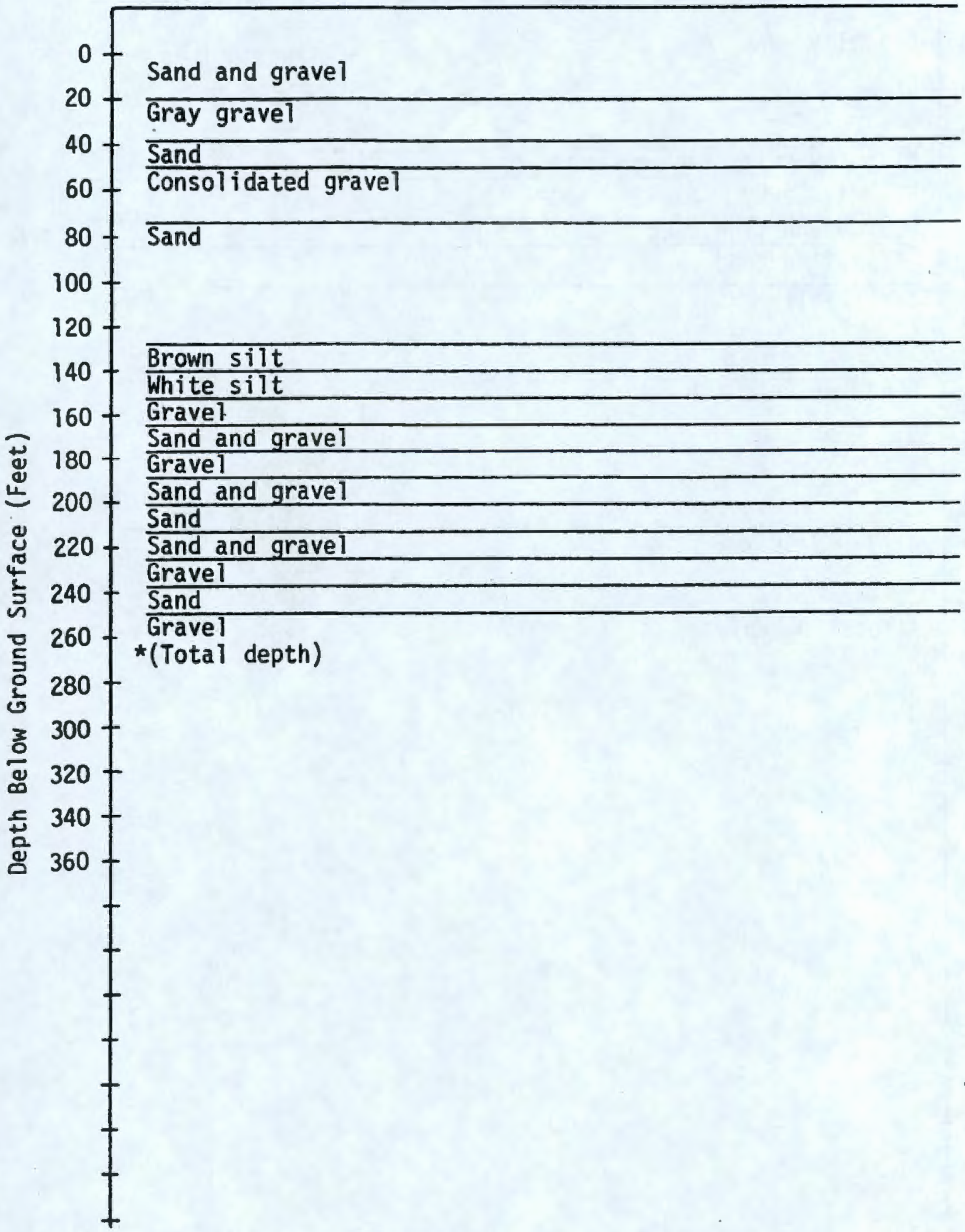


FIGURE 2-5. Borehole 299-W18-18 Summary Textural Log.

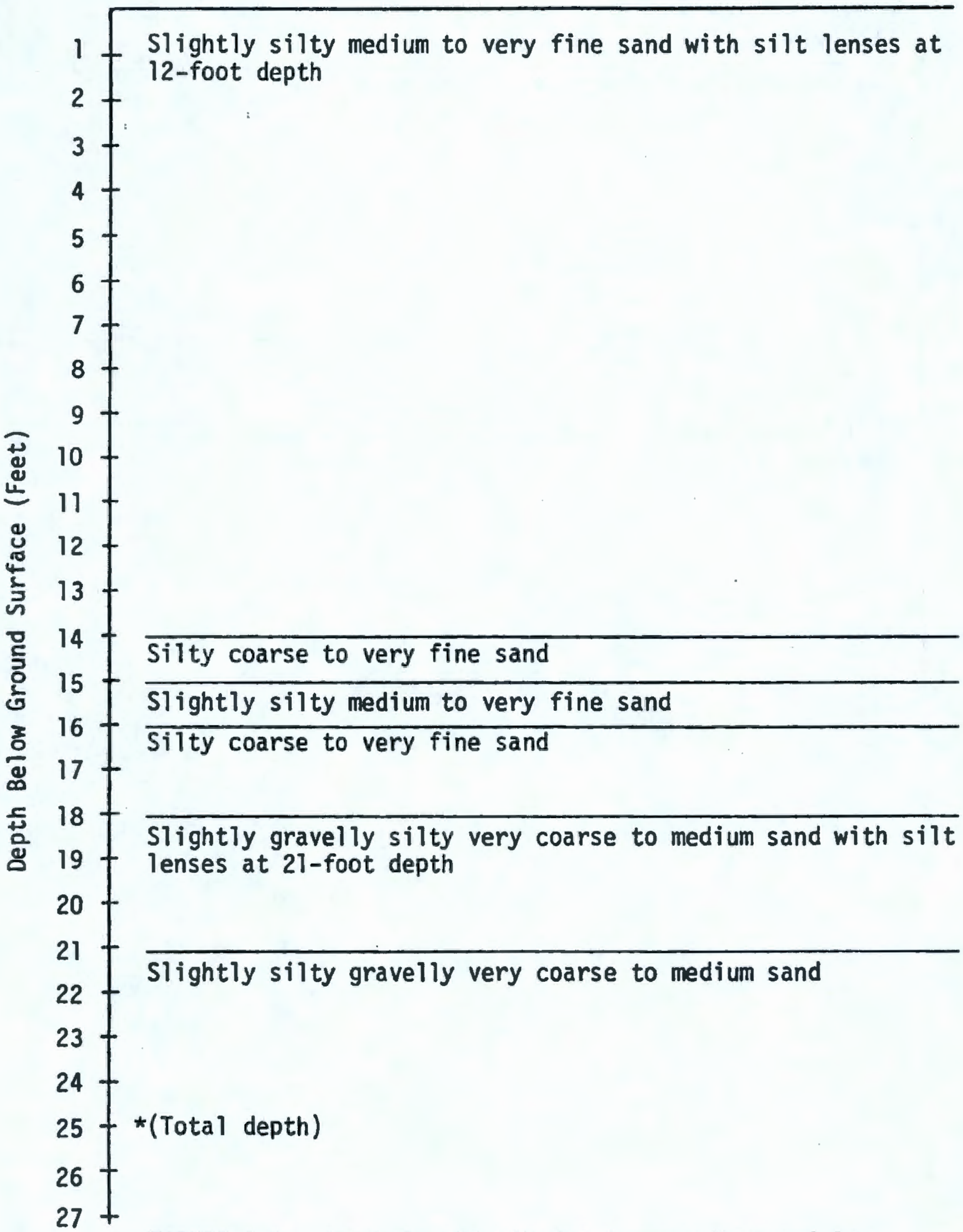


FIGURE 2-6. Borehole 299-W18-201 Summary Textural Log.

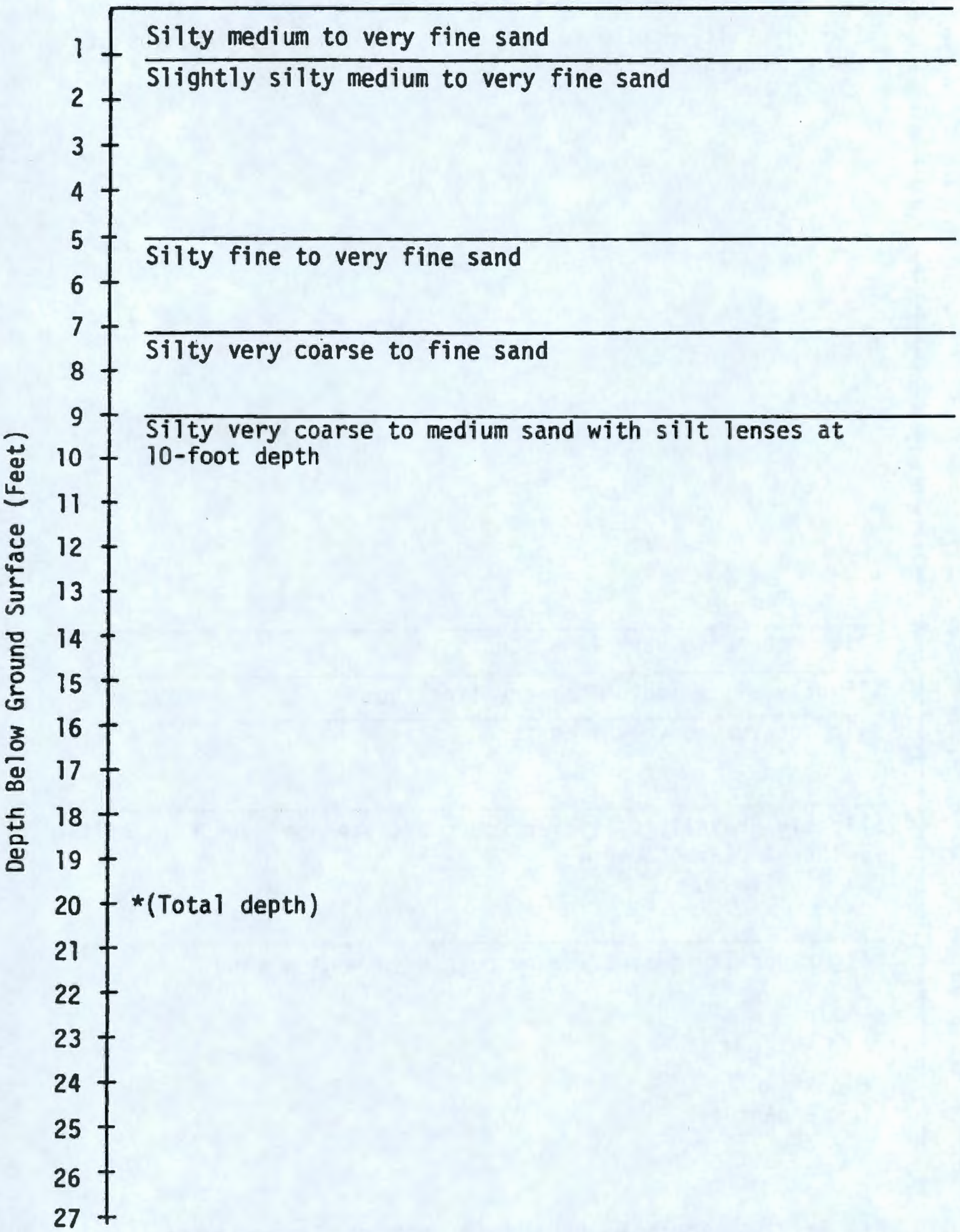


FIGURE 2-7. Borehole 299-W18-202 Summary Textural Log.

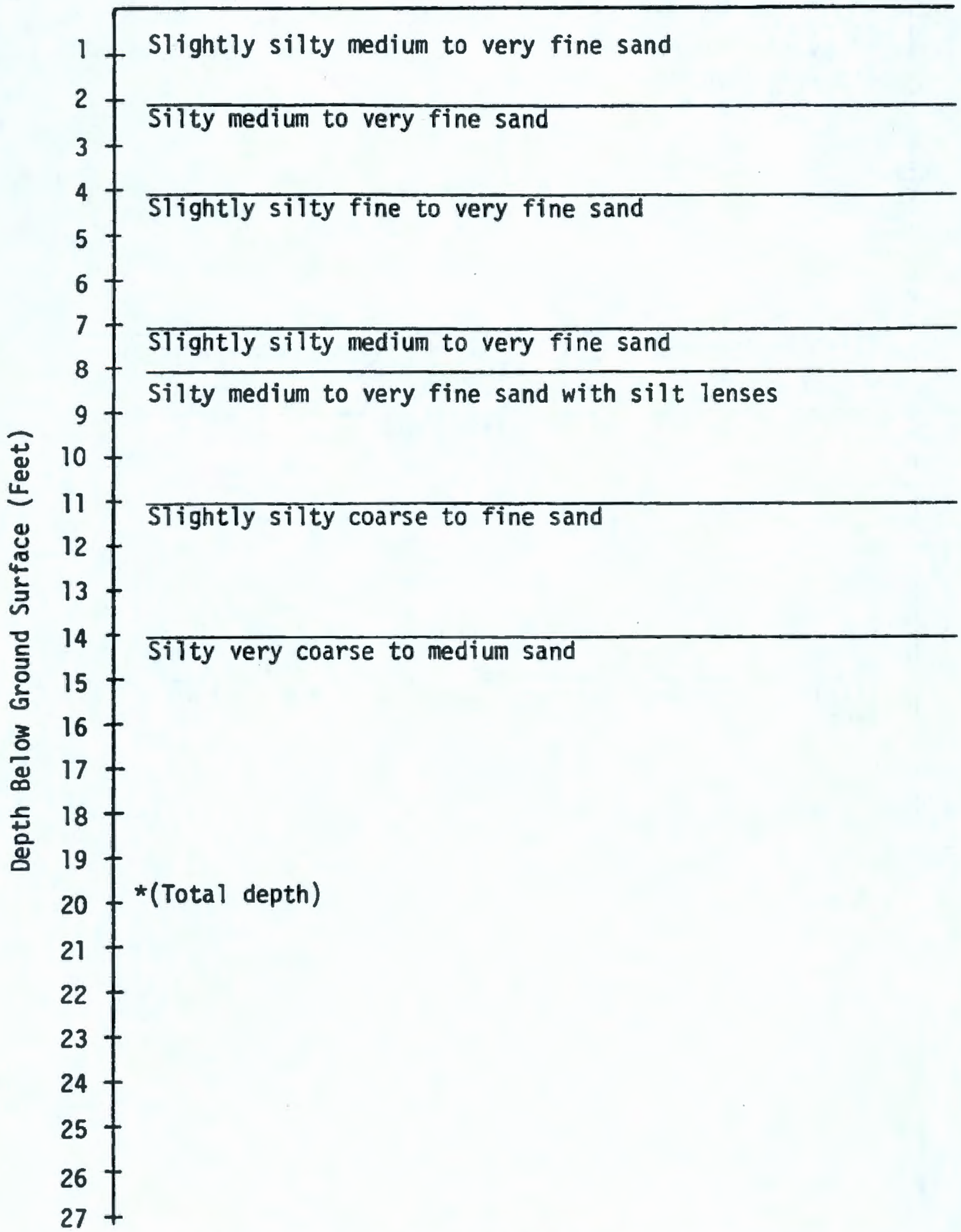


FIGURE 2-8. Borehole 299-W18-203 Summary Textural Log.

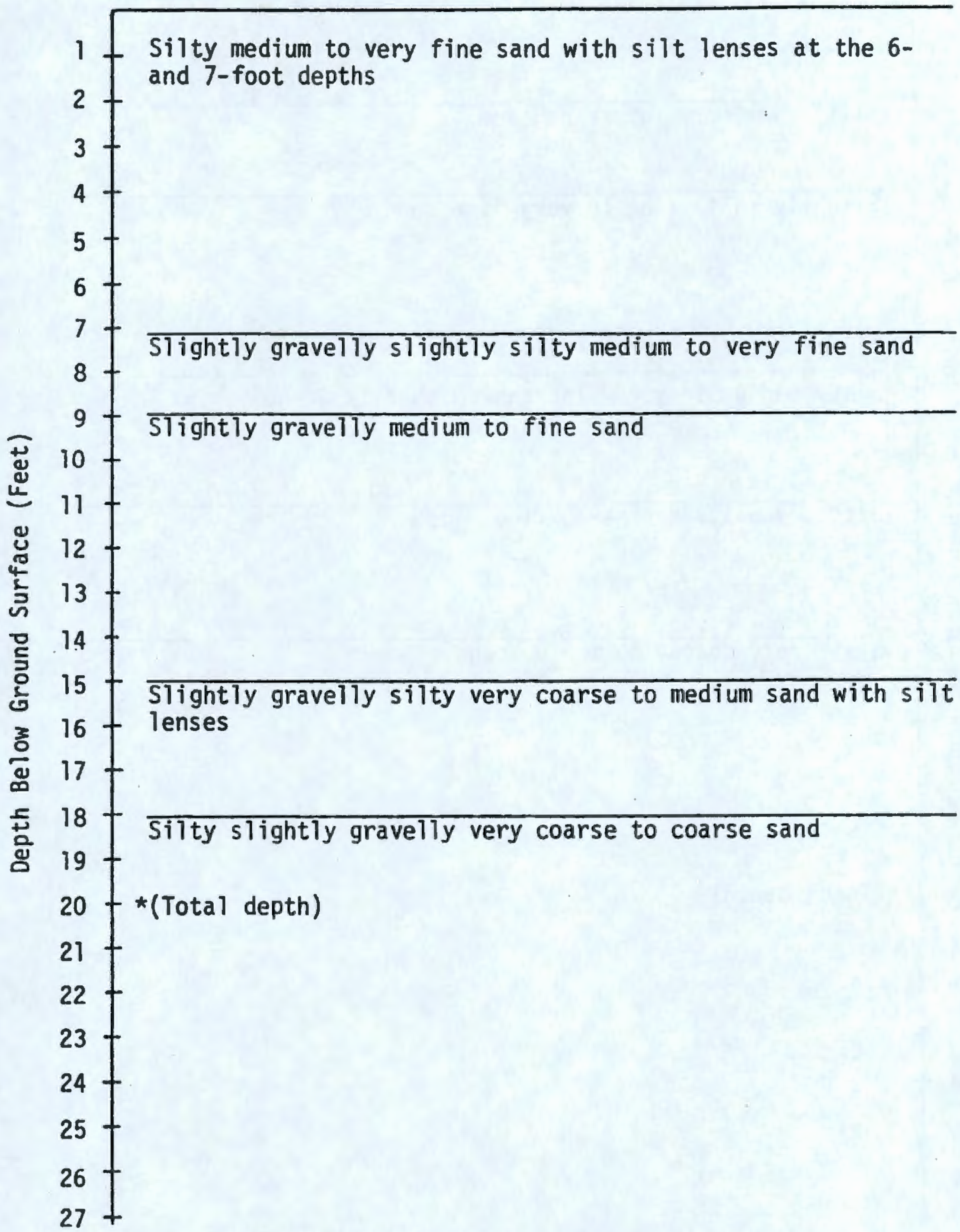


FIGURE 2-9. Borehole 299-W18-204 Summary Textural Log.

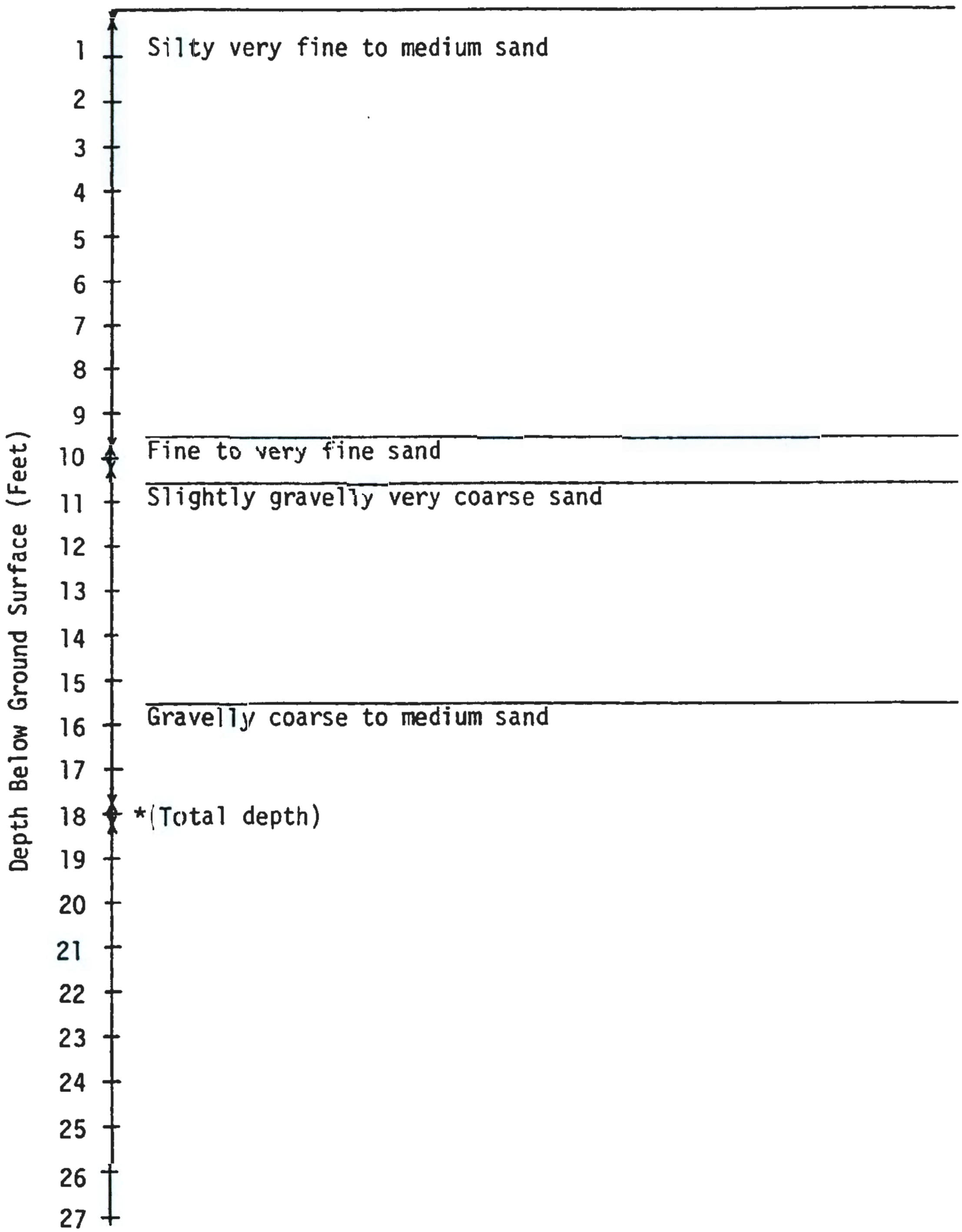


FIGURE 2-10. Borehole 299-W18-205 Summary Textural Log.

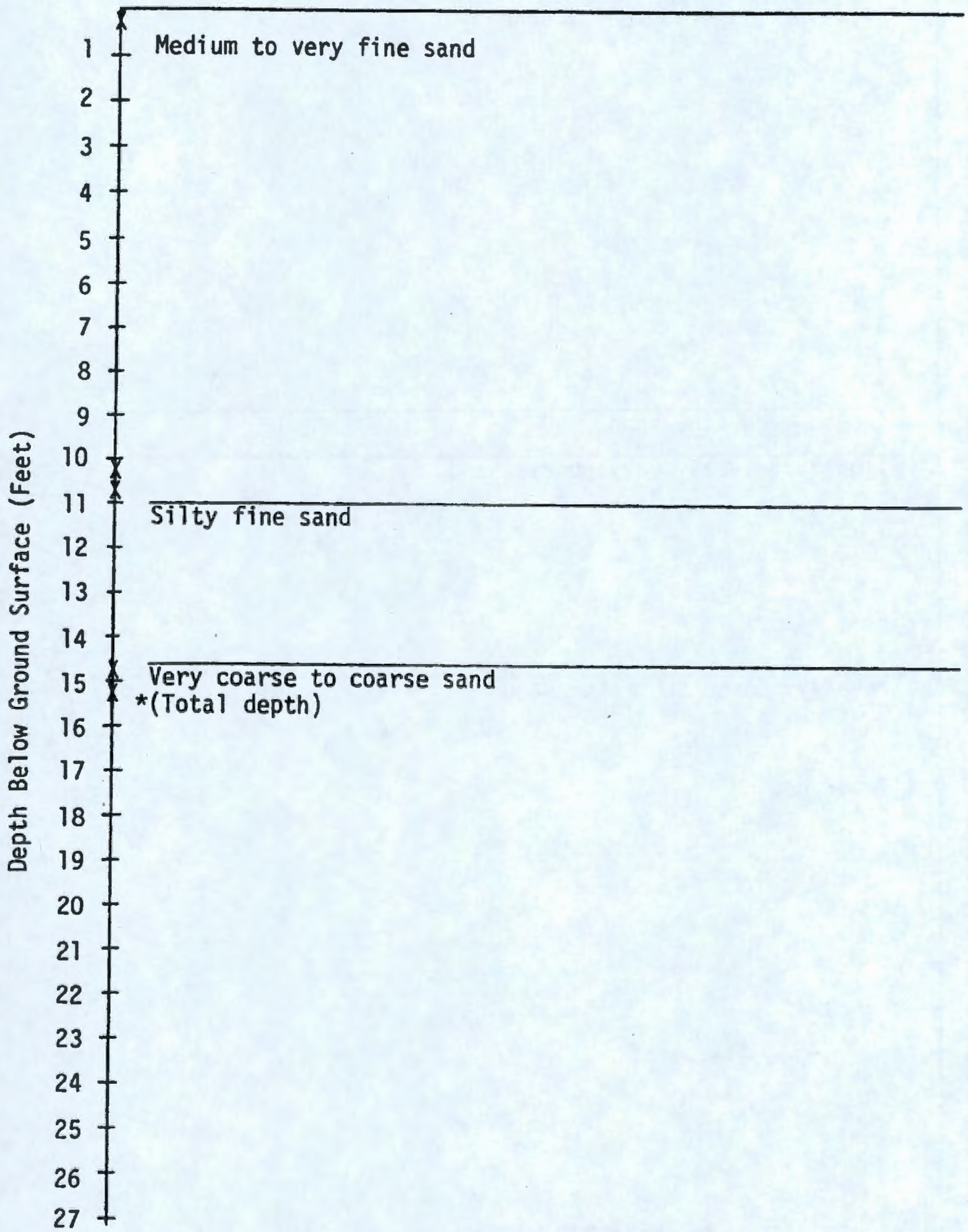


FIGURE 2-11. Borehole 299-W18-206 Summary Textural Log.

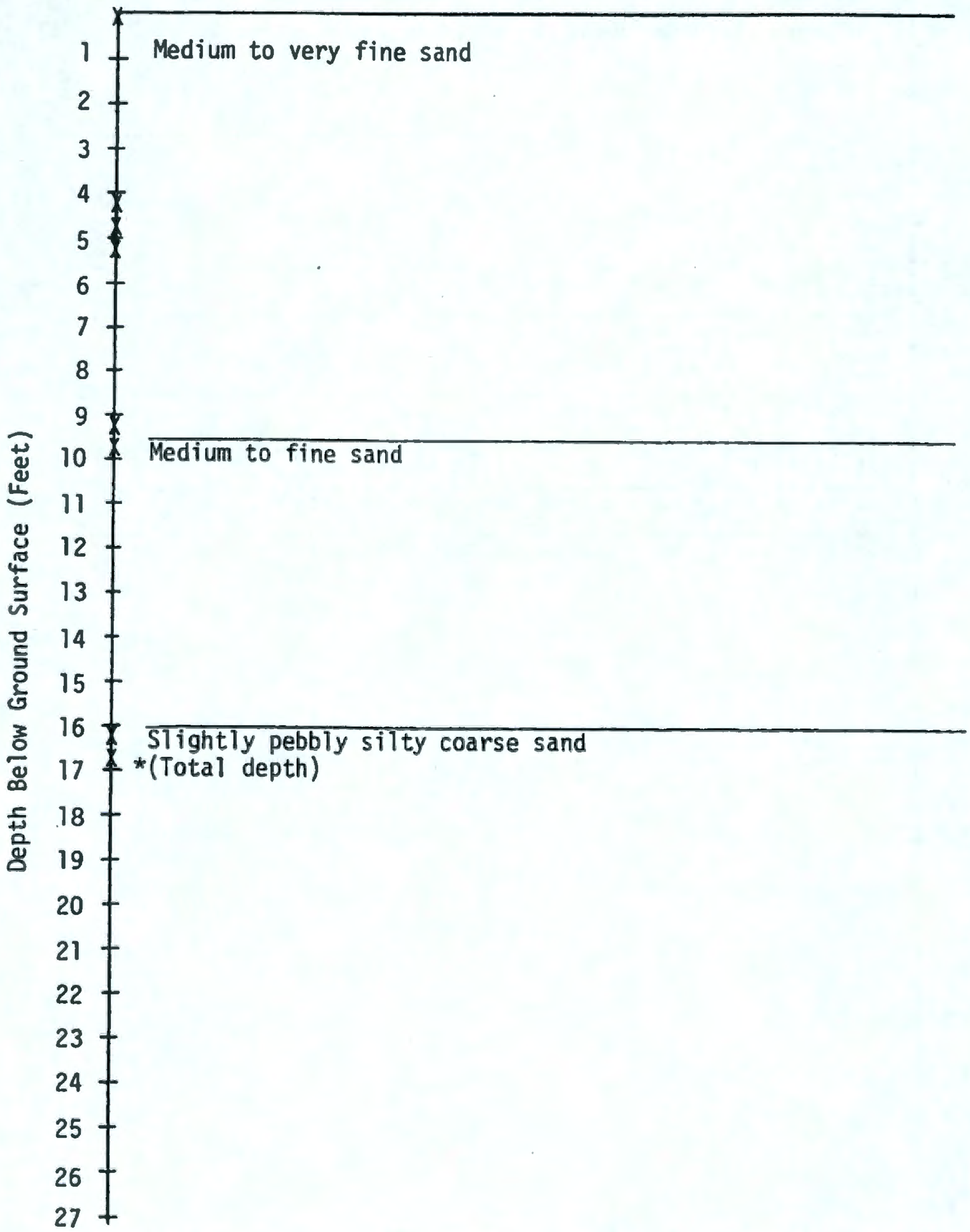


FIGURE 2-12. Borehole 299-W18-207 Summary Textural Log.

