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SCINTILLATION PROBE RESULTS
200 AREA WASTE DISPOSAL SITE MONITORING WELLS

by

J. R. Raymond and V. L. McGhan[1/][2/]

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SCINTILLATION PROBE RESULTS
200 AREA WASTE DISPOSAL SITE MONITORING WELLS

by

J. R. Raymond and V. L. McGhan

INTRODUCTION

Numerous wells have been drilled in the chemical processing areas (200 East and 200 West) on the Hanford Project to permit monitoring of the ground water and subsurface formations in the vicinity of radioactive waste disposal facilities. Data obtained through use of these wells become basic information regarding the movement of radioactive materials downward and laterally from disposal sites. This information, in turn, is used to establish the actual useful life of the disposal crib, trench or cavern.

A gamma scintillation well probe was used to detect the vertical and horizontal movement of radiocontaminants in the sediments beneath waste disposal sites, and to assist in estimating the breakthrough of radionuclides to the water table. Scintillation well logging has application also in evaluating radionuclide migration (due to soil column drainage) and decay after disposal is terminated.

The purpose of this study was to utilize the scintillation probe and logging results to determine as much as possible about the contamination status beneath major active and abandoned ground disposal units. The information presented herein should also have application in future studies related to ground disposal operations and research.

SUMMARY AND CONCLUSIONS

Scintillation probe results provide a semiquantitative evaluation of the magnitude and extent of subsoil contamination beneath radioactive liquid waste ground disposal facilities. Although the present equipment has a quite limited capacity to differentiate between the various gamma emitting nuclides, it is capable of detecting gross gamma emitters over a wide range of concentrations. This type of monitoring, together with ground water sampling, waste inventory, and geologic data, is particularly useful in evaluating the gross movement rates of radionuclides in the unsaturated soil zones. In the case of an abandoned facility, time-depth and time-magnitude comparisons of logging results are of value in assessing the migration rates of radiocontaminants due to subsoil drainage and the relative amount remaining, due to radioactive decay.

Some restrictions are placed on the exactness with which the results can be applied because of the fact that monitoring wells are located alongside, rather than directly through the facilities. In effect, then, the results obtained may not present a precise picture of the contamination status directly beneath a facility. Also, as noted in several instances, geologic features and soil characteristics may influence appreciably the distribution or movement paths of wastes in the unsaturated zone.

Generally, the probe results indicated that significant lateral spread of wastes does occur in the sediments beneath the 200 Areas, and that the downward migration rates of gross gamma emitters is relatively slow—on the order of a few feet per year in the case of a long-abandoned facility.

Equipment and Techniques

Three different scintillation probe systems have been used at Hanford over the past ten years for well logging. The present system[1] is a third generation evolution from earlier developed equipment[2]. The system consists of a detector probe, armored wire line, hoisting equipment, recording and control instruments. The probe is a 13-inch long by 2-3/4-inch diameter stainless steel can that contains a transistorized preamplifier and a 2 x 2-inch NaI(Tl) crystal coupled to a photomultiplier tube. The system is compactly mounted in the back of a $\frac{1}{2}$-ton 4 x 4 Carryall. A 2.5 kw gasoline-engine driven generator supplies power to operate the equipment. The system has a lower detection limit of about 3 pc/cc (Ru^{106}-Rh^{106}) in water and about 3×10^{-4} mr/hr (Ra^{226}) in air. Maximum meter count rate in air (1×10^{6} cpm) is reached in a field of about 150 mr/hr. Maximum meter count rate in water occurs at a Ru^{106}-Rh^{106} concentration of about 5,000 pc/cc.

The probe output is amplified by a linear pulse amplifier and then fed into a log/linear count-rate meter. The rate meter drives a 10 mv potentiometric strip chart recorder. The recorder chart drive is coupled to a cable measuring sheave; thus, count rate is recorded against depth of the probe in the well. Required scale changes during logging make direct observation and interpretation somewhat difficult. Therefore, as was done in this report, the recorder chart data may be transferred to logarithmic graph paper (well depth plotted against count rate) for easier examination.

Discussion

Depth of penetration and extent of lateral spread of radionuclides beneath a waste disposal facility depend upon the volume and type of waste

discharged and the stratigraphic, physical and chemical characteristics of the earth material beneath the site. Thus each facility requires individual study to evaluate the disposition and translocation of radionuclides in the subsoils. The vertical extent of radionuclide migration beneath 200 Area waste disposal sites varies from shallow depths, directly under some facilities, to complete penetration where the entire soil column is contaminated from crib bottom to the water table. Horizontal spread varies from a few feet from the edge of the crib, trench or cavern to several hundred feet from the disposal site. The concentrations of radioisotopes in the soil vary from below detection threshold to beyond the maximum range of the scintillation probe. Adequate monitoring well coverage exists around the major disposal sites to fairly accurately delineate the vertical and lateral extent of subsurface contamination.

Plates I through VI in Appendix A show the locations of the Chemical Processing areas waste disposal sites and the monitoring wells. References 3 through 19 give additional information on disposal facilities and waste inventories; Reference 20 contains information on the wells. Figures 1 through 36 in Appendix B are the scintillation probe logs of representative wells adjacent to the waste disposal sites. Tables I and II show the volume, type of waste and column volumes disposed of at the various facilities. The tables also show the amount of gross beta activity disposed and the dates of facility usage. Logs of wells that show no ground contamination are not included. Also, well logs are not shown that are essentially duplicates of the figures in Appendix B. All originals of the project scintillation well

TABLE I

200-E Area Waste Disposal Facilities

Facility	Type of Waste	Volume of Waste (liters)	Column Volume (input)	Gross Beta Activity (curies)	Time in Service
216-BC Cribs and Trenches	U-Plant, high-salt scavenged and tank farm waste	1.2×10^8	0.9 (cribs)	9.2×10^5	Jan. 1956 - Dec. 1957
216-A-10	Purex process condensate	9.5×10^8	23	8.0×10^4	Nov. 1961 - Present
216-A-5	Purex process condensate	1.8×10^9	180	3.4×10^3	Nov. 1955 - 1961
216-A-9	Purex fractionator condensate	1.3×10^9	19	54	March 1956 - Feb. 1958
216-A-1	Depleted uranium prestart-up wastes	------	----	------	Nov. and Dec. 1955
216-A-6	Purex steam condensate	2.8×10^9	36	4.0×10^3	Nov. 1955 - Jan. 1961
216-A-8	Purex tank farm condensate	1.0×10^9	8.3	1.0×10^4	Nov. 1955 - May 1958
216-A-30	Purex steam condensate	1.2×10^9	5.6	2.8×10^3	Jan. 1961 - Present
216-A-24	Purex tank farm condensate	7.6×10^8	4.3	4.5×10^3	May 1958 - Present
216-B-9 (5-6 crib)	B Plant cell drainage	3.6×10^7	24	7.8×10^3	Aug. 1948 - July 1951
216-BY Cribs	U Plant, high-salt scavenged waste	3.4×10^7	0.9	4.1×10^5	Dec. 1954 - Dec. 1955
216-BX Trenches	B Plant, high-salt, first cycle supernatant	1.5×10^7	0.11	1.6×10^4	Dec. 1953 - Nov. 1954
216-B-8 (241-B-3 crib & tile field)	B Plant high-salt, second cycle and 5-6 waste	2.7×10^7	29.0	7.1×10^2	March 1948 - July 1953
216-B-11 (242-B cribs)	B Plant Waste Evaporator Condensate	3.0×10^7	41.5	39	Dec. 1951 - Nov. 1954
216-B-7 (241-B-1 and 2)	224-B and cell drainage waste	4.5×10^7	17.3	5.4×10^3	Oct. 1946 - Oct. 1955

TABLE II

200-W Area Waste Disposal Facilities

Facility	Type of Waste	Volume of Waste (liters)	Column Volume (input)	Gross Beta Activity (curies)	Time in Service
216-T-5 Trench	T Plant, high-salt second cycle and 112-T Tank waste	2.6×10^6	1.8	125	May 1955
216-T-32 (241-T-1 and 2)	224-T high-salt waste	2.9×10^7	13	1.5×10^3	Nov. 1946 -- May 1952
216-T-7 (241-T-3)	T Plant high-salt 224 second cycle and cell-drainage waste	1.1×10^8	145	3.1×10^3	April 1948 -- 1956
216-T-3 (241-T-361 reverse well)	T Plant 224 and cell drainage waste	1.1×10^7	---	2.8×10^3	Jan. 1945 -- Aug. 1946
216-T-6 (361-T-1 and 2)	T Plant 224 and cell drainage waste	4.5×10^7	16.5	1.8×10^4	Aug. 1946 -- June 1951
216-T-18 (test crib)	T Plant high-salt scavenged waste	1.0×10^6	1.3	8.4×10^2	Nov. 1953
216-T-14 through 17 Trenches (216-T-1 through 4)	T Plant high-salt, first cycle supernatant	7.6×10^6	0.1	3.4×10^3	Jan. 1954 -- June 1954
216-T-26, 27, 28, (261-TY-1, 2, 3)	T Plant high-salt scavenged waste**	1.1×10^7	2.1	2.9×10^4	Aug. 1955 -- Nov. 1956
	Decontamination cell drainage waste*	1.2×10^7	2.3	9.0×10^3	1958 -- to present
216-T-19 (241-TX-153)	T Plant Second Cycle, 224 and 242 Wastes	4.6×10^7	4.4	2.0×10^3	Sept. 1951 -- Jan. 1959
216-T-21, 22, 23, 24 (241-TX Trenches)	T Plant high-salt first cycle supernatant	8.0×10^6	0.15	3.4×10^4	May 1954 -- Sept. 1954

** Sent to 216-T-26 only. * Sent to 216-T-28 only.

TABLE II (contd.)

200-W Area Waste Disposal Facilities

Facility	Type of Waste	Volume of Waste (liters)	Column Volume (input)	Gross Beta Activity (curies)	Time in Service
216-Z-9	Recuplex Process Waste	4.0×10^6	0.14	----	
216-Z-12	234-5 Bldg. aqueous waste	1.7×10^8	5.0		
216-U-1 and 2 (361-WR)	TBP and UO_3 process waste	1.1×10^7	6.9	1.2×10^3	Nov. 1951 -- to present
216-S-1 and 2	Redox process condensate and cell drainage	1.5×10^8	90-	7.5×10^5	Jan. 1952 -- Jan. 1956
216-S-7	Redox process condensate	3.2×10^8	11.7	2.7×10^5	Jan. 1956 -- to present
216-S-13 (276-S)	Redox Plant organic decant	3.0×10^6	1.5	25	Feb. 1952 -- to present
216-S-21 (216-SX-1)	Redox tank farm condensate	4.8×10^7	4.0	2.1×10^2	Nov. 1954 -- to present

logs are on file at the 222-U Building, 200-West Area.

200-EAST AREA DISPOSAL FACILITIES

Plate I (Appendix A) shows the location of monitoring wells adjacent to the 216-BC cribs and trenches. Figures 1 through 3 (Appendix B) show the scintillation probe logs of three representative wells at the "BC" site. Well E13-6 monitors the southeast side of the BC-6 crib. The log made on March 9, 1956, about two months after disposal began in the adjacent cribs 4 and 5, showed gross subsurface contamination from crib bottom down to 85 feet below ground surface. A lateral spread of at least 400 feet is indicated. The log run on April 18, 1958, four months after disposal to BC-6 terminated, shows gross contamination down to 170 feet below ground surface. The well log of May 14, 1959, shows a further waste penetration of 15 feet (down to 185 feet). Four years later, on May 10, 1963, the contamination had moved downward an additional 25 feet to 210 feet total depth. The effect of radioactive decay is clearly shown on this last log.

Wells E13-8 and E13-19 monitor a portion of the 216-BC trenches where specific retention disposal was made. A thin band of contamination exists from 30 to 85 feet at well E13-8 and from 25 feet to 80 feet at well E13-19. Only slight continued soil drainage has occurred since disposal ceased. Ground water occurs at about 340 feet below ground surface at the BC site; therefore, a long soil column is available for retention of these liquid wastes. As only a thin band with a maximum thickness of about 60 feet was contaminated, it is evident that the disposal practice was conservative.

Plate II shows the Purex liquid radioactive waste disposal sites and the related monitoring wells. Well E17-1 (Figure 4) monitors the south end of the 216-A-10 crib. The log of E17-1 shows slight subsurface contamination (probably from the adjoining A-5 crib) prior to crib use. The 1963 well log shows that the entire soil column is contaminated to the water table. Well E24-1 (Figure 5) monitors the west side of the 216-A-5 crib. The well logs show only small changes during the operating years of 1958 and 1959. Penetration of contamination increased only about 15 feet from 1959 to 1963. This is a case where the well log does not indicate the true disposition of nuclides beneath the facility, as it is definitely known from ground-water sampling that contaminants do penetrate the entire depth of the soil column beneath this crib. The increase in count rate noted at 235 feet below ground surface on the 1963 log is probably due to waste from the adjacent 216-A-10 crib site.

Well E24-3 (Figure 6) monitors the southeast end of the 216-A-9 crib. Waste disposed at this site contained only an estimated 54 curies of radioactivity. No ground contamination was noted on the 1959 scintillation well log. A small amount of contamination from 30 feet to 100 feet below ground surface is indicated on the 1963 log. Well E25-2 (Figure 7) monitors the 216-A-1 crib. The crib received depleted uranium waste in November and December, 1955. The well logs show a zone of ground contamination from about 15 feet to 55 feet below ground surface. The count-rate increase at 255 feet on the 1959 log is probably due to contaminants migrating from the adjacent 216-A-8 or 216-A-7 cribs.

Well E25-3 (Figure 8) monitors the 216-A-6 crib. The 1959 log reflects the increase in disposed waste activity that occurred in December, 1958, and January-February, 1959. Over half of the total radioactivity was discharged in December, 1960, and the increased count rate noted on the 1963 log at 30 feet reflects this disposal. Figures 9 and 10 show the scintillation logs of wells E25-4 and E25-9, which monitor the west and east ends of the 216-A-8 crib. The majority of the waste was discharged in 1957 and 1958. Essentially, the entire soil column at this crib site is contaminated. The effect of decay can be noted on the 1963 well log trace.

Well E25-11 (Figure 11) monitors the southwest end of the 216-A-30 crib. The well log indicates low level contamination throughout most of the soil column.

Well E26-5 (Figure 12) monitors the west end of 216-A-24 Crib. Most of the waste (3900 curies) was discharged in 1958 and 1959. After December, 1959, waste volume and activity sent to the A-24 crib was greatly reduced. The scintillation well log of April 28, 1958, shows no ground contamination at the site prior to disposal. On June 17, 1958, about one month after disposal started, gross contamination in the ground was present to a depth of 130 feet. On June 3, 1959, about one year after disposal started, the entire soil column was contaminated. The 1963 log reflects the decay of radionuclides due to reductions in the amount of activity disposed to this site.

Plate III shows the locations of B-Plant radioactive waste disposal sites and the associated monitoring wells. Figure 13 shows the scintillation log of

well E28-55, a typical shallow well that monitors a part of the 216-B-9 crib (5-6 crib). The log indicates a narrow band of ground contamination from 5 to 40 feet. Well E33-4 and E33-7 (Figures 14 and 15) are typical of the wells monitoring the 216-BY cribs. Figure 14 shows that the entire soil column is highly contaminated at Well E33-4. The effect of radioactive decay is clearly shown from 1959 to 1963. Gross soil column contamination exists at well site E33-7 from 10 to 160 feet below ground surface. The effect of decay is also noted on the 1959 to 1963 log comparison. It was not unexpected that highly contaminated soil conditions were found at the BY cribsite, since both Cs^{137} and Co^{60} were noted in ground water samples from beneath the site in 1956. Cobalt-60 is still present at low concentrations. Well E33-8 (Figure 16) monitors the north end of the 216 BX trenches. Disposal there was based on specific retention. The well scintillation log indicates a zone of subsurface contamination from about 20 to 75 feet below ground surface.

Well E33-16 (Figure 17) monitors the 216-B-8 crib (241-B-3 crib and tile field). The well logs for both 1959 and 1963 indicate that most of the soil column is highly contaminated. This observation does not agree with the relatively small amount of radioactivity reportedly discharged to this site over ten years ago. Other sites which received similar wastes and volumes, and had nearly equal periods of duration of disposal and time out of service, show much less subsurface contamination even though radionuclide activity density was higher.

Well E33-20 (Figure 18) monitors one of the 216-B-11 cribs (242-B cribs). The 1959 scintillation log shows low level contamination of the entire soil

column. The sharp peak noted on both logs at about 80 feet is probably caused by waste from the adjacent 216-B-9 crib. The 1963 trace indicates that decay has reduced the radioactivity in most of the soil column to near background level. Well E33-60 (Figure 19) is a shallow well that monitors the 216-B-7 cribs (214-B-1 and 2). The 1963 scintillation log shows a zone of ground contamination from about 15 to 75 feet below ground surface. Two major B Plant waste disposal sites, 216-B-5 reverse well and the 216-B-12 ER cribs, have not been discussed because logs of the adjacent monitoring wells show no detectable surburface radioactivity above background. Waste is certainly present beneath the sites, but the wells are not close enough to intercept the contamination.

200 WEST AREA DISPOSAL FACILITIES

Plate IV shows the location of the 200-W T Plant waste disposal facilities and monitoring wells. Well W10-1 (Figure 20) monitors the 216-T-5 trench. Disposal there was based on specific retention. The scintillation logs show low level ground contamination to a maximum depth of 125 feet below ground surface. The 1963 radiation level was approximately at background. Well W10-3 (Figure 21) monitors the 216-T-32 cribs (241-T-1 and 2). The scintillation log shows moderate subsurface contamination from 35 feet to 90 feet and low level contamination from 90 to about 155 feet. The radiation peak from 80 to 96 feet is probably contamination from the adjacent 216-T-7 crib. Figure 22 shows the scintillation log of W10-60, a shallow well that monitors the 216-T-7 crib (241-T-3 crib). Gross subsurface contamination is observed throughout most of the soil column penetrated by the well.

Well W11-7 (Figure 23) is adjacent to the 216-T-3 reverse well (241-T-3-361). The observed scintillation logs do not agree with the recorded history of the disposal site. The highest perforated zone in the reverse well is 104 feet below ground surface. The radiation peak noted at about 100 feet on the scintillation logs agrees with this perforation information, but the radiation level appears high for a facility that has been out of service for 18 years, and may indicate the presence of appreciable amounts of long-lived nuclides. The contaminated upper zones noted on the logs supposedly cannot be caused by waste from the reverse well because the well was not perforated above 104 feet and waste could not enter the ground above the perforated zone. There is a possibility that a well casing failure permitted waste to enter the ground at this level, but again the radiation levels, particularly the peak at 15 feet, appear too high to be caused by a leaking casing. It is more likely that the entire subsurface contamination, or at least the upper zones, is derived from the 216-T-6 cribs (316-T-1 and 2) located west of the reverse well. The contamination depth seems too shallow and the radiation levels quite high to be caused by the T-6 cribs, but the reverse well and T-6 cribs are the only disposal facilities in the immediate area. Well W11-55 (Figure 24) is a typical shallow well that monitors the 216-T-6 cribs. A thin band of subsurface contamination is noted at 20 feet below ground. Wells toward the east side of the cribs show higher radioactivity and a thicker zone of ground contamination, indicating preferential eastward waste movement.

Waste was disposed of at the 216-T-18 test crib site in November, 1953, under specific retention conditions. Well W11-11 (Figure 25) monitors the

facility. A band of gross subsurface contamination is indicated from about 7 feet to 85 feet beneath ground surface. Ground water is some 200 feet below ground level and little downward waste migration has been noted. Shallow well W11-68 (Figure 26) monitors the 216-T-14 through 17 trenches where specific retention disposal was made. Only a narrow band of contamination 30 feet below ground surface is noted, confirming conservative disposal.

Well W14-2 (Figure 27) monitors the 216-T-26 through 28 cribs, (216-TY-1, 2, 3). The scintillation log shows gross subsurface contamination to 120 feet below ground surface. Some downward migration is noted since 1959. Significant lateral spread of waste was noted at this cribsite several years ago when contaminants were detected in the ground beneath the southernmost (T-28), unused crib. This spread was attributed to the presence of a thin, relatively impermeable caliche layer at a depth of about 120 feet.

Well W15-4 (Figure 28) monitors the 216-T-19 crib and tile field (241-TX-153). The 1963 log shows moderate contamination from 40 to 85 feet and low level contamination throughout the rest of the soil column. Shallow well W15-80 (Figure 29) monitors the 216-T-21 trenches (241-TX trenches). Disposal was on a specific retention basis. The well log shows thin bands of contamination at 35 feet and 55 feet; the count rate again rises at the bottom of the well (100 feet) which indicates a probable third contaminated zone.

Plate V shows the locations of the U Plant and 234-5/231 ground waste disposal sites and associated monitoring wells. Ground disposal of plutonium wastes generally cannot be monitored with the gamma scintillation probe. However, when gross quantities of plutonium are present, the soft gamma and/or

associated trace quantities of fission products allow detection by the scintillation probe. The 216-Z-9 and 12 cribs are examples of this situation. The scintillation log of well W15-83 (Figure 30), located at the south end of the Z-9 crib, shows a contaminated zone from 45 feet below ground surface to well bottom. The well bottoms far above the water table. The scintillation log of well W18-5 (Figure 31), which monitors the Z-12 crib, shows a narrow zone of contamination about 25 feet beneath ground surface. Subsurface contamination cannot be detected at any of the other 234-5/231 disposal sites.

Well W19-3 (Figure 32), the only monitoring well near the 216-U-1 and 2 cribs shows low level contamination from 70 to 105 feet beneath ground surface. Little downward migration of contaminants has occurred from 1958 to 1963. However, low concentrations of uranium have been detected in the ground water at this site.

Plate VI shows the location of the Redox plant waste disposal sites and monitoring wells. Well W22-1 monitors the 216-S-1 and 2 cribs. The scintillation logs (Figure 33) show gross subsurface contamination of the entire soil column above the water table. Depth to water is about 195 feet. Reference 21 gives an extensive discussion on 216-S-1 and 2 ground contamination. The 216-S-7 crib replaced the S-1 and 2 cribs. Figure 34 shows the scintillation log of monitoring well W22-14 at the S-7 crib. The log indicates gross contamination throughout most of the soil column. Well W22-21 monitors the 216-S-13 crib (276-S). The well scintillation log (Figure 35) shows low level contamination from about 25 to 110 feet below ground surface Well W23-4 monitors

the 216-S-21 crib (216-SX-1). Scintillation logs (Figure 36) show a narrow band of contamination at about 40 feet below ground surface.

Future Work

Scintillation logging of disposal site monitoring wells will continue probably on a biannual basis for most disposal facilities. New disposal sites and critical abandoned locations will be monitored annually or more frequently as required. Some of the older cribs that have been out of service for a considerable length of time will be checked every three or four years. It is planned to obtain a multichannel pulse-height analyzer for use with the logger. Studies will then be made to determine the chromatographic distribution of the various gamma emitting isotopes in the soil column.