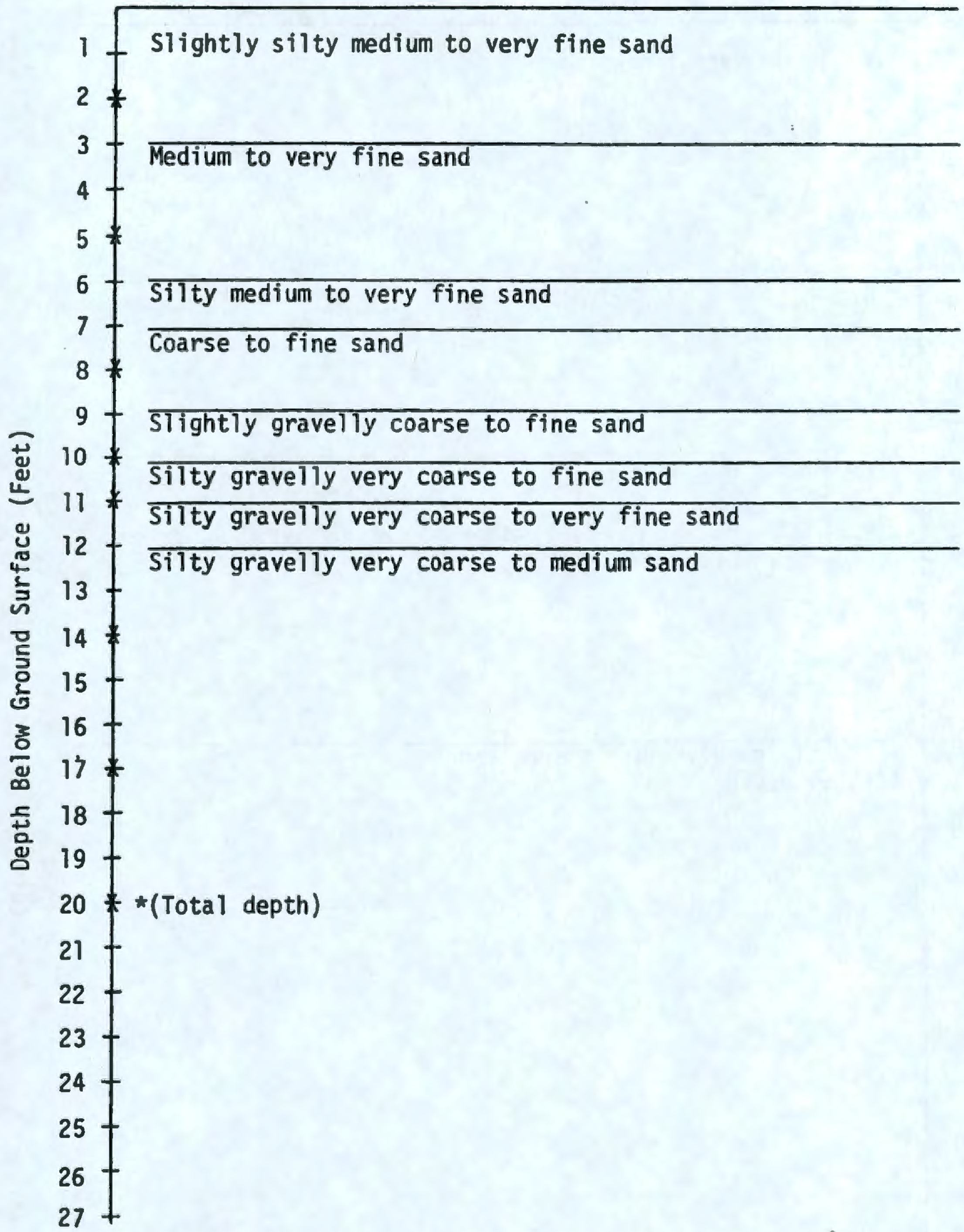


FIGURE 2-13. Borehole 299-W18-208 Summary Textural Log.

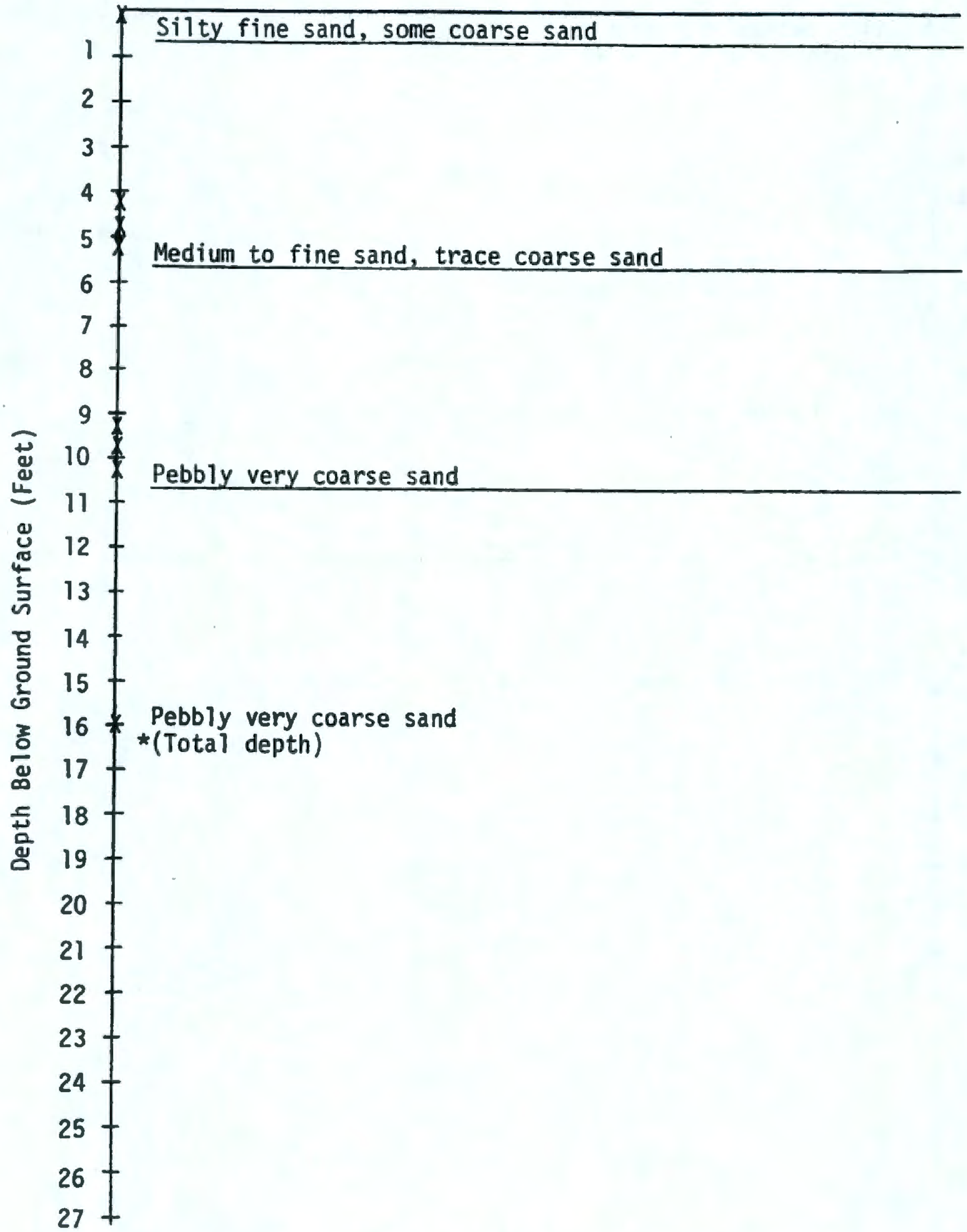


FIGURE 2-14. Borehole 299-W18-209 Summary Textural Log.

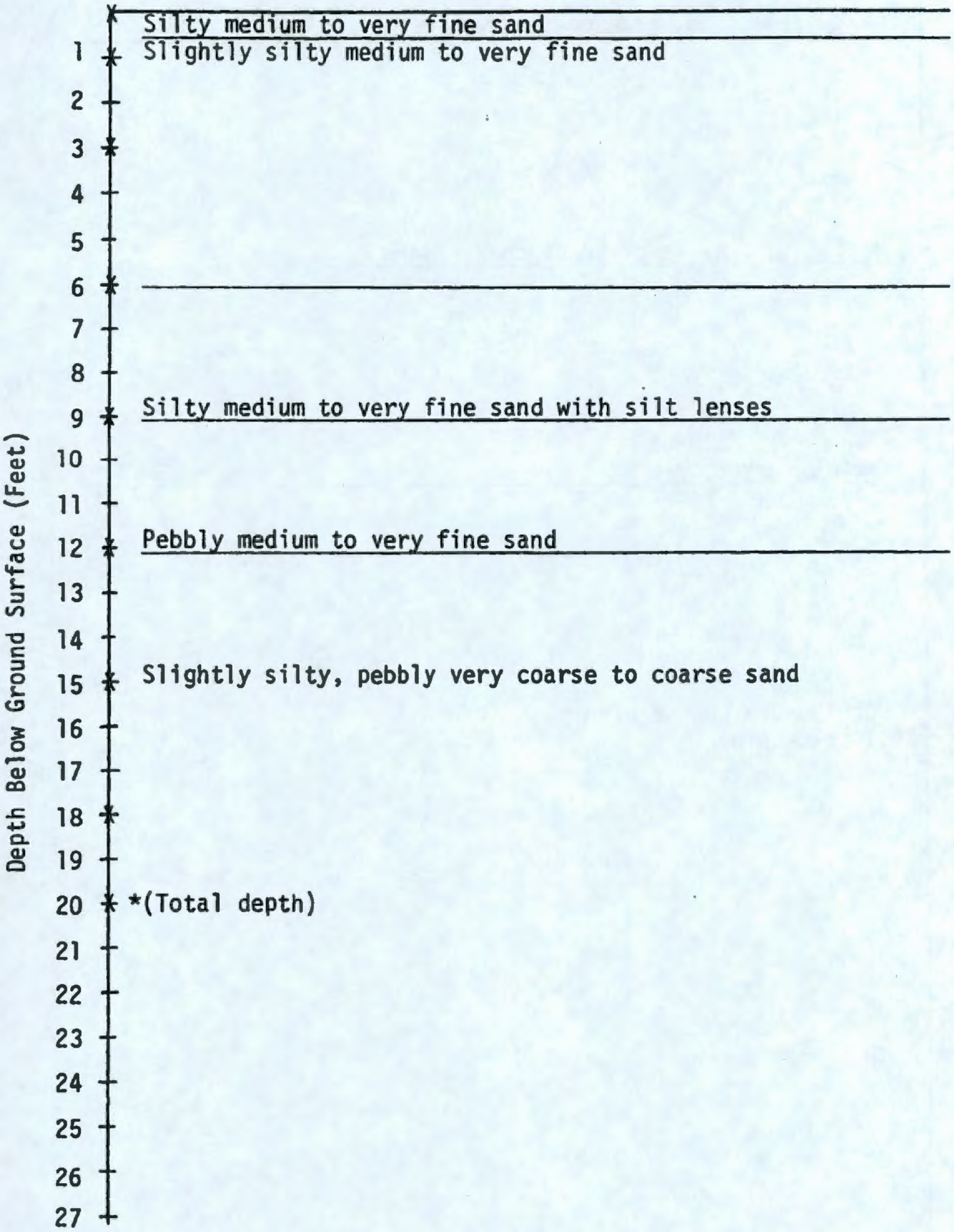


FIGURE 2-15. Borehole 299-W18-210 Summary Textural Log.

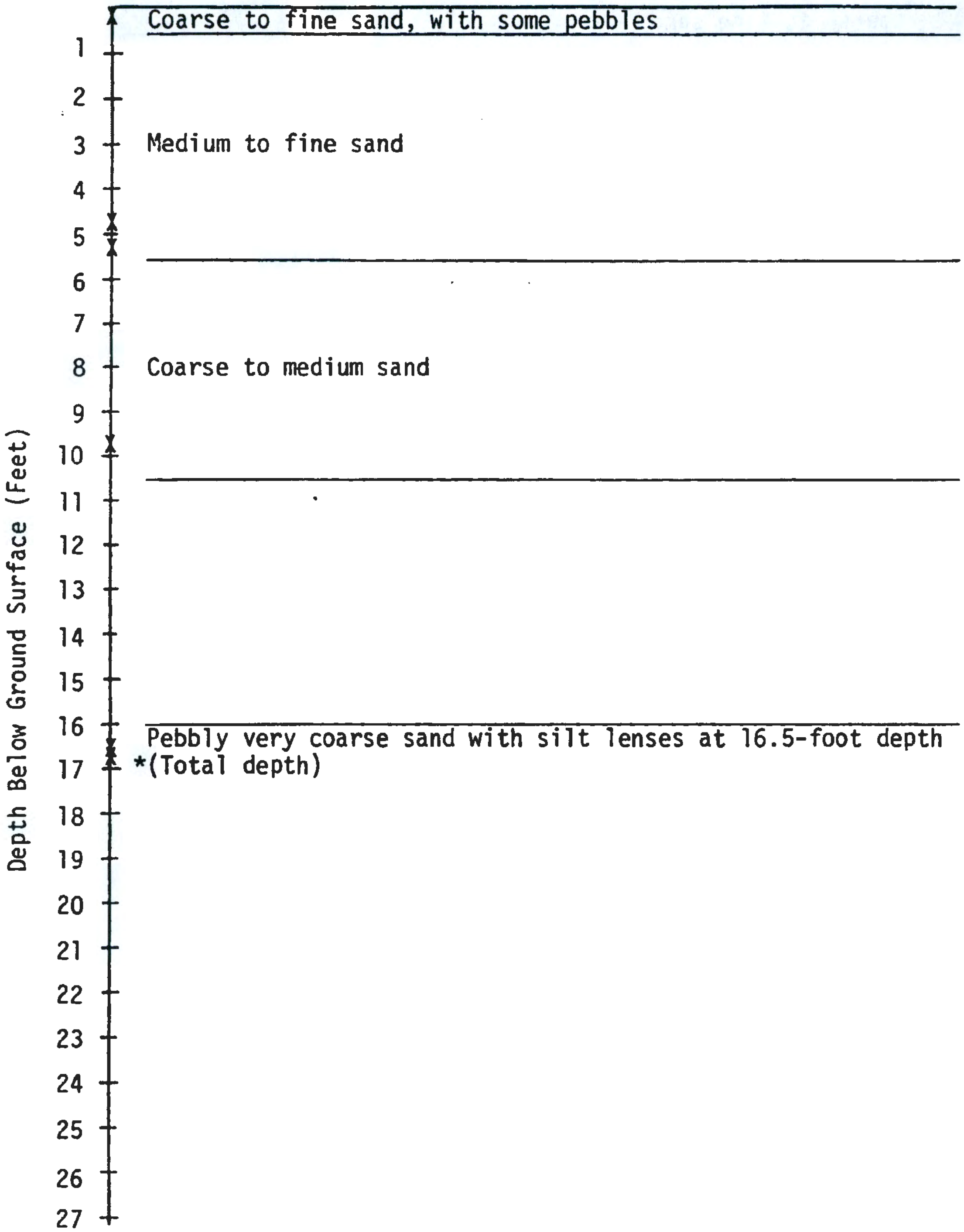


FIGURE 2-16. Borehole 299-W18-211 Summary Textural Log.

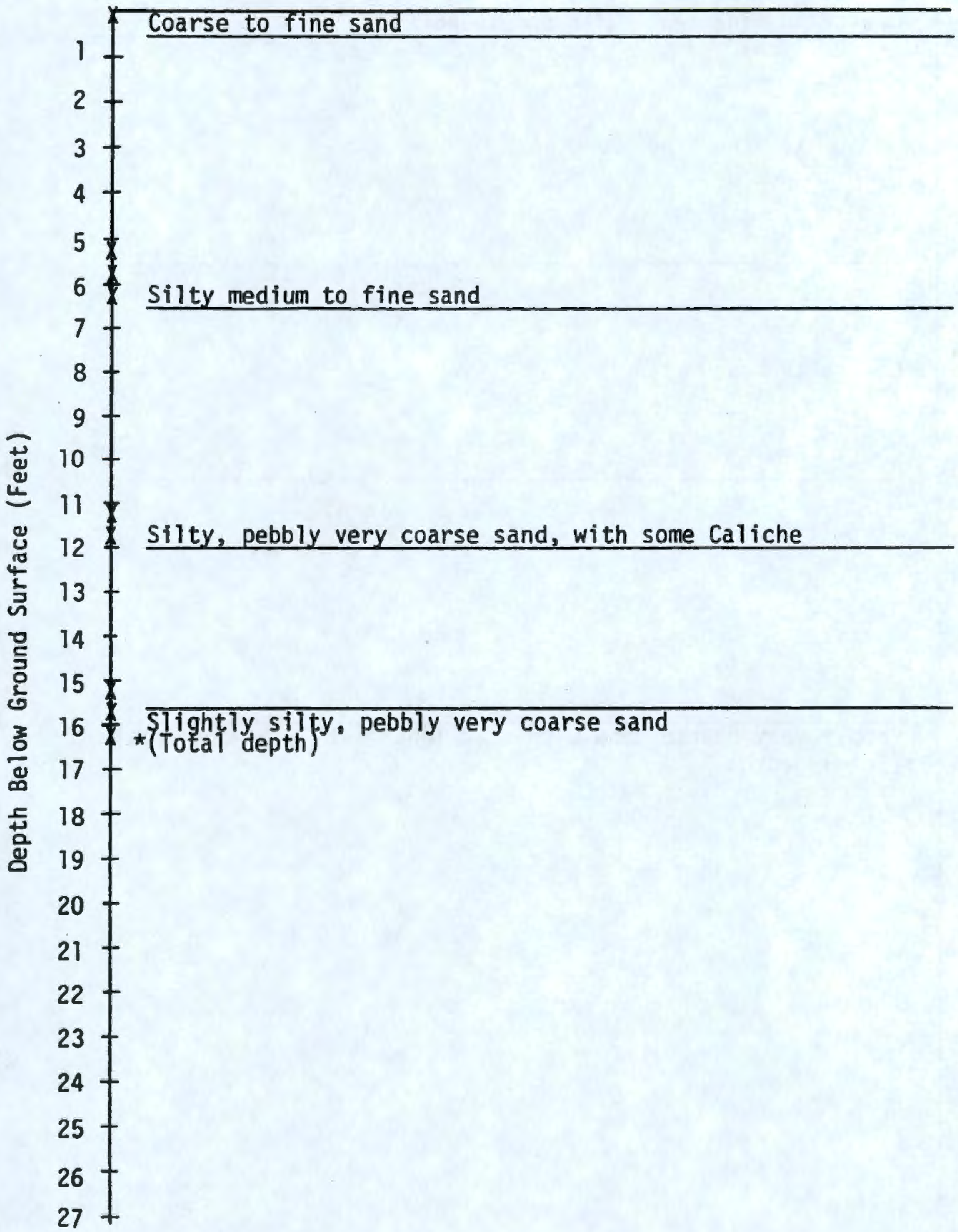


FIGURE 2-17. Borehole 299-W18-212 Summary Textural Log.

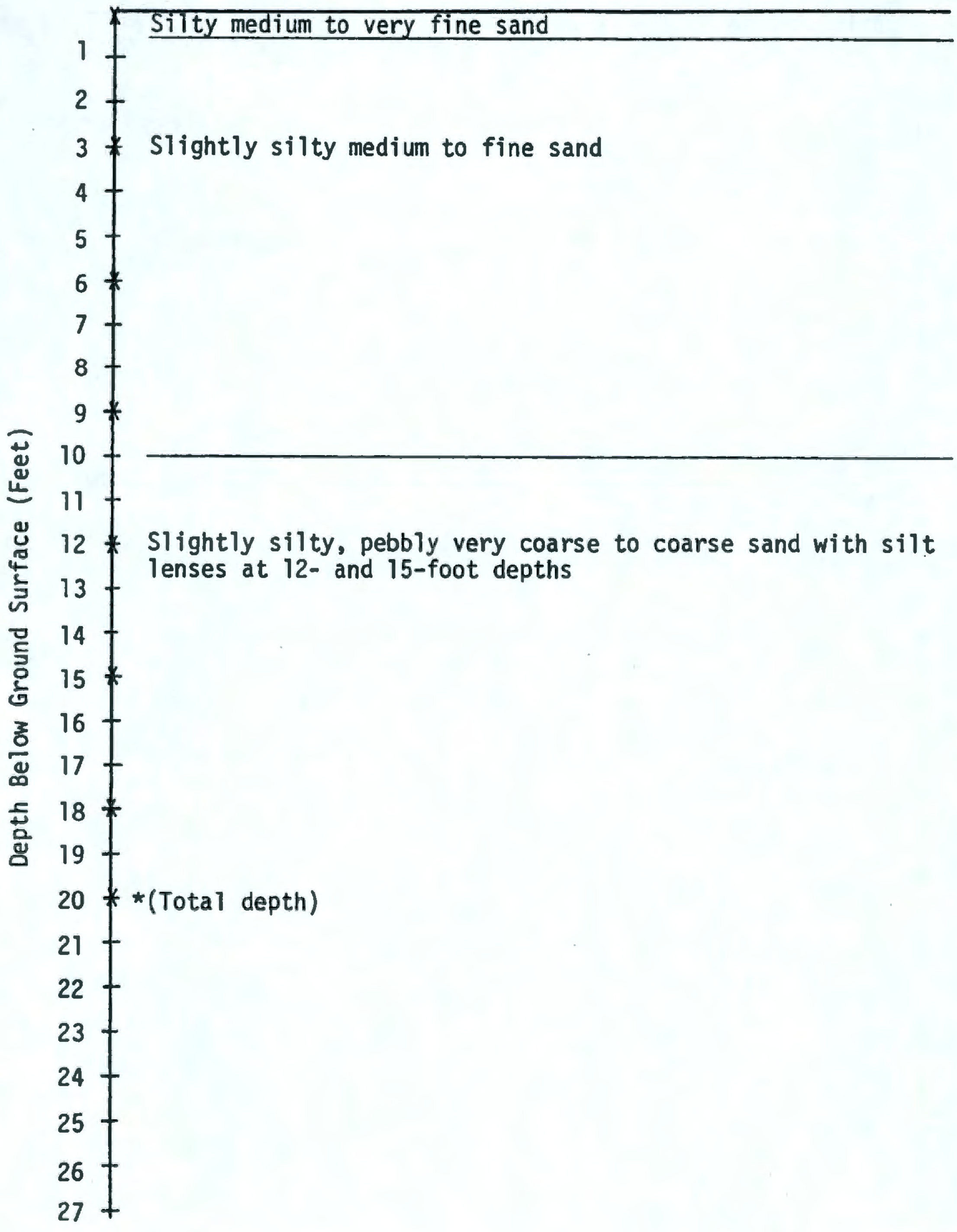


FIGURE 2-18. Borehole 299-W18-213 Summary Textural Log.

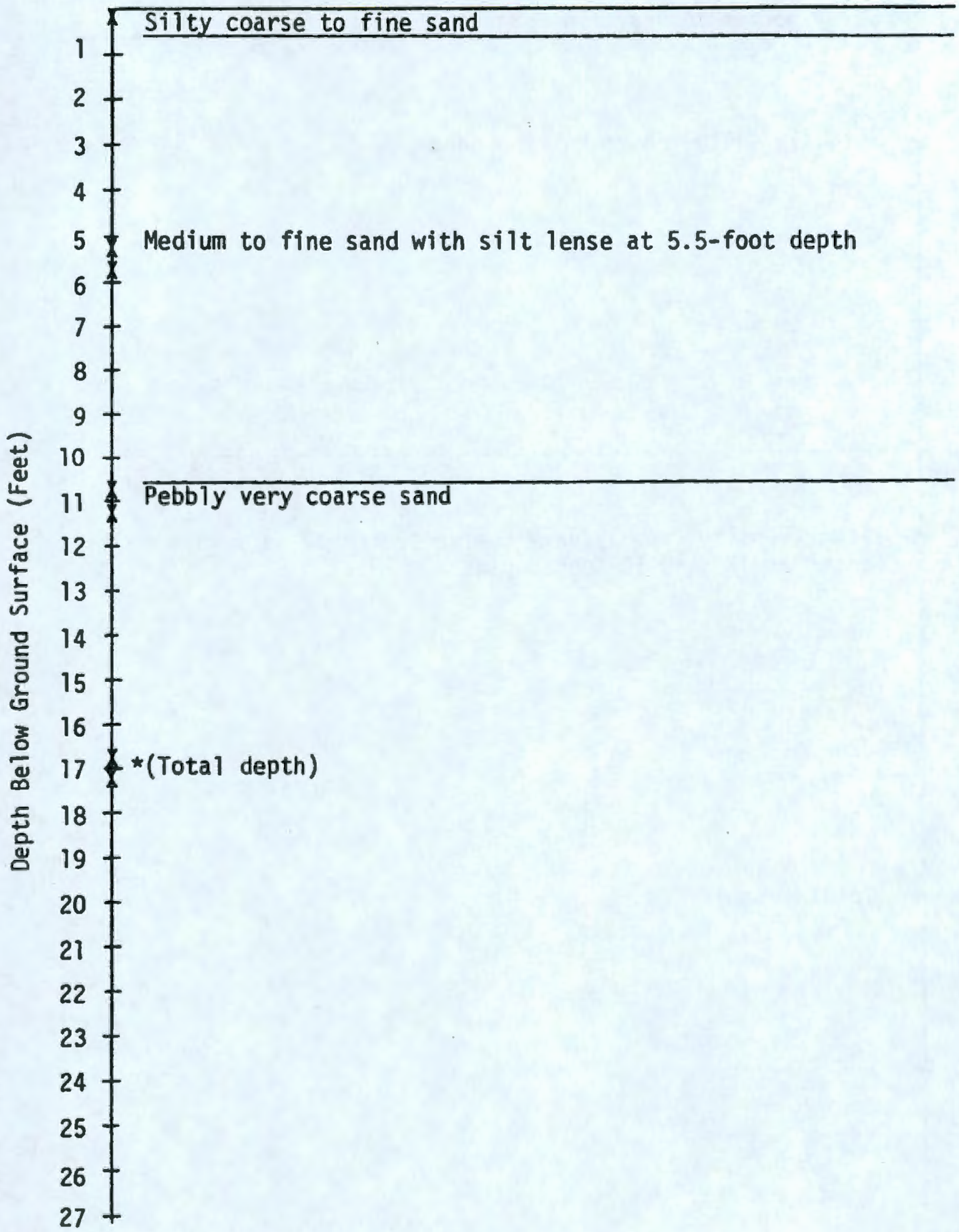


FIGURE 2-19. Borehole 299-W18-214 Summary Textural Log.

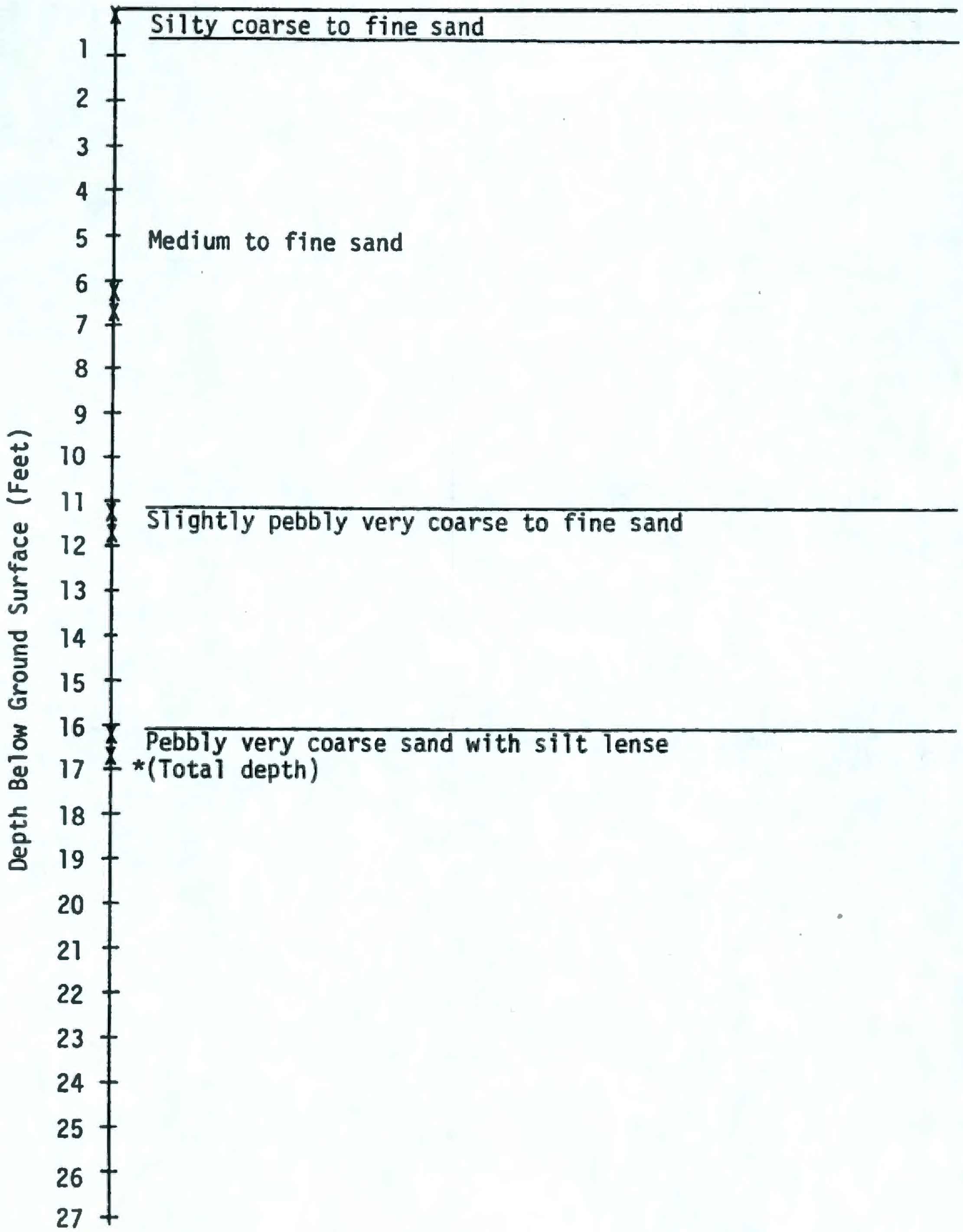


FIGURE 2-20. Borehole 299-W18-215 Summary Textural Log.

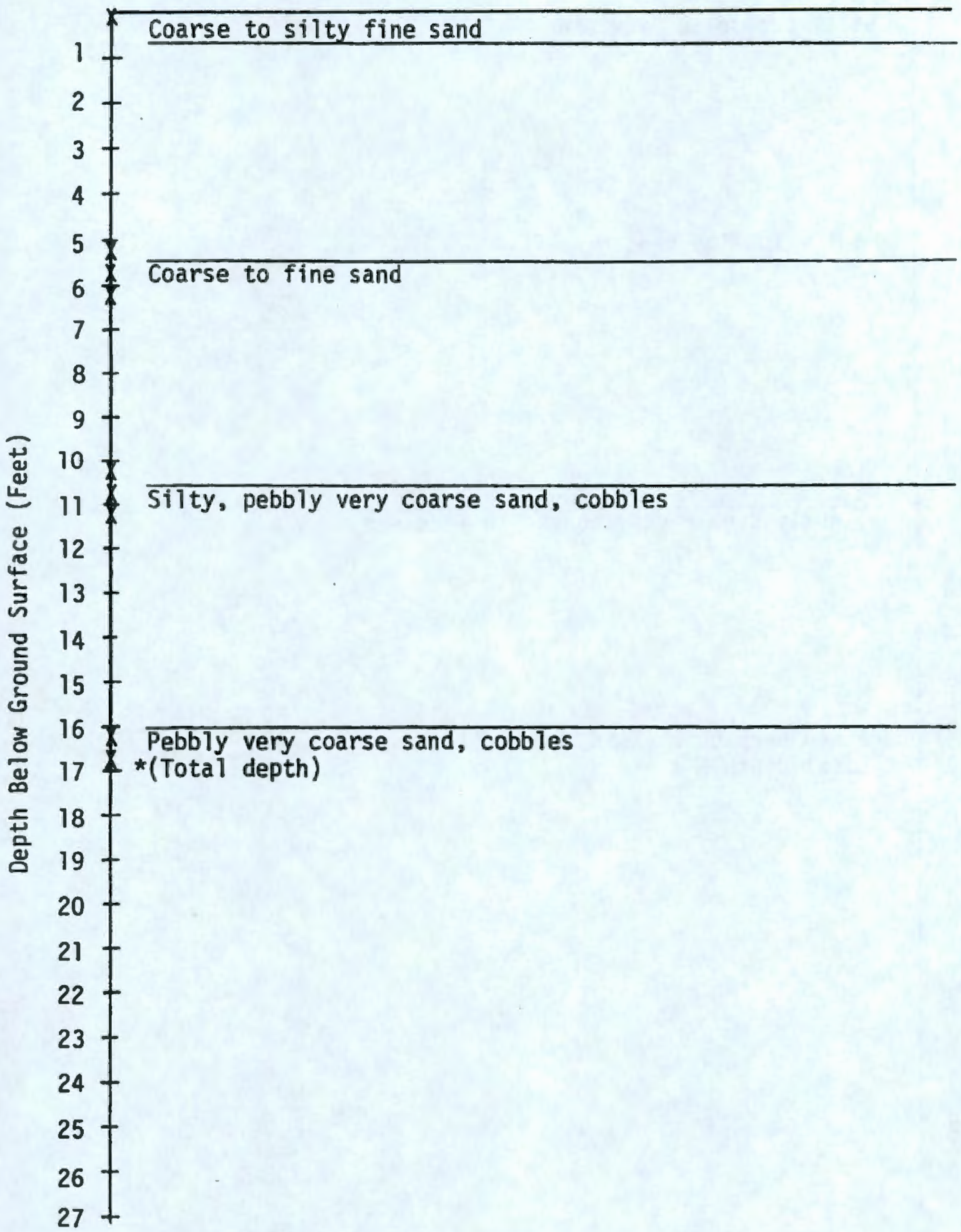
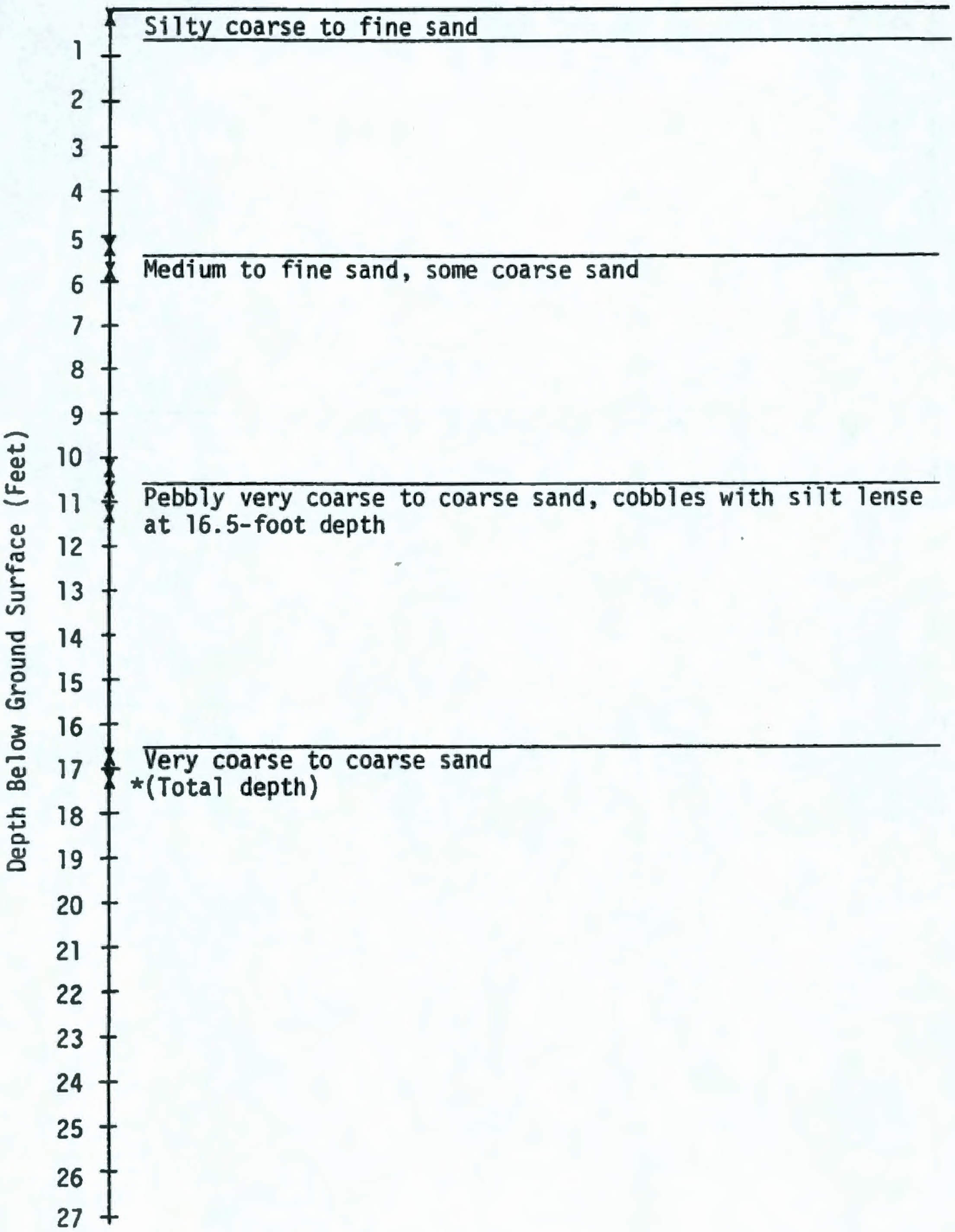


FIGURE 2-21. Borehole 299-W18-216 Summary Textural Log.



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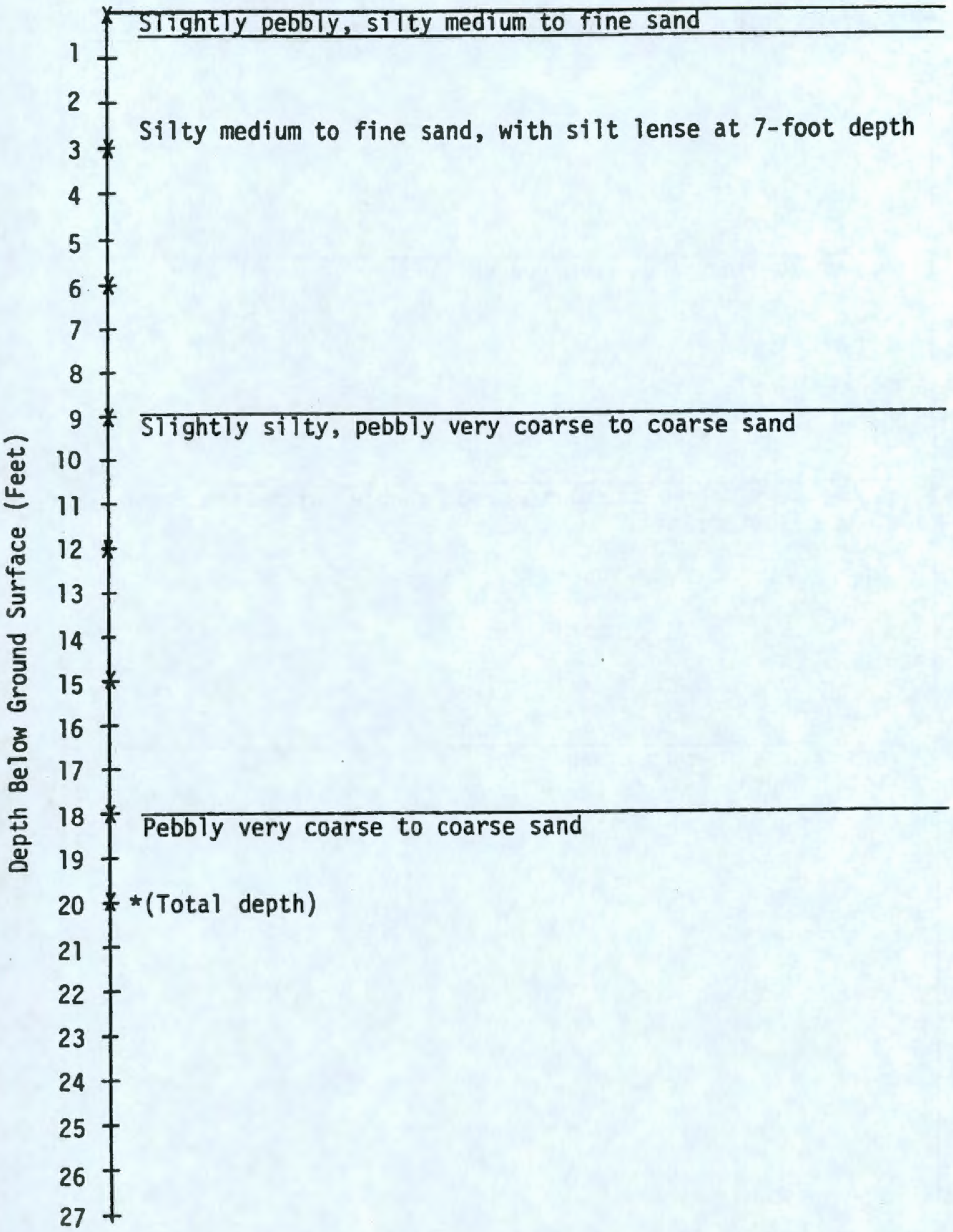

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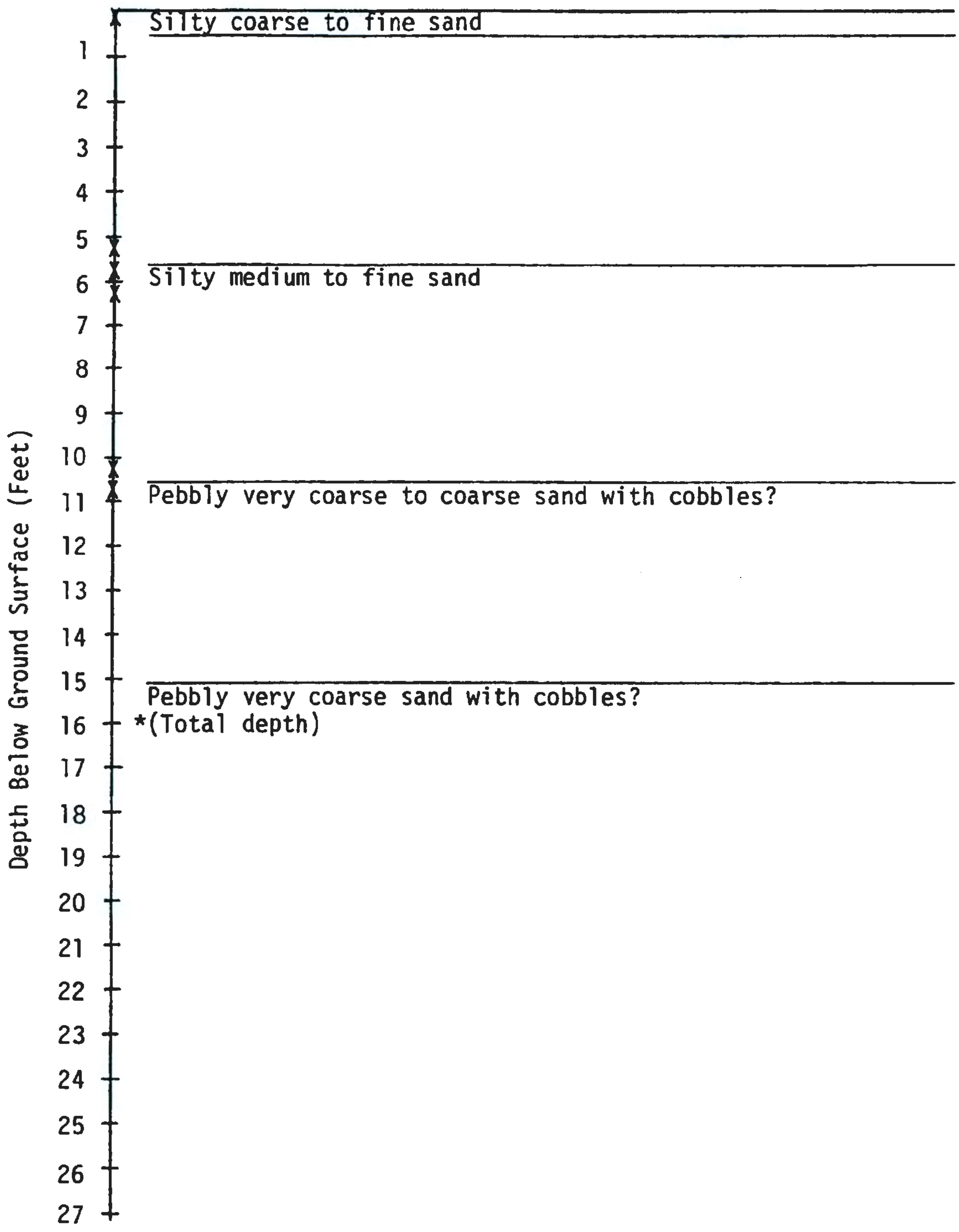
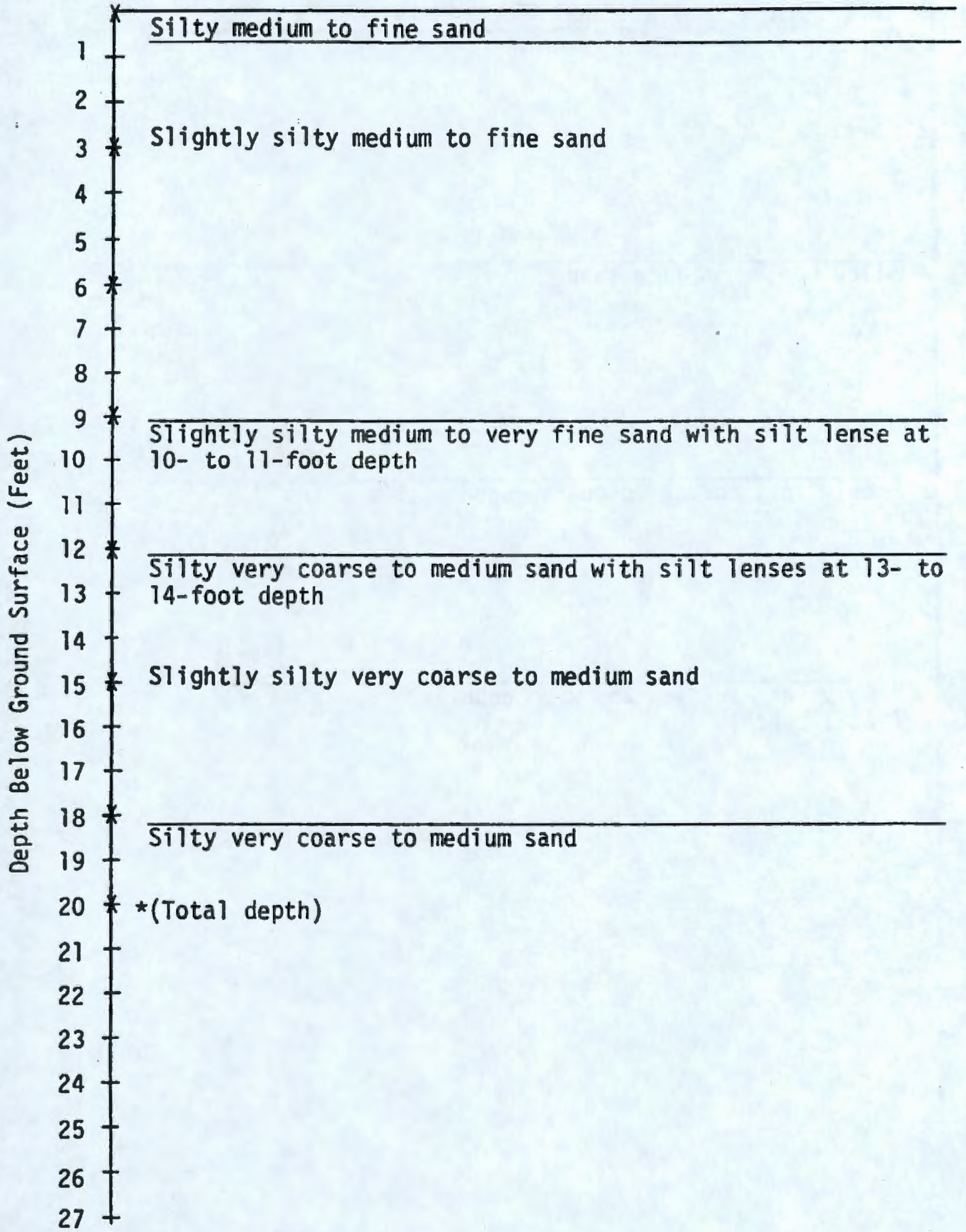


FIGURE 2-24. Borehole 299-W18-219 Summary Textural Log.



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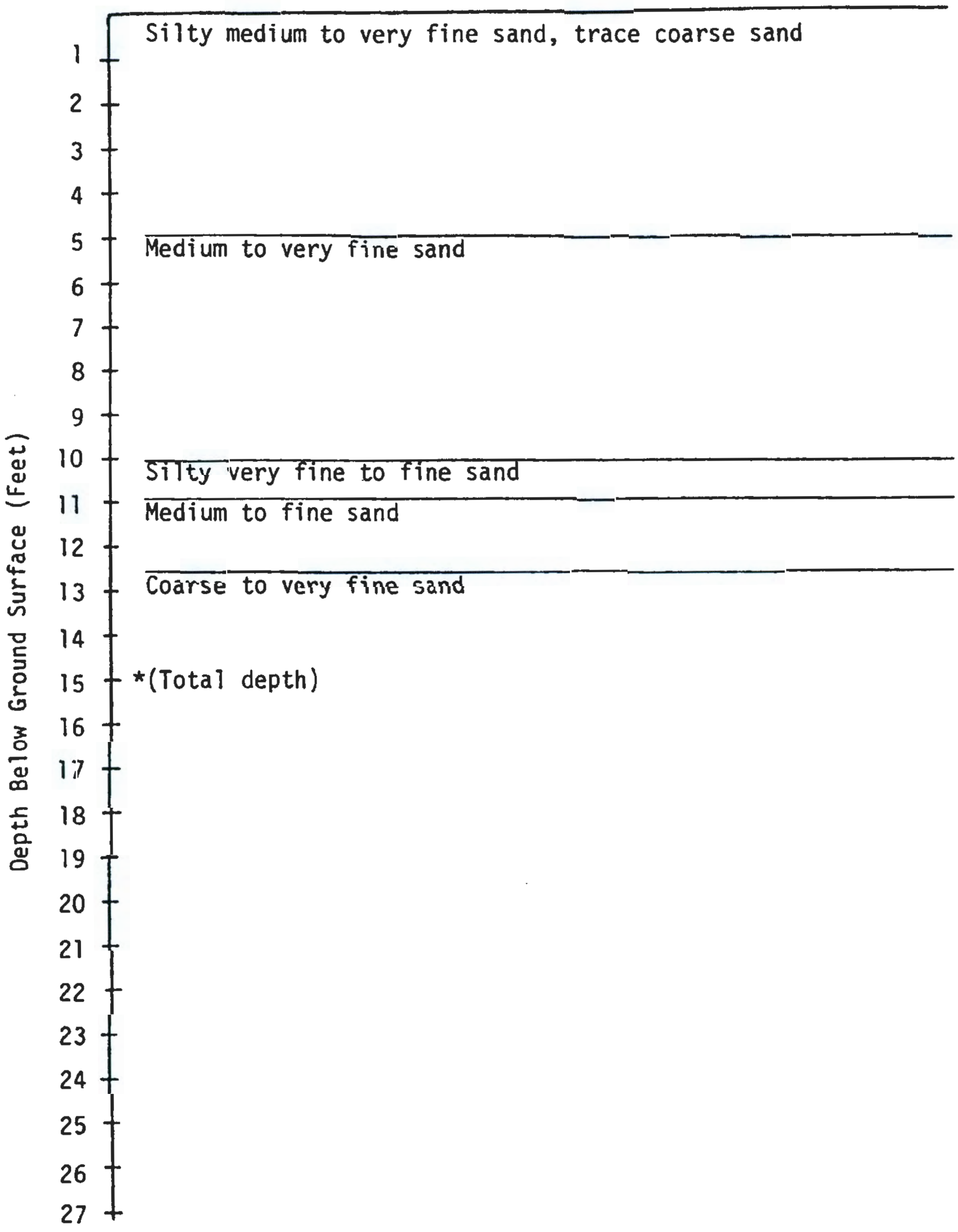


FIGURE 2-26. Borehole 299-W18-221 Summary Textural Log.

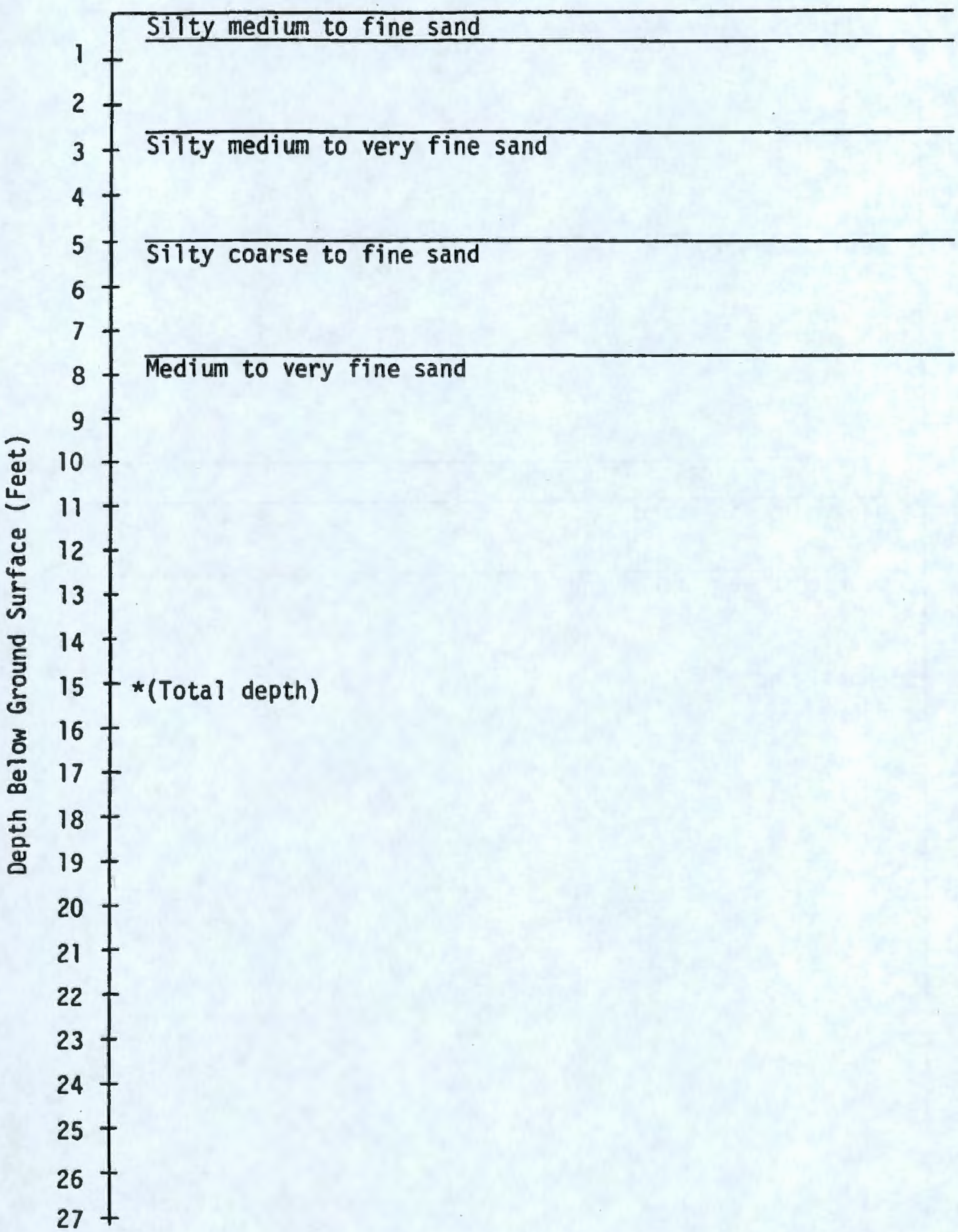


FIGURE 2-27. Borehole 299-W18-222 Summary Textural Log.

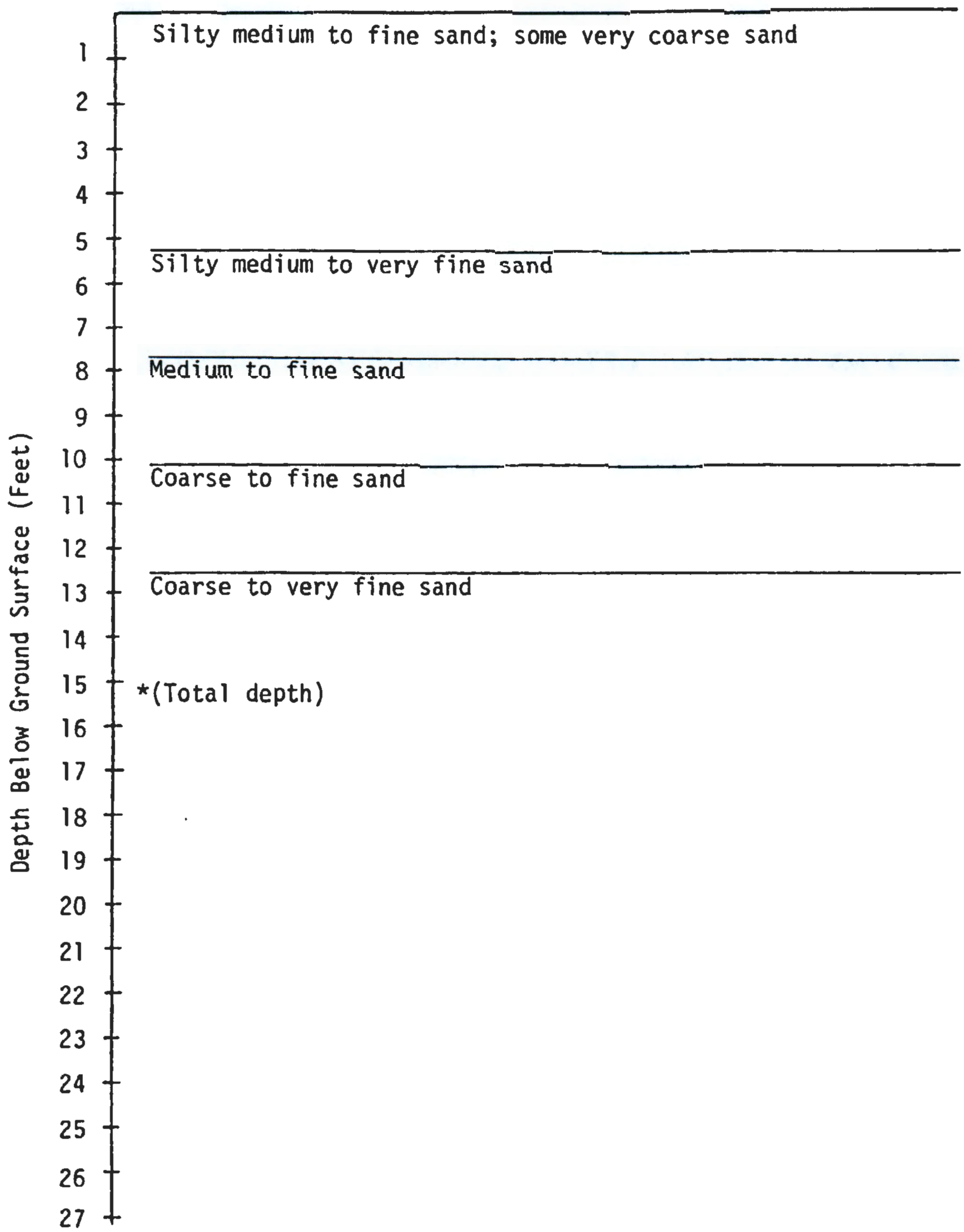


FIGURE 2-28. Borehole 299-W18-223 Summary Textural Log.