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21. D. W. Pearce, et al. A Review of Radioactive Waste Disposal to the Ground at Hanford in Disposal of Radioactive Wastes, Vol. II, pp. 347-363, Proc. Sci. Conf., on Disposal of Radioactive Wastes - Sponsored by the IAEA, Nov. 16-21, 1959.

APPENDIX A

DISPOSAL SITE AND WELL LOCATION MAPS

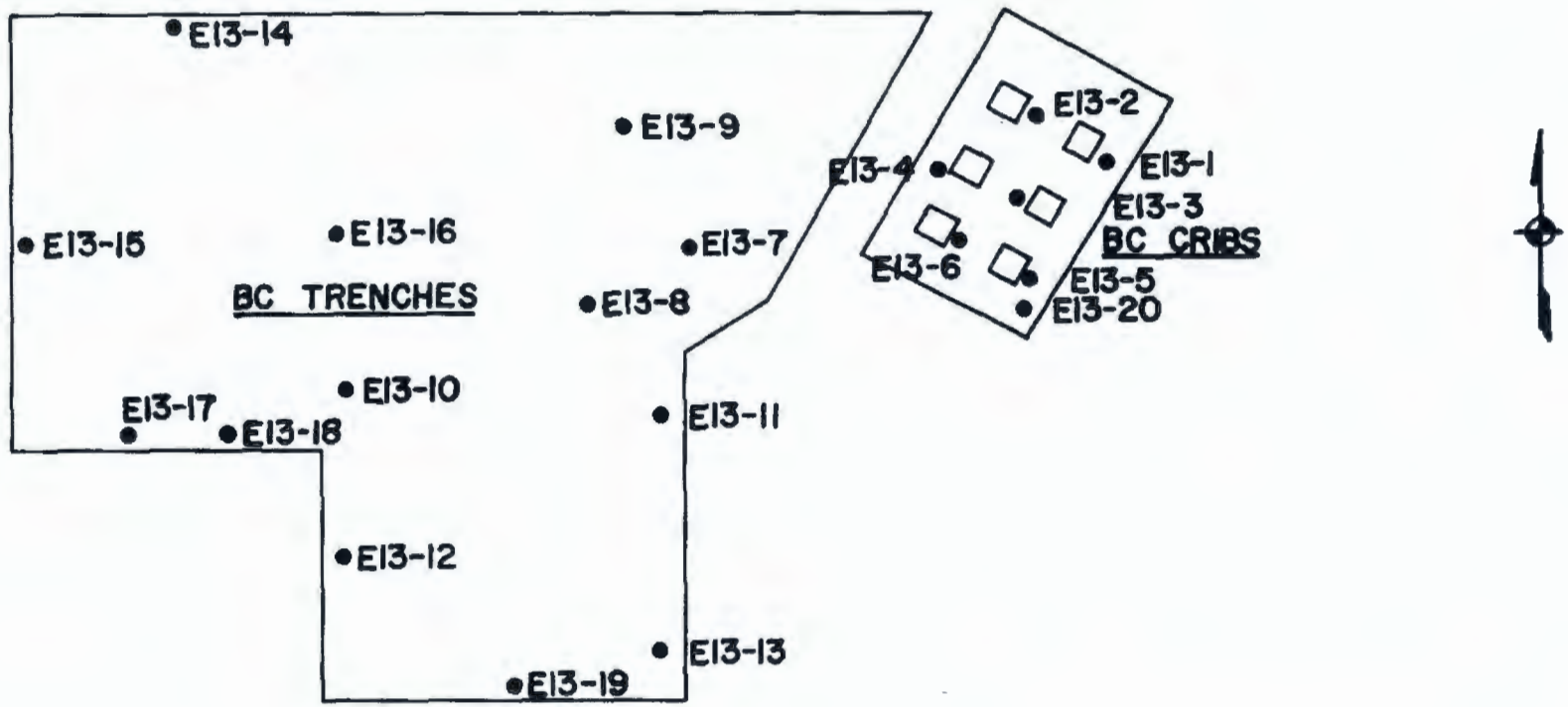

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PLATE I

BC Disposal Site

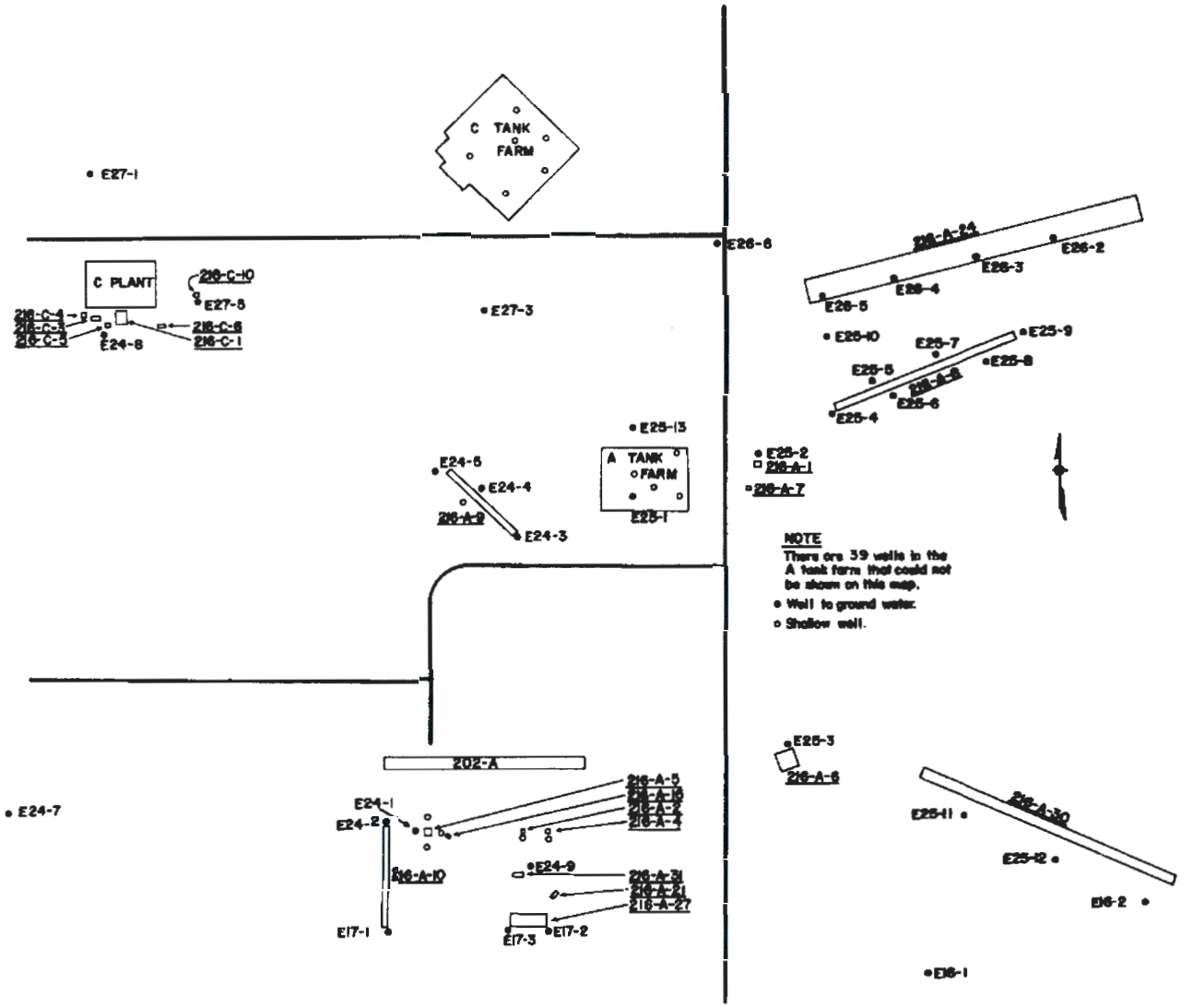
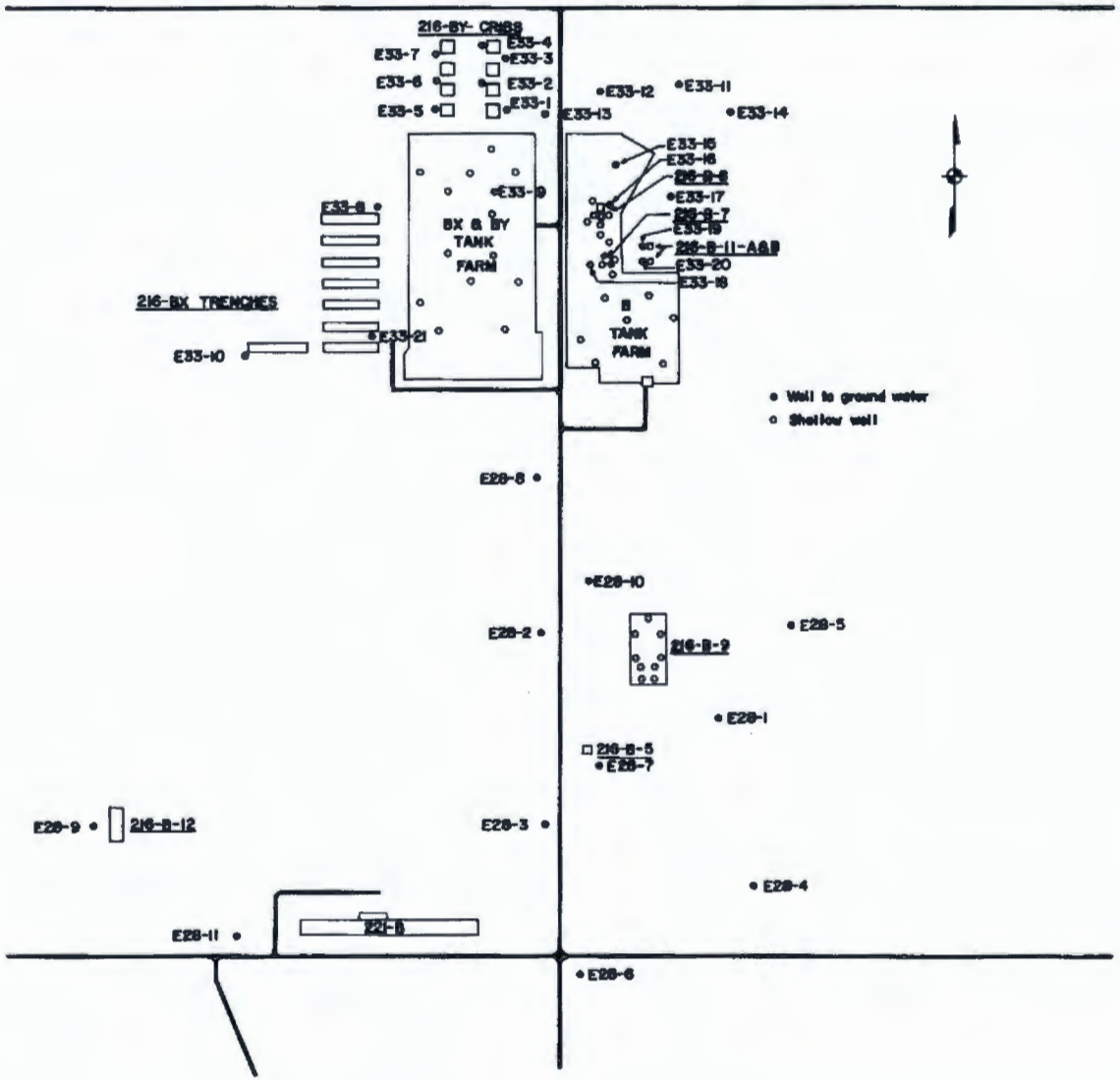