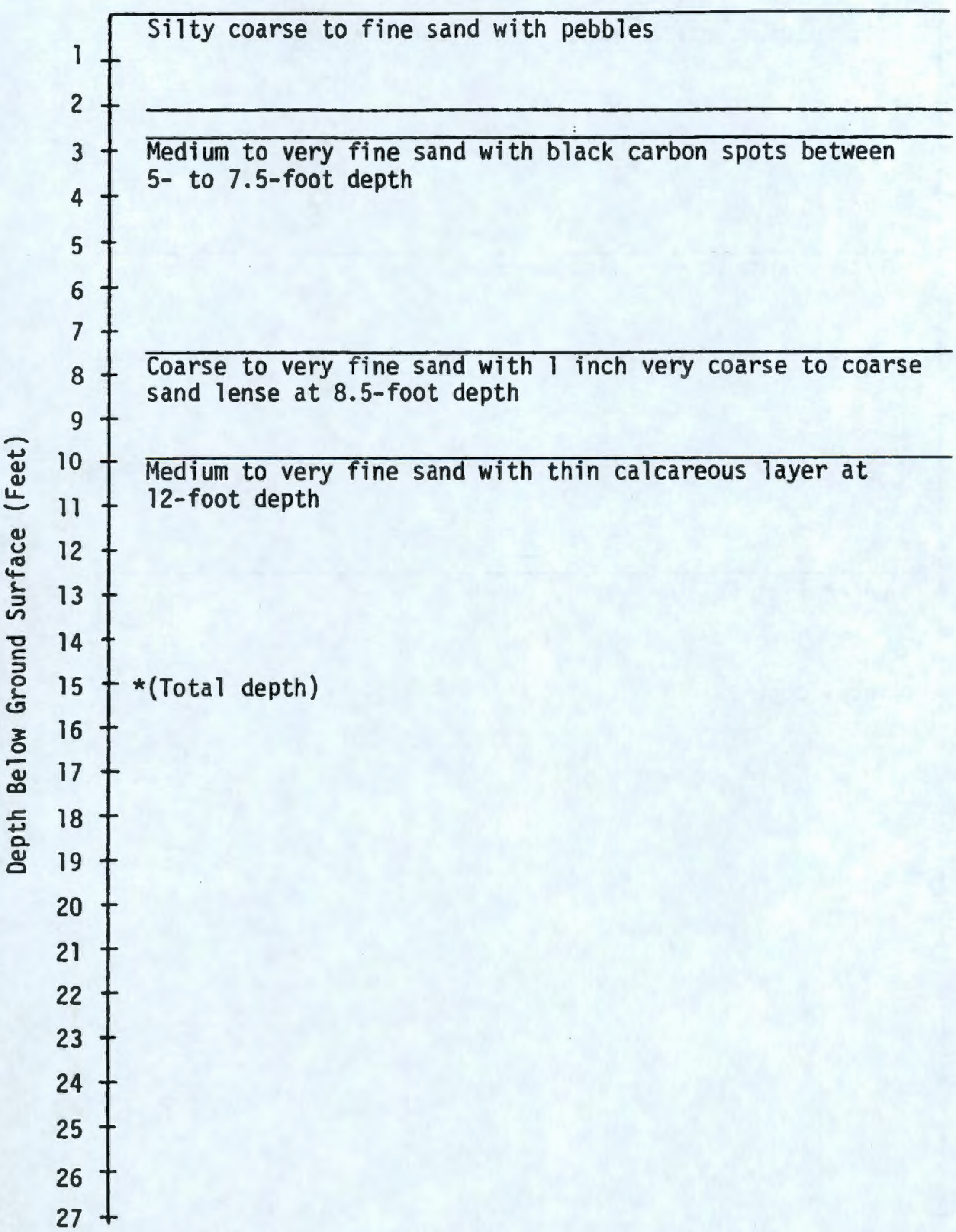


FIGURE 2-29. Borehole 299-W18-224 Summary Textural Log.

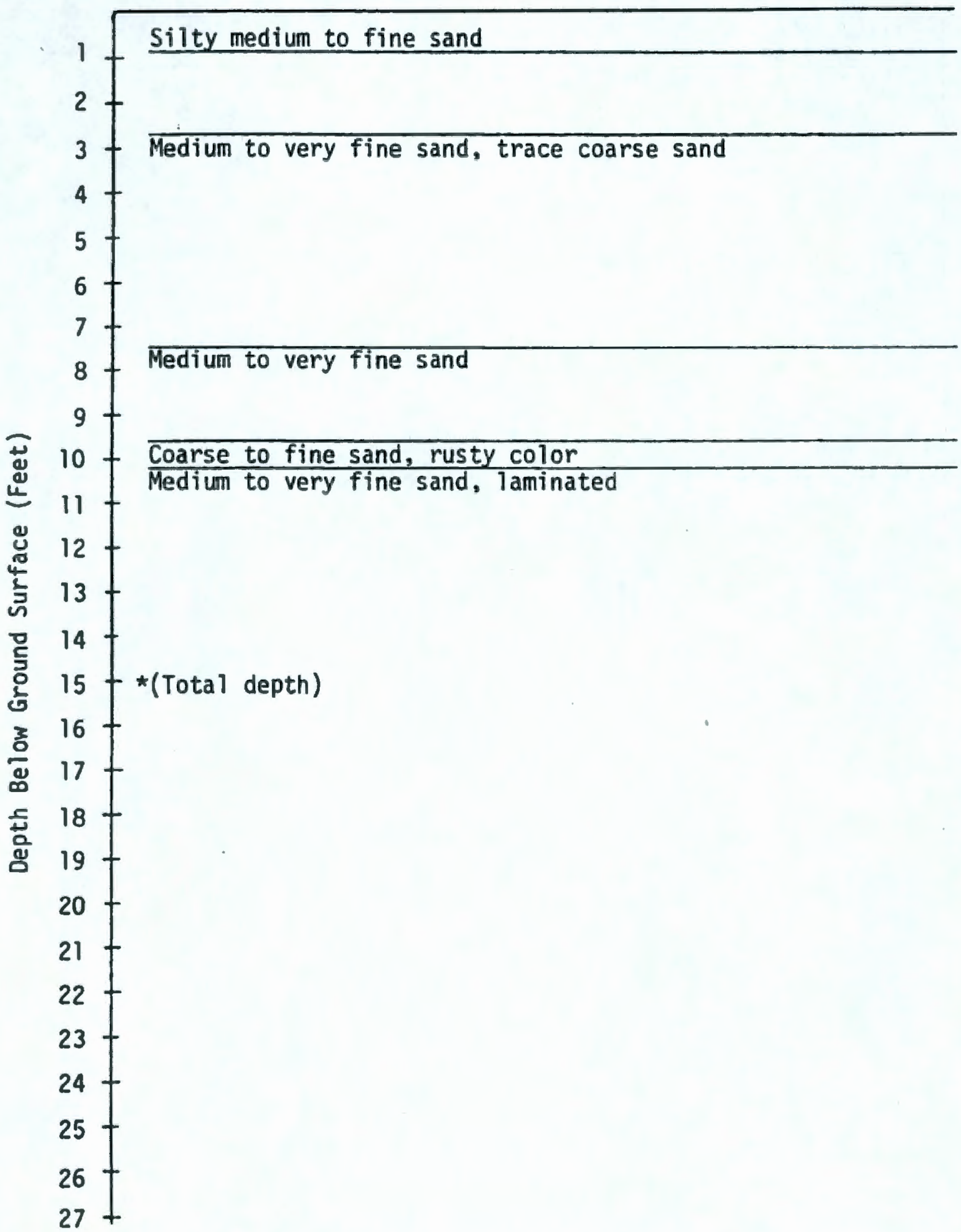


FIGURE 2-30. Borehole 299-W18-225 Summary Textural Log.

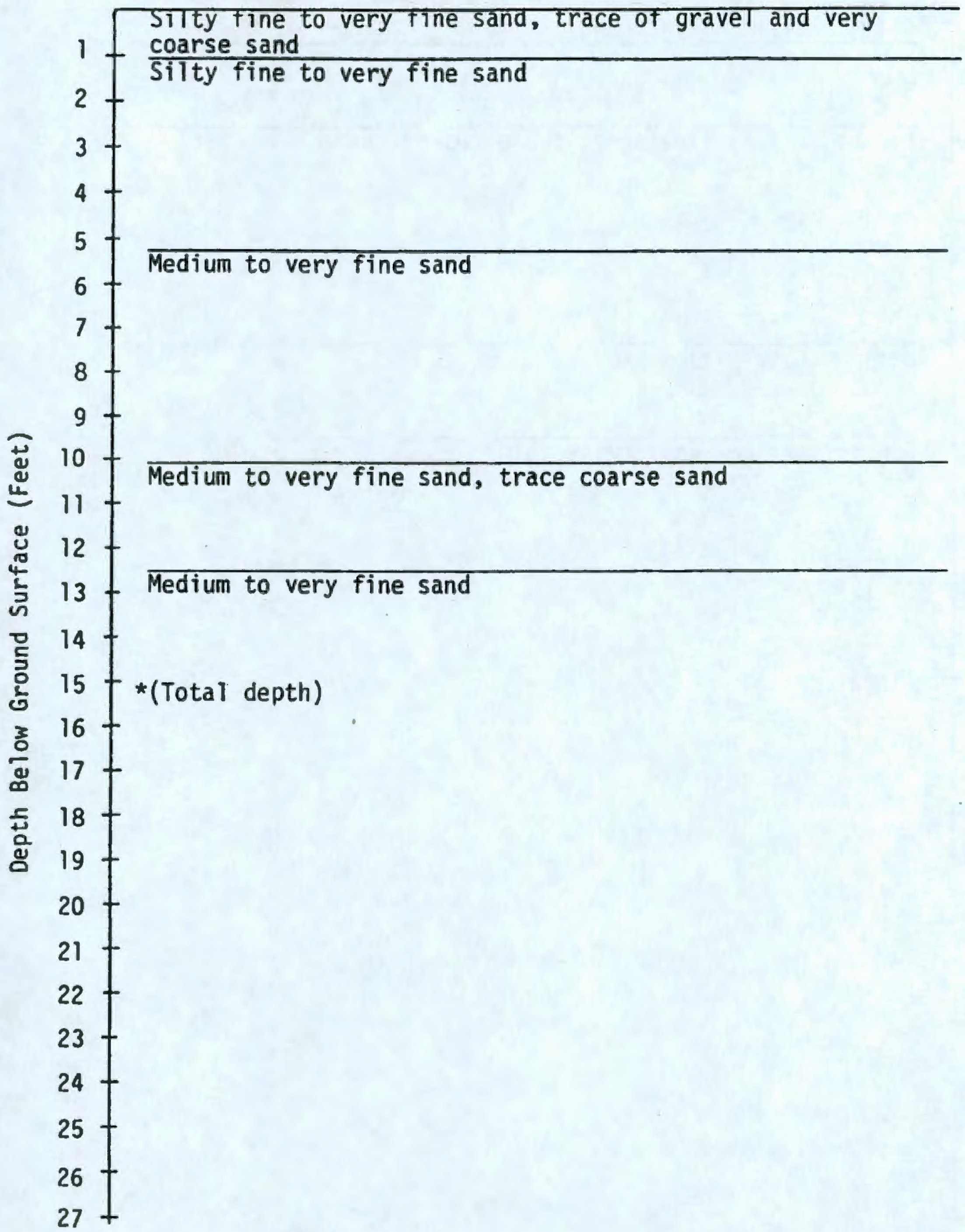


FIGURE 2-31. Borehole 299-W18-226 Summary Textural Log.

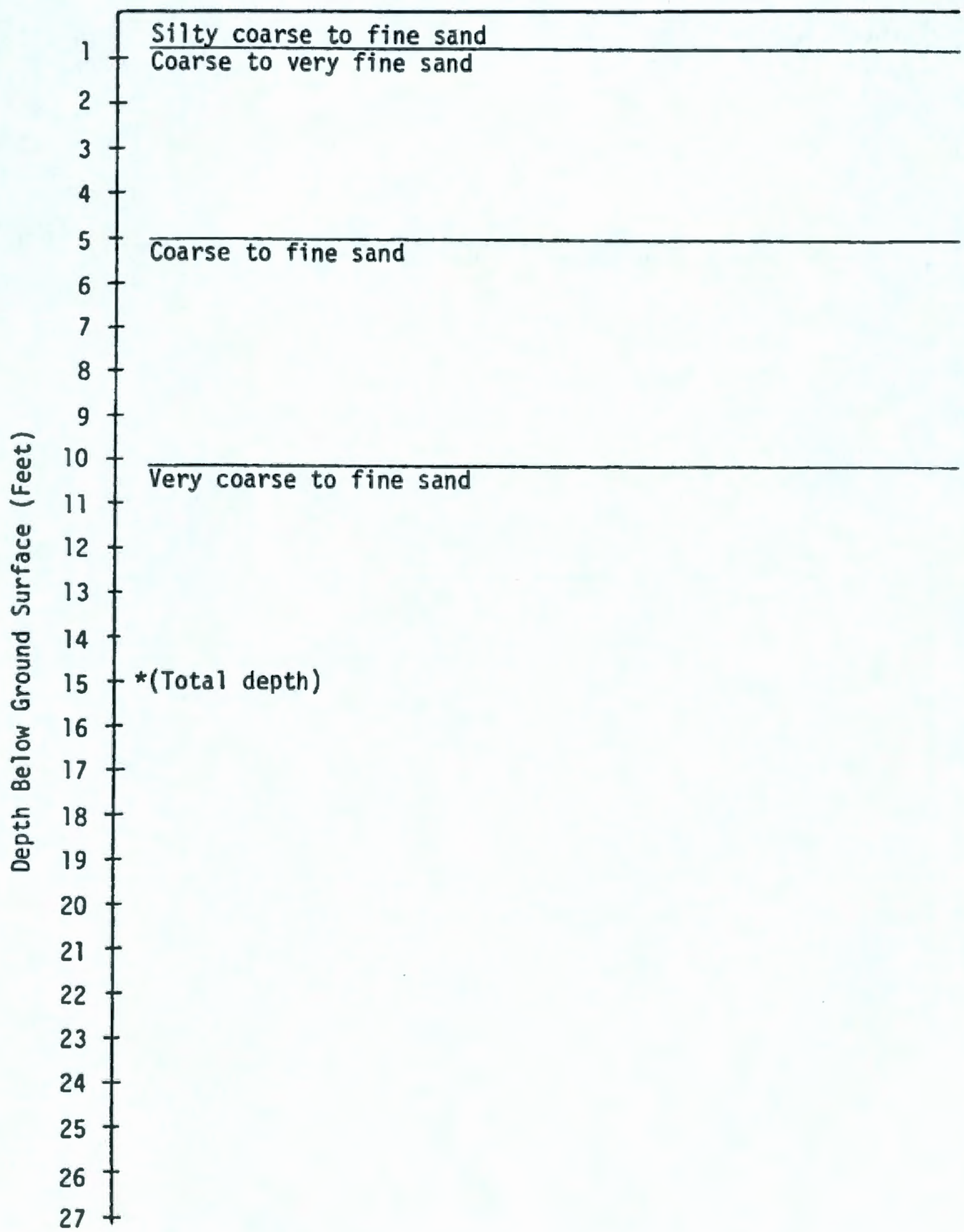


FIGURE 2-32. Borehole 299-W18-227 Summary Textural Log.

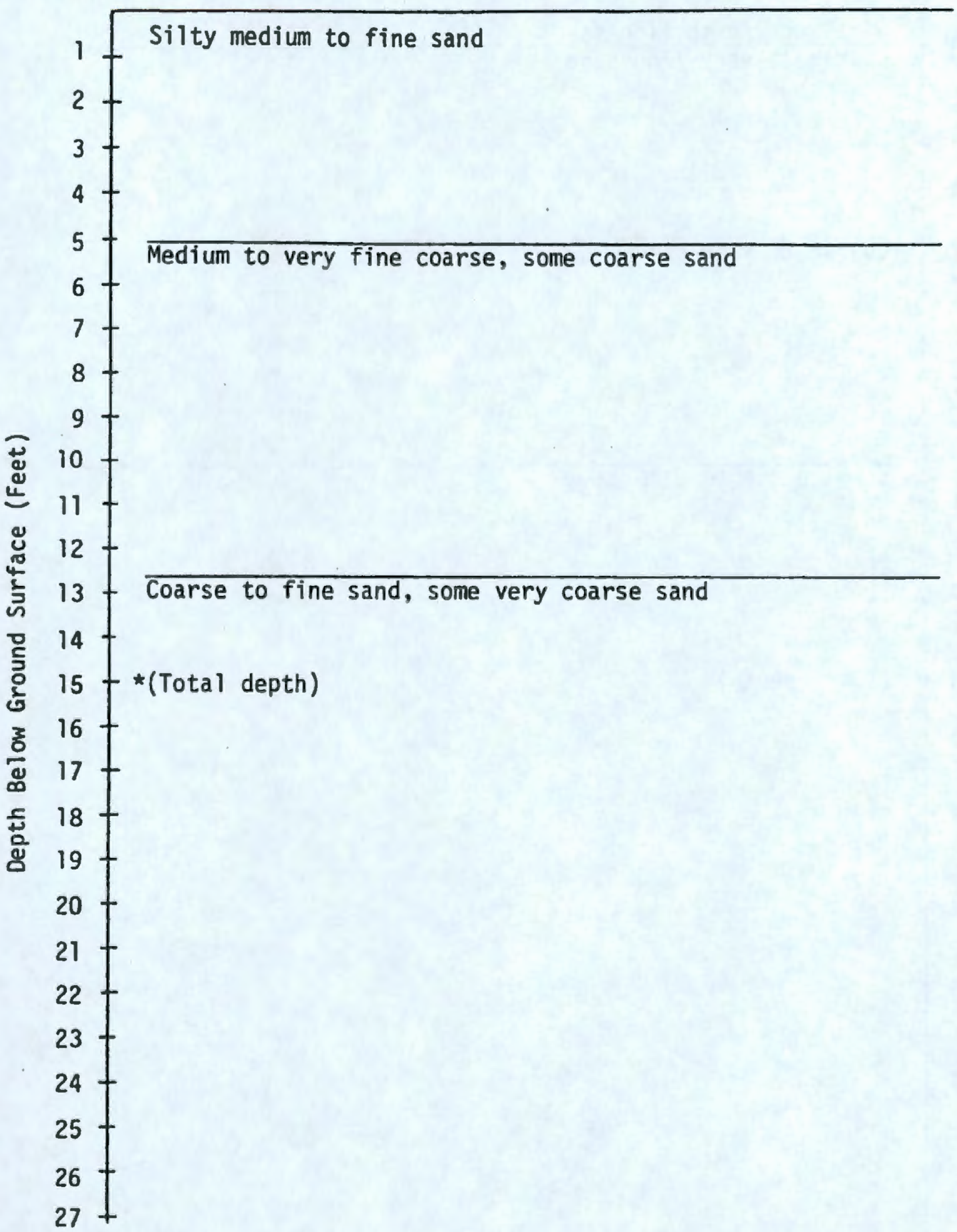


FIGURE 2-33. Borehole 299-W18-228 Summary Textural Log.

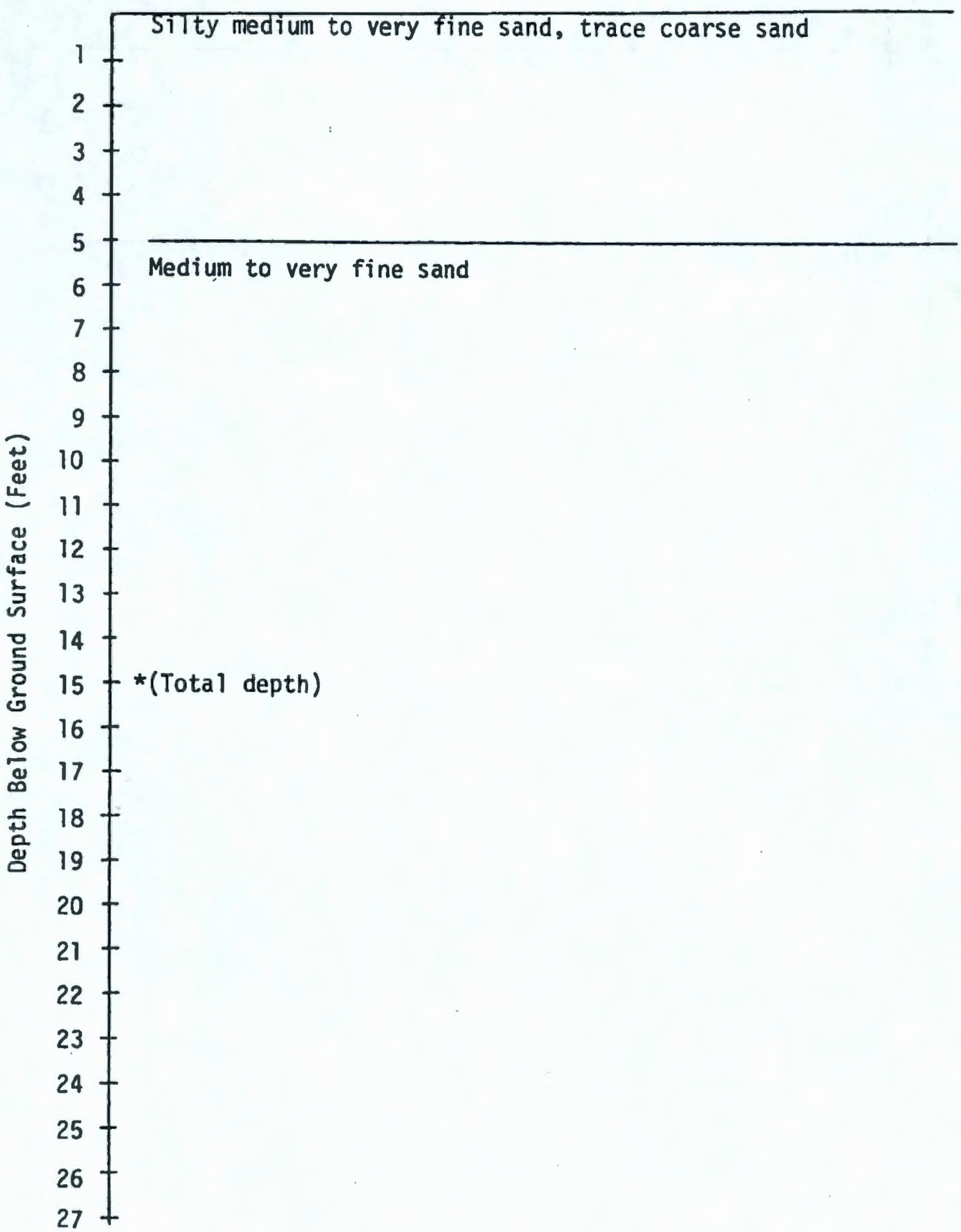


FIGURE 2-34. Borehole 299-W18-229 Summary Textural Log.

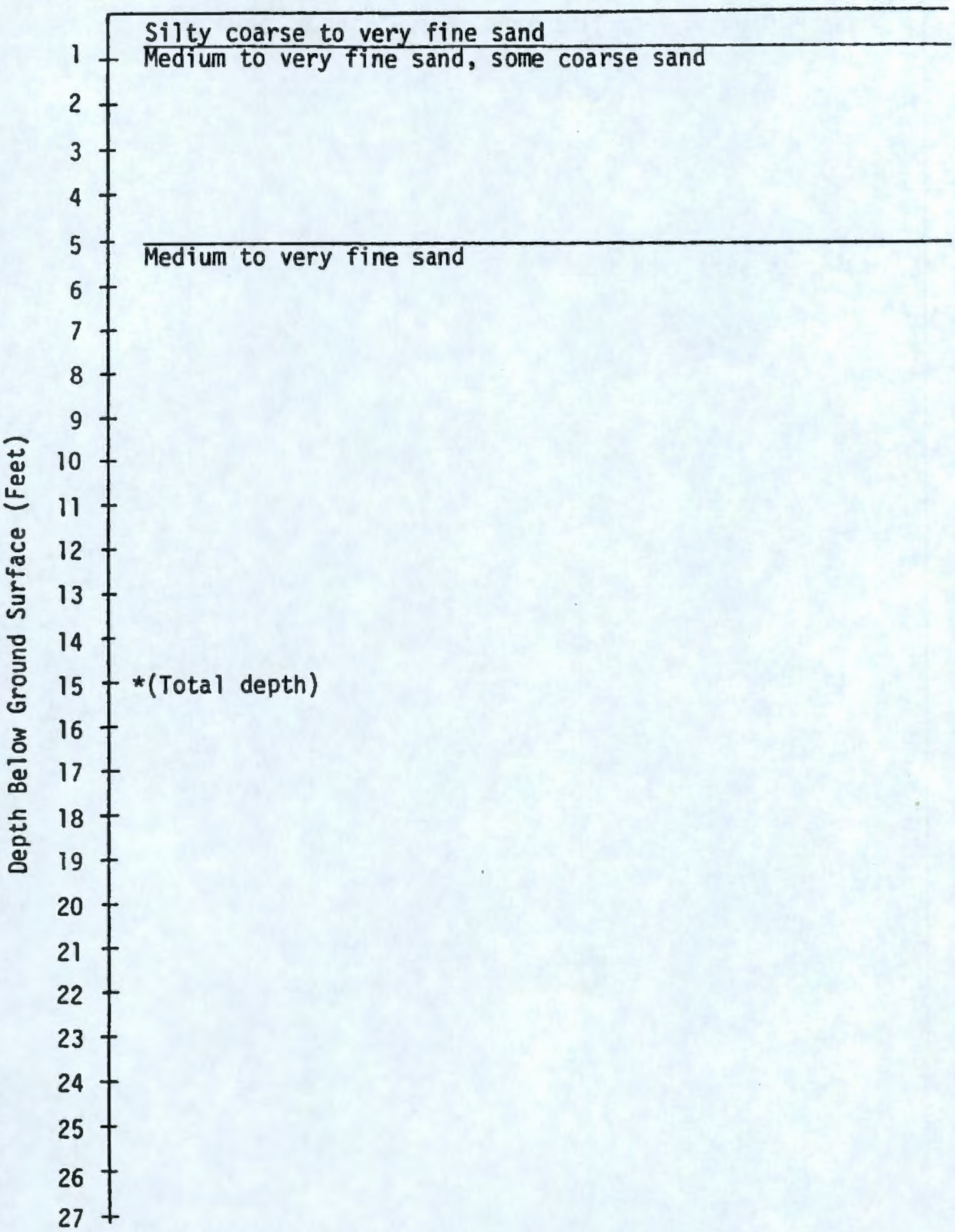


FIGURE 2-35. Borehole 299-W18-230 Summary Textural Log.