PLATE II

Purex Waste Disposal Sites

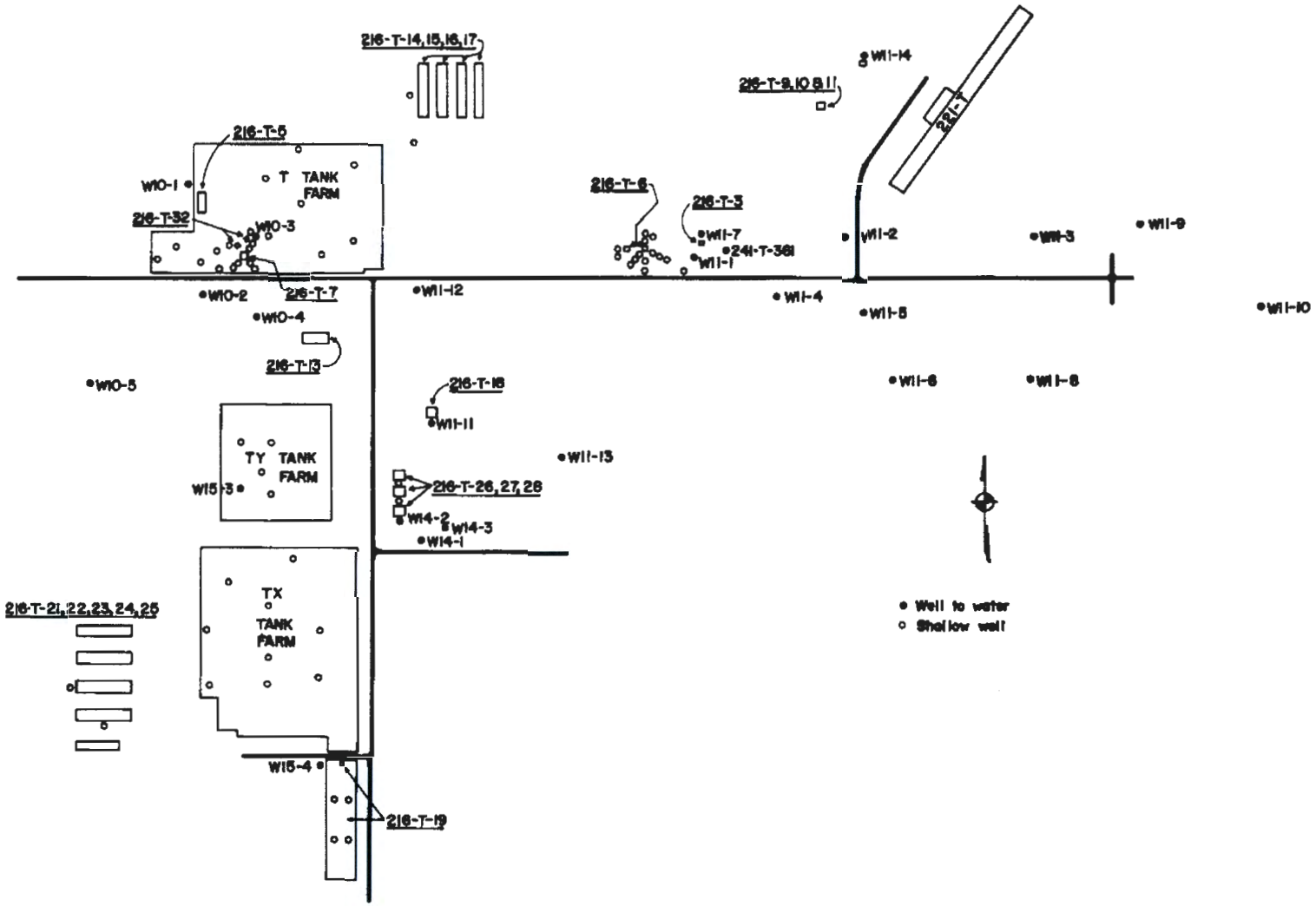
HW-84577



HW-84577

PLATE III

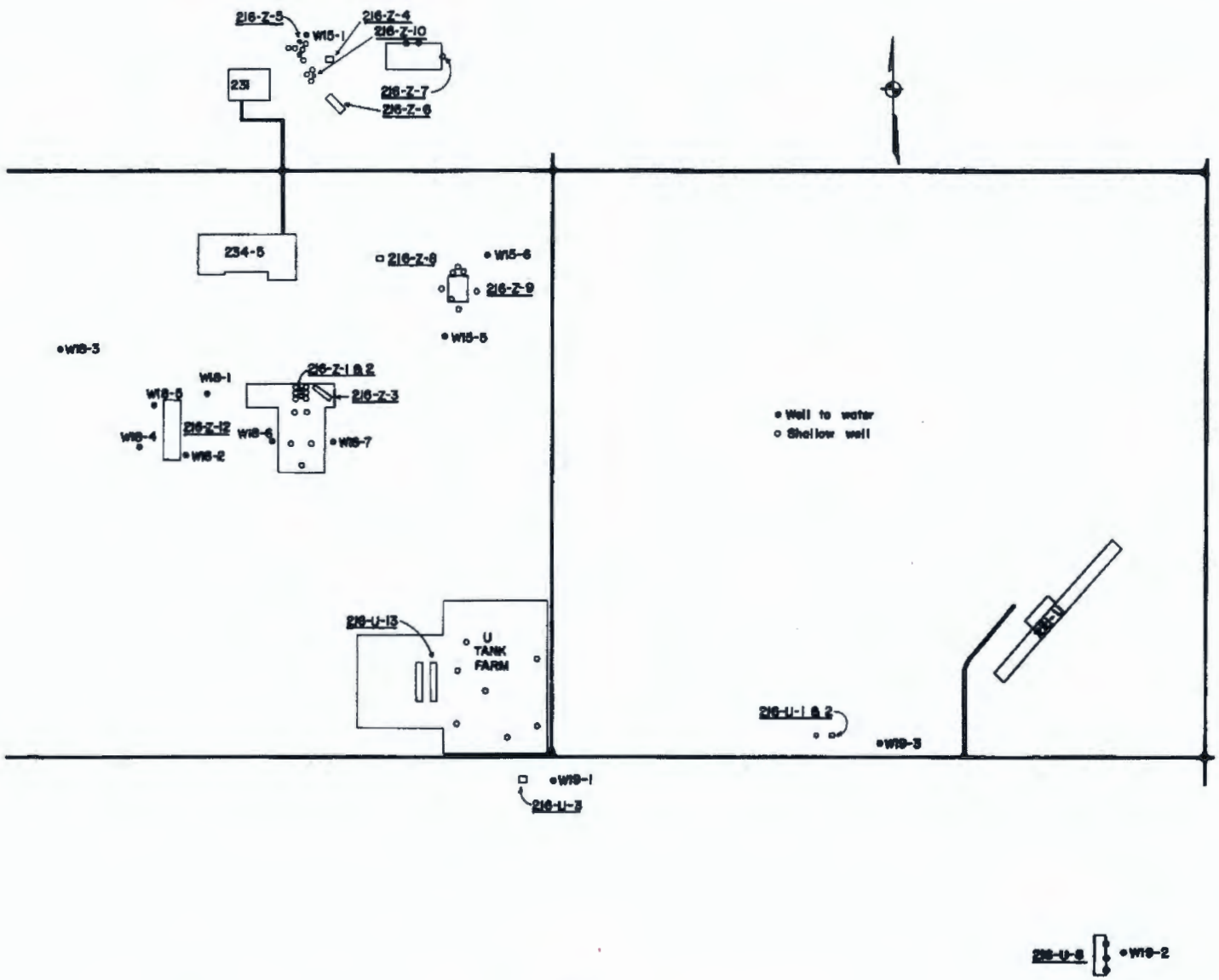
B Plant Waste Disposal Sites



HW-84577

PLATE IV

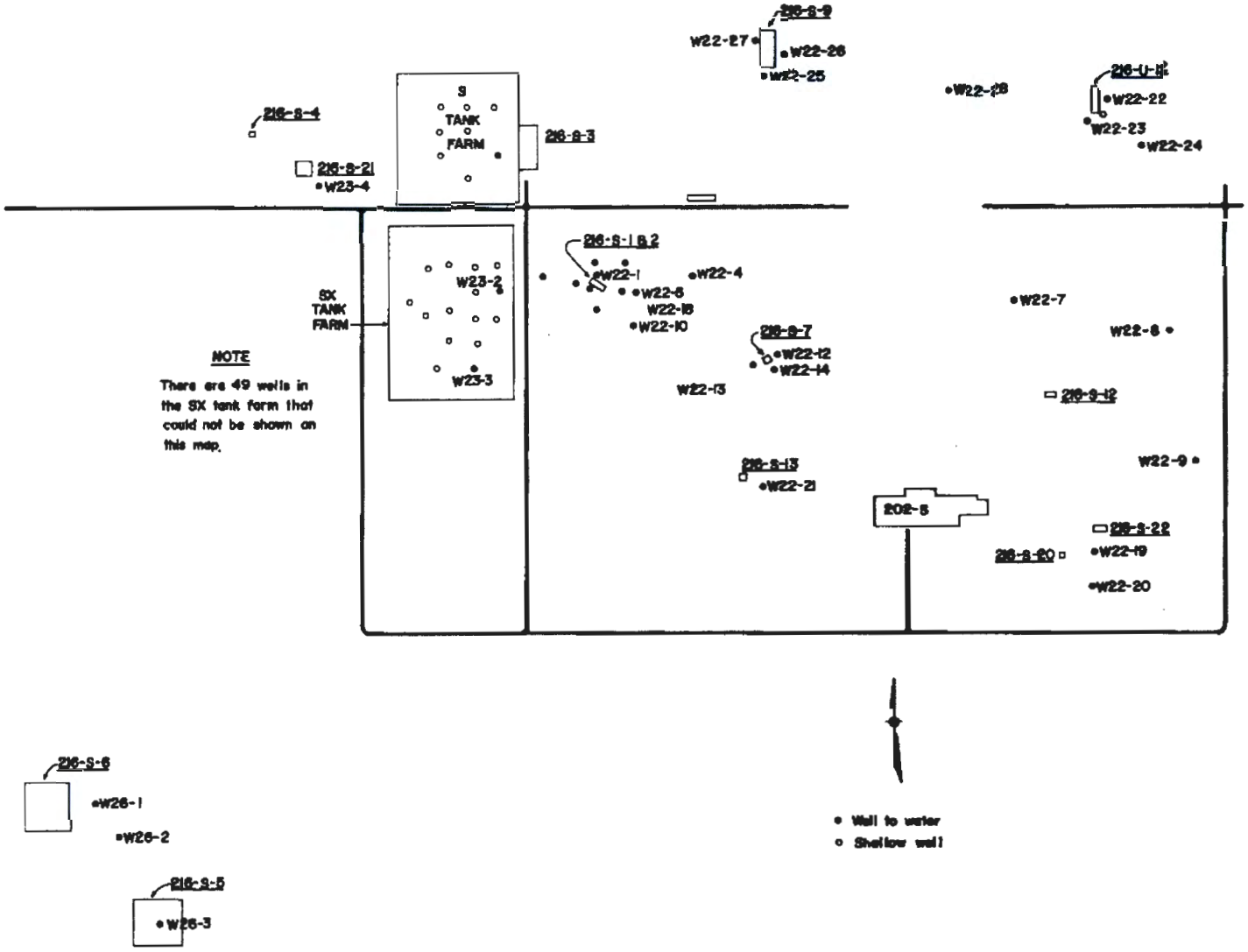
T Plant Waste Disposal Sites



HW-84577

PLATE V

U Plant and 234-5/231 Disposal Sites



HW-84577

PLATE VI

S Plant Disposal Sites

APPENDIX B

MONITORING WELL SCINTILLATION LOGS

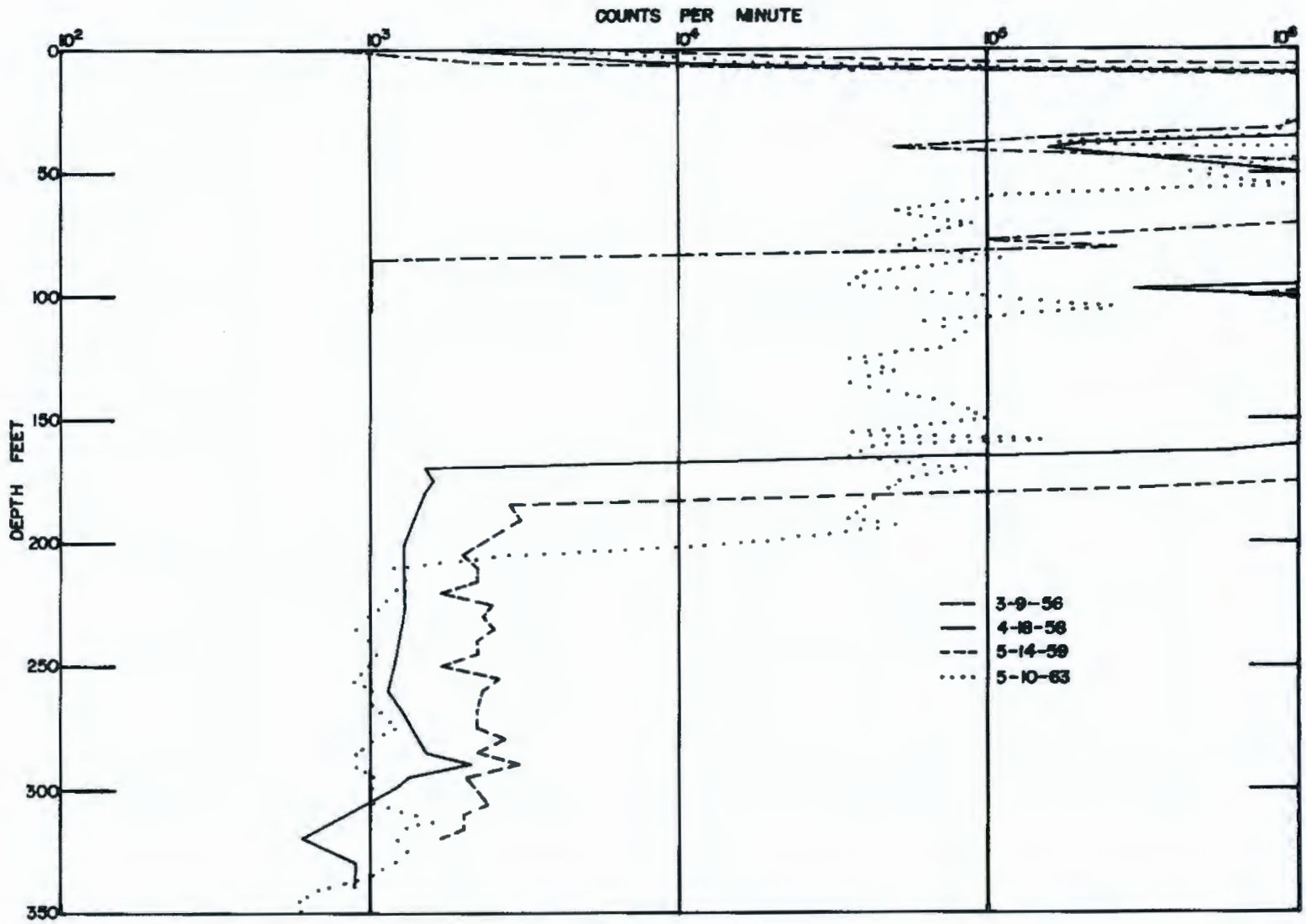


FIGURE 1

Well E13-6 Scintillation Log

HW-84577

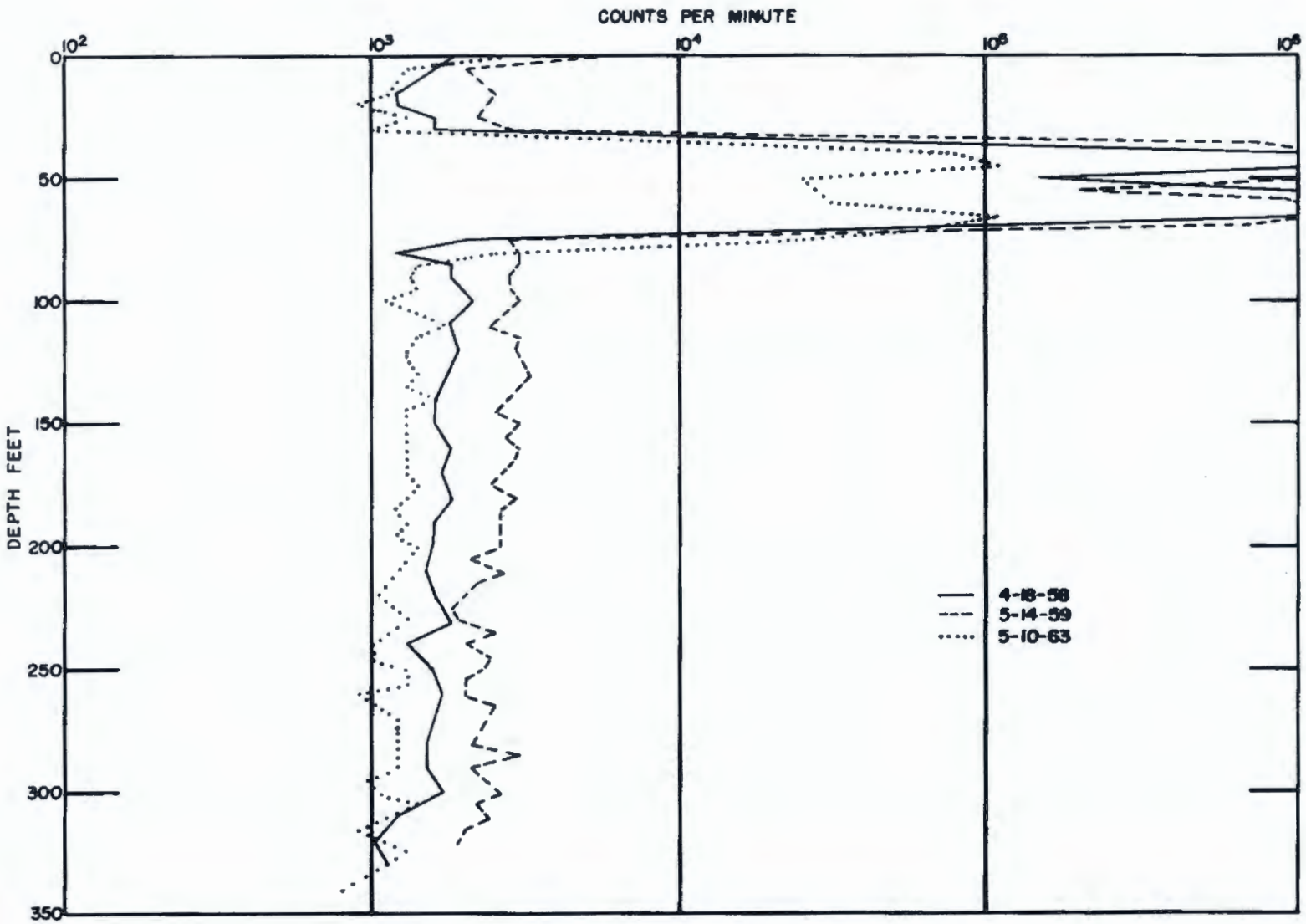


FIGURE 2

Well E13-8 Scintillation Log

HW-84577

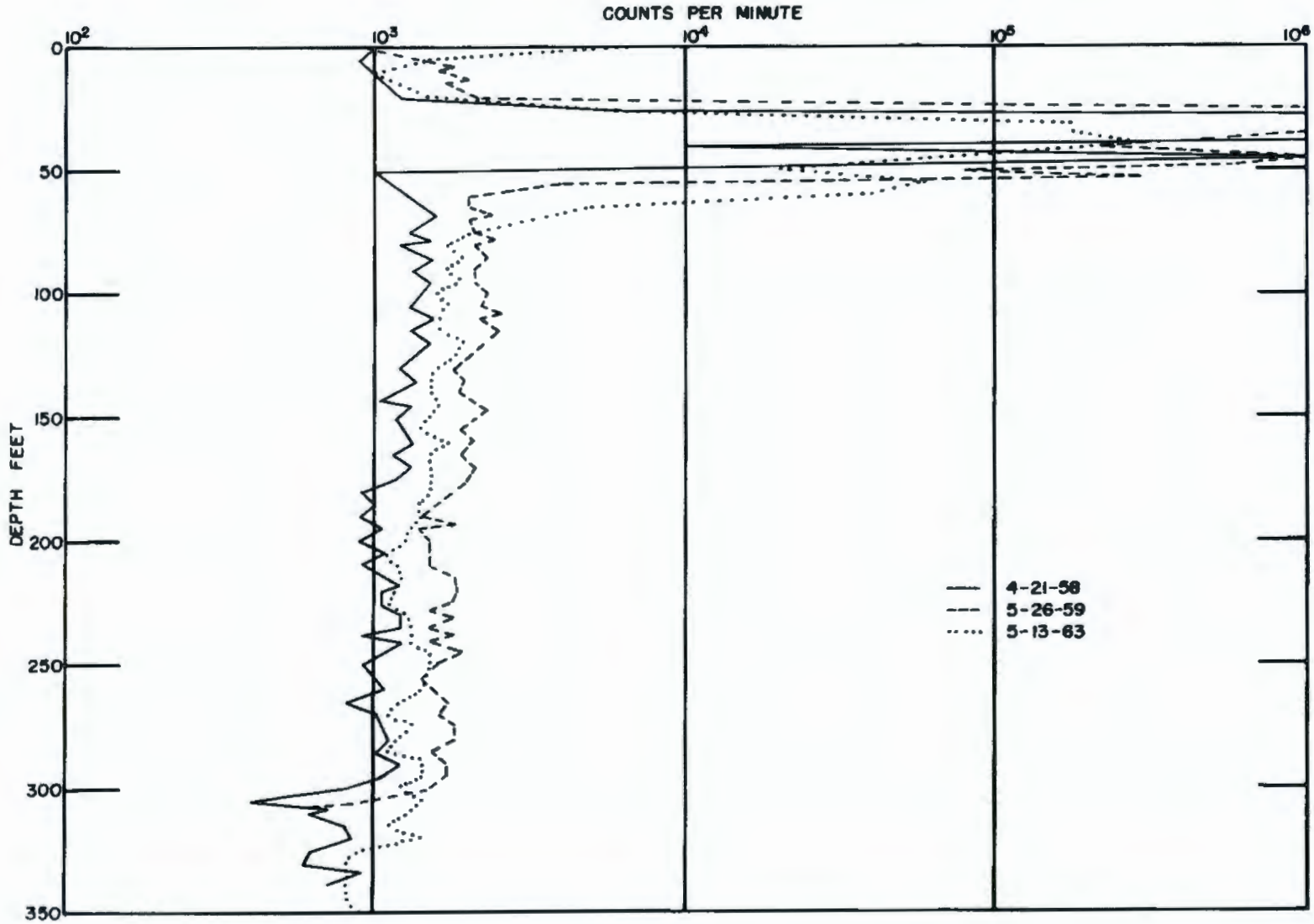


FIGURE 3

Well E13-19 Scintillation Log

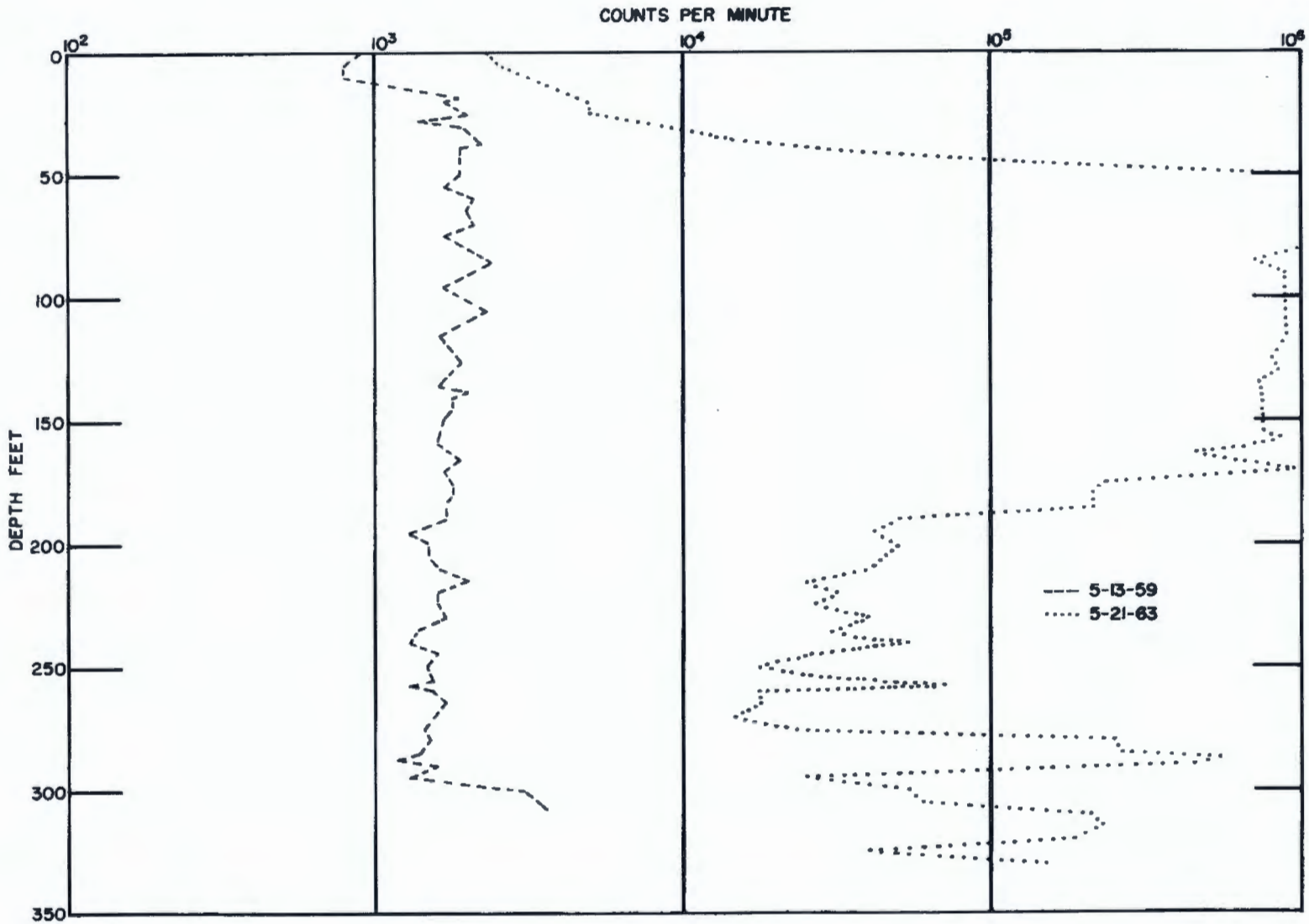


FIGURE 4

Well E17-1 Scintillation Log

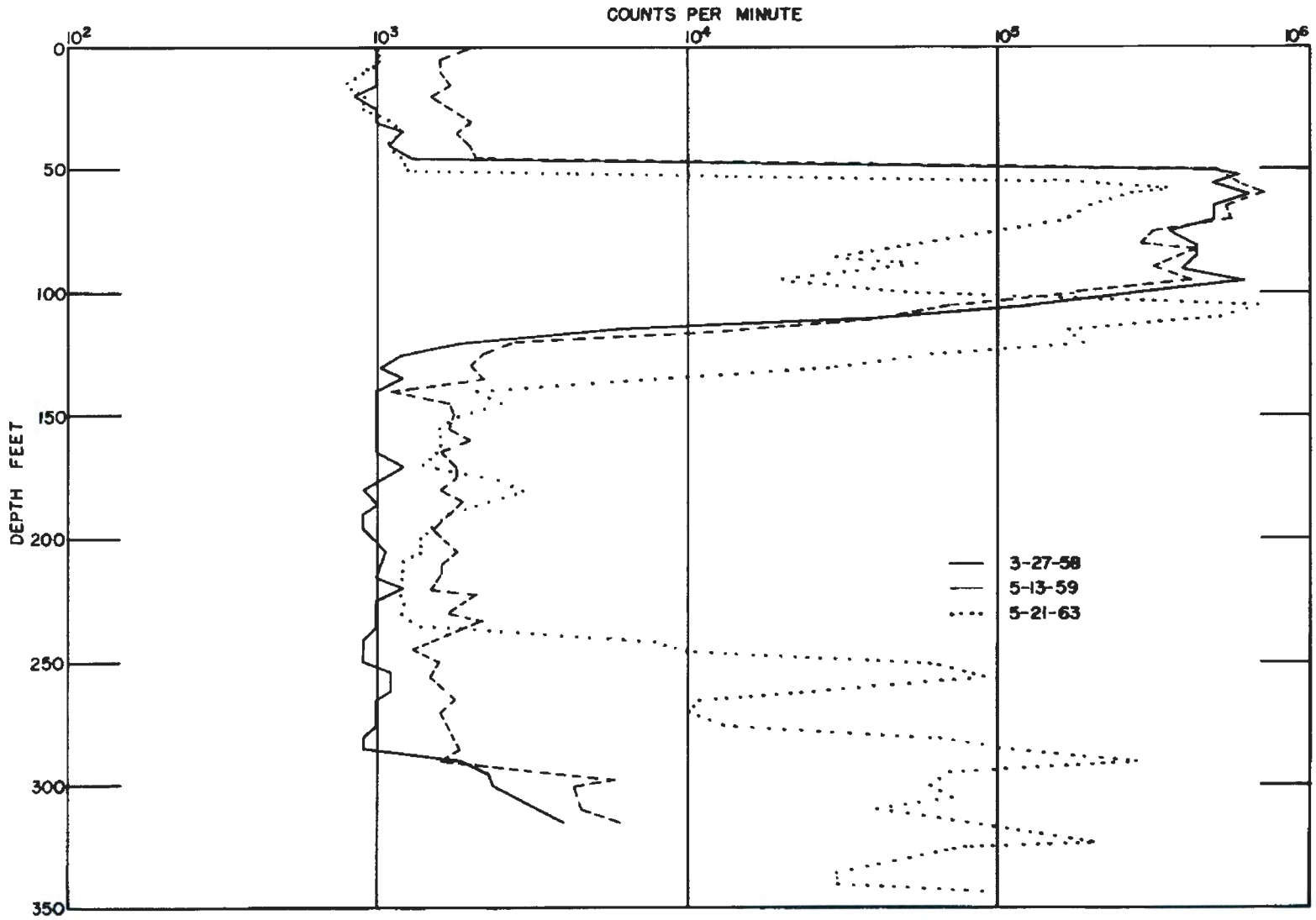


FIGURE 5

Well E24-1 Scintillation Log

HW-84577

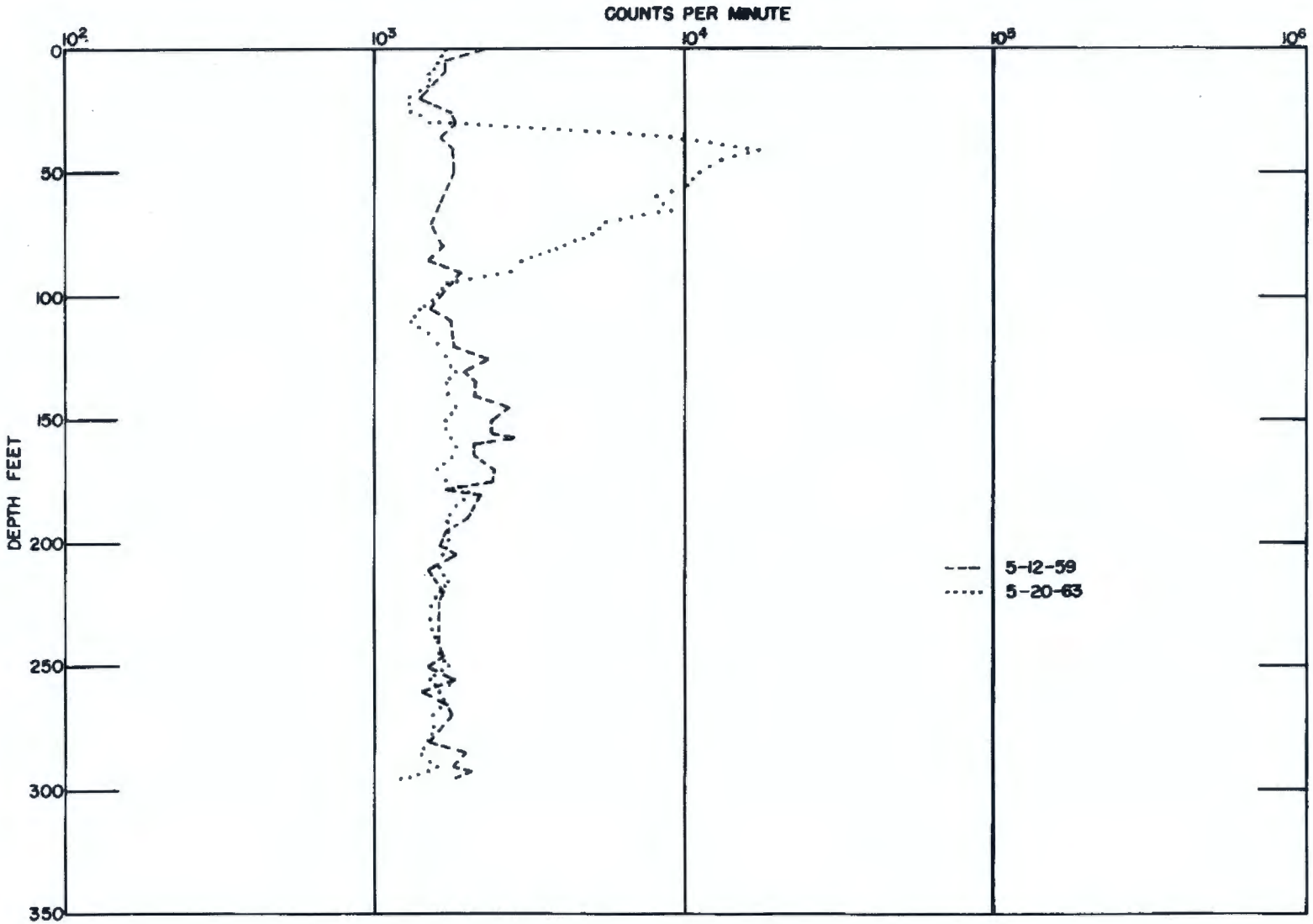


FIGURE 6

Well E24-3 Scintillation Log

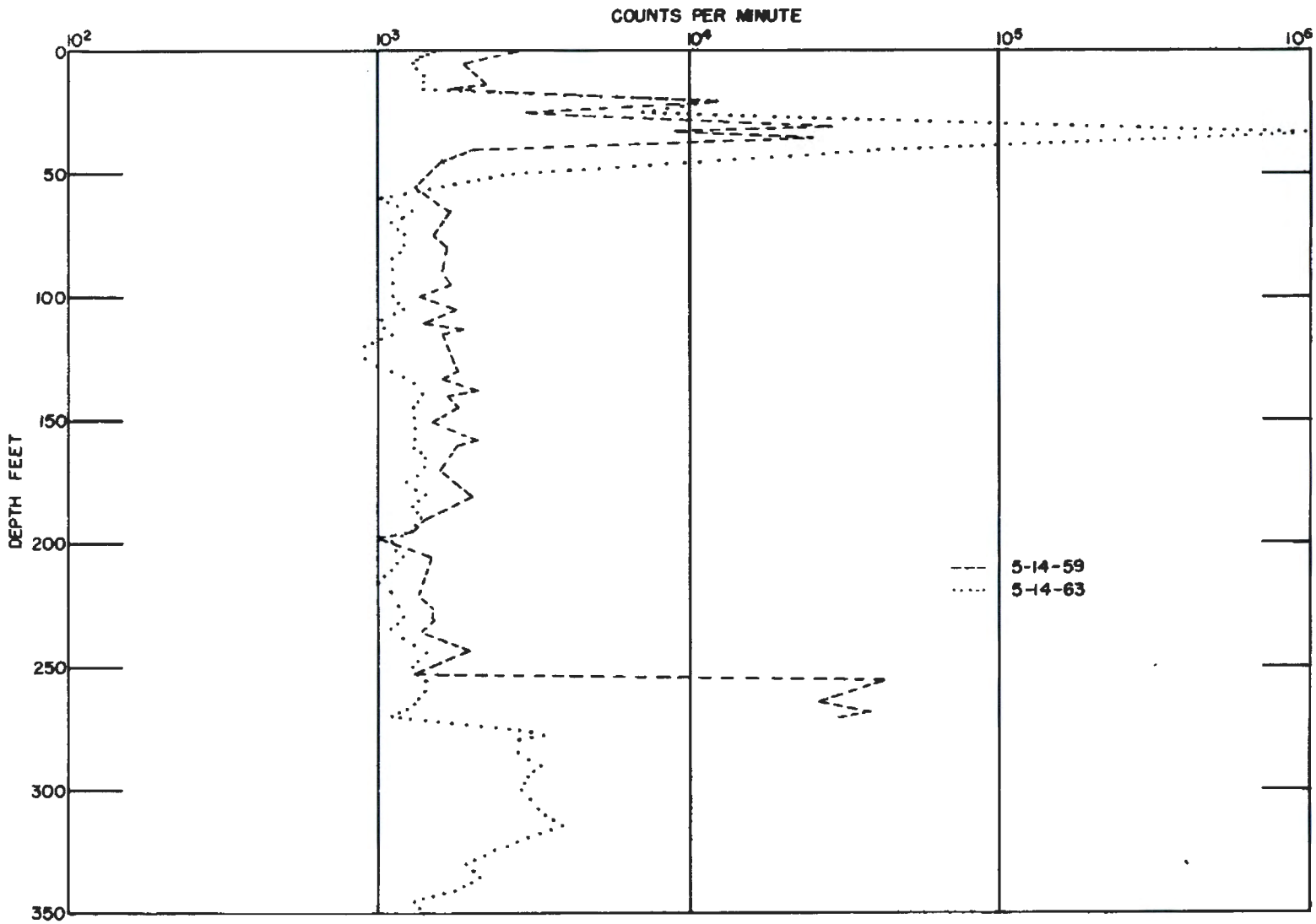


FIGURE 7

Well E25-2 Scintillation Log

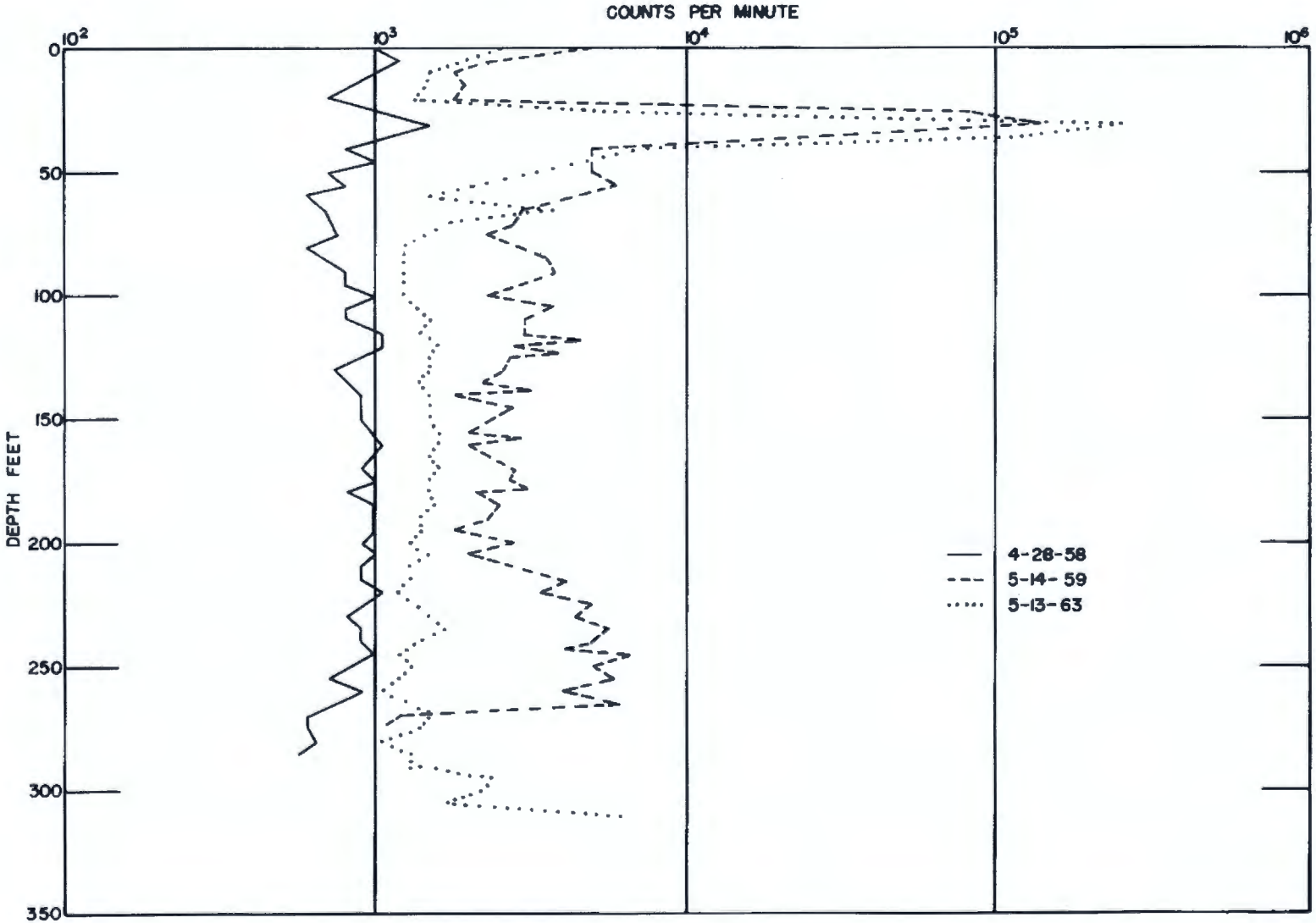


FIGURE 8

Well E25-3 Scintillation Log

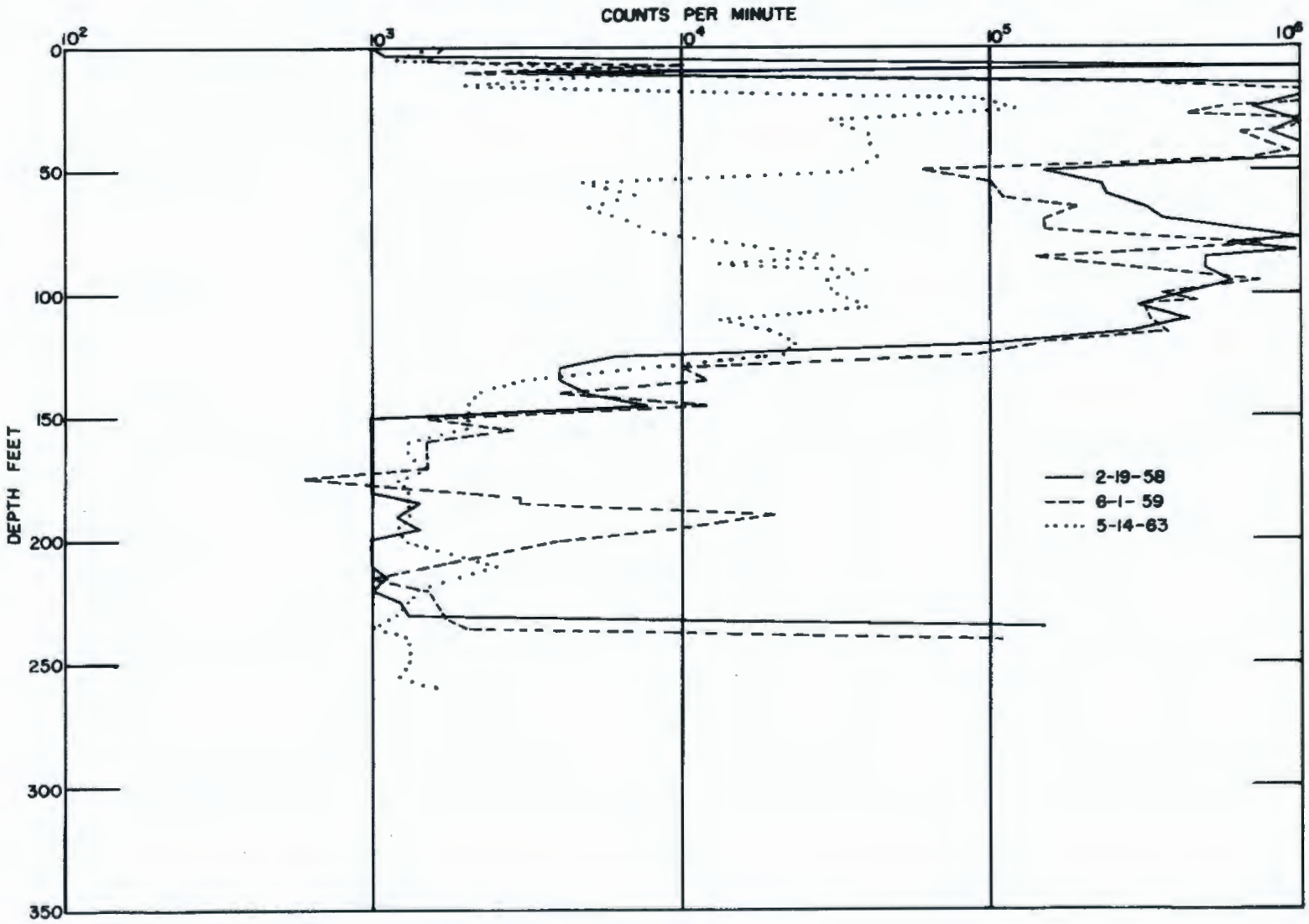


FIGURE 9

Well E25-4 Scintillation Log