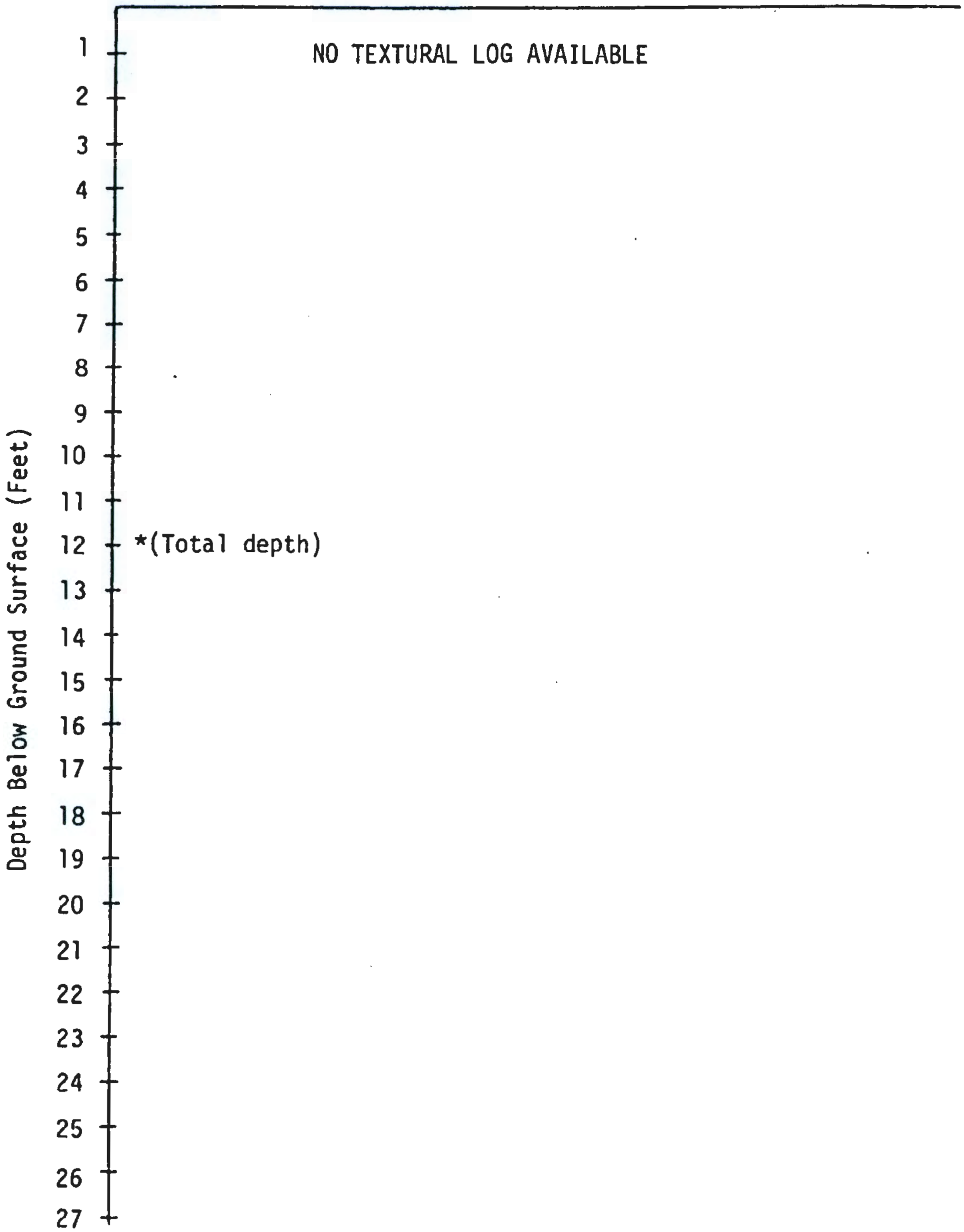


FIGURE 2-36. Borehole 299-W18-231 Summary Textural Log.

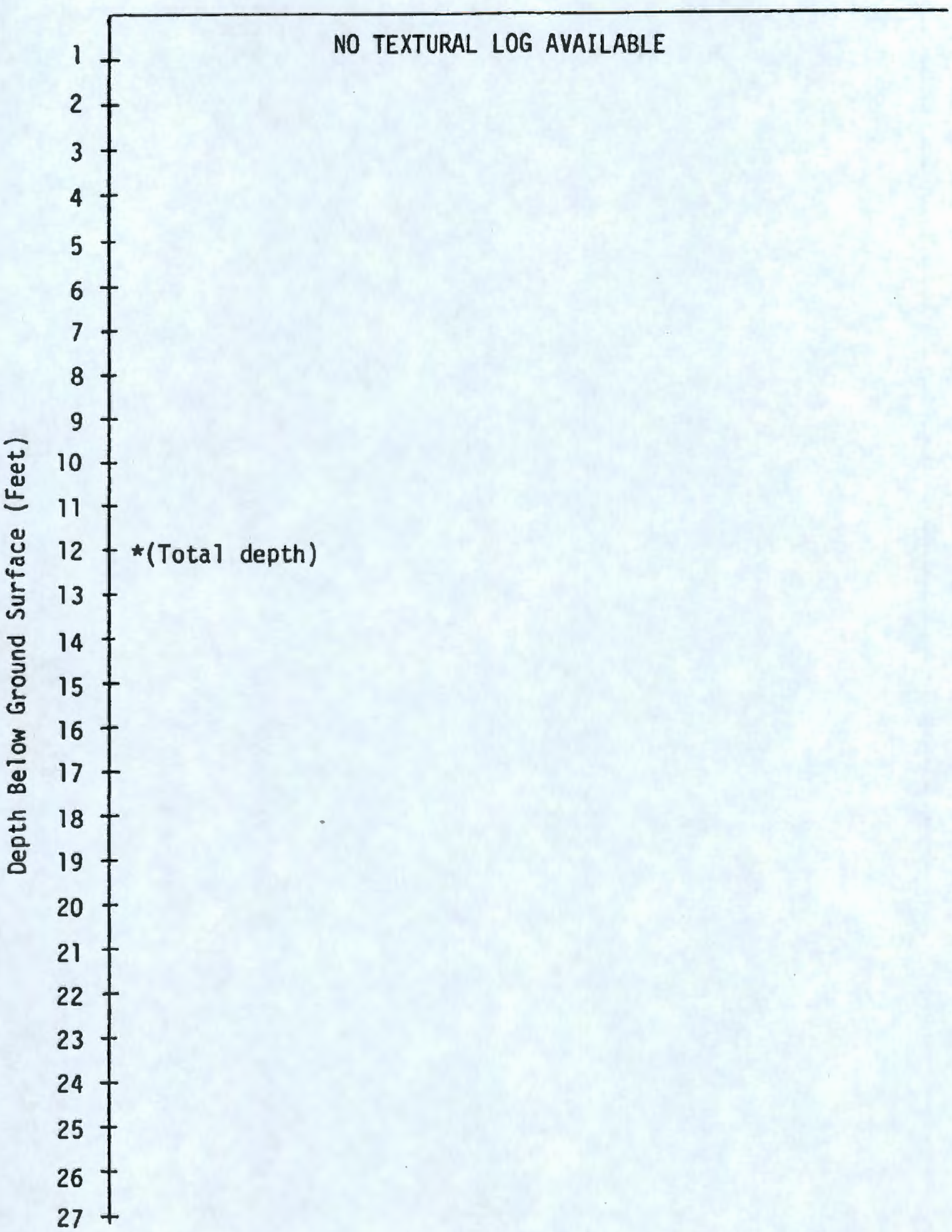


FIGURE 2-37. Borehole 299-W18-232 Summary Textural Log.

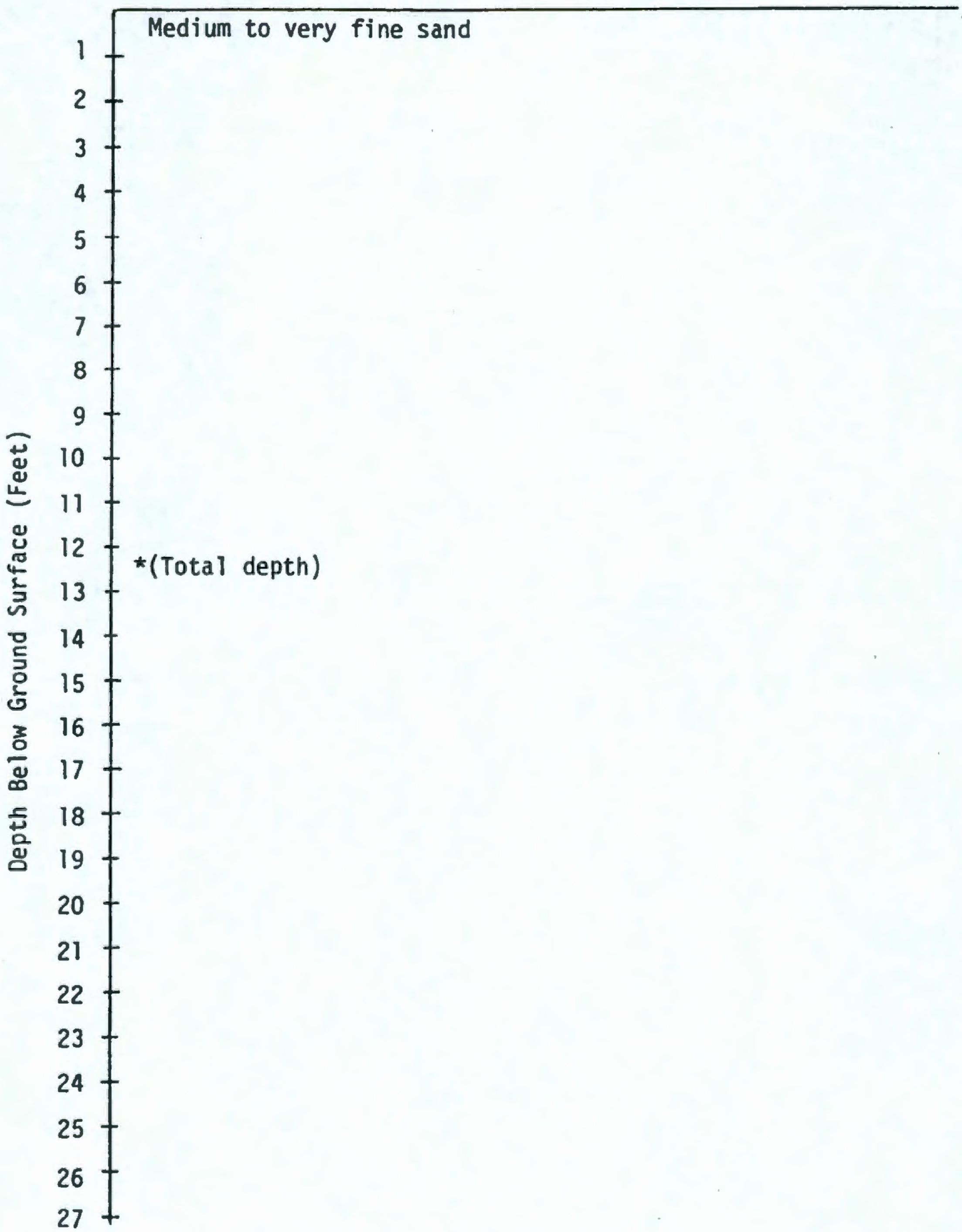
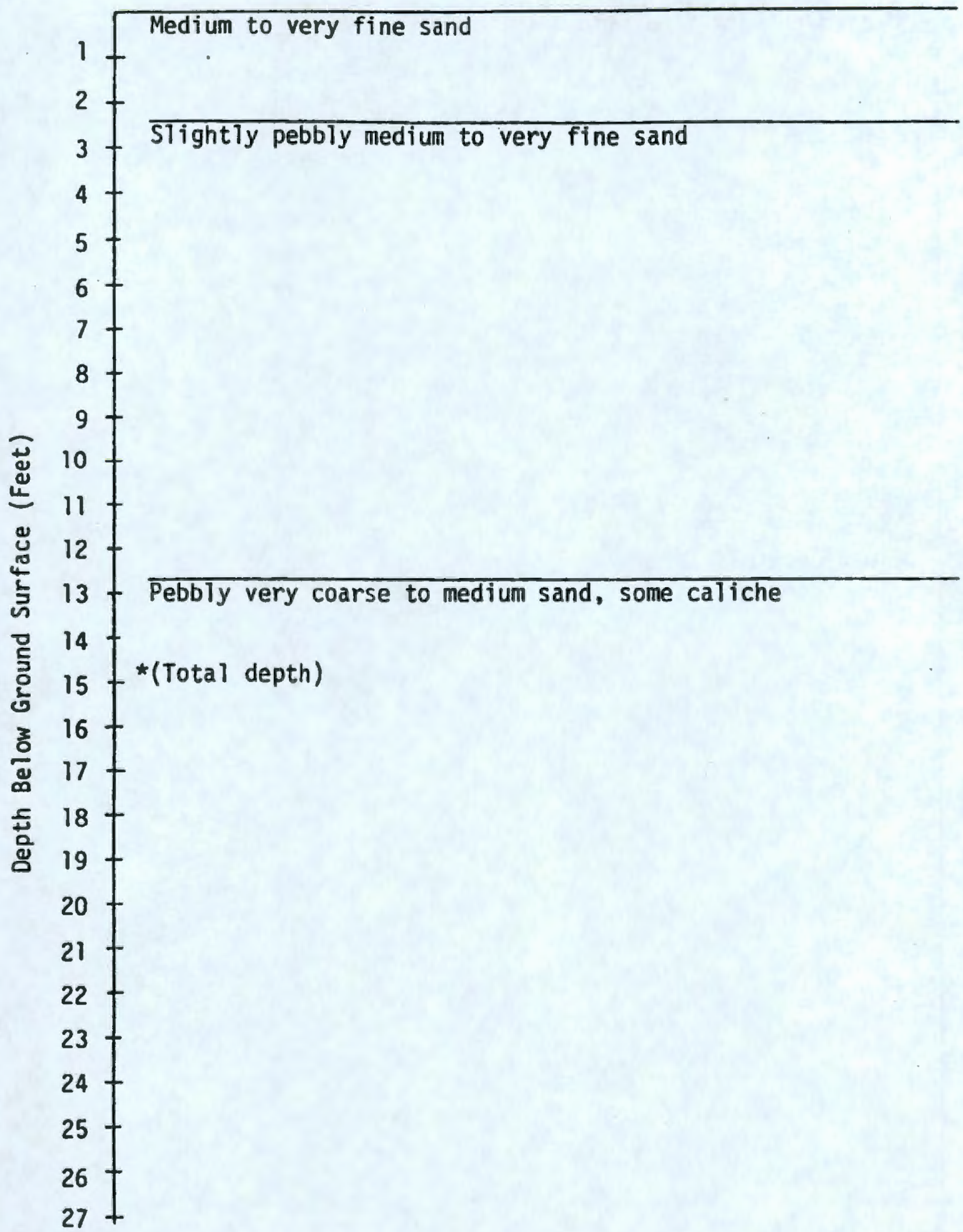


FIGURE 2-38. Borehole 299-W18-233 Summary Textural Log.



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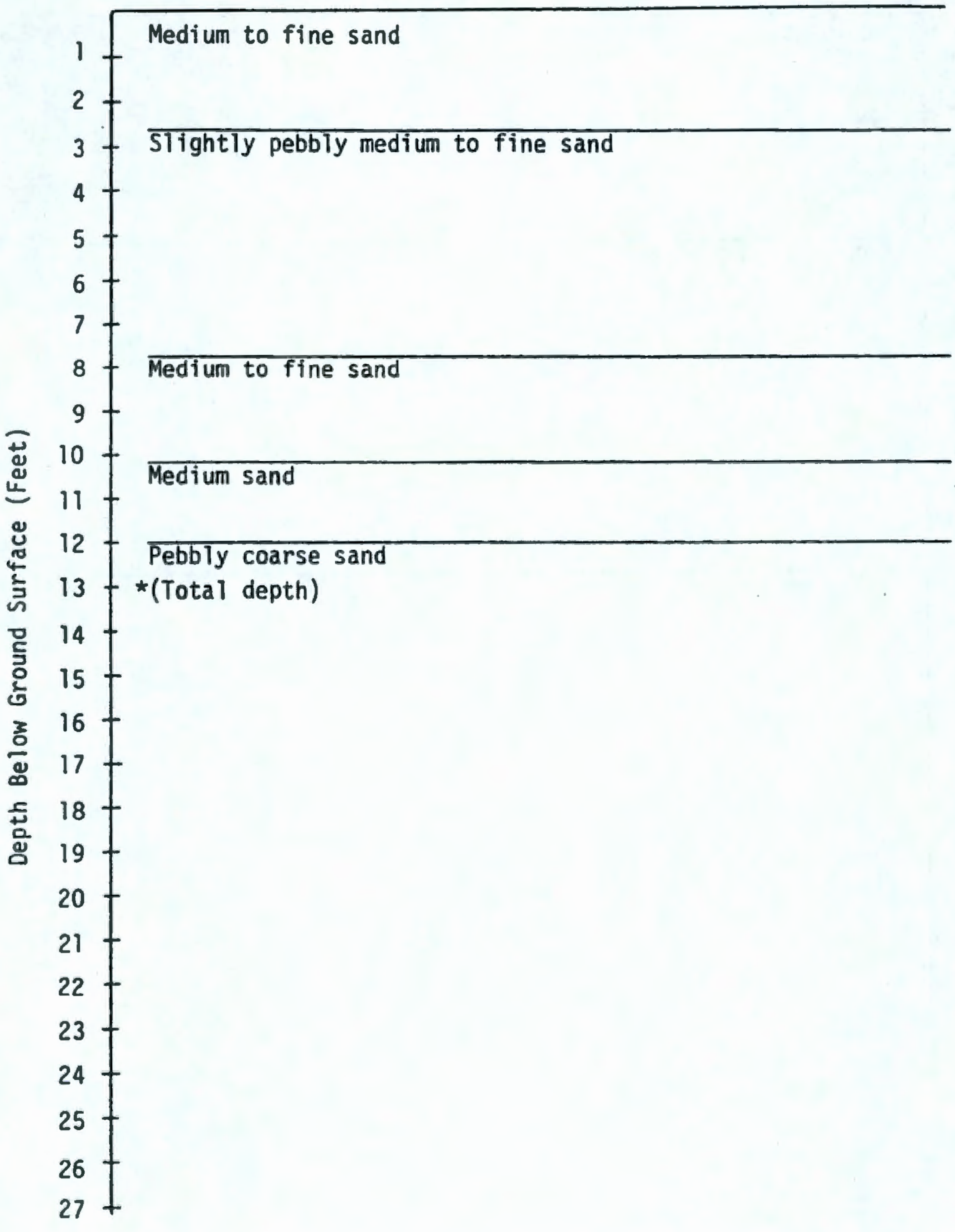

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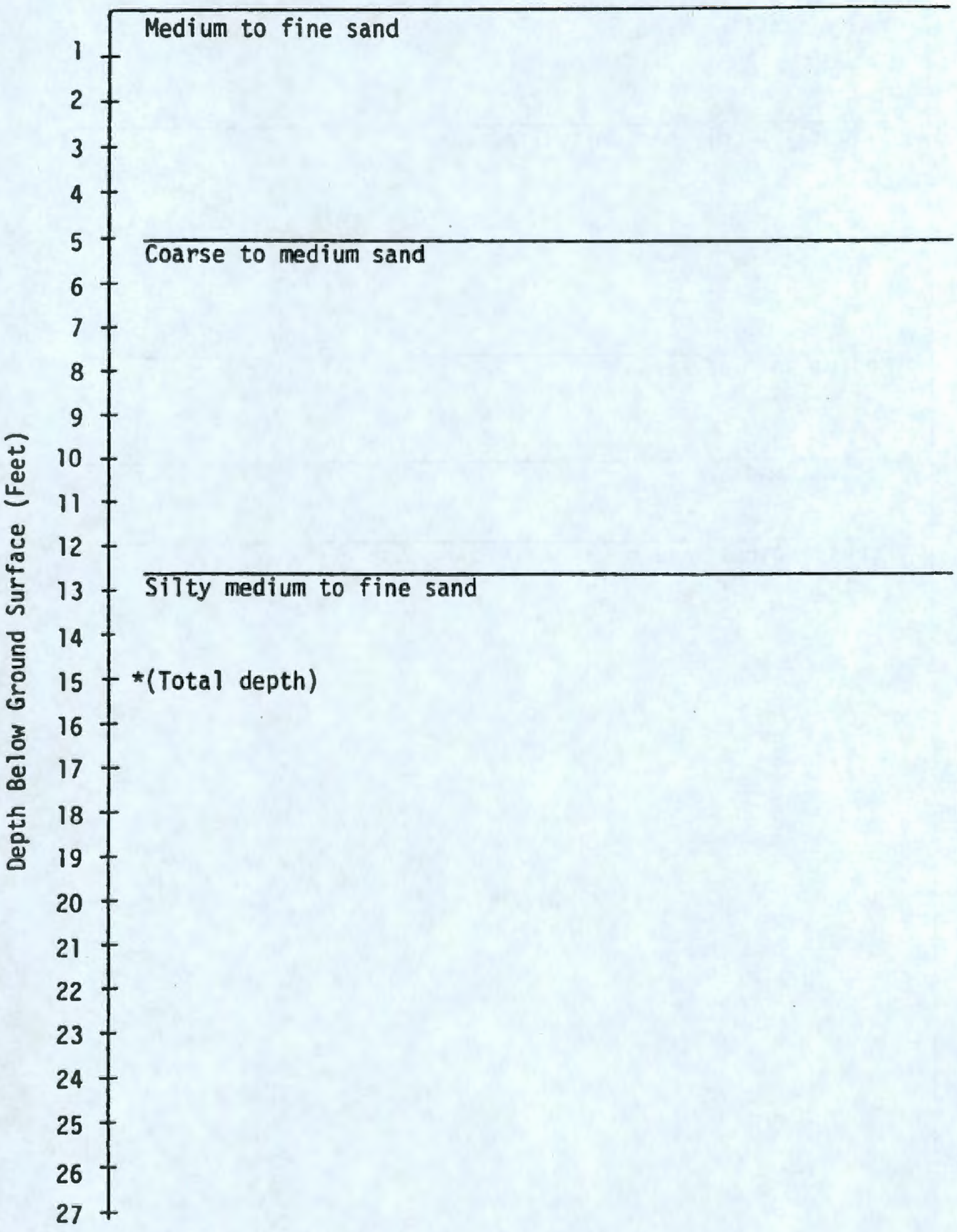


FIGURE 2-41. Borehole 299-W18-236 Summary Textural Log.

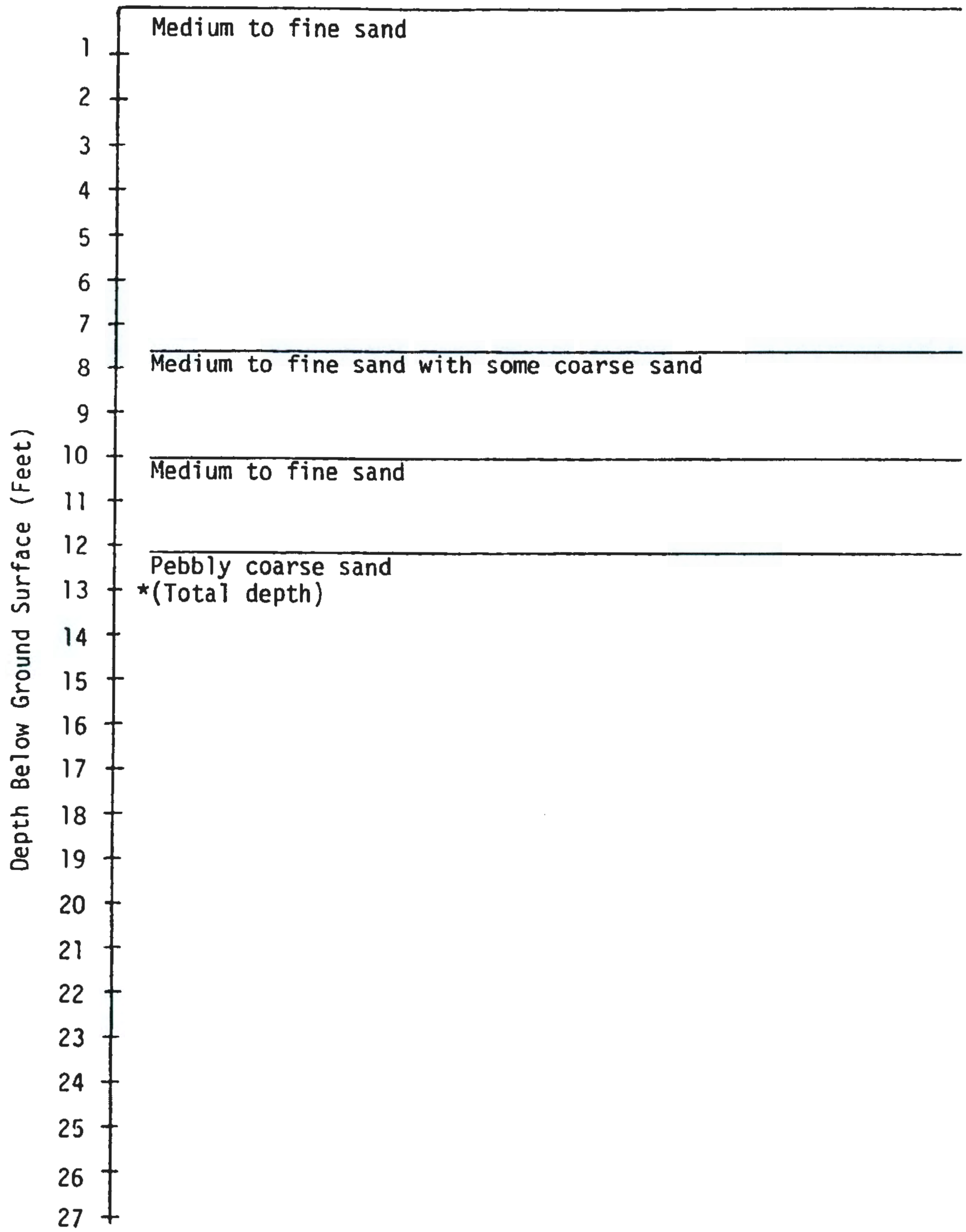


FIGURE 2-42. Borehole 299-W18-237 Summary Textural Log.

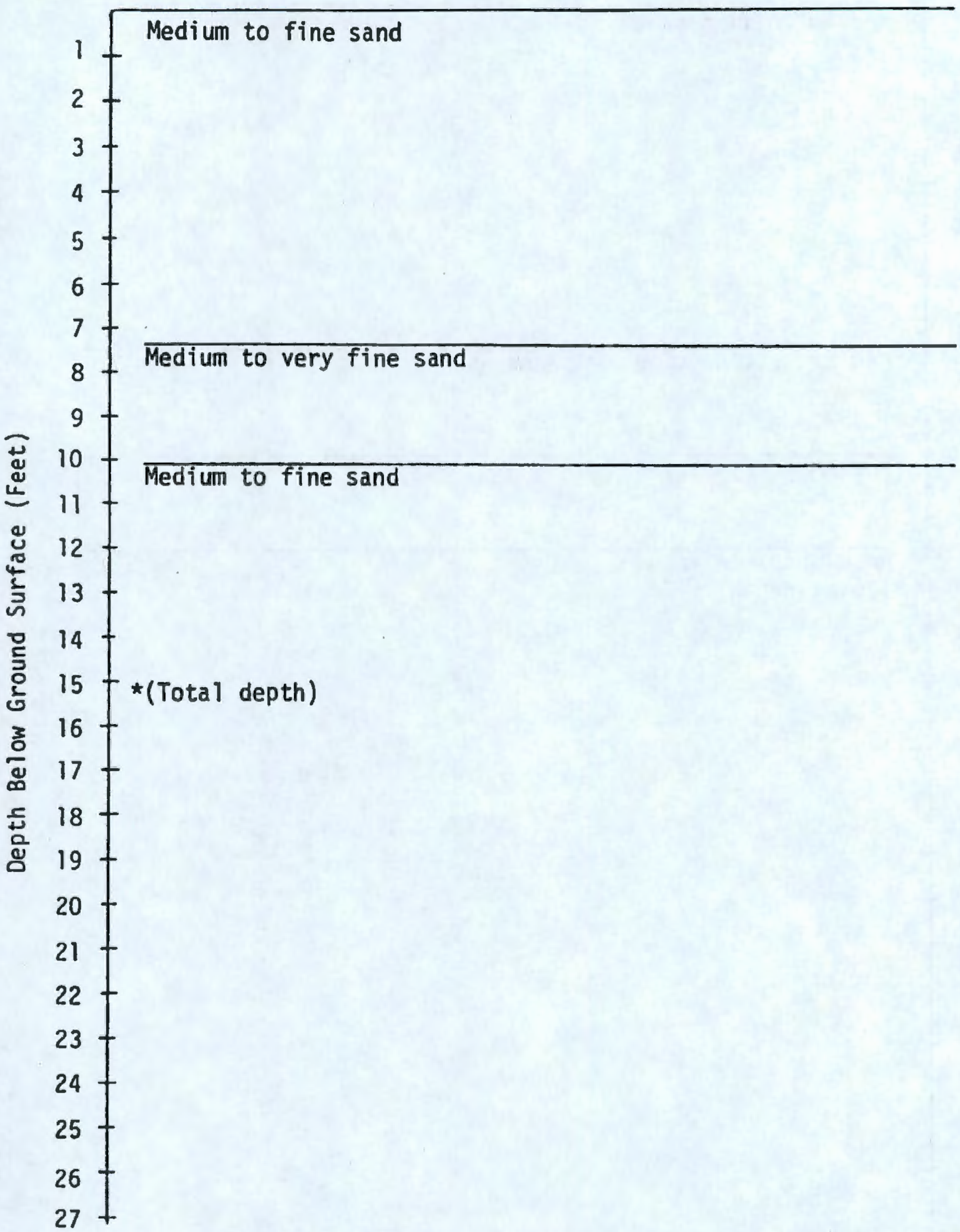


FIGURE 2-43. Borehole 299-W18-238 Summary Textural Log.