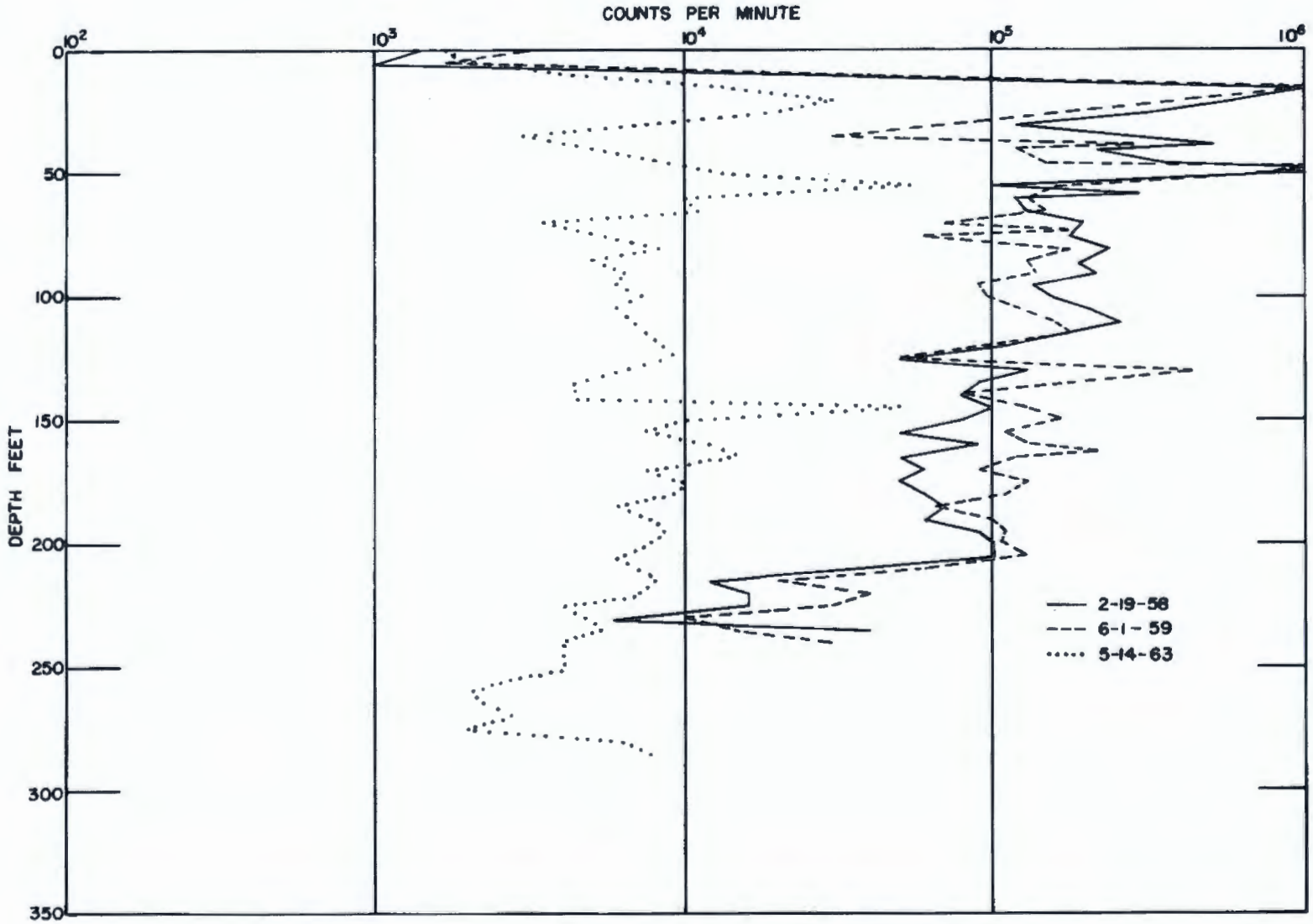


FIGURE 10

Well E25-9 Scintillation Log

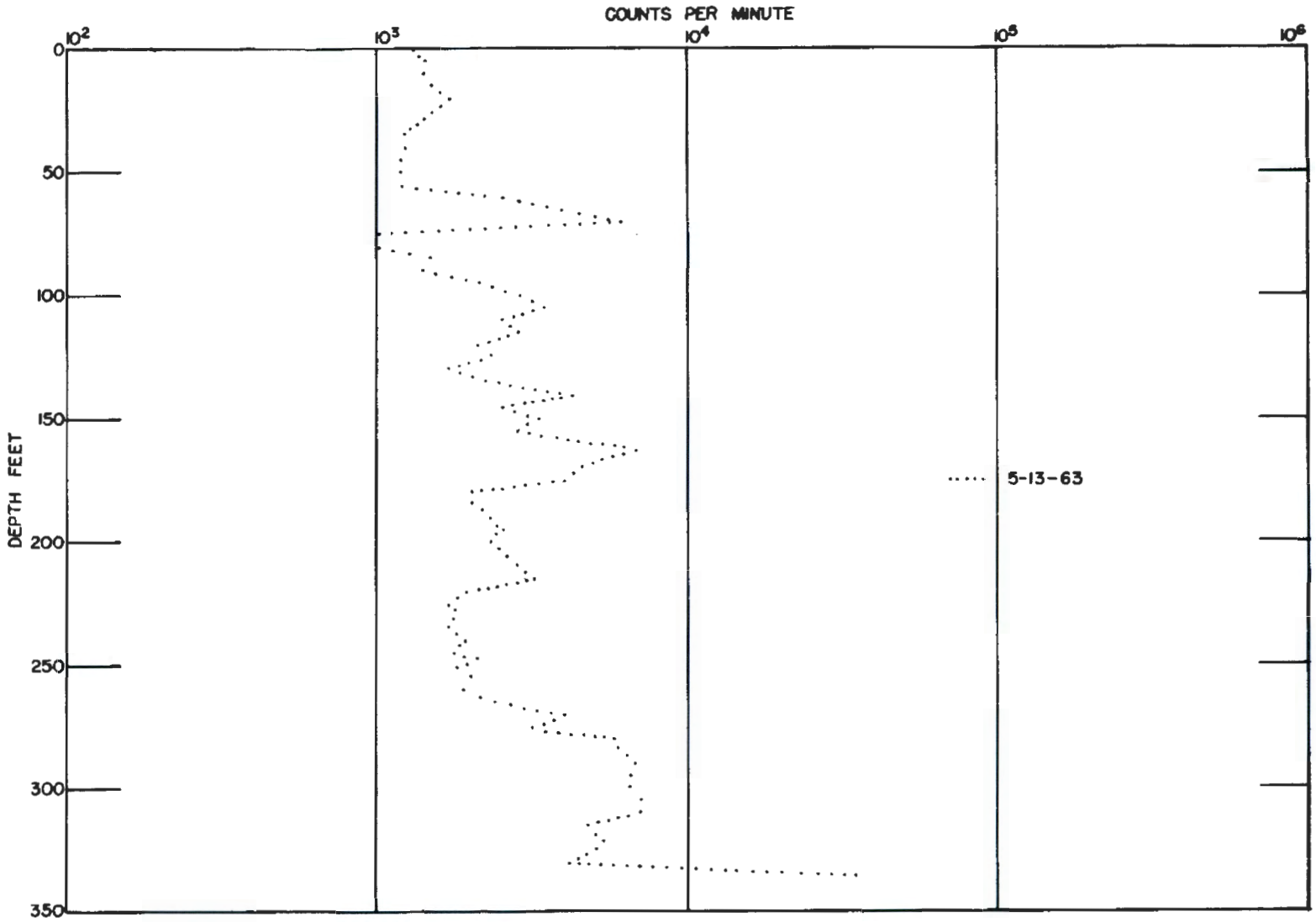


FIGURE 11

Well E25-11 Scintillation Log

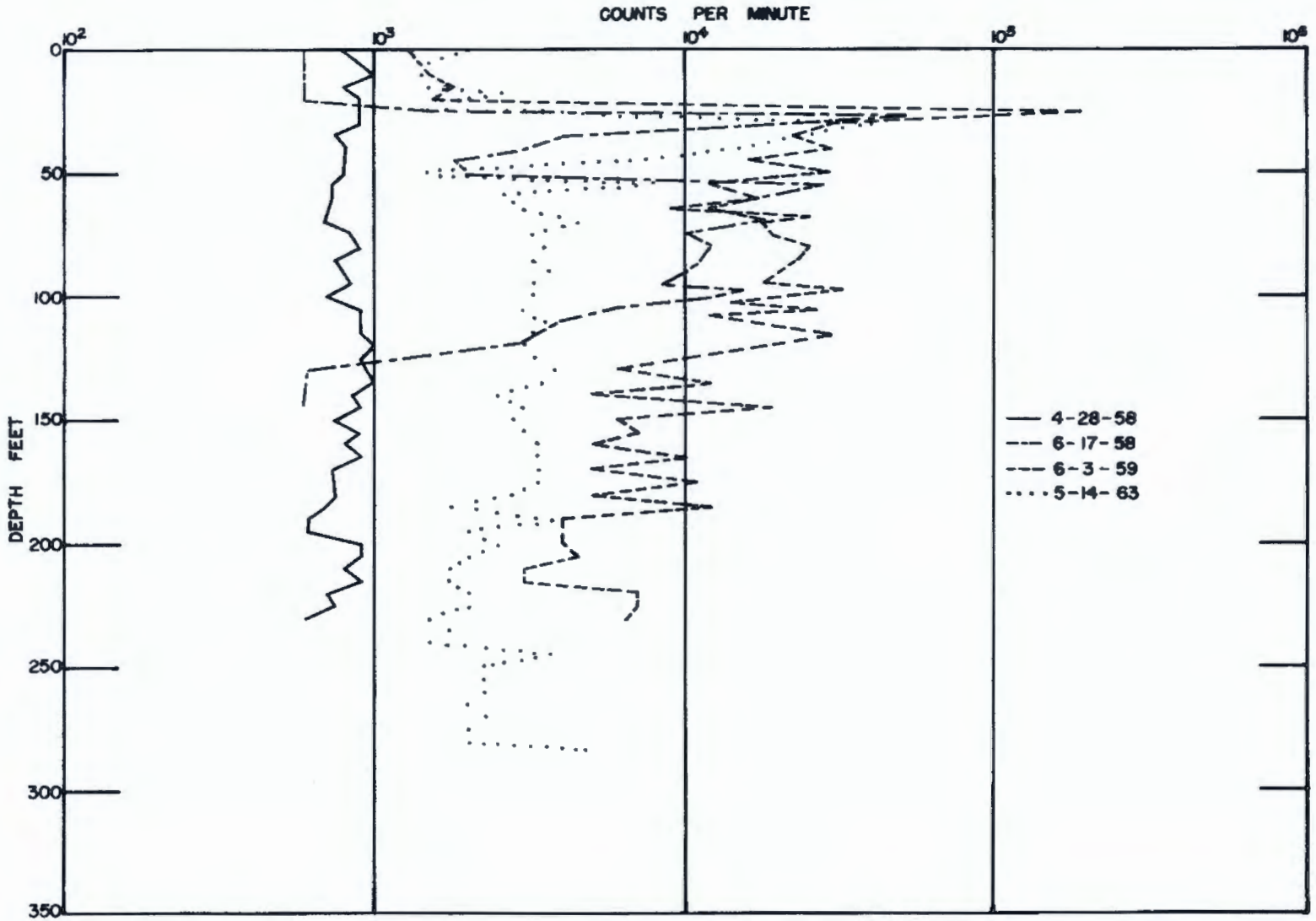


FIGURE 12

Well E26-5 Scintillation Log

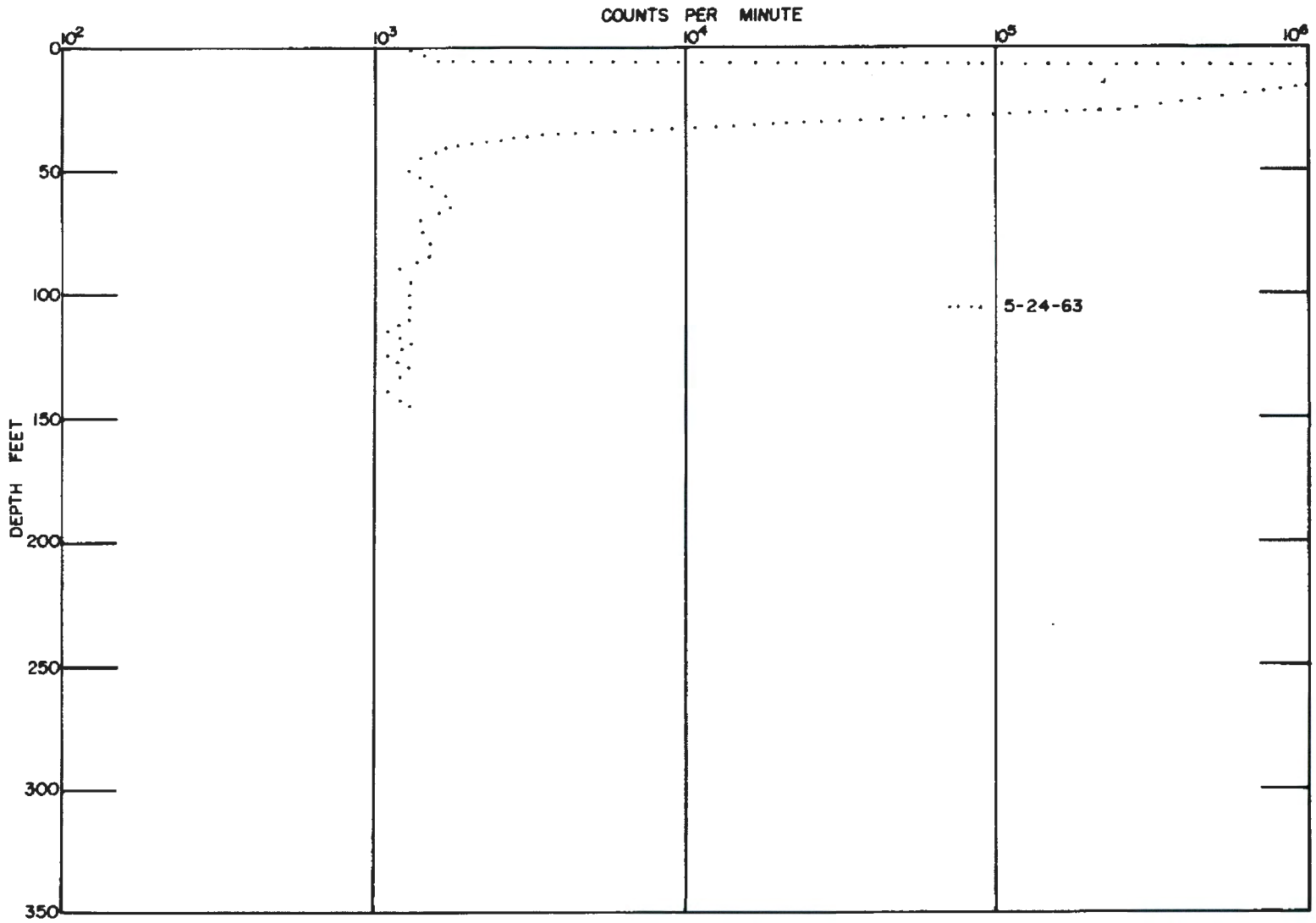


FIGURE 13

Well E28-55 Scintillation Log

HW-84577

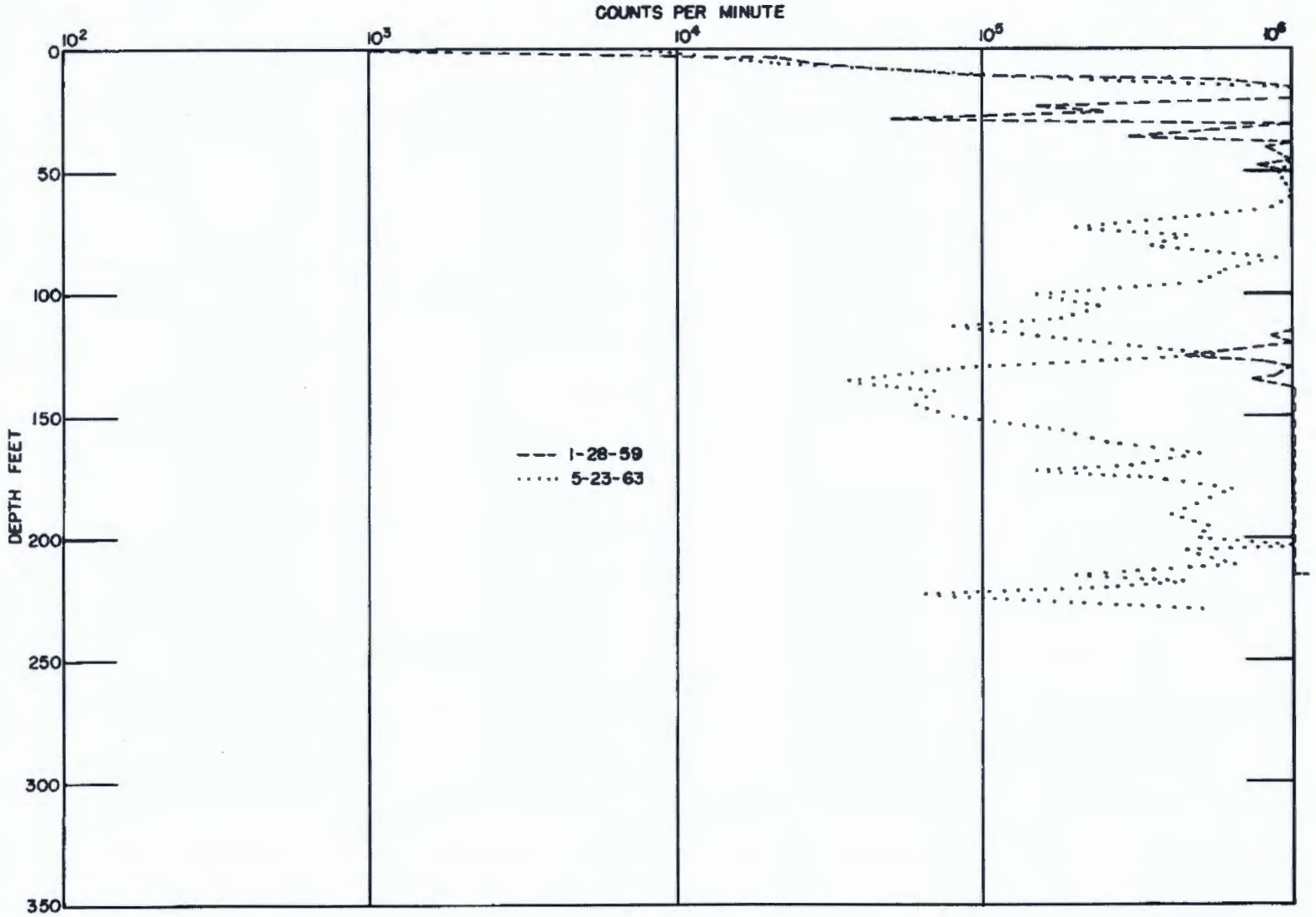


FIGURE 14

Well E33-4 Scintillation Log

HW-84577

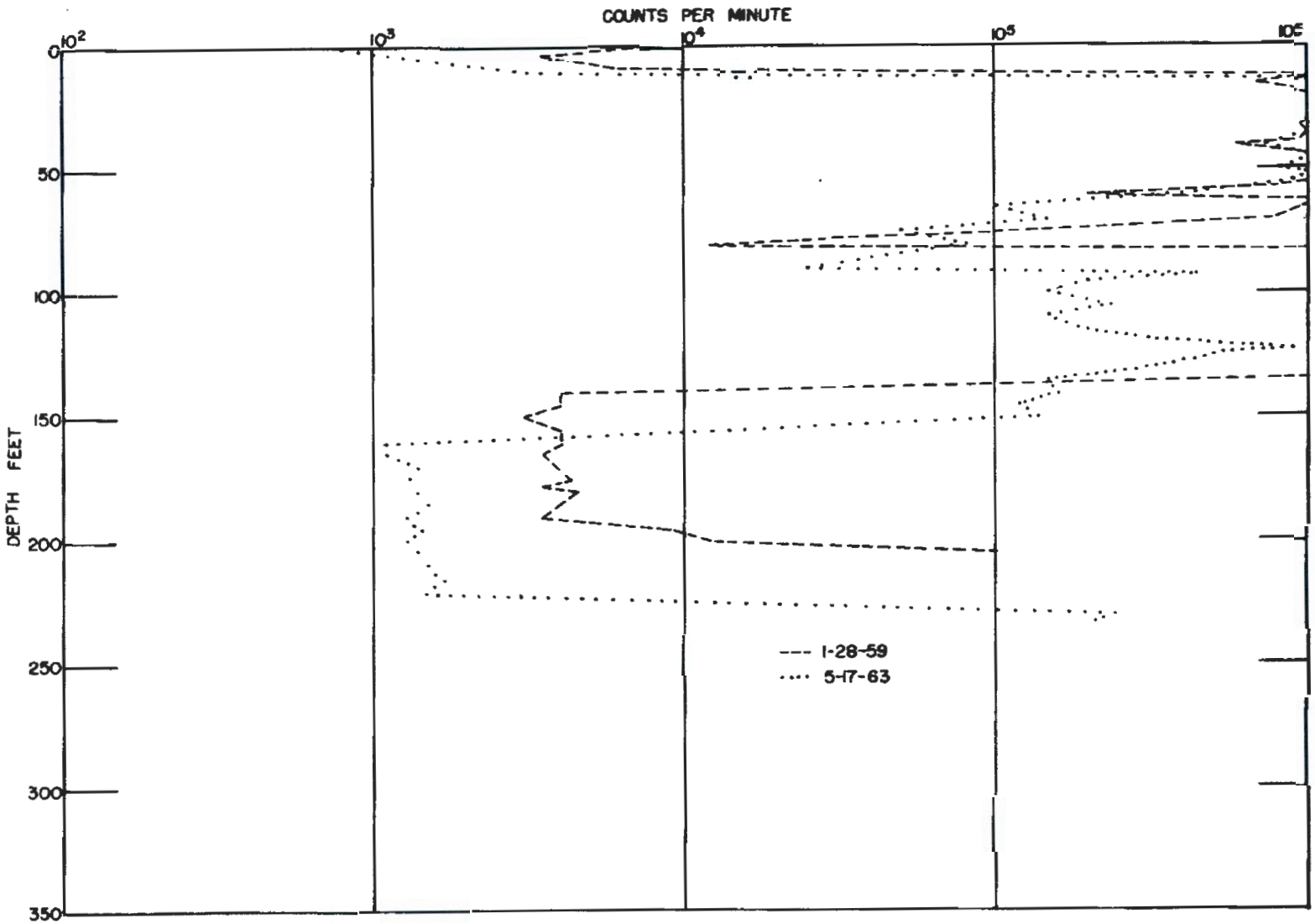


FIGURE 15

Well E33-7 Scintillation Log

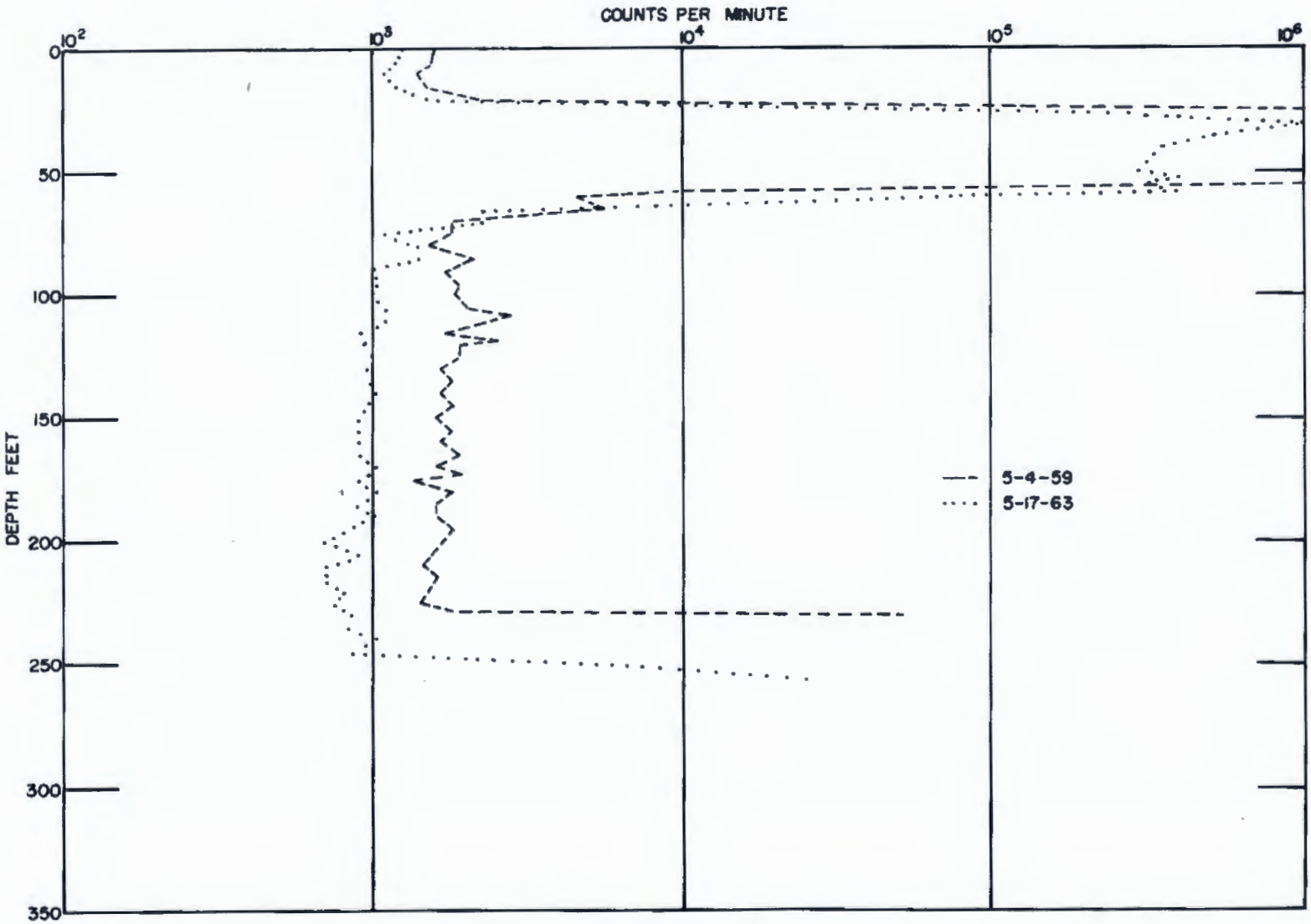
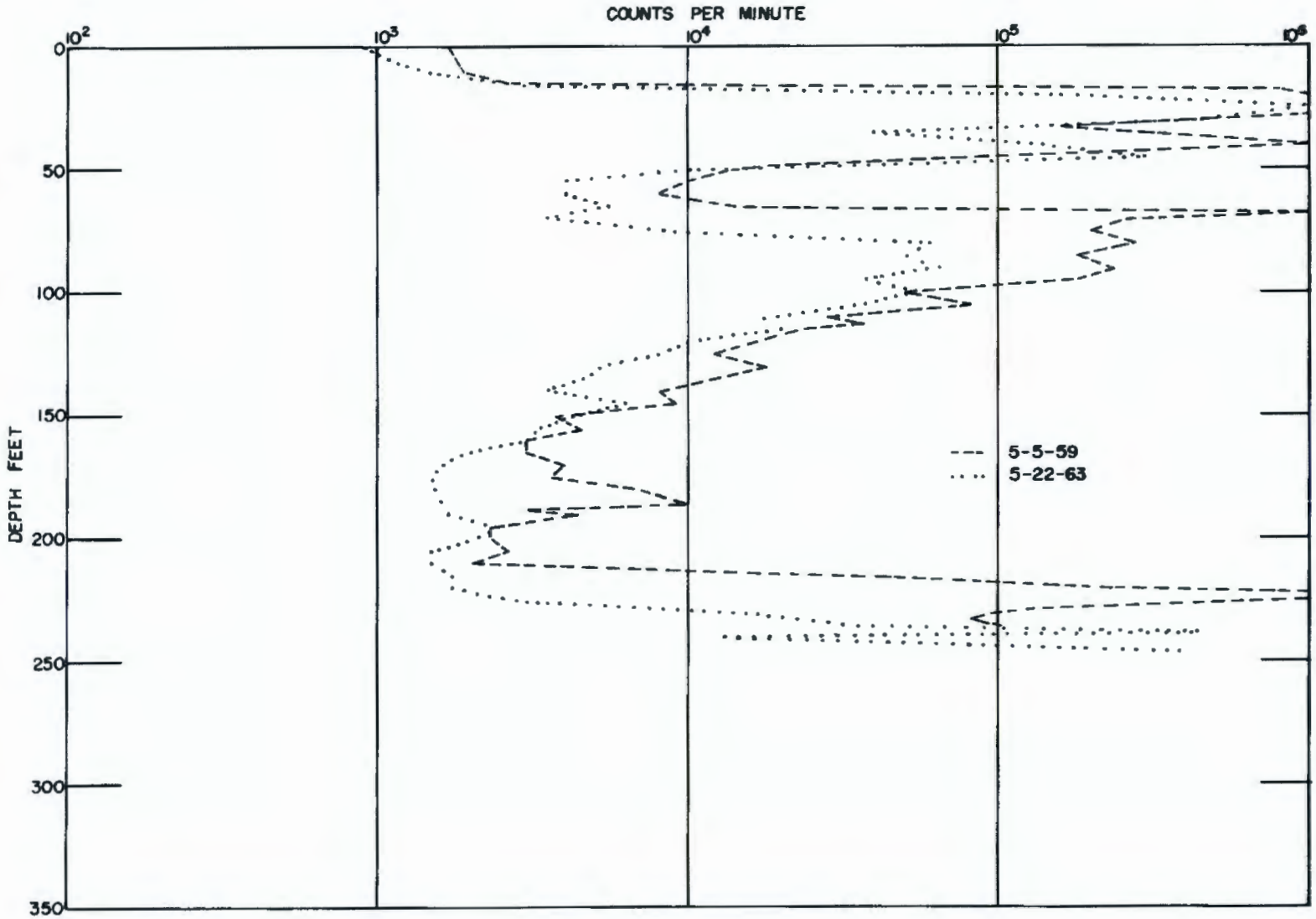