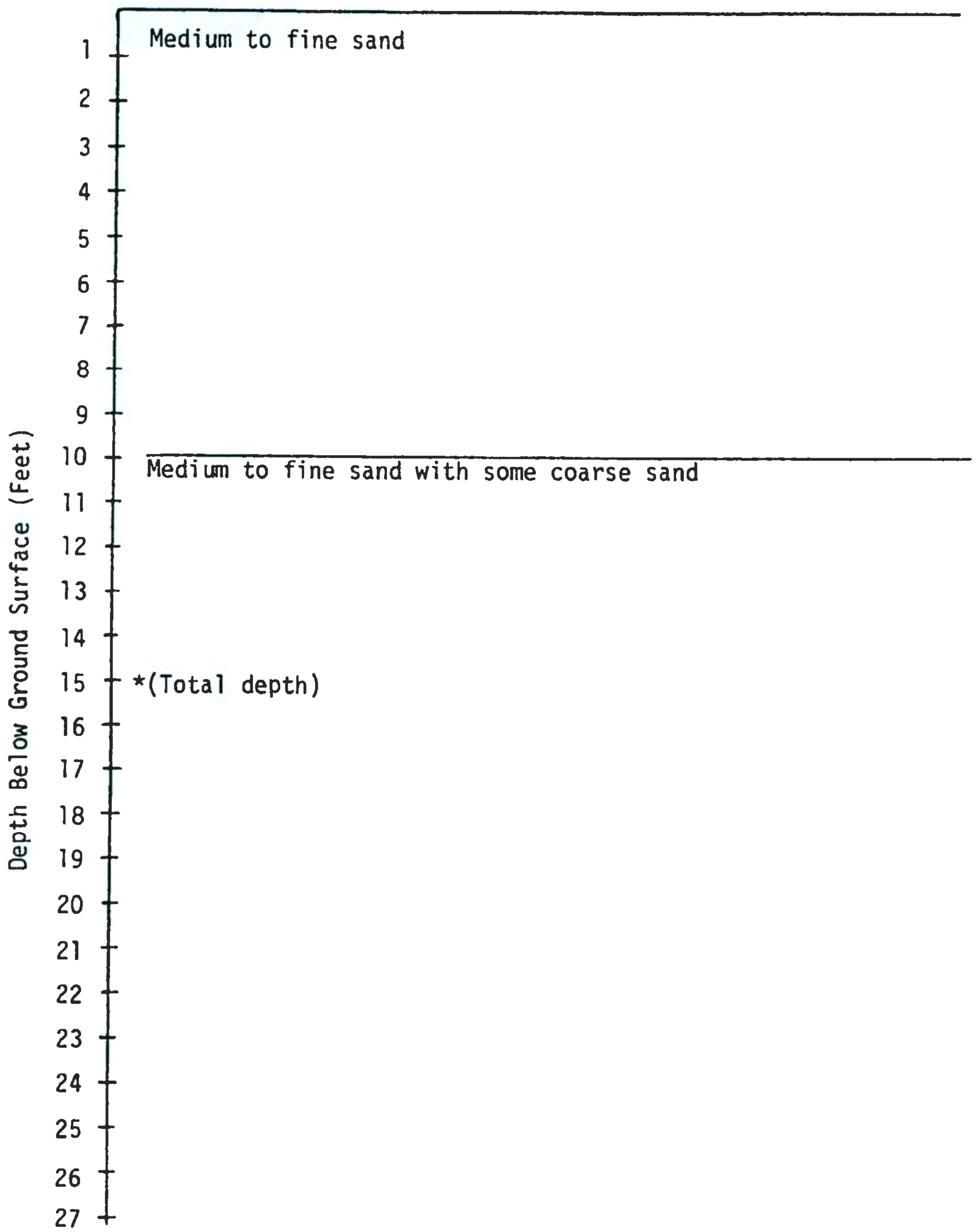


FIGURE 2-44. Borehole 299-W18-239 Summary Textural Log.

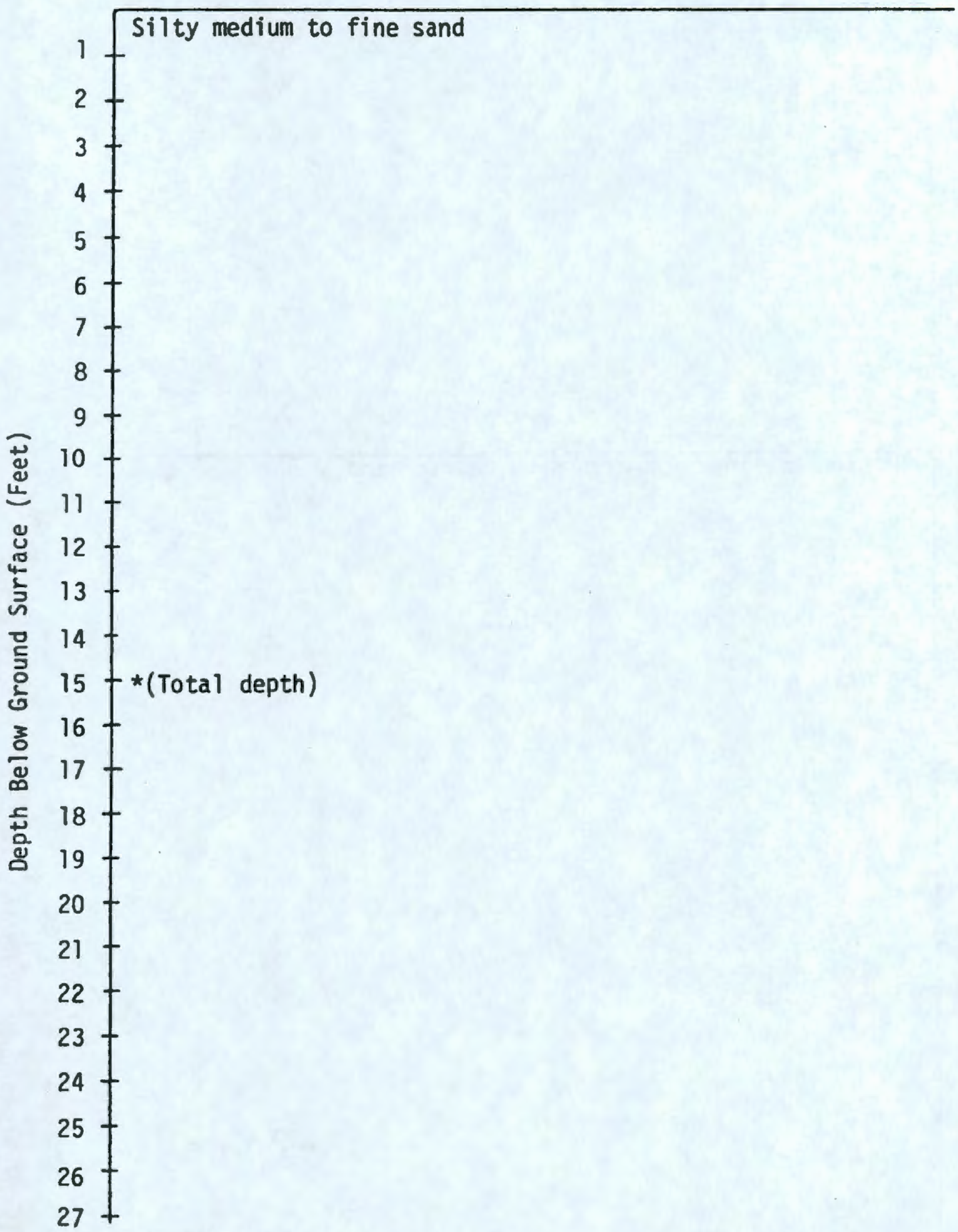


FIGURE 2-45. Borehole 299-W18-240 Summary Textural Log.

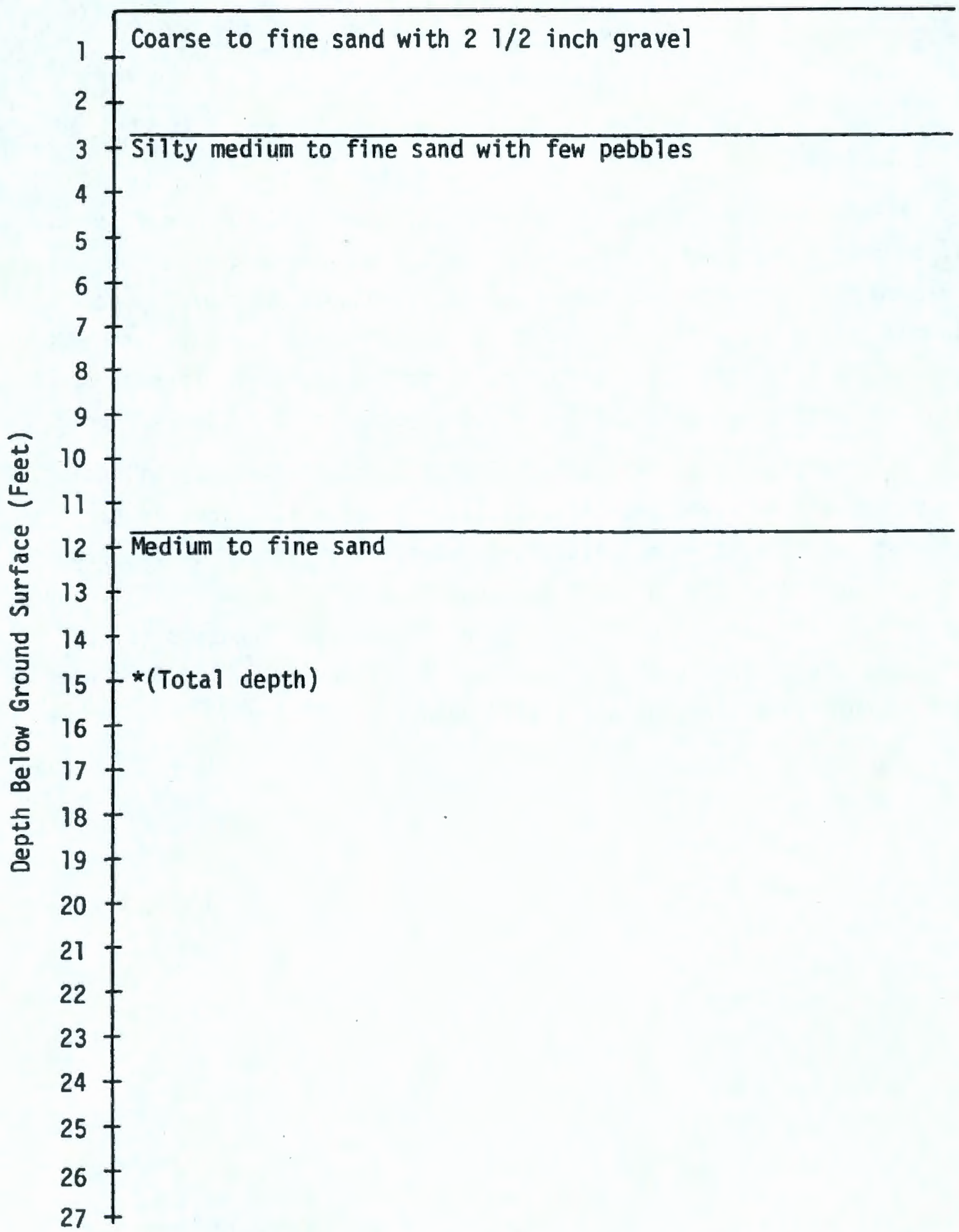


FIGURE 2-46. Borehole 299-W18-241 Summary Textural Log.

CHAPTER 3
SOIL MOISTURE INVESTIGATIONS
By D. E. Conover

216-Z-20 CRIB

A soil moisture investigation was conducted to determine if percolation into the ground of liquid waste effluent discharged to the 216-Z-20 crib might be impeded by subtle, shallow and laterally continuous geologic strata (e.g., silt lenses, calcrete horizons) immediately beneath the crib site. The study was performed utilizing boreholes along the active 216-Z-19 ditch located adjacent to the 216-Z-20 crib.

Soil moisture data was collected with Campbell Pacific Soil Moisture Probes (Models 501A and 503) in selected boreholes at 1-foot intervals. The counting time at each measurement point was 15 seconds. The probes were calibrated at the 200 East Area borehole calibration facility and two barrels of material containing 0 and 25.5% water contents (Figure 3-1). The locations of the boreholes are given in Figure 2-1. The boreholes used in this investigation are listed below:

- 299-W18-188
- 299-W18-189
- 299-W18-192
- 299-W18-193
- 299-W18-194
- 299-W18-196
- 299-W18-208
- 299-W18-210
- 299-W18-213
- 299-W18-218
- 299-W18-220.

Based on the soil moisture data collected from the 12 boreholes (Tables 3-1 through 3-11), it was determined that no anomalously high soil moisture has accumulated immediately beneath the 216-Z-19 ditch area. This evidence suggests that shallow geologic strata should not excessively impede downward infiltration of waste-water discharges to the 216-Z-20 crib.

231-Z TRANSFER LINE

Moisture conditions were assessed at the location where the storm sewer line was projected to cross the 231-Z transfer line. The investigation was conducted to determine if the 231-Z transfer line was leaking sufficiently to affect construction activities across the line. Waste effluent was known to be backed up the transfer line from high water levels in the 216-Z-19 ditch and that relatively lush, green vegetation suggested the waste line was leaking. The assessment consisted of visually inspecting sediment samples collected from 10 auger borings for anomously high moisture conditions that might affect construction activities and slope stability of the excavation.

The results of the inspection indicate higher than normal conditions in the immediate vicinity of the 231-Z transfer line, but not sufficiently high to adversely impact construction activities across the transfer line or maintaining side slopes of the excavation.

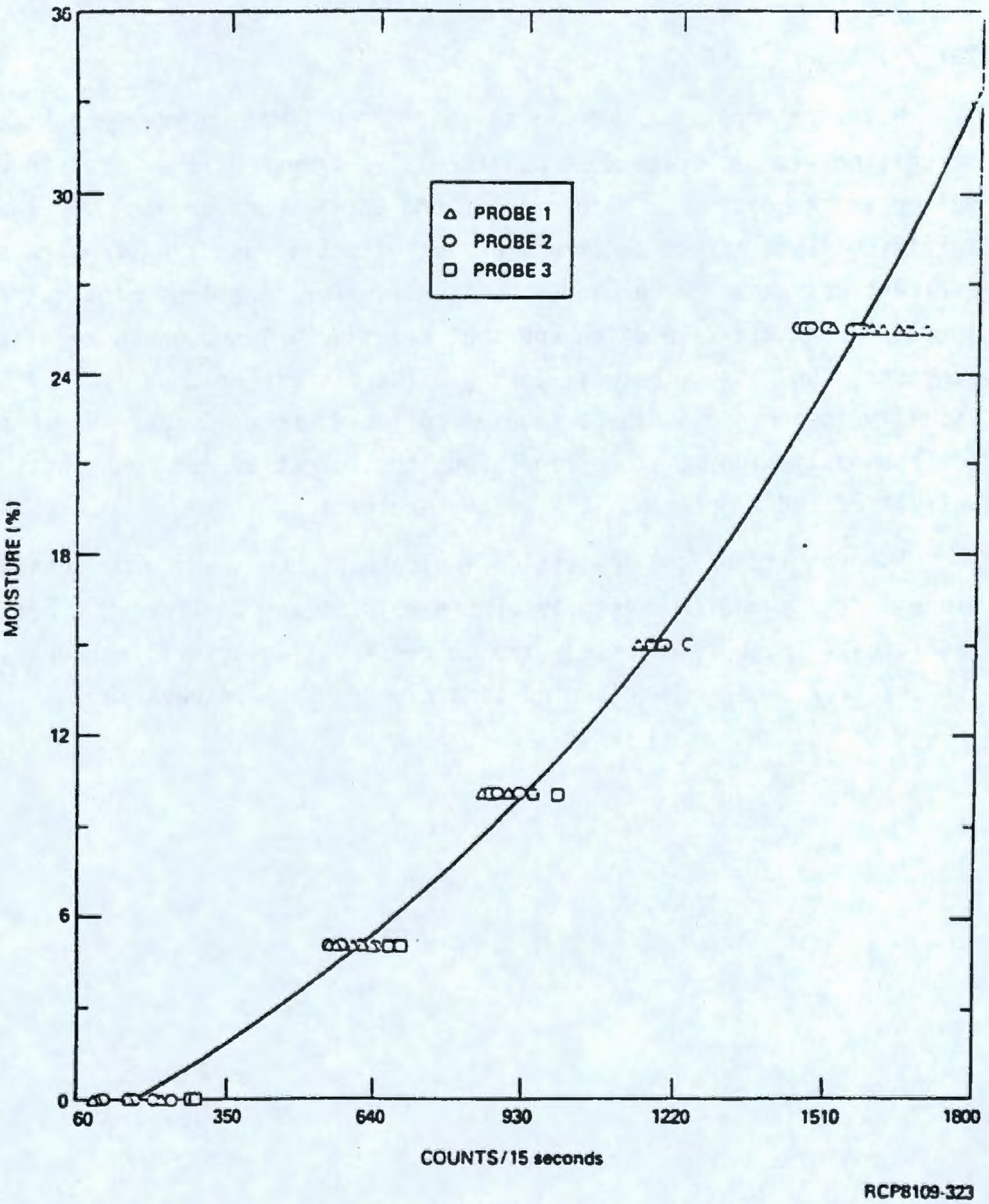


FIGURE 3-1. Neutron-Neutron Probe Calibration Curve.

TABLE 3-1. Soil Moisture Data
Borehole 299-W18-188
June 19, 1981.

Depth (ft)	Count Rate	Percent Moisture (Vol)
2	709	6.38
3	577	4.55
4	450	2.98
5	345	1.79
6	484	3.39
7	910	9.60
8	1296	17.73
9	972	10.72
10	774	7.36
11	769	7.28
12	772	7.33
13	1046	12.14
14	832	8.28
15	812	7.96
16	704	6.30
17	732	6.72
18	734	6.75
19	794	7.67
20	935	10.04

TABLE 3-2. Soil Moisture Data
Borehole 299-W18-189
June 19, 1981.

Depth (ft)	Count Rate	Percent Moisture (Vol)
2	822	8.12
3	818	8.05
4	718	6.51
5	578	4.57
6	606	4.94
7	643	5.44
8	578	4.57
9	605	4.92
10	545	4.14
11	694	6.16
12	818	8.05
13	838	8.38
14	707	6.35
15	584	4.65
16	616	5.07
17	637	5.36
18	723	6.58
19	808	7.89
20	865	8.83
21	924	9.85

TABLE 3-3. Soil Moisture Data
Borehole 299-W18-192
June 19, 1981.

Depth (ft)	Count Rate	Percent Moisture (Vol)
2	677	5.92
3	768	7.26
4	786	7.54
5	499	3.57
6	453	3.01
7	571	4.48
8	1307	18.00
9	1209	15.64
10	798	7.73
11	722	6.57
12	905	9.51
13	887	9.20
14	779	7.43
15	821	8.10
16	1086	12.95
17	1153	14.38
18	1219	15.87
19	1760	31.96
20	2351	59.49

TABLE 3-4. Soil Moisture Data
Borehole 299-W18-193
June 19, 1981.

Depth (ft)	Count Rate	Percent Moisture (Vol)
1	--	--
2	847	8.53
3	860	8.74
4	871	8.93
5	856	8.68
6	686	6.04
7	833	8.30
8	1187	15.14
9	1279	17.31
10	886	9.18
11	798	7.73
12	733	6.73
13	723	6.58
14	890	9.25
15	765	7.22
16	729	6.67
17	823	8.13
18	1104	13.33
19	1280	17.33
20	2021	42.66
21	2476	66.94

TABLE 3-5. Soil Moisture Data
Borehole 299-W18-194
June 19, 1981.

Depth (ft)	Count Rate	Percent Moisture (Vol)
2	920	9.78
3	889	9.24
4	606	4.94
5	582	4.62
6	586	4.67
7	598	4.83
8	800	7.76
9	1476	22.60
10	1517	23.81
11	1251	16.63
12	1378	19.85
13	1148	14.27
14	832	8.28
15	871	8.93
16	821	8.10
17	870	8.91
18	911	9.62
19	880	9.08
20	1112	13.50

TABLE 3-6. Soil Moisture Data
Borehole 299-W18-196
June 19, 1981.

Depth (ft)	Count Rate	Percent Moisture (Vol)
2	764	7.20
3	642	5.43
4	526	3.90
5	627	5.22
6	745	6.91
7	1023	11.69
8	1448	21.79
9	993	11.11
10	803	7.81
11	765	7.22
12	869	8.89

TABLE 3-7. Soil Moisture Data
Borehole 299-W18-208
June 22, 1981.

Depth (ft)	Count Rate	Percent Moisture (Vol)
2	487	3.42
3	815	8.00
4	892	9.29
5	815	8.00
6	726	6.63
7	797	7.72
8	799	7.75
9	824	8.15
10	1115	13.56
11	1738	31.15
12	1596	26.29
13	916	9.71
14	716	6.48
15	664	5.73
16	757	7.09
17	630	5.26
18	684	6.02
19	722	6.57
20	736	6.78
21	768	7.26
22	850	8.58

TABLE 3-8. Soil Moisture Data
Borehole 299-W18-210
June 22, 1981.

Depth (ft)	Count Rate	Percent Moisture (Vol)
2	603	4.90
3	799	7.75
4	840	8.41
5	881	9.10
6	976	10.80
7	1337	18.77
8	1238	16.32
9	1001	11.27
10	1007	11.38
11	986	10.98
12	1124	13.75
13	1079	12.81
14	1254	16.70
15	1271	17.11
16	854	8.64
17	660	5.68
18	692	6.13
19	615	5.06
20	659	5.66
21	655	5.61
22	843	8.46

TABLE 3-9. Soil Moisture Data
Borehole 299-W18-213
June 21, 1981.

Depth (ft)	Count Rate	Percent Moisture (Vol)
1	695	6.17
2	863	8.79
3	874	8.98
4	1026	11.75
5	1411	20.75
6	1124	13.75
7	952	10.35
8	995	11.15
9	816	8.02
10	874	8.98
11	753	7.03
12	937	10.08
13	1085	12.93
14	760	7.14
15	692	6.13
16	763	7.19
17	764	7.20
18	693	6.15
19	692	6.13
20	927	9.90
21	1528	24.15

TABLE 3-10. Soil Moisture Data
Borehole 299-W18-218
June 22, 1981.

Depth (ft)	Count Rate	Percent Moisture (Vol)
2	712	6.42
3	855	8.66
4	1212	15.71
5	1234	16.22
6	1124	13.75
7	828	8.21
8	1022	11.67
9	1026	11.75
10	1080	12.83
11	1219	15.87
12	1094	13.12
13	1072	12.67
14	848	8.54
15	1210	15.66
16	745	6.91
17	749	6.97
18	792	7.64
19	884	9.15
20	863	8.79
21	947	10.26
22	2505	68.76

TABLE 3-11. Soil Moisture Data
Borehole 299-W18-220
June 22, 1981.

Depth (ft)	Count Rate	Percent Moisture (Vol)
2	644	5.45
3	577	4.55
4	538	4.05
5	538	4.05
6	674	5.87
7	782	7.48
8	1027	11.77
9	1231	16.15
10	1431	21.31
11	941	10.15
12	817	8.04
13	716	6.48
14	857	8.69
15	764	7.20
16	722	6.57
17	789	7.59
18	709	6.38
19	748	6.96
20	1589	26.06
21	1500	23.30

CHAPTER 4
PERCOLATION TESTS

By J. B. Sisson

The 216-Z-20 crib and the storm sewer pond has been constructed to receive waste liquids from Z-Plant. An estimation of infiltration rates of the unsaturated sediments beneath these facilities was needed to support designing these waste disposal facilities. An acceptable method of estimating these rates is the infiltration-drainage test which consists of conducting a short-term, limited volume, infiltration test at the site.

Four infiltration tests were conducted at 500-foot intervals along the centerline of the 216-Z-20 crib site and one infiltration test at the storm sewer site (Figures 2-1 and 2-2). A 6-inch diameter borehole was installed to a depth of 20 feet at each test site to provide access for neutron probes. After the boreholes were installed, sediments surrounding the borehole casing were excavated with a backhoe to expose the sediments on which the facilities have been constructed. A circular infiltration basin of 15.7 square feet was formed around the borehole casing. Water was ponded to an approximate depth of 4 inches in the basins for at least 24 hours or sufficient time for the wetting front to move past the end of the borehole casing.

Water was supplied directly to percolation test sites 1 and 2 through a firehose, flowmeter and ball valve. The ball valve was used to regulate flow to maintain a constant water depth in the infiltration basins. Water for the remaining tests was hauled to the sites in 500 gallon vinyl bags. Water was obtained from the same hydrant for all tests and supplied through water meters and ball valves. The water meter data is given in Table 4-1.

Soil (neutron) moisture probes were used to measure changes in soil moisture in the sediments adjacent to the cased borehole as the result of infiltration from ponded water in the percolation pit. The neutron moisture probes used in the investigation were calibrated at the 200 East Area calibration facility. The calibration curve is given in

TABLE 4-1. Water Meter Readings for Percolation Tests Near Z-Plant.[a]

Test Site #1		Test Site #2		Test Site #3		Test Site #4		Test Site #5	
Time	Gal.	Time	Gal.	Time	Gal.	Time	Gal.	Time	Gal.
14:09	0	15:04	0	15:12	0	14:20	0	11:30	0
15:04	37	15:00	37	16:06	111	15:03	78	12:00	100
16:06	230	16:00	390	17:05	177	16:09	169	13:00	185
17:05	335	17:00	543	18:07	228	17:09	187	14:00	302
18:05	430	18:00	692	19:11	292	18:09	253	15:00	375
19:05	534	19:06	858	20:06	334	19:10	294	16:17	461
20:05	638	20:00	979	21:05	372	20:17	365	17:11	544
21:05	750	21:00	1151	22:05	429	21:11	394	18:10	611
22:05	864	22:00	2325	23:05	466	22:11	443	19:18	703
23:05	977	23:00	2467	24:06	527	23:10	501	20:38	804
24:04	1157	24:00	2614	25:02	561	24:10	544	22:04	911
02:02	1311	01:20	2815	02:00	594	01:00	591	00:16	1121
03:57	1525	02:10	2939	03:39	682	02:13	659	01:00	1158
05:03	1680	03:19	3015	04:37	725	04:10	712	02:00	1241
07:13	1975	04:34	3245	06:13	808	05:05	805	03:30	1338
09:07	2233	06:10	3500	07:15	862	07:42	900	05:00	1450
11:07	2544	07:02	3582	08:15	912	09:14	956	06:30	1641
13:14	2791	09:06	3926	10:21	1003	13:00	1142	10:00	1855
		11:21	4380	13:11	1130	13:19	1142	14:00	2155
		13:22	4558	15:06	1233			18:00	2461
				18:00	1418			21:57	2864
				21:01	1588			22:50	2864
				22:00	1661				
				00:27	1800				
				13:00	2530				
				13:25	2530				

[a]Test site locations given on Figures 2-1 and 2-2.

Figure 3-1. This curve was used to convert the neutron probe counts to soil moisture content. The soil moisture data obtained by the neutron probes are given in Tables 4-2 through 4-6.

The field data were analyzed by three methods. Each method and the resulting data are discussed below.

DATA ANALYSIS METHOD 1

Infiltration rates per unit area were estimated for each site by dividing steady state flow rates by the area of the infiltration basins. Flow rate data are given in Table 4-1. These results are given in Table 4-7. This method assumes that a steady state infiltration rate was established and that water entering the soil surface moves straight downward without spreading.

TABLE 4-7. Estimated Infiltration Rates for the 216-Z-20 Crib and Storm Sewer Pond.

Percolation Pit Number	Field Rate	Adjusted Rate
1	184	70
2	230	ND
3	84	ND
4	76	47
5	124	ND

NOTE: ND = not determined.

As an example calculation using data from borehole 299-W18-201 at times 16:00 and 13:22

$$i = Q/(A\ t) = (4558 - 390)/(15.7(21.4/24)) = 298\ \text{gal/ft}^2\text{-day}$$

where:

i = infiltration rate in gallons/ft^2-day

TABLE 4-2. Moisture Data, Percolation Test Site #1.

DEPTH (CM)	5/ 6 18:29	5/ 6 19: 0	5/ 6 19:30	5/ 6 20: 0	5/ 6 21: 0	5/ 6 22: C	5/ 6 23: 0	5/ 7 0:45	5/ 7 2: 5	5/ 7 4: 2	5/ 7 5:10	5/ 7 7:17
30.	.2635	.2511	.2724	.2641	.2868	.2650	.2647	.2888	.2848	.3080	.3123	.2901
60.	.2685	.3014	.2962	.2928	.3038	.0657	.2682	.3063	.3031	.3101	.3231	.3246
90.	.2585	.2466	.2676	.2775	.2616	.2638	.2647	.2628	.2536	.2635	.2834	.2821
120.	.2023	.2440	.2542	.2434	.2390	.2369	.2202	.2463	.2484	.2554	.2594	.2496
150.	.1560	.1670	.1629	.1589	.1542	.1527	.1480	.2052	.1934	.2086	.3216	.3028
180.	.0880	.1230	.1346	.1611	.1702	.1825	.1916	.2039	.1916	.2033	.1972	.1876
210.	.0664	.0895	.1069	.1043	.1368	.1366	.1370	.1432	.1415	.1310	.1374	.1328
240.	.0640	.0538	.0925	.0999	.1322	.1175	.1338	.1322	.1360	.1378	.1430	.1334
270.	.0569	.0531	.0633	.0872	.1153	.1185	.1228	.1332	.1263	.1232	.1209	.1334
300.	.0576	.0581	.0627	.0828	.1125	.1426	.1388	.1403	.1364	.1344	.1417	.1354
330.	.0682	.0707	.0675	.0719	.1238	.1609	.1626	.1782	.1491	.1615	.1624	.1622
360.	.0785	.0753	.0927	.0841	.1213	.2028	.1916	.2105	.1921	.1852	.1949	.1992

DEPTH (CM)	5/ 7 9: 0	5/ 7 11: 0	5/ 7 13:19	5/ 6 14: 0	5/ 6 14:27	5/ 6 14:58	5/ 6 15:28	5/ 6 16: 1	15/ 6 16:29	5/ 6 16:59	5/ 6 17:30	5/ 6 18: 0
30.	.2911	.3116	[illegible]	.0467	.1340	.2527	.2588	.2597	.2493	.2597	.2381	.2469
60.	.2935	.3290	.3209	.0594	.0582	.1879	.2451	.2560	.2851	.2795	.2932	.2785
90.	.2673	.2825	.2644	.1196	.1175	.1538	.2278	.2619	.2490	.2460	.2554	.2788
120.	.2469	.2320	.2202	.0796	.0578	.0848	.0791	.1089	.1966	.2360	.2404	.2384
150.	.2831	.2962	.3007	.0925	.0937	.0912	.0900	.0961	.0885	.0929	.1271	.1491
180.	.1871	.1974	.1844	.0667	.0827	.0736	.0719	.0651	.0750	.0843	.0672	[illegible]
210.	.1253	.1251	.1340	.0563	.0575	.0637	.0603	.0631	.0646	.0622	.0573	[illegible]
240.	.1314	.1324	.1326	.0594	.0613	.0588	.0579	.0587	.0554	.0666	.0578	.0581
270.	.1271	.1267	.1232	.0587	.0595	.0560	.0587	.0612	.0603	.0651	.0550	.0551
300.	.1292	.1370	.1465	.0661	.0604	.0664	.0649	.0664	.0609	.0663	.0645	.0628
330.	.1702	.1656	.1667	.0753	.0645	.0727	.0648	.0713	.0698	.0727	.0685	[illegible]
360.	.2156	.2156	.2208	.0801	.0793	.0866	.0862	.0864	.0835	.0920	.0877	.0912

TABLE 4-3. Moisture Data, Percolation Test Site #2.