FIGURE 16
Well E33-8 Scintillation Log



HW-84577

FIGURE 17

Well E33-16 Scintillation Log

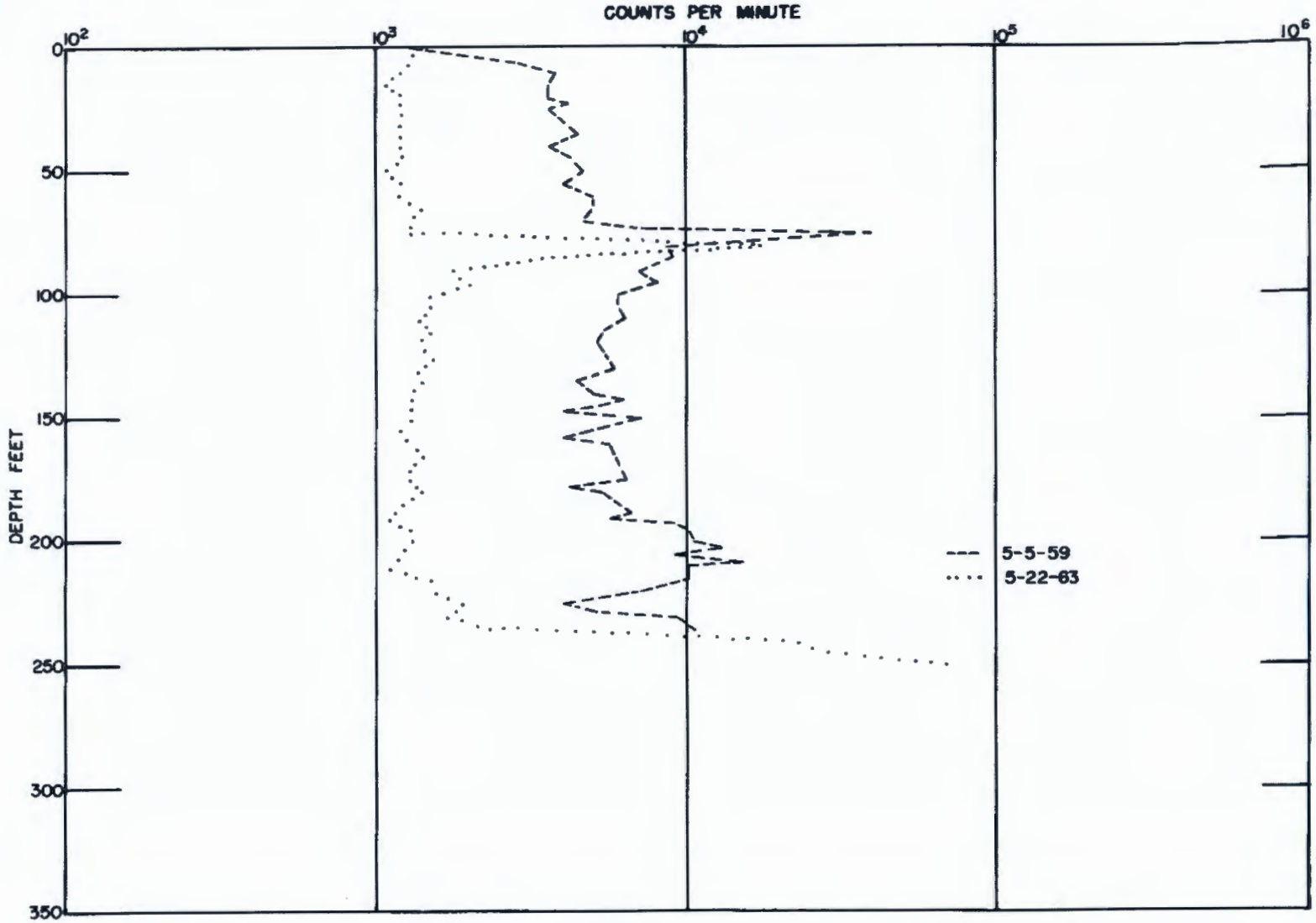


FIGURE 18

Well E33-20 Scintillation Log

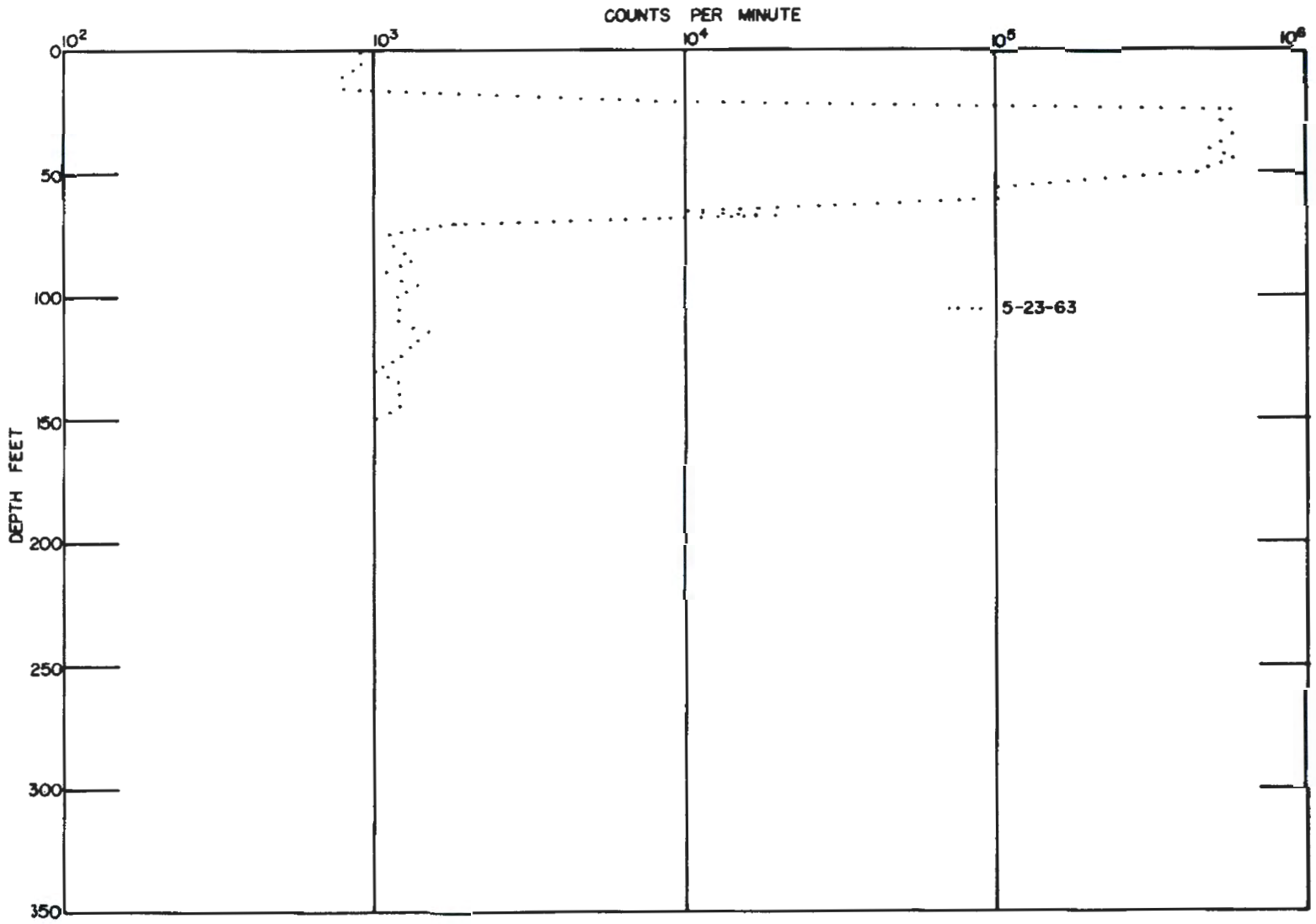


FIGURE 19
Well E33-60 Scintillation Log

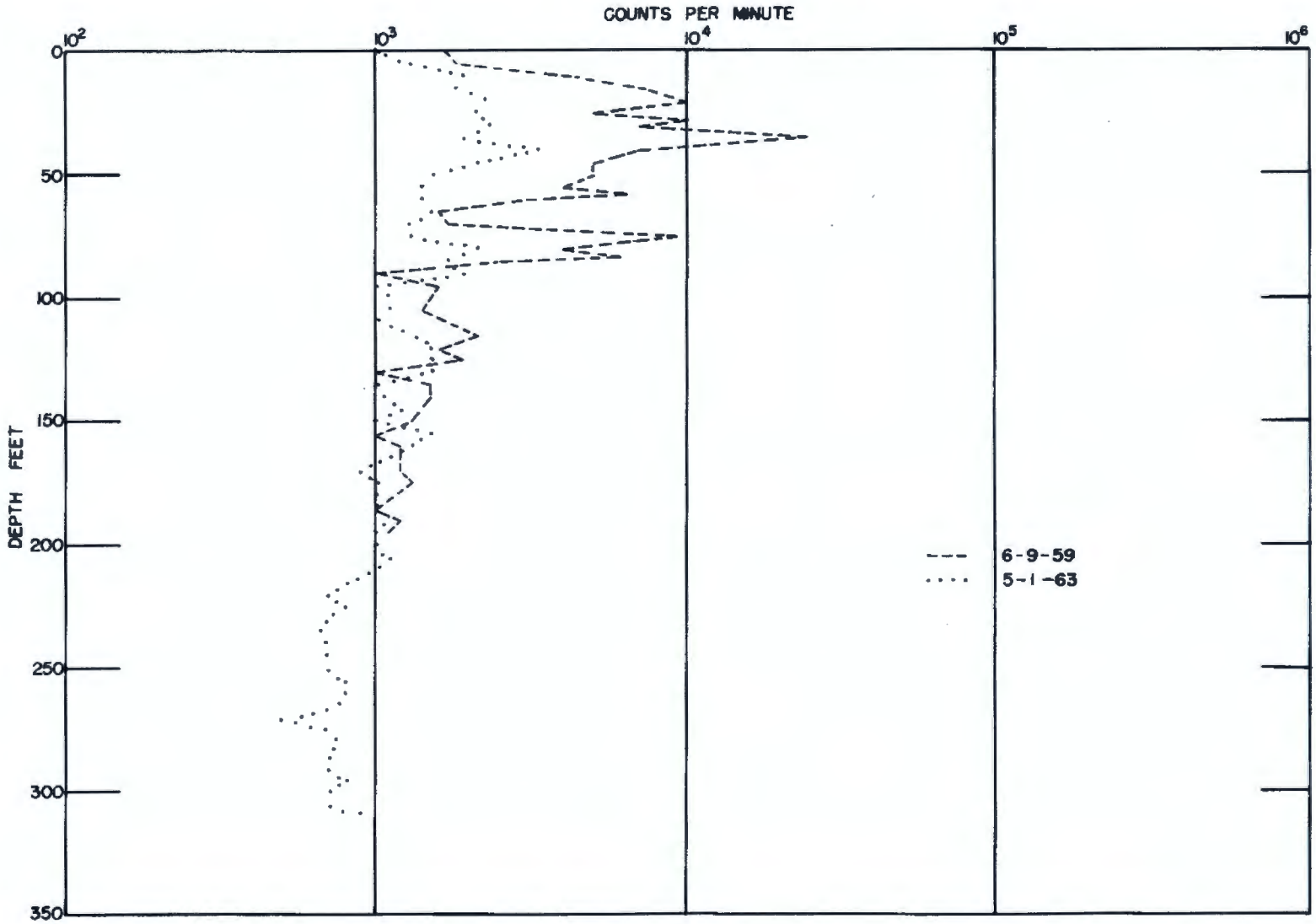


FIGURE 20

Well W10-1 Scintillation Log

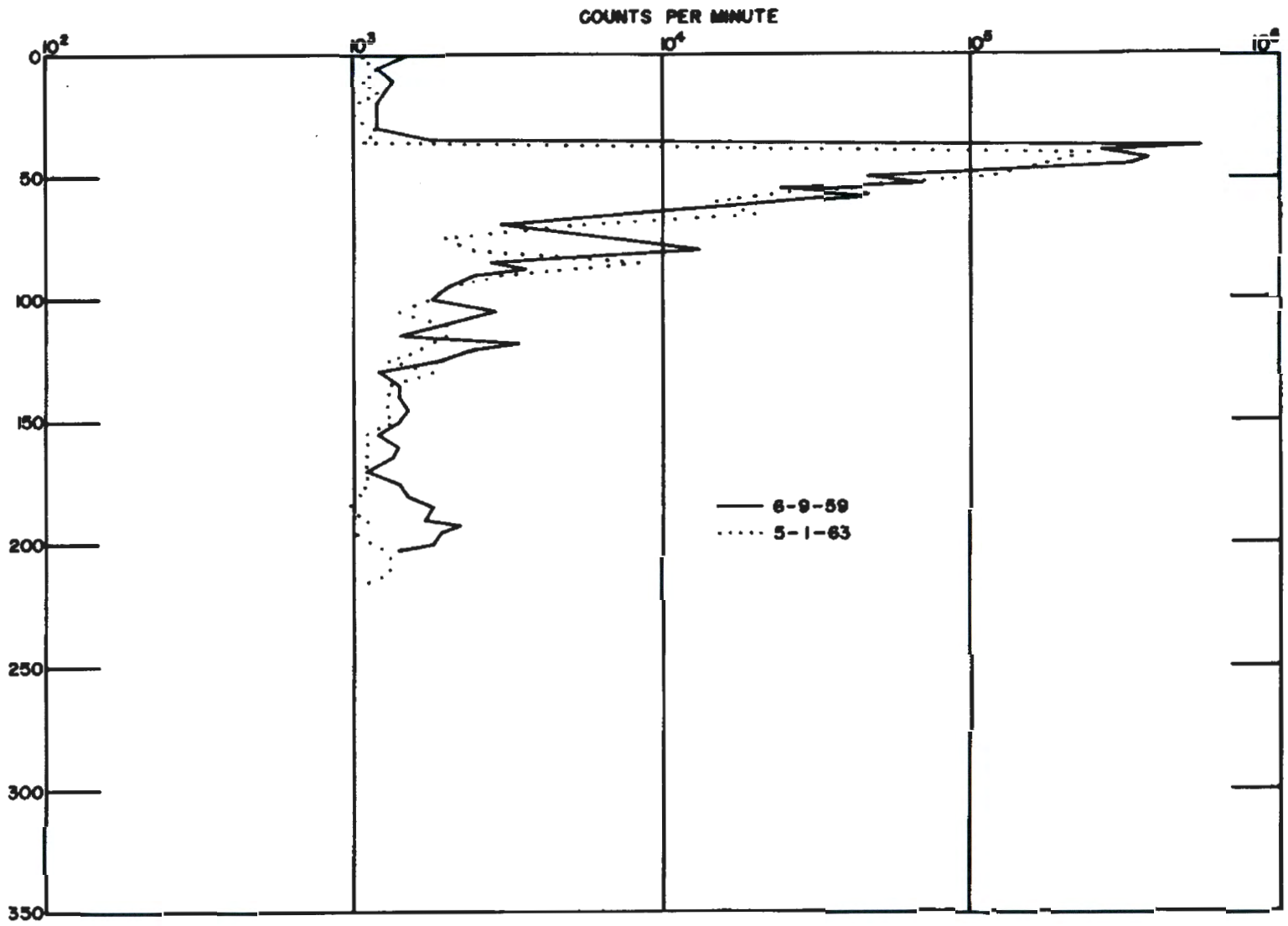


FIGURE 21

Well W10-3 Scintillation Log

HW-84577

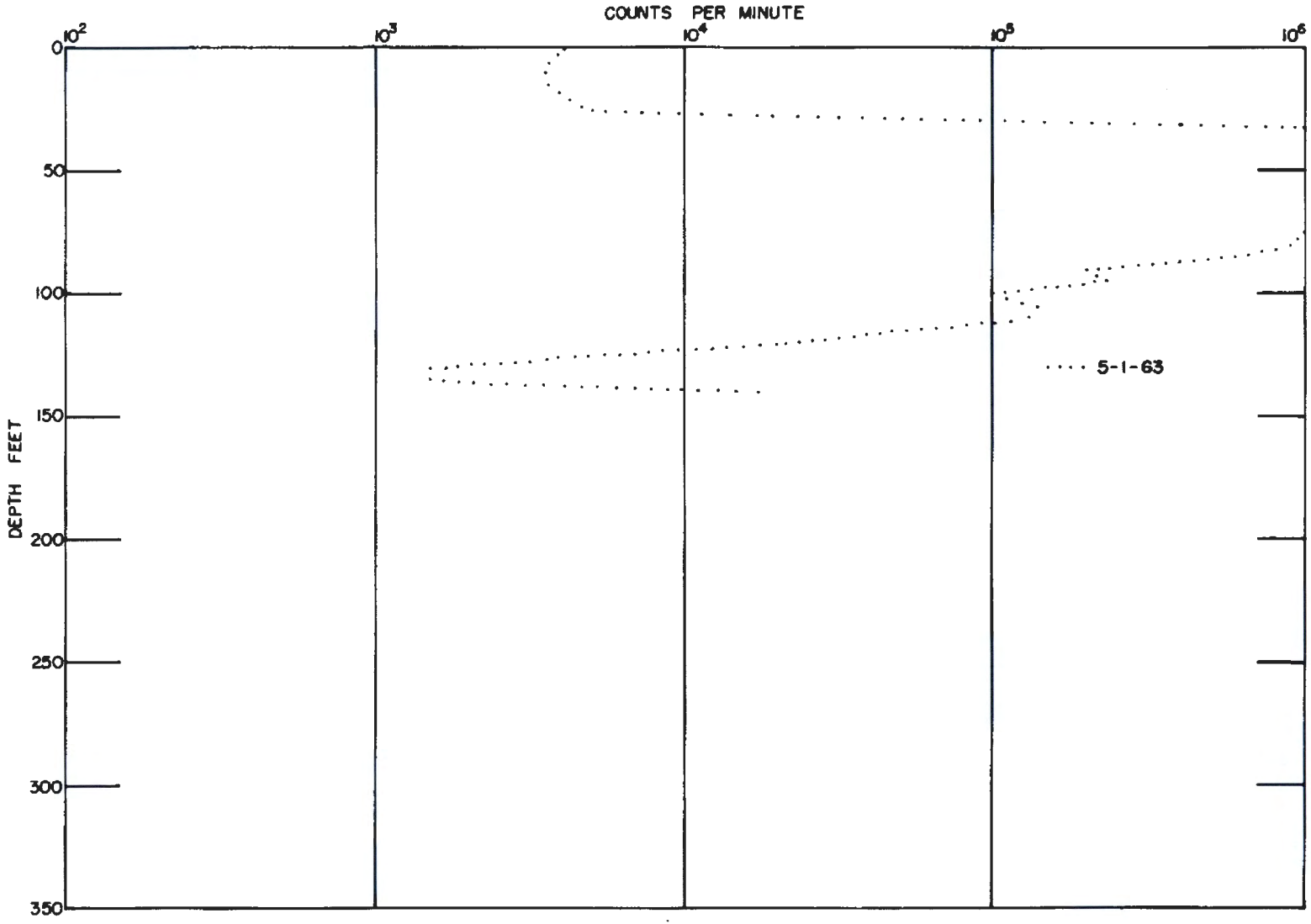
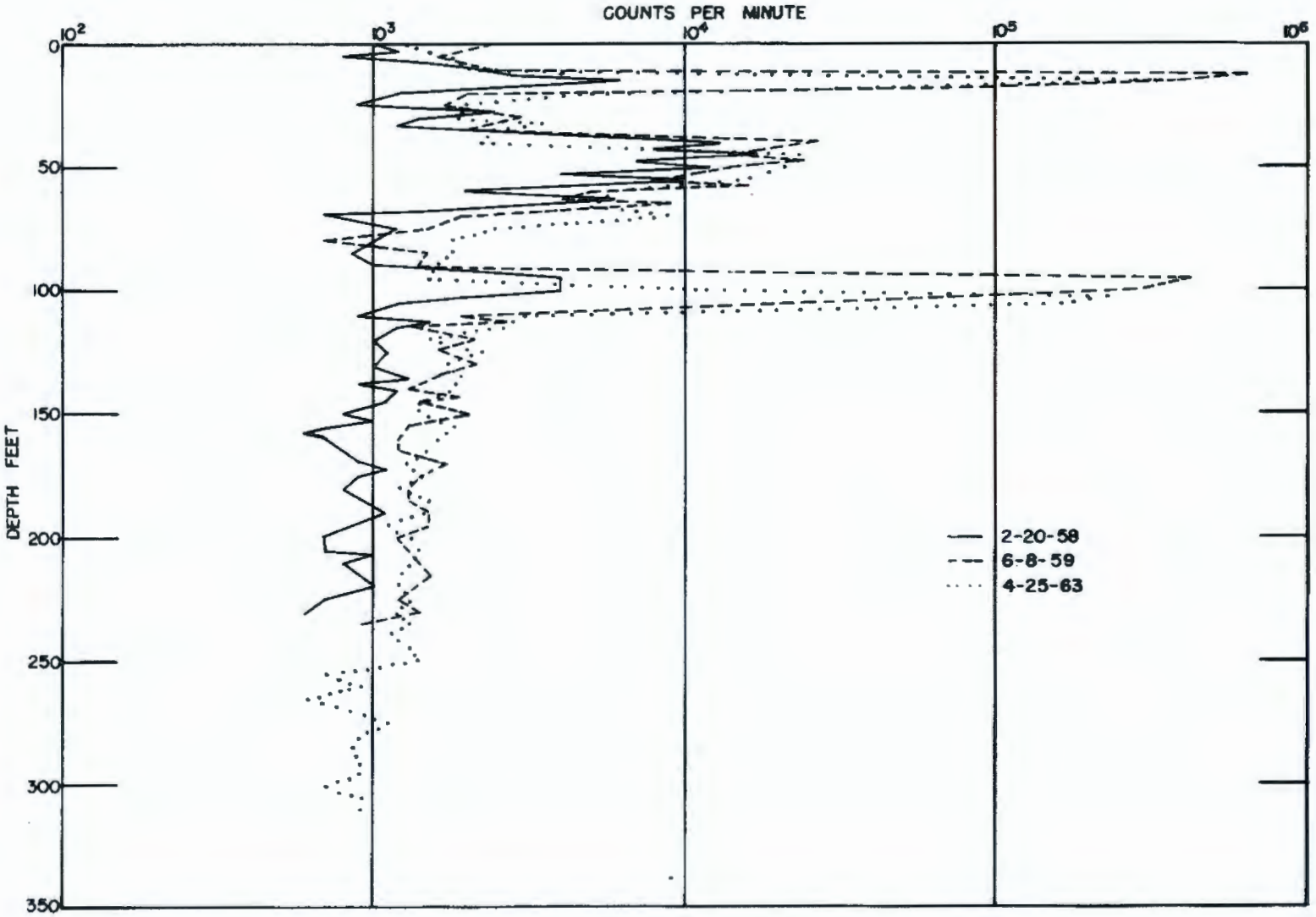


FIGURE 22

Well W10-60 Scintillation Log

HW-84577



HW-84577

FIGURE 23

Well W11-7 Scintillation Log

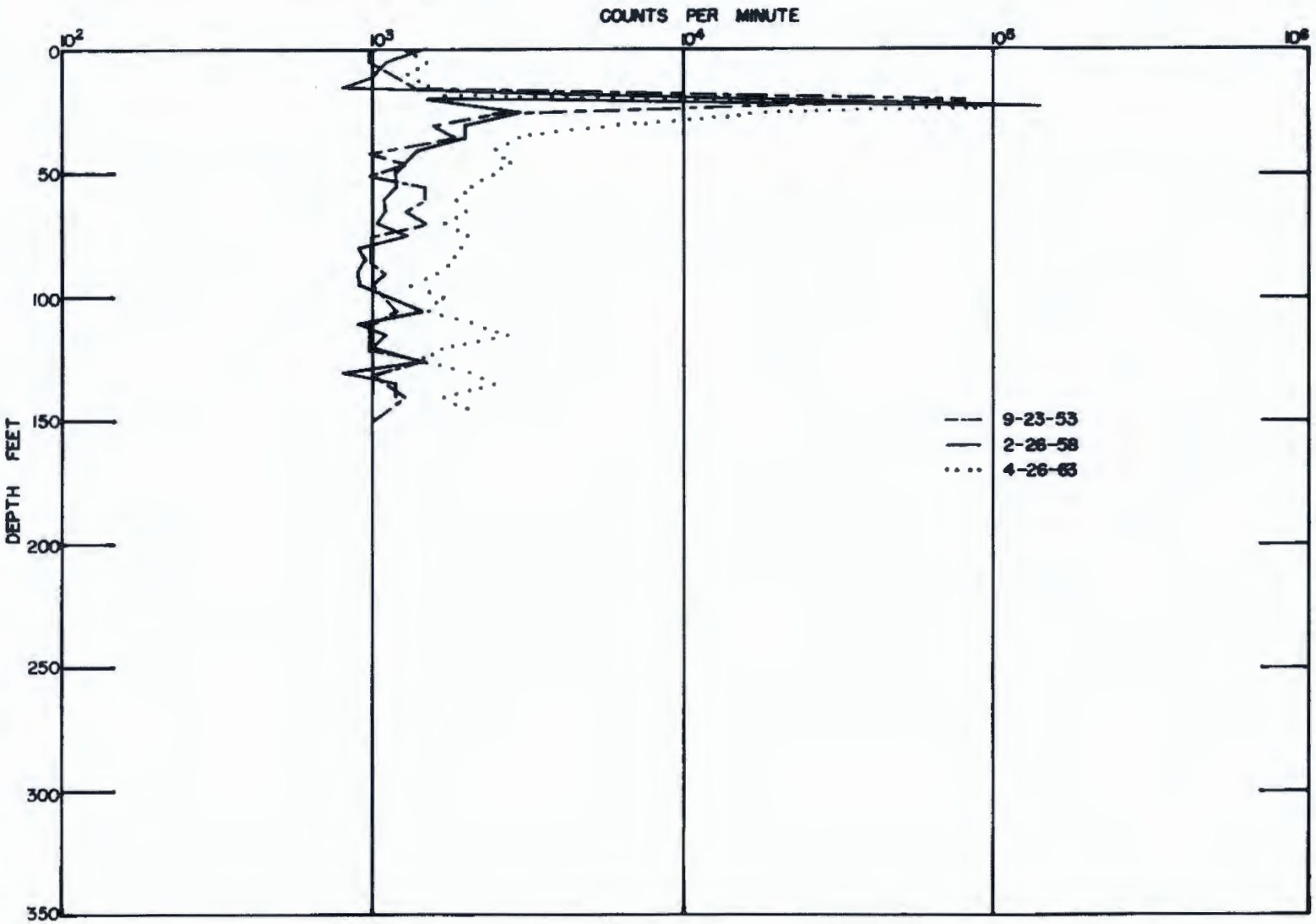


FIGURE 24

Well W11-55 Scintillation Log

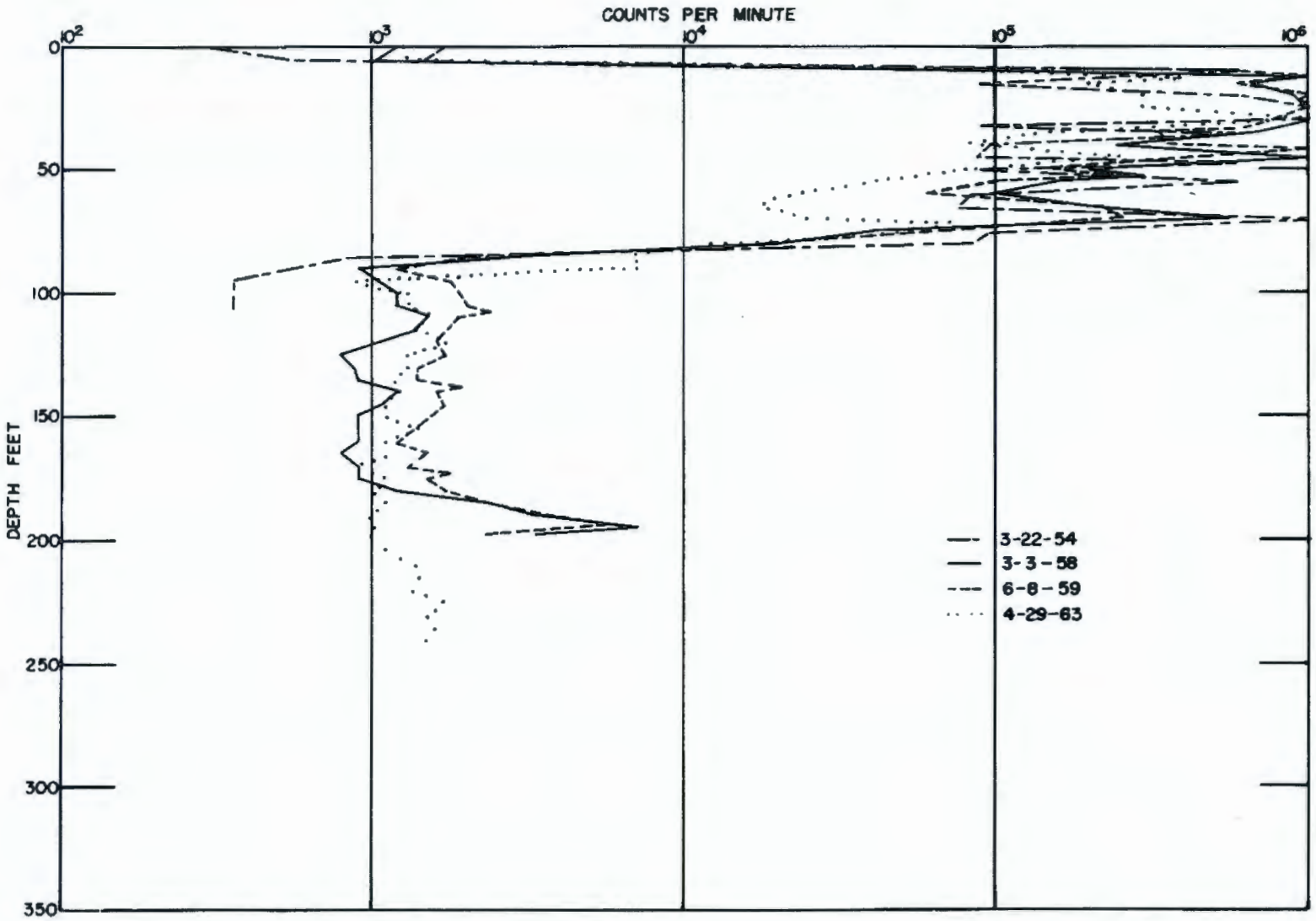


FIGURE 25

Well W11-11 Scintillation Log

HW-84577

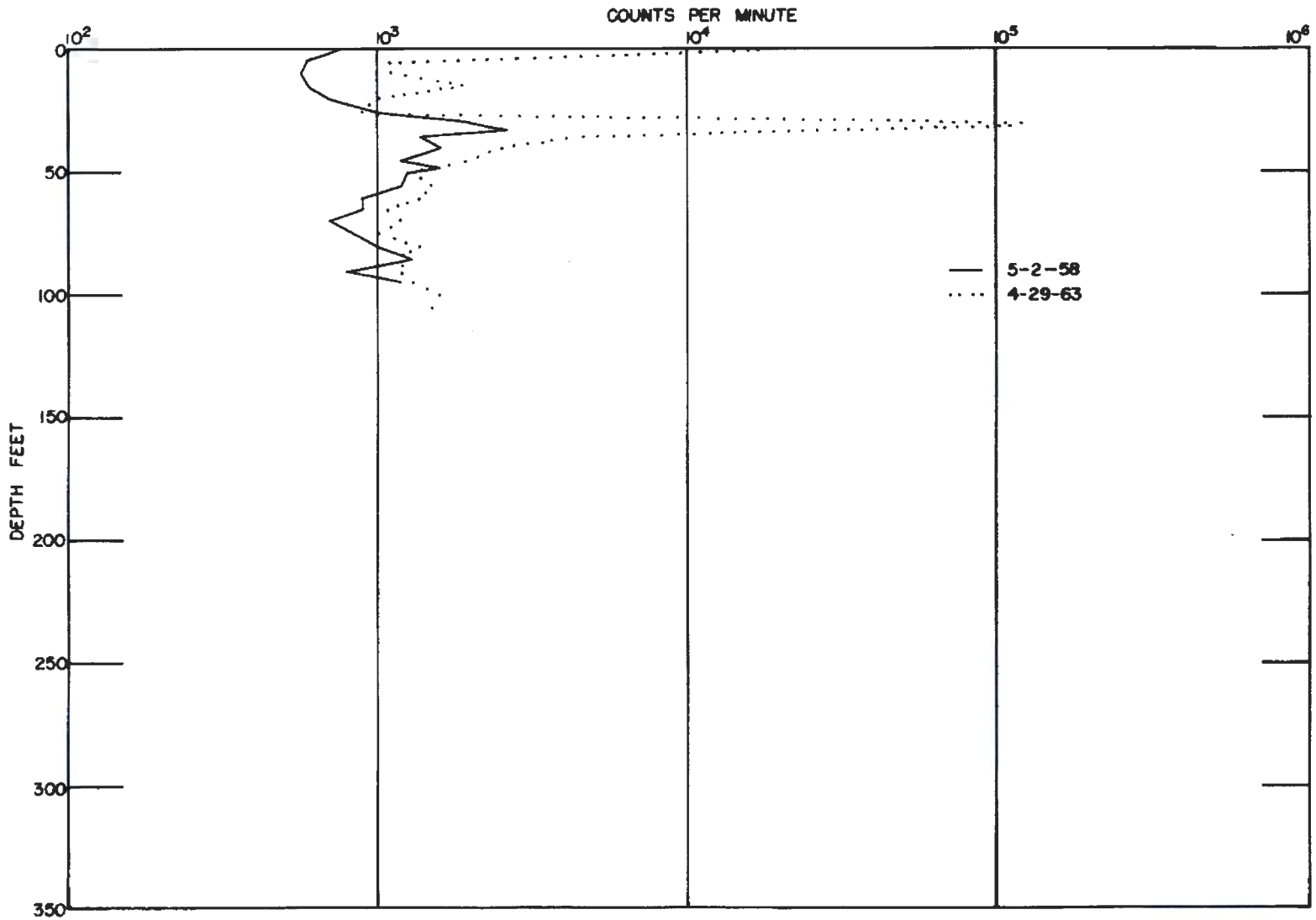


FIGURE 26

Well W11-68 Scintillation Log

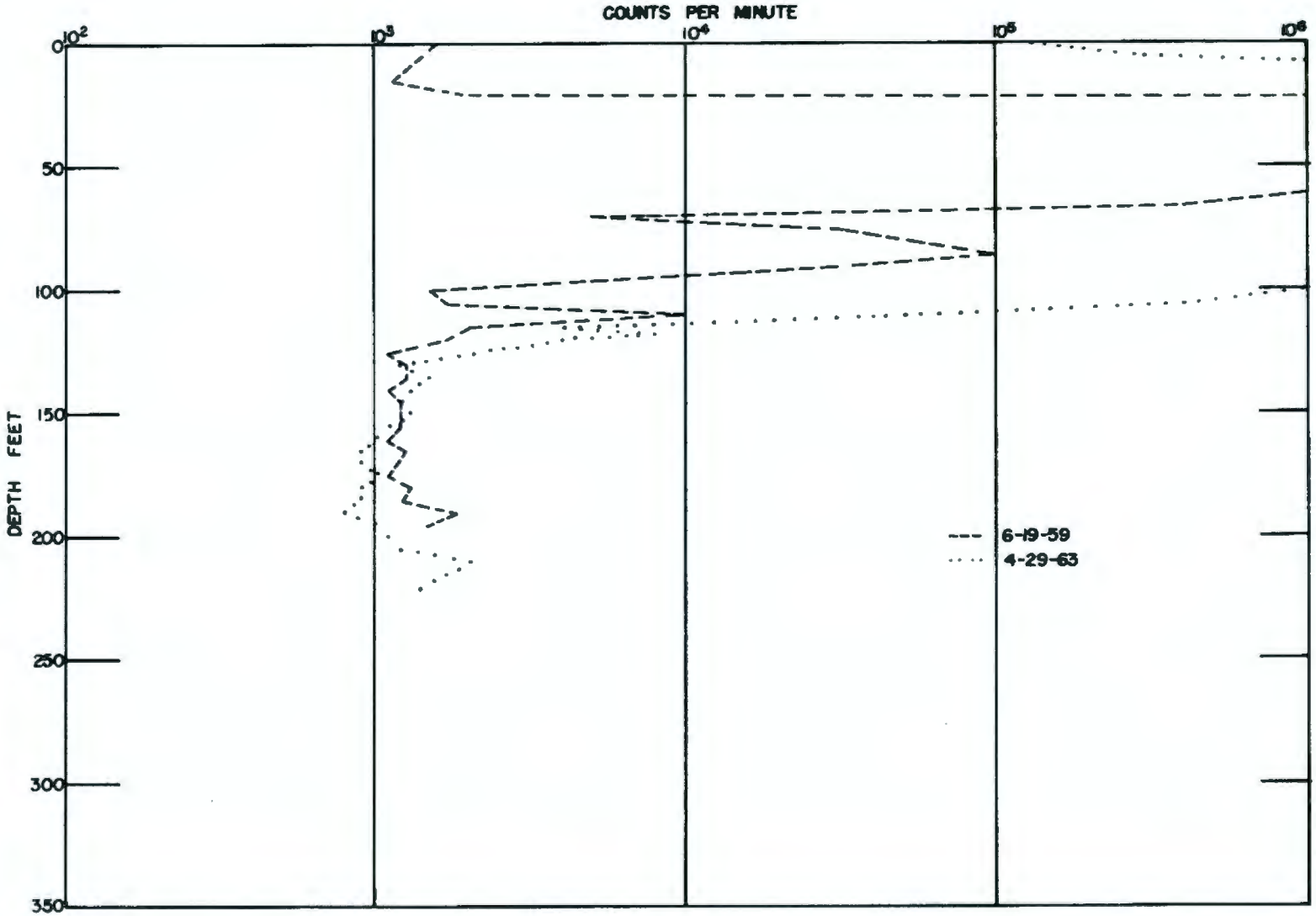


FIGURE 27

Well W14-2 Scintillation Log

HW-84577

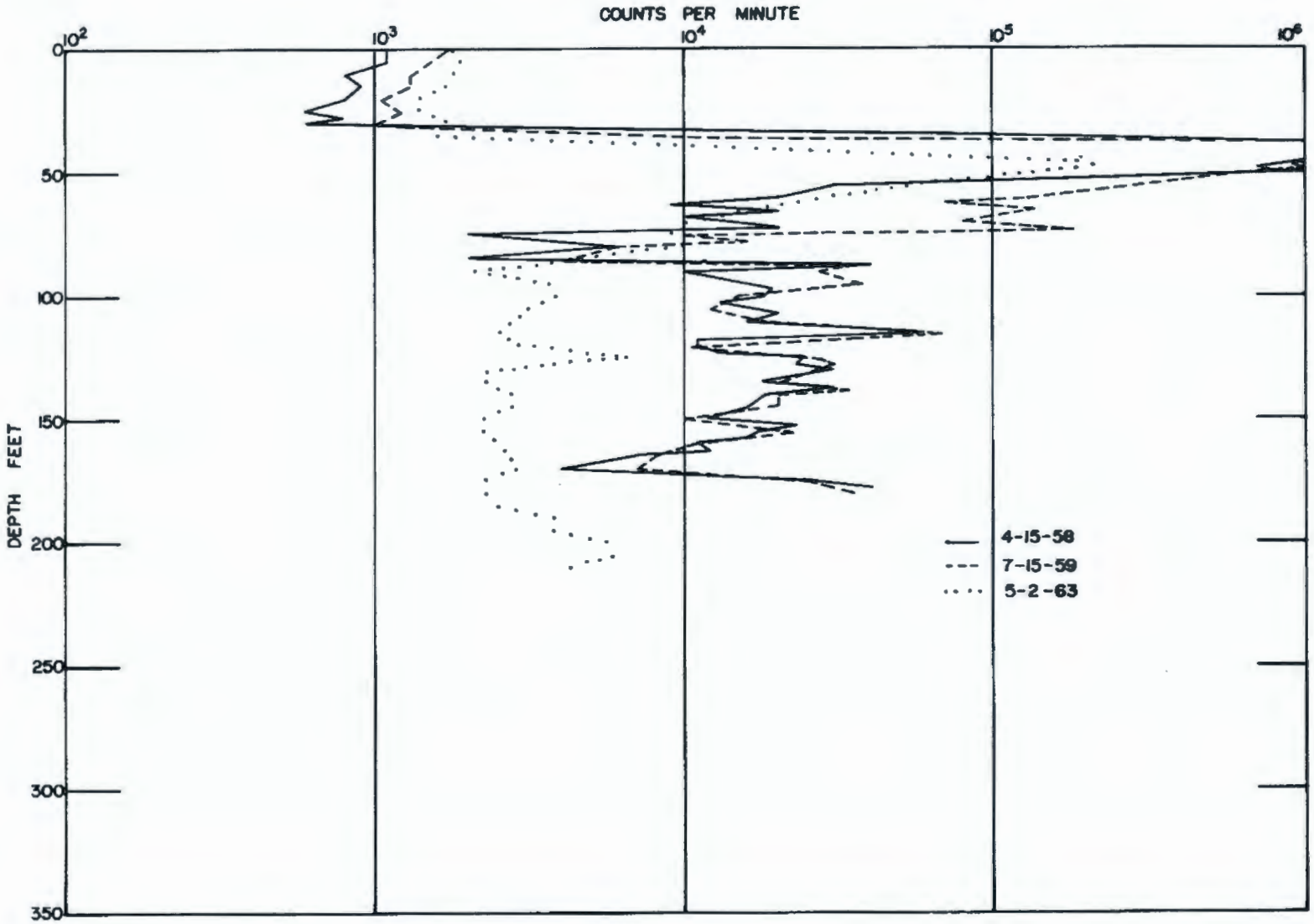


FIGURE 28

Well W15-4 Scintillation Log

HW-84577

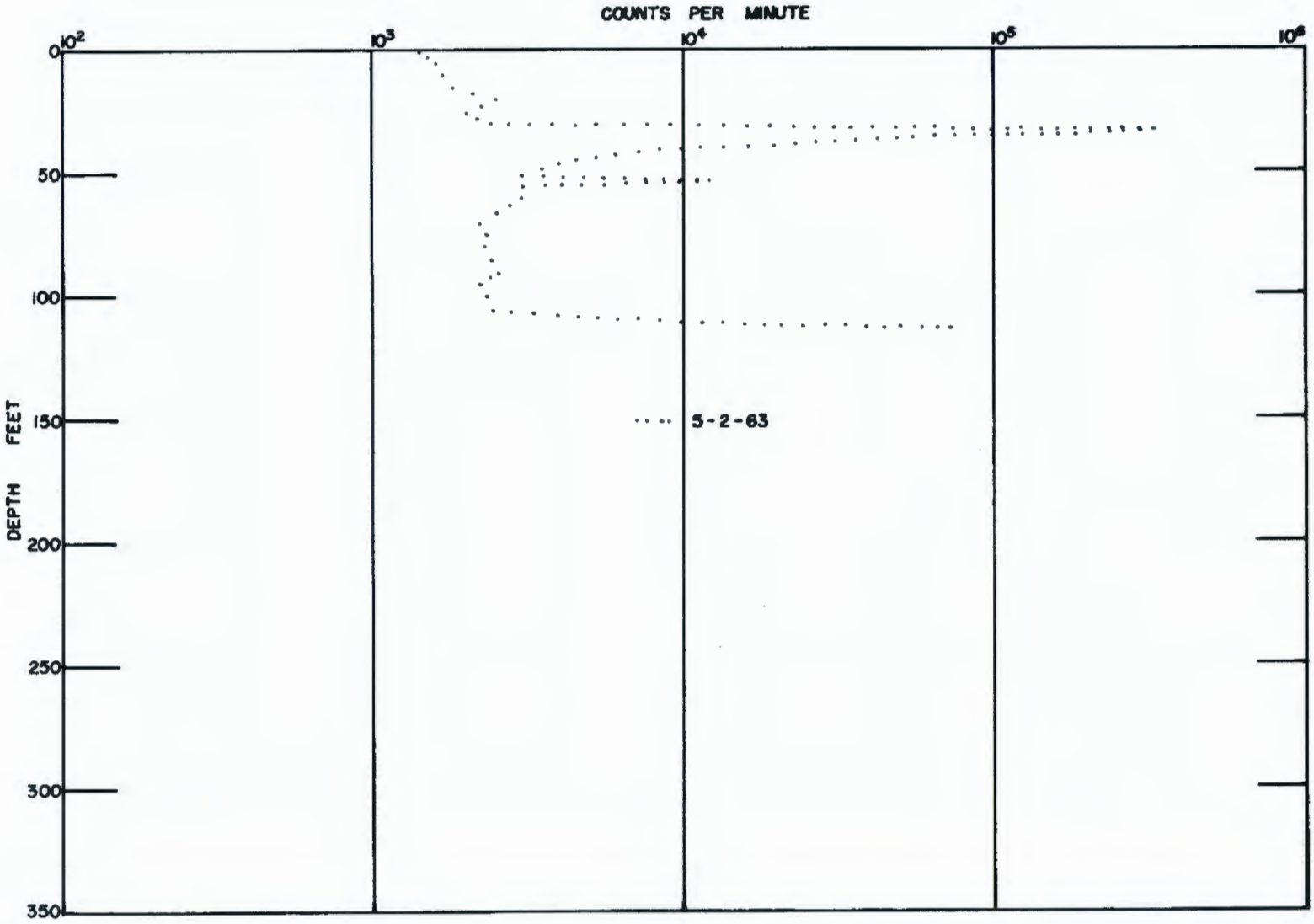


FIGURE 29

Well W15-80 Scintillation Log