DEPTH (CM)	5/ 7 13:48	5/ 7 14:10	5/ 7 14:24	5/ 7 14:32	5/ 7 14:45	5/ 7 15: 0	5/ 7 15:30	5/ 7 17:90	5/ 7 16:30	5/ 7 18: 0	5/ 7 19: 6	5/ 5 20: 0	5/ 7 21: 0	5/ 7 22: 0
30.	.0451	.1997	.3338	.3644	.3246	.3612	.3549	.3271	.3502	.3612	.0841	.3741	.3588	.3696
60.	.0551	.0681	.0862	.1298	.2428	.2701	.2898	.2911	.2993	.2935	.3133	.2986	.2962	.3141
90.	.0625	.0556	.0575	.0572	.0678	.0779	.2932	.3195	.3166	.3346	.3151	.3406	.3290	.3198
120.	.0732	.0692	.0710	.0733	.0738	.0735	.0904	.1849	.3144	.2990	.3264	.3471	.3545	.3410
150.	.0844	.0869	.0934	.0812	.0857	.0825	.0949	.0822	.1257	.3425	.3260	.3414	.3414	.3502
180.	.0681	.0687	.0684	.0615	.0672	.0660	.0719	.0672	.0692	.2445	.2775	.2901	.3028	.2854
210.	.0458	.0445	.0538	.0481	.0507	.0481	.0502	.0454	.0488	.0518	.1491	.1803	.1813	.2369
240.	.0779	.0735	.0794	.0707	.0774	.0688	.0707	.0780	.0749	.0812	.0750	.1352	.2340	.3191
270.	.1032	.1100	.1050	.1058	.1085	.1062	.1009	.1125	.1076	.1109	.1102	.1027	.1463	.2413
300.	.1209	.1093	.1173	.1046	.1100	.1185	.1125	.1162	.1109	.1181	.1129	.1244	.1144	.1200
330.	.1046	.0994	.1096	.1034	.1025	.1004	.1025	.1131	.1066	.1080	.1071	.1082	.0968	.0995
360.	.0961	.1021	.1085	.1067	.1028	.0890	.1028	.1021	.0915	.1055	.1032	.0835	.0966	.1051

DEPTH (CM)	5/ 7 23: 0	5/ 8 0: 0	5/ 8 1:24	5/ 8 2:12	5/ 8 3:24	5/ 8 4:23	5/ 8 5:56	5/ 8 7: 3	5/ 8 7:58	5/ 8 8:59	5/ 8 9:54	5/ 8 11:22	5/ 8 13:15
30.	.3745	.3242	.3592	.3676	.3391	.3312	.3498	.3479	.3402	.3620	.3323	.3612	.3448
60.	.2979	.3073	.3038	.3130	.3123	.3123	.3268	.3275	.2962	.3028	.3087	.3126	.3066
90.	.3537	.3101	.3159	.3209	.3094	.3398	.3346	.3198	.3331	.3564	.3173	.3297	.3440
120.	.3580	.3433	.3387	.3429	.3537	.3391	.3561	.3417	.3475	.3231	.3398	.3514	.3479
150.	.3572	.3557	.3620	.3676	.3741	.3728	.3769	.3414	.3692	.3692	.3417	.3576	.3376
180.	.3191	.3105	.3162	.3087	.3268	.0725	.3098	.3180	.3080	.3494	.2997	.3084	.3098
210.	.2585	.2508	.2588	.2811	.3080	.0758	.3376	.3372	.3398	.3316	.3087	.3576	.3620
240.	.3066	.3112	.3471	.3533	.3452	.3564	.3564	.3652	.3616	.3553	.3066	.3440	.3353
270.	.2478	.2524	.2576	.2701	.2698	.2496	.2679	.2638	.2560	.2727	.2569	.2466	.2505
300.	.1527	.2121	.2323	.2496	.2398	.2443	.2521	.2475	.2434	.2448	.2261	.2375	.2481
330.	.1032	.0894	.1342	.1767	.2451	.2472	.2295	.2233	.2300	.2457	.2369	.2346	.2610
360.	.0930	.1037	.1093	.1028	.1006	.1421	.2099	.2407	.2410	.2134	.2358	.2448	.2521

TABLE 4-4. Moisture Data, Percolation Test Site #3.

DEPTH (CM)	5/ 7 14:45	5/ 7 15:20	5/ 7 15:30	5/ 7 15:46	5/ 7 16: 0	5/ 7 16:30	5/ 7 17: 0	5/ 7 18: 0	5/ 7 19: 6	5/ 7 20: 0	5/ 7 21: 0	5/ 7 22: 0	5/ 7 23: 0	5/ 7 24: 0	5/ 8 1: 7	5/ 8 2: 0	5/ 8 3:39	5/ 8 4:38	5/ 8 6:15	5/ 8 7:16	5/ 8 8:15	5/ 8 9: 9	5/ 8 10:15	5/ 8 11: 7	5/ 8 13:13	5/ 8 14:22	5/ 8 15: 7
30.	.0169	.0408	.0713	.1318	.1440	.1549	.1519	.1638	.1725	.1624	.1744	.1584	.1506	.1602	.1674	.1626	.1551	.1613	.1681	.1681	.1679	.1597	.1584	.1564	.1663	.1647	.1624
60.	.0291	.0258	.0248	.0263	.0363	.0560	.0964	.1547	.1620	.1547	.1718	.1645	.1521	.1478	.1635	.1591	.1638	.1656	.1676	.1688	.1534	.1571	.1595	.1709	.1624	.1609	.1647
90.	.0251	.0267	.0297	.0304	.0246	.0248	.0276	.0387	.0682	.0830	.0909	.1000	.1091	.0981	.1221	.1228	.1162	.1192	.1202	.1153	.1211	.1162	.1234	.1162	.1205	.1213	.1255
120.	.0254	.0242	.0215	.0261	.0276	.0201	.0225	.0235	.0221	.0266	.0242	.0321	.0509	.0968	.1348	.1348	.1308	.1304	.1244	.1399	.1382	.1374	.1352	.1380	.1222	.1320	.1413
150.	.0304	.0323	.0267	.0288	.0282	.0276	.0318	.0271	.0316	.0266	.0276	.0318	.0312	.0471	.1094	.1160	.1207	.1162	.3160	.1131	.1162	.1275	.1209	.1175	.1144	.1173	.1247
180.	.0408	.0388	.0410	.0332	.0390	.0396	.0348	.0330	.0402	.0369	.0373	.0359	.0356	.0327	.0391	.0527	.0791	.0912	.0964	.0869	.0917	.0932	.0964	.0925	.0942	.0892	.0866
210.	.0284	.0212	.0263	.0303	.0259	.0243	.0291	.0242	.0297	.0288	.0250	.0225	.0259	.0281	.0306	.0232	.0307	.0507	.0616	.0672	.0639	.0648	.0543	.0573	.0607	.0565	.0570
240.	.0119	.0091	.0079	.0100	.0092	.0107	.0072	.0070	.0063	.0062	.0096	.0076	.0106	.0111	.0099	.0115	.0094	.0087	.0202	.0190	.0180	.0250	.0205	.0265	.0221	.0274	.0301
270.	.0118	.0118	.0087	.0115	.0130	.0143	.0119	.0071	.0123	.0125	.0145	.0119	.0130	.0110	.0153	.0169	.0174	.0194	.0258	.0325	.0303	.0330	.0359	.0362	.0383	.0371	.0321
300.	.0212	.0181	.0213	.0198	.0224	.0213	.0224	.0197	.0223	.0262	.0212	.0201	.0217	.0285	.0182	.0215	.0220	.0297	.0358	.0352	.0352	.0392	.0394	.0399	.0474	.0423	.0431
330.	.0200	.0180	.0188	.0212	.0212	.0181	.0153	.0184	.0227	.0227	.0231	.0181	.0159	.0194	.0208	.0196	.0197	.0201	.0201	.0254	.0213	.0273	.0388	.0352	.0429	.0426	.0433
360.	.0223	.0158	.0238	.0200	.0196	.0225	.0200	.0211	.0197	.0225	.0182	.0188	.0212	.0192	.0204	.0186	.0223	.0212	.0217	.0196	.0190	.0178	.0238	.0238	.0289	.0314	.0378

DEPTH (CM)	5/ 8 16: 4	5/ 8 17: 2	5/ 8 18: 2	5/ 8 19: 2	5/ 8 20: 9	5/ 8 21: 1	5/ 8 22: 1	5/ 8 23: 1	5/ 9 0:20	5/ 9 0:57	5/ 9 2: 1	5/ 9 4:14	5/ 9 5:32	5/ 9 7:47	5/ 9 9: 7	5/ 9 11: 7	5/ 9 13: 0
30.	.1558	.1577	.1649	.1611	.1672	.1577	.1635	.1595	.1656	.1584	.1606	.1553	.1626	.1629	.1611	.1676	.1683
60.	.1690	.1635	.1571	.1604	.1597	.1647	.1734	.1618	.1600	.1667	.1779	.1615	.1577	.1695	.1506	.1584	.1716
90.	.1290	.1192	.1240	.1290	.1185	.1177	.1226	.1217	.1196	.1275	.1205	.1215	.1200	.1288	.1278	.1280	.1249
120.	.1390	.1376	.1393	.1405	.1356	.1372	.1419	.1395	.1453	.1405	.1304	.1442	.1390	.1320	.1310	.1457	.1296
150.	.1238	.1247	.1209	.1173	.1236	.1232	.1183	.1213	.1209	.1203	.1175	.1123	.1170	.1186	.1173	.1247	.1228
180.	.0935	.0969	.0907	.0919	.0932	.0959	.0917	.0961	.0889	.0937	.0952	.0976	.0859	.0884	.0905	.0951	.0952
210.	.0584	.0606	.0636	.0560	.0559	.0607	.0601	.0592	.0663	.0594	.0657	.0636	.0595	.0606	.0541	.0640	.0640
240.	.0314	.0276	.0304	.0321	.0316	.0343	.0338	.0330	.0343	.0354	.0318	.0323	.0330	.0373	.0415	.0344	.0355
270.	.0366	.0345	.0340	.0348	.0359	.0354	.0371	.0403	.0475	.0479	.0406	.0515	.0511	.0479	.0478	.0455	.0495
300.	.0461	.0424	.0433	.0413	.0474	.0474	.0470	.0481	.0436	.0481	.0557	.0494	.0518	.0497	.0547	.0573	.0535
330.	.0434	.0381	.0423	.0441	.0475	.0437	.0467	.0478	.0533	.0462	.0491	.0471	.0502	.0468	.0457	.0491	.0507
360.	.0365	.0398	.0399	.0391	.0409	.0395	.0416	.0402	.0461	.0448	.0484	.0450	.0447	.0433	.0444	.0501	.0522

TABLE 4-5. Moisture Data, Percolation Test Site #4.

DEPTH (CM)	5/ 8 13:57	5/ 8 14:30	5/ 8 14:40	5/ 8 14:50	5/ 8 15: 4	5/ 8 15:30	5/ 8 16: 0	5/ 8 16:32	5/ 8 17: 0	5/ 8 18: 0	5/ 8 19: 1	5/ 8 20: 5	5/ 8 21: 0	5/ 8 22: 0	5/ 8 23: 0	5/ 9 0: 0	5/ 9 1: 0	5/ 9 2: 2	5/ 9 4: 1	5/ 9 5:43	5/ 9 7:31	5/ 9 9: 8	5/ 9 11: 0	5/ 9 13: 1
30.	.0444	.0679	.1112	.1506	.2339	.3155	.3402	.3517	.3541	.3514	.3510	.3452	.3357	.3696	.3533	.3444	.3391	.3253	.3231	.3383	.3557	.3475	.3475	.3514
60.	.0430	.0445	.0427	.0434	.0453	.0544	.0968	.1399	.1881	.2169	.2161	.2153	.2178	.2172	.2211	.2363	.2289	.2422	.2194	.2346	.2329	.2054	.2047	.2075
90.	.0352	.0447	.0426	.0462	.0447	.0457	.0464	.0499	.0464	.0569	.0783	.1084	.1306	.1553	.1642	.1777	.1886	.1770	.1969	.1794	.2039	.2020	.1906	.2110
120.	.0494	.0489	.0509	.0471	.0522	.0546	.0528	.0543	.0498	.0458	.0484	.0482	.0846	.1551	.2186	.2197	.2585	.2548	.2622	.2524	.2831	.2762	.2894	.2775
150.	.0559	.0497	.0589	.0509	.0548	.0587	.0548	.0517	.0547	.0509	.0538	.0559	.0512	.3127	.2249	.2666	.2884	.3024	.3021	.3098	.3077	.2908	.2945	.3066
180.	.0533	.0489	.0475	.0489	.0511	.0517	.0530	.0507	.0488	.0515	.0512	.0540	.0472	.0489	.1224	.2841	.2874	.2901	.2908	.2679	.2795	.3066	.2908	.2795
210.	.0551	.0533	.0505	.0515	.0501	.0507	.0512	.0543	.0477	.0508	.0541	.0514	.0492	.0478	.0551	.1109	.2650	.2711	.2756	.2888	.2743	.2782	.2868	.2717
240.	.0533	.0520	.0572	.0514	.0550	.0550	.0528	.0551	.0572	.0582	.0537	.0507	.0524	.0584	.0531	.0566	.0895	.2110	.2594	.2585	.2369	.2392	.2422	.2650
270.	.0465	.0565	.0527	.0550	.0531	.0585	.0533	.0544	.0502	.0595	.0601	.0567	.0548	.0563	.0505	.0546	.0548	.1129	.2191	.2317	.2340	.2404	.2390	.2337
300.	.0511	.0492	.0497	.0548	.0515	.0548	.0488	.0512	.0554	.0521	.0475	.0554	.0485	.0557	.0491	.0567	.0553	.0915	.1534	.1827	.1866	.1974	.1859	.2020
330.	.0570	.0518	.0556	.0559	.0524	.0575	.0502	.0544	.0551	.0521	.0573	.0512	.0551	.0582	.0547	.0495	.0474	.0690	.1510	.1732	.1881	.1690	.1777	.1774
360.	.0716	.0618	.0679	.0663	.0681	.0646	.0603	.0681	.0704	.0713	.0642	.0643	.0715	.0688	.0634	.0679	.0749	.0640	.1770	.1977	.1972	.2073	.2145	.2015
390.	.0445	.0482	.0518	.0453	.0448	.0458	.0431	.0474	.0453	.0484	.0402	.0524	.0448	.0517	.0562	.0505	.0455	.0468	.0924	.1516	.1589	.1727	.1827	.1826
420.	.0546	.0527	.0546	.0556	.0585	.0562	.0538	.0624	.0576	.0541	.0562	.0535	.0530	.0581	.0607	.0578	.0514	.0548	.0624	.1690	.2121	.2180	.2238	.2309

TABLE 4-6. Moisture Data, Percolation Test Site #5.

EPTH (CM)	5/11 11:23	5/11 11:45	5/11 12: 0	5/11 12:30	5/11 13: 0	5/11 14: 0	5/11 14:50	5/11 16: 8	5/11 17: 0	5/11 18: 0	5/11 19: 0	5/11 20:26	5/11 22: 0	5/12 0: 4	5/12 1: 0	5/12 2: 0	5/12 3:30	5/12 5: 0	5/12 6:30	5/12 8: 0	5/12 10: 0	5/12 11:45	5/14 14: 0	5/12 15:45	5/12 18: 0	5/12 20: 0	5/12 21: 0
30.	.0613	.1134	.1808	.2921	.2881	.2874	.3123	.3112	.3035	.2969	.3130	.2949	.2795	.3238	.2894	.3297	.3123	.3004	.3112	.3028	.3014	.2868	.3070	.3028	.3290	.3126	.3323
60.	.0872	.0800	.0932	.1084	.1580	.3059	.2874	.2759	.3137	.3195	.3297	.3035	.3308	.3187	.3316	.3282	.3286	.3533	.3545	.3286	.3308	.3126	.3349	.3433	.3205	.3433	.3209
90.	.1209	.1057	.1158	.1162	.1096	.1553	.2028	.2821	.2901	.2938	.3084	.2881	.2993	.3042	.3066	.3105	.3066	.3227	.3246	.3253	.3130	.3077	.3195	.2871	.3177	.3353	.3024
120.	.0887	.0930	.0915	.0904	.0992	.0924	.0995	.0975	.1461	.2224	.2454	.2569	.2679	.2736	.2733	.2650	.2616	.2607	.2673	.2756	.2600	.2603	.2654	.2746	.2795	.2772	.2711
150.	.0460	.0499	.0494	.0509	.0475	.0514	.0562	.0502	.0444	.0538	.0594	.1158	.1459	.1516	.1378	.1467	.1352	.1384	.1397	.1409	.1476	.1589	.1459	.1493	.1660	.1584	.1415
180.	.0311	.0301	.0327	.0278	.0286	.0281	.0270	.0271	.0318	.0285	.0163	.0318	.0507	.0772	.0838	.0779	.0895	.0815	.0867	.0843	.0869	.0785	.0823	.0874	.0764	.0848	.0892
210.	.0236	.0303	.0261	.0285	.0259	.0292	.0261	.0307	.0267	.0310	.0308	.0274	.0315	.0485	.0636	.0814	.0884	.0812	.0875	.0867	.1002	.0964	.0909	.0975	.0909	.0681	.0929
240.	.0336	.0312	.0269	.0297	.0380	.0380	.0394	.0310	.0358	.0358	.0351	.0376	.0366	.0359	.0395	.0492	.0804	.0981	.1039	.1170	.1093	.1082	.1112	.1053	.1138	.1181	.1007
270.	.0353	.0403	.0322	.0330	.0336	.0366	.0351	.0344	.0355	.0334	.0352	.0356	.0340	.0325	.0318	.0354	.0373	.0413	.0782	.1064	.1213	.1245	.1292	.1261	.1328	.1338	.1386
300.	.0424	.0465	.0462	.0517	.0427	.0497	.0437	.0487	.0475	.0484	.0437	.0485	.0455	.0470	.0410	.0447	.0448	.0474	.0491	.1298	.2252	.2191	.2283	.2340	.2278	.2407	.2249
330.	.0531	.0507	.0524	.0546	.0443	.0504	.0538	.0436	.0546	.0508	.0405	.0522	.0540	.0525	.0547	.0492	.0520	.0544	.0566	.0612	.2536	.2782	.2785	.3052	.2682	.2740	.3004
360.	.0494	.0556	.0489	.0507	.0517	.0559	.0474	.0538	.0541	.0520	.0457	.0579	.0472	.0511	.0478	.0528	.0465	.0471	.0560	.0447	.1384	.1808	.1934	.2140	.2097	.1984	.2015
390.	.0844	.0814	.0838	.0817	.0831	.0779	.0775	.0746	.0856	.0804	.0787	.0810	.0779	.0838	.0872	.0885	.0758	.0835	.0782	.0787	.0866	.1939	.1951	.2191	.2054	.2363	.2247
420.	.0592	.0520	.0495	.0570	.0582	.0578	.0578	.0522	.0565	.0548	.0595	.0591	.0624	.0487	.0541	.0562	.0520	.0494	.0541	.0527	.0594	.0615	.0591	.0827	.1122	.1519	.1417
450.	.1249	.1116	.1300	.1320	.1232	.1267	.1376	.1328	.1346	.1308	.1320	.1461	.1251	.1356	.1453	.1324	.1372	.1469	.1457	.1556	.1421	.1476	.1348	.1324	.1532	.1495	.1827
480.	.1286	.1340	.1271	.1320	.1296	.1401	.1267	.1308	.1352	.1213	.1302	.1277	.1251	.1234	.1314	.1107	.1253	.1202	.1222	.1166	.1364	.1198	.1188	.1192	.1209	.1372	.1265
510.	.1798	.1774	.1924	.1913	.1763	.1782	.1822	.1741	.1737	.1741	.1815	.1725	.1716	.1624	.1839	.1803	.1908	.1876	.1859	.1941	.1854	.1911	.1977	.1813	.1822	.1806	.1667

Q = gallons

A = area of basin in ft^2

t = time in days (hours/24).

DATA ANALYSIS METHOD 2

The equation for predicting the one-dimensional flow of water in porous materials is

$$\frac{\partial\Theta}{\partial t} = \frac{\partial}{\partial z}\left(K\frac{\partial H}{\partial z}\right) \qquad (1)$$

where:

$\Theta = \Theta(z,t)$ is the volumetric moisture content

t = time

z = depth (positive downward)

$K = K(\Theta)$ is the hydraulic conductivity

$H = H(\Theta,z) = h(\Theta)-z$; i.e., H(hydraulic head) = h(pressure head) - z(gravitational head).

Pressure head has been referred to as capillary pressure. In coarse-textured materials such as the sands and gravels occuring at the 216-Z-20 site and the storm sewer pond where the gradient in capillary pressure approaches zero and the gradient in total head approaches -1. When a unit gradient in the total head H is assumed, $\partial H/\partial z = -1$, Equation 1 becomes

$$\frac{\partial\Theta}{\partial t} = -\frac{\partial K}{\partial z} = -\frac{dK}{d\Theta}\frac{\partial\Theta}{\partial z} \qquad (2)$$

Equation 2 has been solved for a number of $K(\Theta)$ relationships in current use by Sisson, et al. (1980)*, and for a layered soil by Sisson and Gibbs (1979)**. The solution for a layered system is similar to that for a uniform system and the layered soils can be treated as uniform layers. The uniform case being applied to each layer.

*Sisson, et al., 1980, "Simple Method for Estimating Drainage from Field Plots", Soil Science Society of America Journal, 44:1147-1152.

**Sisson, J. B. and A. G. Gibbs, 1979, "Application of Hydraulic Conductivity Scaling to Infiltration-Drainage Field Tests", RHO-SA-121, Rockwell Hanford Operations, Richland, Washington.

The solution to Equation 3 is

$$\theta(z,t) = \begin{cases} \Theta_m & 0<z<(K_m-K_o)t/(\Theta_m-\Theta_o) \\ \Theta_o & \text{otherwise} \end{cases} \tag{3}$$

where:

Θ_o = the initial moisture content

K_o = the initial hydraulic conductivity

m = (subscript m) refers to saturated values.

The maximum depth of saturated soil in a uniform system is

$$Z_f = \frac{\{K_m-K_o\}}{\{\Theta_m-\Theta_o\}} t_f \simeq K_m t_f/(\Theta_m-\Theta_o) \tag{4}$$

Solving Equation 4 for K_m yields

$$K_m = (\Theta_m-\Theta_o)\ Z_f/t_f \tag{5}$$

where:

f = (subscript f) refers to the wetting front.

For layered systems Equation 5 can be modified to allow estimation of K_m for each layer or

$$K_i = (\Theta_m-\Theta_o)_i \Delta Z_i/\Delta t_i \tag{6}$$

where:

Subscript = denotes values for the i^{th} layer

ΔZ_i = thickness of the layer

Δt_i = the time required for the wetting front to cross the layer.

The result of using Equation 6 to estimate K_i (q_i when a unit gradient prevails) at the Percolation Test Site #1 are in Table 4-8 along with

TABLE 4-8. Computation Steps for Percolation Test Site #2.

Depth (cm)	θ_o	θ_m	$\Delta\theta$	t_i (min)	ν_i (cm/min)	q_i (cm/min)	A_i	r_i	A"	K_i (cm/min)
30	.0451	.3502	.3051	6.0	6.00	1.83	.36	.6	1.2	1.2
60	.0551	.3067	.2516	28.6	1.33	0.33	1.97	1.4	2.8	0.92
90	.0582	.3272	.2690	69.2	0.74	0.20	3.25	1.8	3.6	0.72
120	.0723	.3442	.2719	120	0.59	0.16	4.06	2.0	4.0	0.64
150	.0864	.3554	.2690	150	1.00	0.27	2.41	1.6	3.2	0.86
180	.0676	.3107	.2431	200	0.60	0.15	4.33	2.1	4.2	0.63
210	.0484	.3116	.2632	356	0.16	0.043	15.12	3.9	7.8	0.34
240	.0746	.3402	.2656	358	0.38	0.10	6.50	2.6	5.2	0.52
270	.1066	.2574	.1508	443	0.35	0.053	12.26	3.5	7.0	0.37
300	.1134	.2423	.1289	536	0.32	0.078	8.33	2.9	5.8	0.45
330	.1047	.2392	.1345	728	0.16	0.021	30.95	5.6	10.2	0.21
360	.1002	.2340	.1338	857	0.23	0.054	12.04	3.5	7.0	0.38

the data used in the analysis. The differences existing between the various depths and between these results and Method 1 are believed to be the result of water spreading on less permeable soil layers. The least permeable layer is easily identified at each site.

DATA ANALYSIS METHOD 3

In Method 2 the soil water flux and the hydraulic conductivity are equivalent by the assumption of a unit gradient in pressure head. The equivalence will prevail here and will be used to convert a circular wetting geometry to a long linear shape. This geometric conversion can be carried out as follows:

Step 1: From the data in Table 4-8 calculate an apparent wetted area for each layer of soil from mass conservative principles:

$$q_i A_i = q_o A_o$$

where

Ai = the apparent wetted area through which flow takes place

q_o = the soil water flux

A_o = wetted area at the surface.

Table 4-8 contains all the data and results of these computations.

In Table 4-8 it should be noted that A_i is assumed to be circular in shape, and thus knowing A_i, one can compute a radius r_i for the circle. When a long linear area is to be wetted a safe assumption would be that the wetted area can be no wider than r_i at a depth. Otherwise the pressure gradients would be substantially different than with a small plot used here. If the gradients are different then it would not be possible to "scale up" small plots to a large crib by a simple method. Using an 0.65 cm/min (230 gal/ft^2-day) infiltration rate, a reduced infiltration rate was computed (Table 4-8). The lowest value of reduced infiltration rate was used as the minimum and hence the estimated value for the actual crib. These computations were done only for the sites with the highest and lowest infiltration rates, at boreholes 299-W18-201 and 299-W18-204, respectively. The adjusted field rates were calculated to be 47 to 70 gal/ft^2-day for Percolation Test Sites #1 and #4, respectively (Table 4-6).

CHAPTER 5
RADIOLOGICAL INVESTIGATIONS
By W. F. Nicaise and G. V. Last

IN-FIELD ANALYSES

216-Z-19 Ditch

Radiological measurements of borehole sediment samples from the 216-Z-19 ditch area were made to determine if waste discharges to the ditch spread laterally beneath the 216-Z-20 crib area. The sediment samples were analyzed for plutonium and americium content using the Si(Li) x-ray spectrometer system in MRAL I.

Eighty-seven samples from 16 boreholes were collected from selected intervals at major bedding interfaces, some within relatively thick beds and others within relatively fine-grained beds. The samples analyzed using x-ray spectrometry are given in Table 5-1. The boreholes were spaced at 100-foot intervals along the west side of the 216-Z-19 ditch from the overflow to 16th Street (Figure 1-2). All radiological measurements made were below the detection limit of the x-ray spectrometer system. The detection limits were established at

<2 nCi/g for plutonium

<0.2 nCi/g for americium.

Storm Sewer Pond

The radiological conditions of the surface soil in the proposed storm sewer pond area were assessed using both in situ measurements and grab sample analytical data (Figure 1-2). All samples were analyzed for plutonium and americium content using the MRAL I instrumentation capabilities. The radiological measurements were taken from nine sampling points on a rectangular grid measuring 190 feet by 166 feet (Figure 2-2).

In situ radiological measurements were made with a Si(Li) x-ray spectrometer, DL-3081, which is sensitive to x-rays and low energy (<70 KeV) gamma-rays from americium and plutonium in sediments down to a

TABLE 5-1. Sediment Samples Analyzed By MRAL I.

Borehole Number	Depth (ft)	Borehole Number	Depth (ft)
299-W18-205	0-0.5	299-W18-213	0
	4-5.5		3
	9.5-10.5		6
	14.5-15.5		9
	17.5-18.5		12
299-W18-206	0-0.5		15
	10-11		18
	14.5-15.5		20
299-W18-207	0-0.3	299-W18-214	0-0.3
	4-5.5		5-6
	9-10		10.5-11.5
	16-17		16.5-17.5
299-W18-208	2	299-W18-215	0-0.3
	5		6-7
	8		11-12
	10		16-17
	11	299-W18-216	0-0.3
	14		5-6.5
	17		10-11.5
	20		16-17
299-W18-209	0-0.3	299-W18-217	0-0.3
	4-5.5		5-6
	9-9.5		10-11.5
	16		16.5-17.5
299-W18-210	0-0.3	299-W18-218	0
	1		3
	3		6
	6		9
	9		12
	12		15
	15		18
	18		20
	20	299-W18-219	0-0.3
299-W18-211	0-0.3		5-6.5
	4.5-5.5		10-11
	9.5-10	299-W18-220	0
	16.5		3
	16.5-17		6
299-W18-212	0-0.3		9
	5-6.5		12
	11-12		15
	15-16.5		18
			20

depth of approximately one centimeter. The detector was calibrated by placing it on a collimator cone and counting a known 65 cm^3 plutonium-americium standard mounted flush with the surface of the ground directly below the detector. This was done in an area adjacent to 216-Z-19 ditch which had been surveyed and found to have no x-ray emitting radionuclides detectable at levels above natural background. This method of calibration will overestimate a uniform surface concentration, so that there is a bias in the measurements on the high, i.e., conservative side. All nine in situ grid point measurements yielded results

<2 nCi/g of plutonium, and

<0.2 nCi/g of americium.