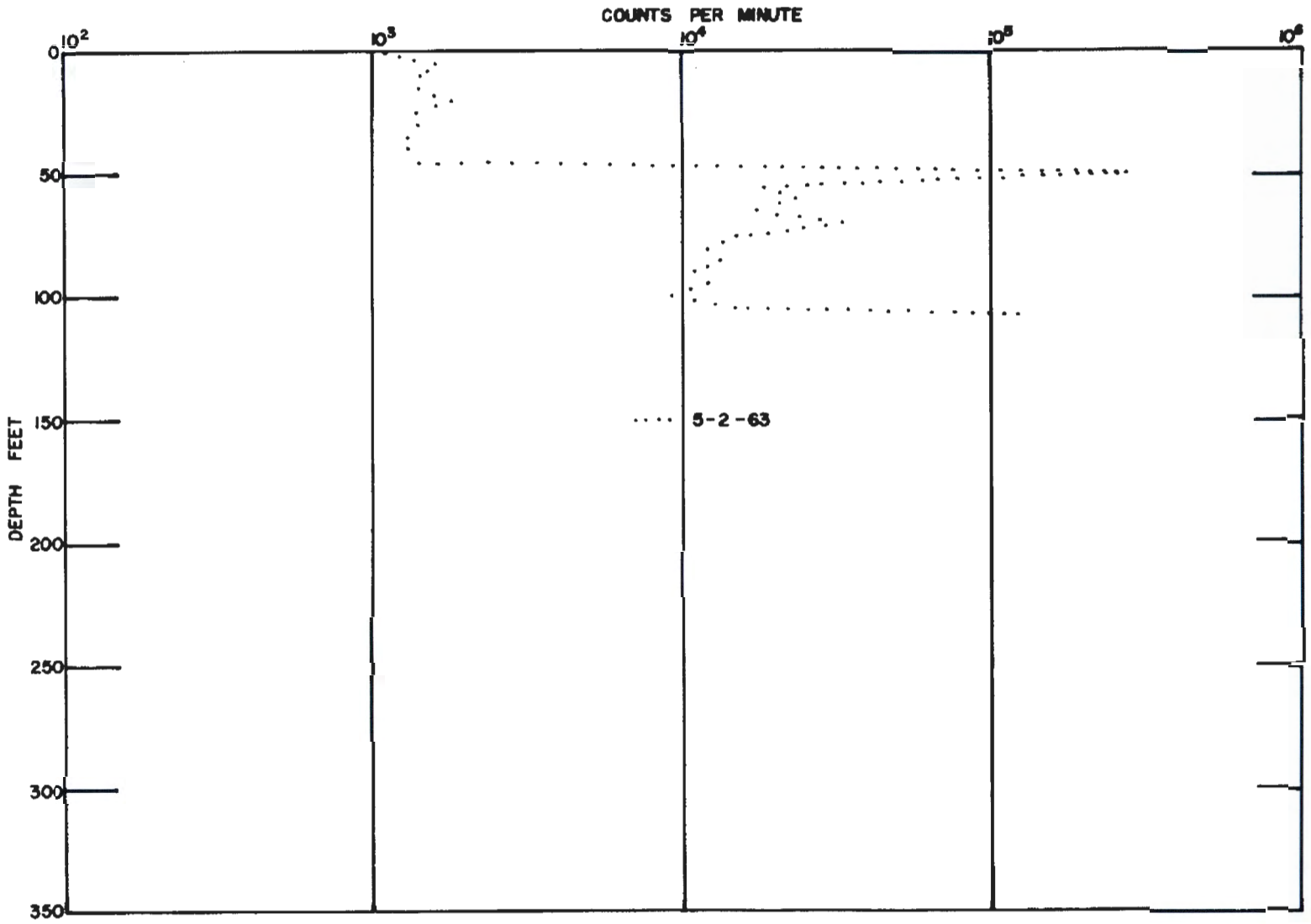


FIGURE 30

Well W15-83 Scintillation Log

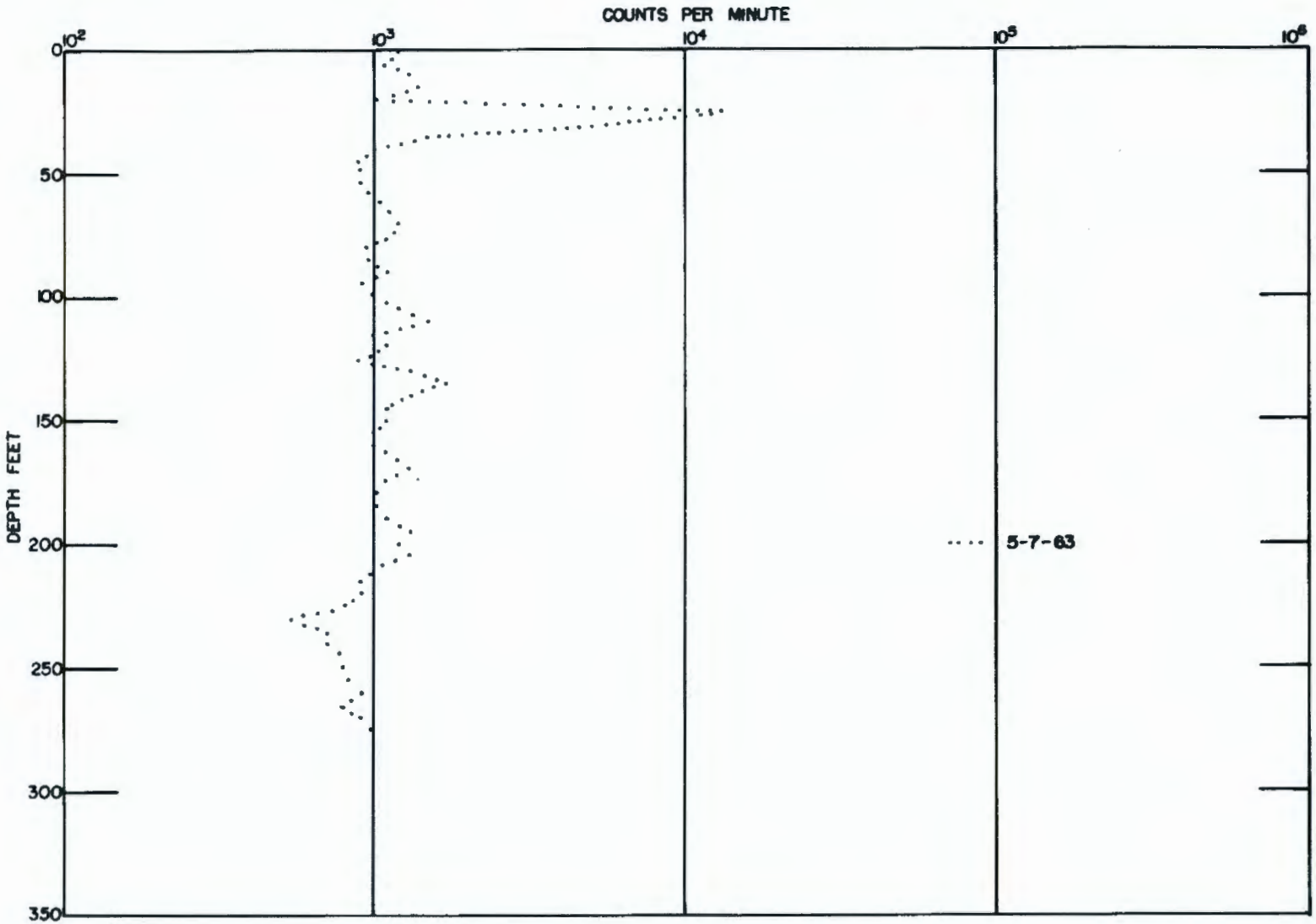


FIGURE 31

Well W18-5 Scintillation Log

HW-84577

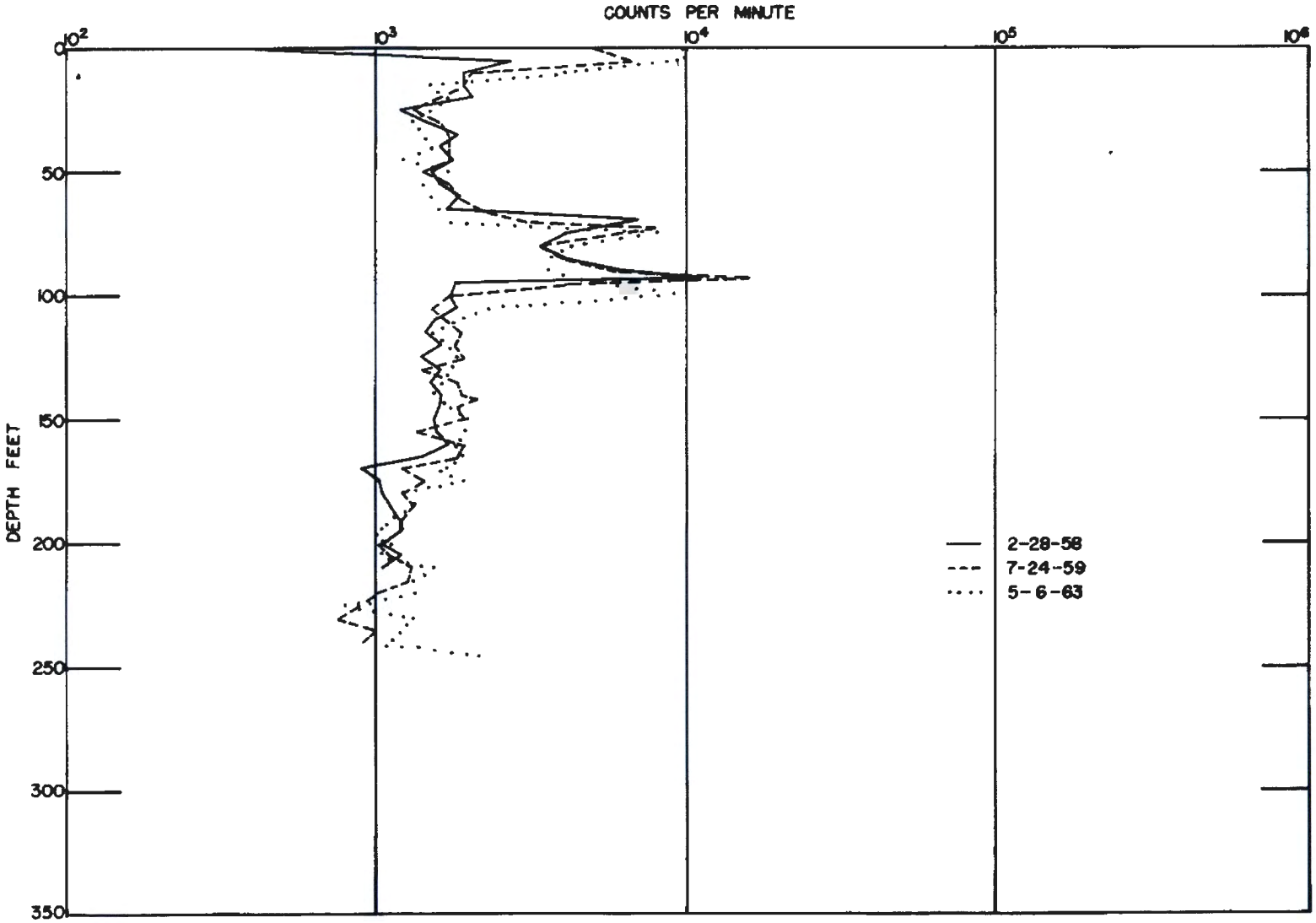


FIGURE 32

Well W19-3 Scintillation Log

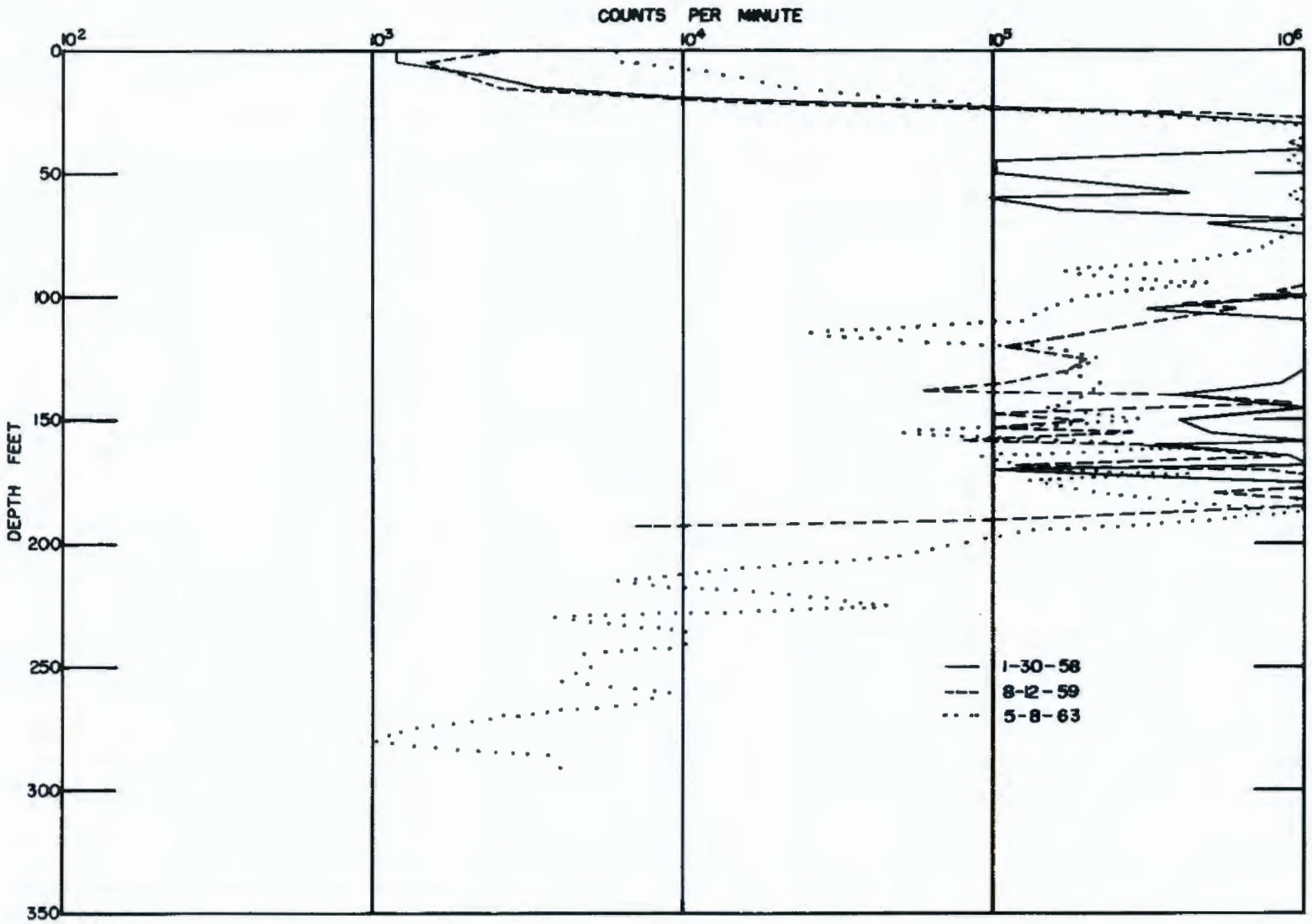


FIGURE 33

Well W22-1 Scintillation Log

HW-84577

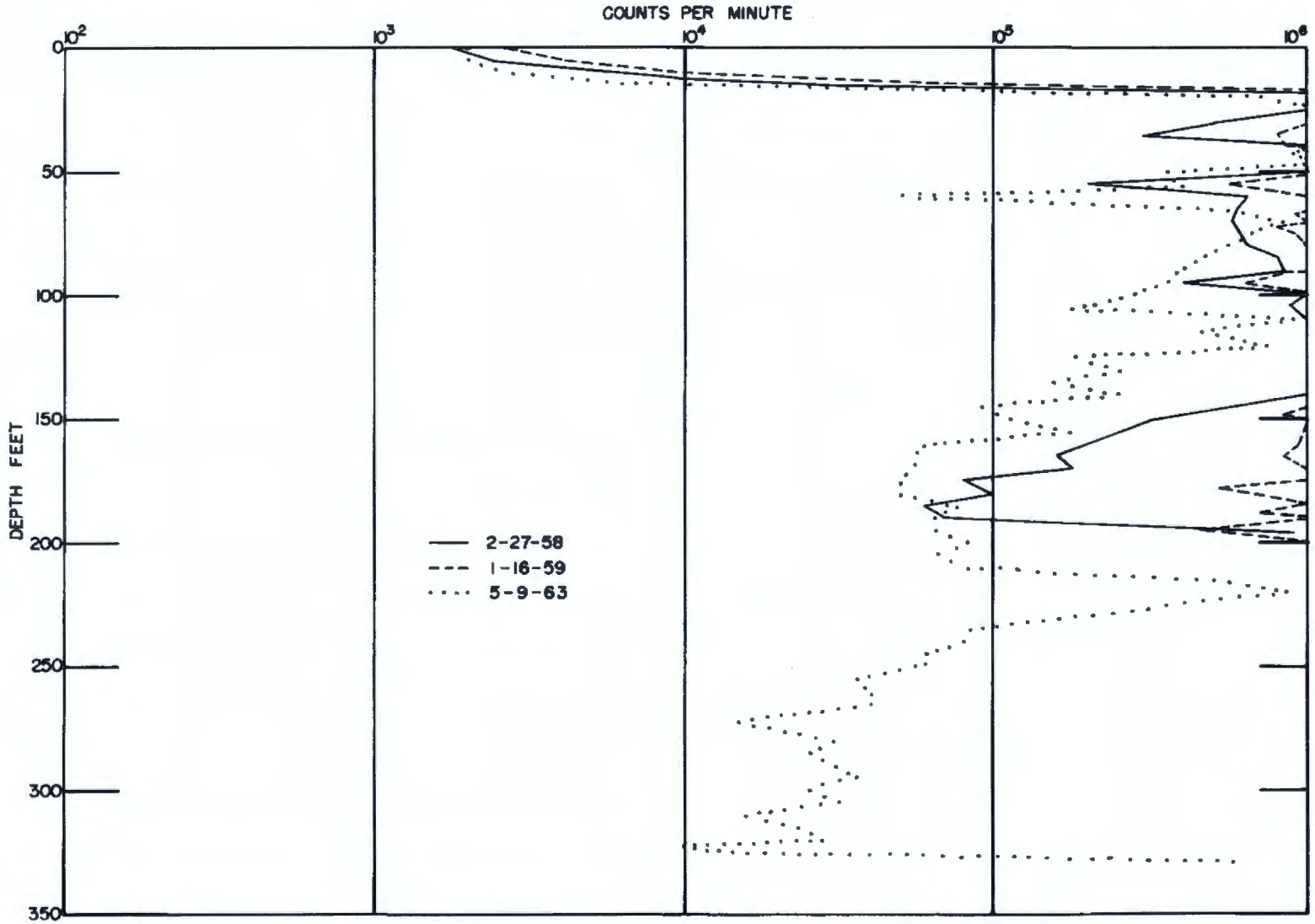


FIGURE 34

Well W22-14 Scintillation Log

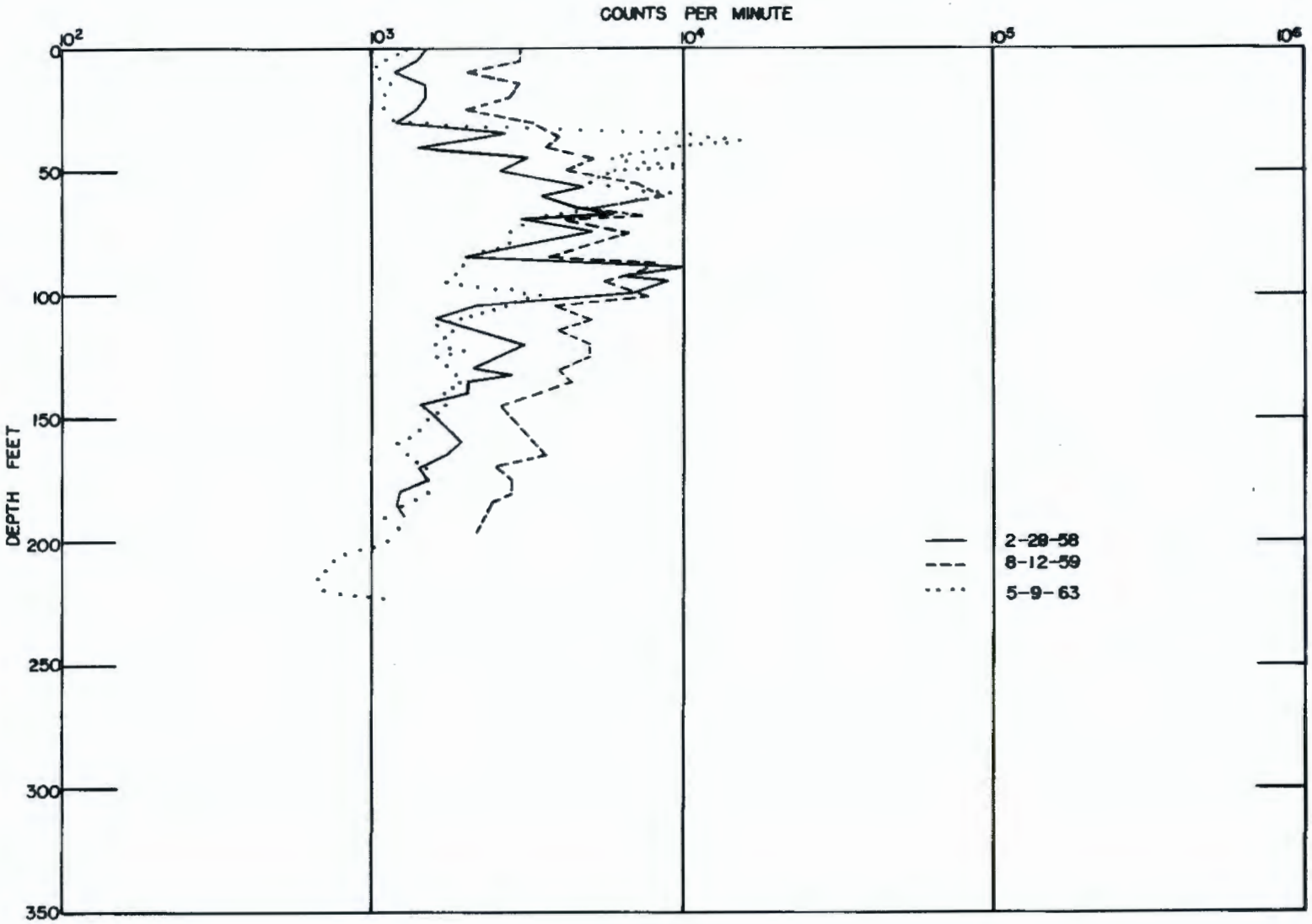


FIGURE 35

Well W22-21 Scintillation Log

HW-84577

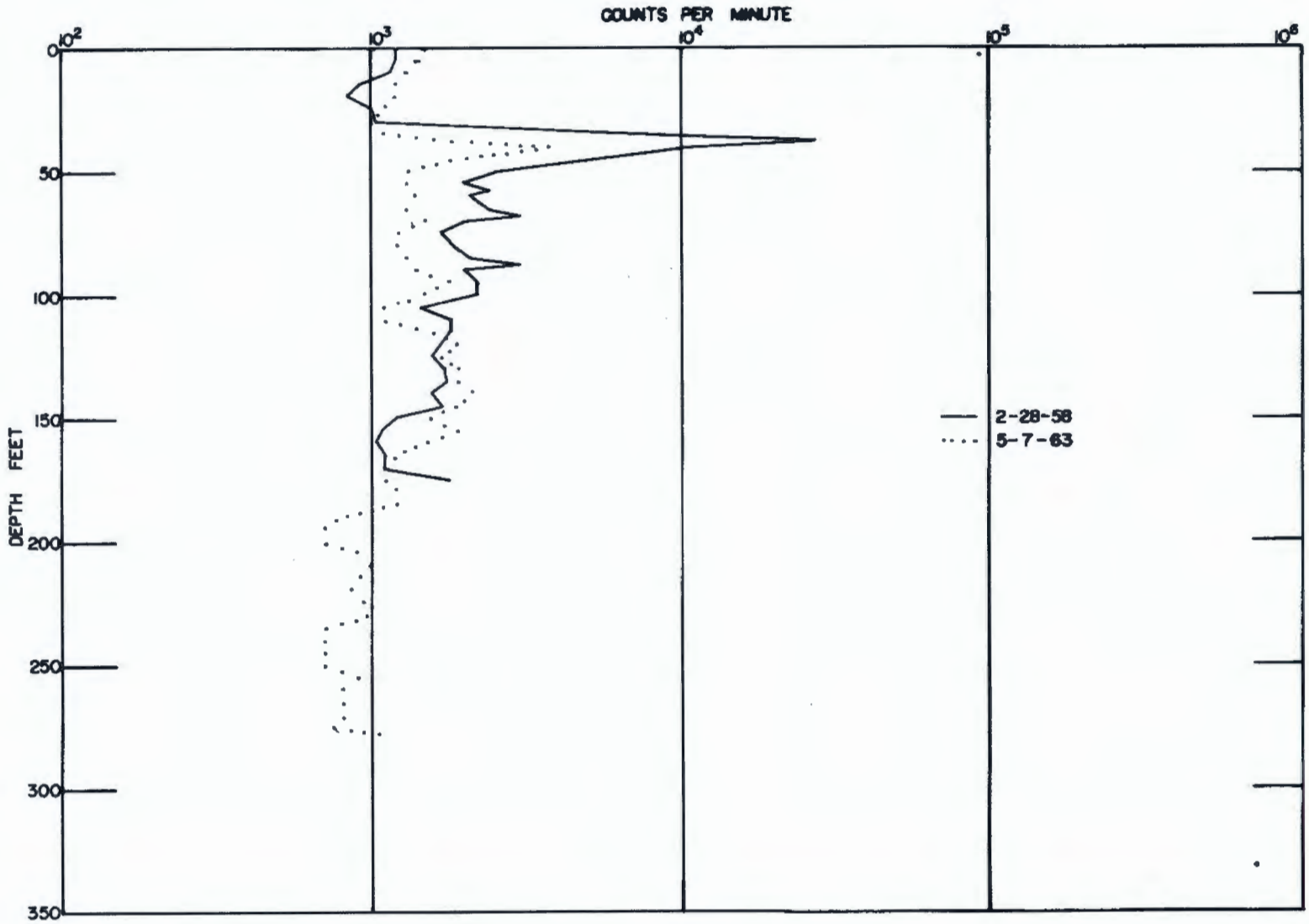


FIGURE 36

Well W23-4 Scintillation Log