The MRAL I instrumentation capabilities also allowed the radiological analyses of grab samples on a second Si(Li) x-ray spectrometer, UL-3004, simultaneously with the in situ measurements. In this way, grab samples from each of the nine in situ grid measurement points were analyzed. The grab samples were taken from the soil surface directly under the detector at the base of the collimating cone, after the in situ measurement had been completed. The samples were prepared in a 65 cm^3 counting geometry and counted for 600 seconds. The detector had previously been calibrated with a plutonium-americium standard of the same counting geometry. As with the in situ measurements, it was found that all of the grab samples contained

<2 nCi/g of plutonium, and

<0.2 nCi/g of americium.

No radioactive contaminants were detected in the storm sewer pond area based on the results of in situ measurements and grab sample analyses.

216-Z-1 Ditch

A cursory near-surface radiological investigation was conducted across the buried 216-Z-1 ditch at the location where the storm sewer line was projected across to determine levels of radiocontaminants present (Figure 2-1). Sediment samples recovered during the drilling of

10 auger borings were surveyed by Radiation Monitoring personnel using portable field instruments. No detectable contamination was observed in the sediment samples.

In augering borehole 299-W18-225, the buried ditch was penetrated at about the 10-foot depth. Sediments at that depth changed from loose sediments to compact sediments. At the ditch bottom the sediments were slightly coarser than the surrounding sediments and stained a rusty orange color.

A followup radiological survey was conducted in the open excavation to assess the level of alpha contamination in this portion of the buried 216-Z-1 ditch. Portable field instruments were used to determine the levels of alpha contamination along the exposed ditch bottom. No detectable alpha contamination was encountered.

UN-216-W-20 Spoil Trench

Sediment samples collected from boreholes in and around the UN-216-W-20 spoil trench were analyzed for transuranic radionuclides to delineate the boundaries of the trench. The spoil trench, located adjacent to the head end of the 216-Z-19 ditch, contains contaminated sediments that were inadvertently excavated from the buried 216-Z-1 ditch. An accurate location of the trench was needed to stabilize the ground surface above buried contaminated sediments in the 216-Z-19 ditch/spoil trench area.

In order to determine the presence of transuranic radionuclides in and around the spoil trench, in-field radiological measurements of sediment samples from nine boreholes were made using the data acquisition and analysis system on board the MRAL I. This system has an uplooking Si(Li) spectrometer which is capable of assaying grab samples for plutonium-239 and americium-241 content by L x-ray spectroscopy. The sensitivities of this system in a natural background counting area are given in Table 5-2.

In each of the boreholes, five or six cores, each 2.5 feet long were collected. From the shoe at the bottom of each core, a sample was prepared in a 65 cm^3 counting geometry and assayed in MRAL I, shortly

TABLE 5-2. Sensitivities of the Si(Li) X-Ray Spectrometer System in MRAL I.

Radionuclide	Concentration, nCi/g	Time, min.	% Error[a]
^{241}Am	2.0	15	1.5
	1.0	15	3.0
	0.5	15	3.5
	0.1	15	4.0
	0.01	15	N/D[b]
		30	22.0
		45	3.0
		60	1.0
^{239}Pu	6.0	15	21.0
	2.0	15	28.3
	1.0	15	64.0
	0.5	15	100.0
	0.5	20	63.0
	0.5	30	37.3

[a] At the 1σ C.L.
[b] N/D = Not detected.

after collection. A few of the cores inside the split tube sampler above the shoe were found to contain radioactive contaminants by a radiation monitor using a hand held alpha survey meter. In these cases a composite sample from the core was prepared in a 65 cm^3 counting geometry and also analyzed in MRAL I.

The results of these Sa-De (for sample-to-detector) analyses of the core samples are shown in Figures 5-1 through 5-9. Positive values of radionuclide concentrations were observed in boreholes 299-W18-233, 299-W18-234, 299-W18-236, 299-W18-240, and 299-W18-241. All the samples were counted for at least 15 minutes, and in cases where there was any indication of a positive concentration near the system's limit of detection, the samples were counted longer. From these data, the following conclusions can be drawn. Boreholes 299-W18-233, 299-W18-236, and 299-W18-241 are contaminated. Borehole 299-W18-234 is possibly contaminated since americium-241 was detected at the 12.5 foot level in disturbed material. Borehole 299-W18-240 is also possibly contaminated since americium-241 was detected at both the 5 and 15 foot levels near the limit of the systems sensitivity. Sediment samples from the remaining borehole did not contain detectable contamination.

LABORATORY ANALYSES

Alpha Energy Analysis

Alpha Energy Analysis (AEA) was conducted on 22 selected sediment samples from eleven boreholes adjacent to the 216-Z-19 ditch and within the planned excavation for the 216-Z-20 crib. The procedure requires chemical digestion of the sediment using nitric-hydrofluoric acids, extraction and purification of plutonium and americium, and electroplating the purified elements onto stainless steel planchettes. The alpha particle energy spectrum is then counted by AEA.

Initially low-level alpha contamination was measured for 14 selected sediment samples (Table 5-3). Six samples contained plutonium and/or americium concentrations exceeding the average soil contamination limits

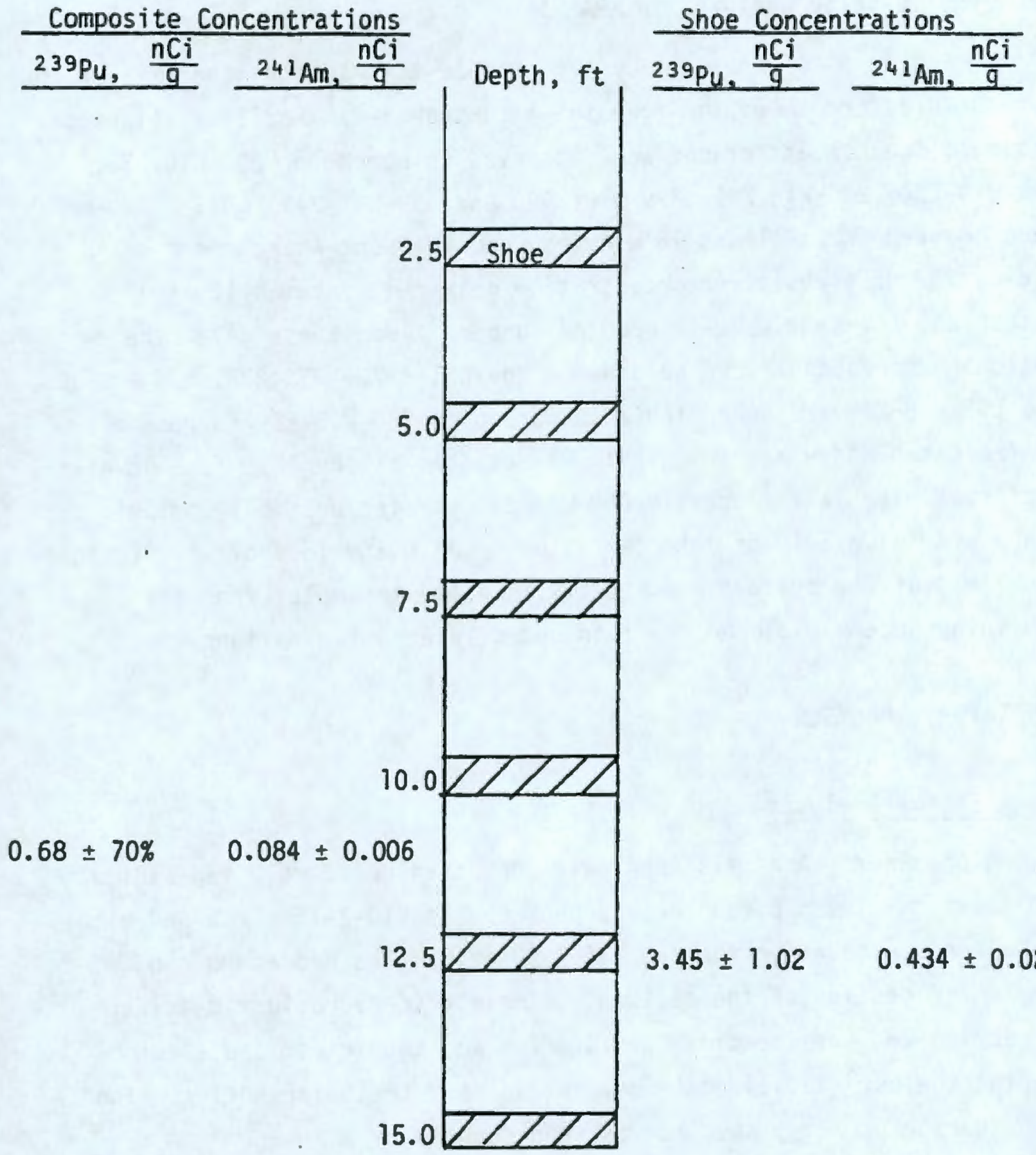


FIGURE 5-1. Borehole 299-W18-233 Sa-De Analysis Data.

Composite Concentrations: ^{239}Pu, $\frac{nCi}{g}$	Composite Concentrations: ^{241}Am, $\frac{nCi}{g}$	Depth, ft	Shoe Concentrations: ^{239}Pu, $\frac{nCi}{g}$	Shoe Concentrations: ^{241}Am, $\frac{nCi}{g}$
		2.5 (Shoe)	<0.67	<0.016
		5.0	<0.50	<0.012
		7.5	<0.55	<0.013
		10.0	<0.55	<0.013
		12.5	<0.64	0.028 ± 0.005
		15.0	<0.46	<0.011

FIGURE 5-2. Borehole 299-W18-234 Sa-De Analysis Data.

Composite Concentrations			Shoe Concentrations	
^{239}Pu, $\frac{nCi}{g}$	^{241}Am, $\frac{nCi}{g}$	Depth, ft	^{239}Pu, $\frac{nCi}{g}$	^{241}Am, $\frac{nCi}{g}$
		2.5 Shoe	<0.57	<0.013
		5.0	<0.58	<0.014
		7.5	<0.7	<0.017
		10.0	<0.78	<0.004
		12.5	<0.44	<0.01
		15.0		

FIGURE 5-3. Borehole 299-W18-235 Sa-De Analysis Data.

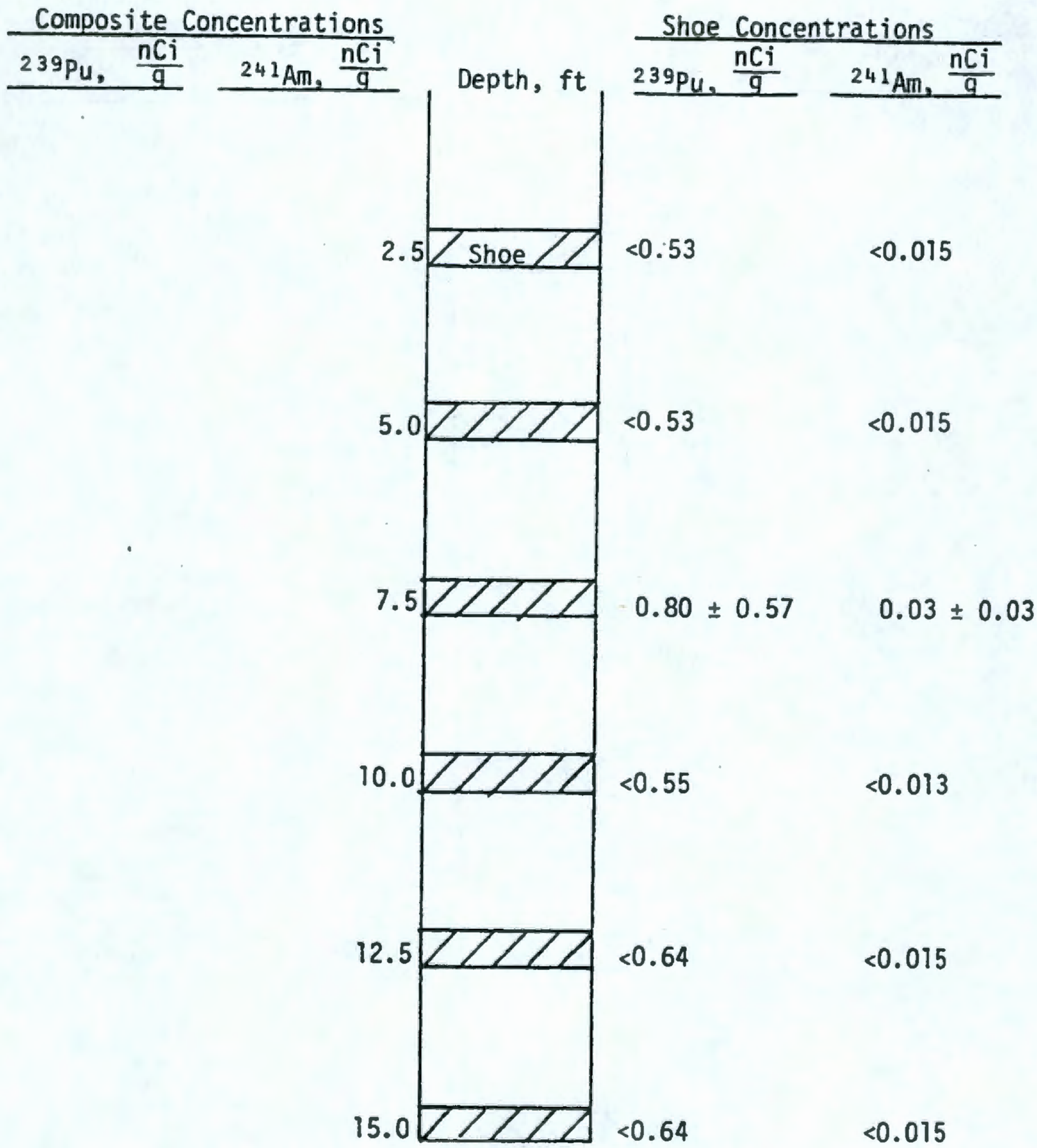
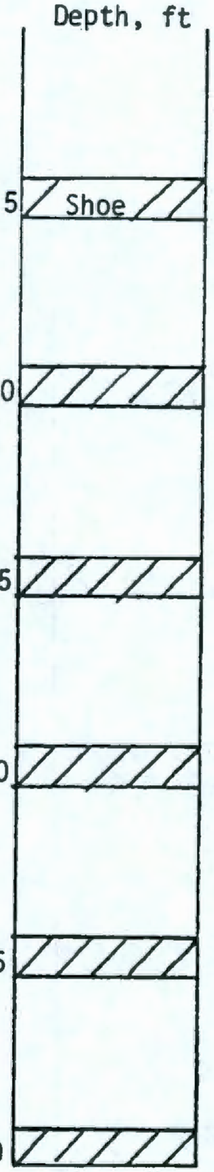


FIGURE 5-4. Borehole 299-W18-236 Sa-De Analysis Data.

Composite Concentrations ^{239}Pu, $\frac{nCi}{g}$	Composite Concentrations ^{241}Am, $\frac{nCi}{g}$	Depth, ft	Shoe Concentrations ^{239}Pu, $\frac{nCi}{g}$	Shoe Concentrations ^{241}Am, $\frac{nCi}{g}$
		2.5 (Shoe)	<0.7	<0.017
		5.0	<0.61	<0.014
		7.5	<0.68	<0.016
		10.0	<0.6	<0.014
		12.5	<0.6	<0.014
		15.0		

FIGURE 5-5. Borehole 299-W18-237 Sa-De Analysis Data.



Composite Concentrations: ^{239}Pu, $\frac{nCi}{g}$	Composite Concentrations: ^{241}Am, $\frac{nCi}{g}$	Depth, ft	Shoe Concentrations: ^{239}Pu, $\frac{nCi}{g}$	Shoe Concentrations: ^{241}Am, $\frac{nCi}{g}$
		2.5 (Shoe)	<0.67	<0.016
		5.0	<0.58	<0.014
		7.5	<0.6	<0.014
		10.0	<0.61	<0.015
		12.5	<0.58	<0.014
		15.0	<0.58	<0.014

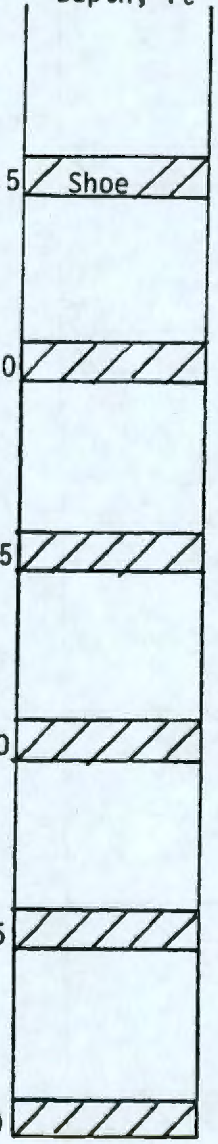
FIGURE 5-6. Borehole 299-W18-238 Sa-De Analysis Data.

Composite Concentrations ^{239}Pu, $\frac{nCi}{g}$	Composite Concentrations ^{241}Am, $\frac{nCi}{g}$	Depth, ft	Shoe Concentrations ^{239}Pu, $\frac{nCi}{g}$	Shoe Concentrations ^{241}Am, $\frac{nCi}{g}$
		2.5 (Shoe)	<0.7	<0.017
		5.0	<0.59	<0.014
		7.5	<0.52	<0.012
		10.0	<0.57	<0.014
		12.5	<0.6	<0.014
		15.0	<0.61	<0.015

FIGURE 5-7. Borehole 299-W18-239 Sa-De Analysis Data.

Composite Concentrations: ^{239}Pu, $\frac{nCi}{g}$	Composite Concentrations: ^{241}Am, $\frac{nCi}{g}$	Depth, ft	Shoe Concentrations: ^{239}Pu, $\frac{nCi}{g}$	Shoe Concentrations: ^{241}Am, $\frac{nCi}{g}$
		2.5 (Shoe)	<0.56	<0.013
		5.0	<0.55	0.013 ± 0.013
		7.5	<0.57	<0.014
		10.0	<0.64	<0.015
		12.5	<0.65	<0.015
		15.0	<0.59	0.018 ± 0.018

FIGURE 5-8. Borehole 299-W18-240 Sa-De Analysis Data.



Composite Concentrations ^{239}Pu, nCi/g	Composite Concentrations ^{241}Am, nCi/g	Depth, ft	Shoe Concentrations ^{239}Pu, nCi/g	Shoe Concentrations ^{241}Am, nCi/g
		2.5	0.55 ± 100%	<0.014
		5.0	<0.56	0.013 ± 0.013
		7.5	<0.49	<0.012
		10.0	0.63 ± 0.63	0.04 ± 0.04
1.17 ± 0.8	0.31 ± 0.02			
		12.5	<0.59	0.019 ± 0.019
		15.0	<0.63	0.017 ± 0.017

FIGURE 5-9. Borehole 299-W18-241 Sa-De Analysis Data.

TABLE 5-3. Transuranic Activity Results for Sediment Samples From Boreholes Adjacent to the 216-Z-19 Ditch Based on Alpha Energy Analysis.

Borehole Number	Sample Depth (ft)	Radionuclide Concentrations (pCi/g)		
		$^{239,240}Pu$	^{238}Pu	^{241}Am
299-W18-203	6	22	36	<0.3
299-W18-204	5-6	68	2.9	9.7
299-W18-205	4.5-5.9	390	110	950
299-W18-205	9.5-10.5	400	7.5	52
299-W18-208	5	180	3.6	23
299-W18-208	8	18	0.7	2.5
299-W18-208	10	14	0.6	<0.3
299-W18-210	3	27	1.0	2.9
299-W18-210	6	18	13	3.0
299-W18-210	9	18	0.9	<0.4
299-W18-218	3	7.8	1.0	<0.5
299-W18-218	6	88	2.2	11
299-W18-218	9	130	3.5	19
299-W18-225	∿10	29	1.2	<0.4

established in RHO-MA-139*. The average soil contamination limits for plutonium-238/239/240 and americium-241 are 60 pCi/g and 300 pCi/g, respectively. Five of the samples exceeding the levels are from boreholes located in areas immediately adjacent to the proposed 216-Z-20 crib site. One sample from 299-W18-204, which exceeds the average soil contamination level, is located in the proposed 216-Z-20 crib excavation.

Eight additional samples from five boreholes were analyzed for plutonium-239/240 in light of the plutonium contamination found adjacent to and within the proposed 216-Z-20 crib excavation. The plutonium-239/240 measurements are given in Table 5-4. All measurements were less than the average soil contamination levels for plutonium-239/240.

Gamma Energy Analysis

Non-destructive Gamma Energy Analysis (GEA) was made in the analytical laboratory on eight selected sediment samples to determine the plutonium-239 and americium-241 content. A GEA system consisting of four newly installed high efficiency germanium detectors was used to measure the transuranic content by counting for about 4,000 seconds. No measureable amount of plutonium or americium was detected in the samples. It was estimated that the sediment samples contained <600 pCi/g of plutonium-239 and <0.8 pCi/g of americium-241 (Table 5-5). To further improve the lower detection limit of these radionuclides, two samples from borehole 299-W18-201 were counted for 16 hours. The lower level of detection was found to be about 150 pCi/g for plutonium-239 and 0.15 pCi/g for americium-241. No measureable amount of activity was detected from the two samples (Table 5-5).

*Environmental Analysis and Monitoring Department Staff, 1981, "Environmental Protection Manual", RHO-MA-139, Rockwell Hanford Operations, Richland, Washington.

TABLE 5-4. Plutonium-239/240 Activity Results for Sediment Samples From Boreholes Adjacent to the 216-Z-19 Ditch Based on Alpha Energy Analysis.

Borehole Number	Sample Depth (ft)	$^{239,240}Pu$ (pCi/g)
299-W18-201	5	1.3
299-W18-201	10	2.2
299-W18-202	5	0.3
299-W18-203	8	0.56
299-W18-231	5-7	<0.5
299-W18-231	7-9	<0.6
299-W18-232	5-7	1.1
299-W18-232	7-9	0.29

TABLE 5-5. Transuranic Activity Results for Selected Sediment Samples From Boreholes Adjacent to 216-Z-19 Ditch Based on Gamma Energy Analysis.

Borehole Number	Sample Depth (ft)	^{239}Pu (pCi/g)	^{241}Am (pCi/g)
299-W18-201	5	<146	<0.15
299-W18-201	10	<149	<0.16
299-W18-202	5	<560	<0.63
299-W18-203	8	<500	<0.60
299-W18-231	5-7	<450	<0.50
299-W18-231	7-9	<430	<0.50
299-W18-232	5-7	<600	<0.75
299-W18-232	7-9	<600	<0.63

CHAPTER 6

SUMMARY AND CONCLUSIONS

By K. R. Fecht

This chapter integrates and summarizes the technical information presented in Chapters 2 through 5 as well as other pertinent information related to the 216-Z-20 crib, UN-216-W-20 spoil trench and the storm sewer pond facilities.

216-Z-20 CRIB RADIOLOGICAL ASSESSMENT

A radiological assessment was made of the near-surface environment of the 216-Z-20 crib site prior to excavating for the crib site. Sediment samples collected from 20 boreholes which were analyzed by x-ray spectroscopy for americium and plutonium. No field detectable contamination was found in the sediment samples using the Si(Li) detectors onboard MRAL I. Selected samples were submitted to Analytical Laboratories to check the MRAL I field results. Some samples analyzed by the laboratory were found to contain plutonium concentrations above the surface soil standards of 60 pCi/g at the south end and along the eastern boundary of the 216-Z-20 crib site. Additional borehole samples in the crib site area were analyzed by the laboratory to determine the extent of radiocontaminants. However, no radiocontaminants above the surface soil standards were found. It was determined that the presence of plutonium above the limits indicates a high potential for additional radiocontaminants in the south end of the crib site. Therefore, the Environmental Technologies Group and program team decided to reduce the length of the crib by 25 to 50 feet to exclude the area of known radiocontamination. The remainder of the crib site area is considered to be free of near-surface contaminants.

STORM SEWER POND SITE RADIOLOGICAL ASSESSMENT

The storm sewer pond is not an area of known surface or near-surface radiological contamination. Therefore, the radiological survey of the pond site was designed to locate potential nuisance spot activity which, based on the proximity to Z-Plant, would be primarily americium and plutonium. In situ sediment radiological measurements were collected from nine surface sample points on a rectangular grid in the pond site area. The measurements were made with a Si(Li) x-ray spectrometer which is sensitive to x-rays emitted from americium and plutonium. No x-ray emitting radionuclides were detected, so the concentrations of plutonium and americium were <2 nCi/g and <0.2 nCi/g, respectively; based on the detection levels of the instrumentation. It is concluded from the absence of detectable radionuclides that no significant nuisance radiological contamination is present in the storm sewer pond area.

STORM SEWER LINE ASSESSMENT

A radiological and sediment moisture assessment of the western end of the new storm sewer line was made to determine if radiocontaminants in the bottom of the buried 216-Z-1 ditch or radiocontaminants and waste water leaking from the 231-Z process sewer line would adversely impact excavation operations and construction of the storm sewer line. Ten closely spaced boreholes were drilled across the buried ditch and the process sewer line at the location where the new storm sewer line was projected across. Sediment samples were collected from these boreholes to determine the levels of radiocontaminants and sediment moisture conditions to be encountered during excavation for the storm sewer line.

Sediment samples were field surveyed for radiocontaminants by Radiation Monitoring. Environmental Technologies Group drilling engineers visually inspected the sediment samples for abnormally high sediment moisture and for evidence of the buried 216-Z-1 ditch. No field detectable radiocontaminants were found in these sediments including borehole 299-W18-225 which penetrated the buried ditch bottom and boreholes 299-W18-222 and 299-W18-223 adjacent to the leaking process sewer line. Sediment samples were damp to dry with a few wet samples adjacent to the leaking process sewer line. It is interpreted that the levels of radiocontaminants are sufficiently low so as not to adversely impact excavation operations. Also, the sediment moisture is near normal conditions so as not to cause side wall stability problems in the excavation for the storm sewer line.

IMPACT OF THE STORM SEWER POND ON ADJACENT FACILITIES

The most proximal facility to the storm sewer pond is the 216-Z-9 crib which received plutonium-bearing waste from Z-Plant. The 216-Z-9 crib is located about 300 feet from the center of the depression that was selected for the pond site. This distance is judged too great for waste discharges to the storm sewer pond to impact on waste previously discharged to the 216-Z-9 crib. For additional assurance the Environmental Technologies Group suggested the storm sewer pond be located in the southern portion of the depression to maximize the distance between the two facilities. No other facilities were considered capable of being impacted by routine operation of the storm sewer pond.

ESTIMATION OF INFILTRATION RATES FOR THE 216-Z-20 CRIB AND STORM SEWER POND

An estimation of the infiltration rates was made for the 216-Z-20 crib and storm sewer pond to assist in design requirements of the two facilities. The infiltration rate was conservatively estimated to be 40 $gal/ft^2/day$ based on the adjusted rates for a three dimensional system, the correction of circular wetting patterns to a linear pattern and the sediment texture and soil moisture observed during the study.

UN-216-W-20 SPOIL TRENCH STUDY

The investigation was conducted to support the decommissioning and stabilization of the 216-Z-19 ditch area. The boundaries of the spoil trench were delineated on the basis of sediment conditions encountered during drilling of shallow boreholes, radiological measurements of sediment samples collected during drilling operations and vegetation growing in and around the spoil trench area.

Nine boreholes were drilled at the site to investigate the sediment conditions and to collect sediment samples for radiological analyses. Five boreholes encountered sediments with normal moisture conditions (damp) that were penetrated at a moderately slow to slow rate. These sediments were judged not to have been disturbed by human intrusion except at the ground surface. In contrast the sediments encountered in four other boreholes were drier and the penetration rate during drilling was faster. These sediments were judged be to disturbed by human intrusion.

Radiological analyses were performed on the collected sediment samples using the on-board detectors in MRAL I. Based on the results from the radiological analyses, five boreholes contained [detectable,] contaminated sediments. Positive radionuclide values were not detected from sediments in the remaining four boreholes.

Why no lab analysis? What is the significance of these remaining four boreholes

Vegetation growing in and around the site was inspected in a cursory manner to aid in determining the spoil trench boundaries. That is the spoil trench is about 10 years old and can not support a plant community greater than 10 years. Vegetation located south and east of the suspected trench area indicate plants that are greater than 10 years in age. This suggests that these areas were not distributed during excavation or backfilling the UN-216-W-20 spoil trench.

Using this information the spoil trench boundaries can reasonably be located within the accuracy needed for stabilization. The coordinates for the corners of the proposed spoil trench area to be stabilized are given in Table 6-1.

(KARL: AT THE TIME OF THIS WORK, HADN'T MRAL I IMPROVED ITS "Pu-SEEING" CAPABILITY?

GROUND-WATER MONITORING BOREHOLES

Four ground-water monitoring boreholes were determine by the Hydrogeology Unit to be required to adequately monitor water-level changes and water quality beneath the 216-Z-20 crib. Two ground-water monitoring boreholes were constructed to provide monitoring upon startup of the 216-Z-20 crib. The remaining two boreholes are currently being drilled. The constructed boreholes (299-W18-17 and 299-W18-18) have been added to the ground-water monitoring network and are being sampled for radiological contaminants as per U.S. Department of Energy Order 5480.1.

TABLE 6-1. Corner Locations Of UN-216-W-20 Spoil Trench Stabilized Zone.

Corner	Northing	Westing
Northwest	N39338	W75972
Northeast	N39217	W75912
Southeast	N38814	W76122
Southwest	N38855	W76200