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RECHARGE ESTIMATES FOR THE HANFORD SITE 200 AREA PLATEAU

R. C. Routson
V. G. Johnson

ABSTRACT

An evaluation was made to assess the magnitude of recharge from natural precipitation on the Hanford Site 200 Area Plateau. Two sources of data were used in the evaluation: (1) moisture accumulation in an 18-m deep 200 East Area closed-bottom lysimeter for 13 yr and (2) distribution of ^{137}Cs in a solid-waste trench in which contaminated soil had been buried for 16 yr.

A well was core drilled in 1985 to the bottom of the 200 East Area closed-bottom lysimeter, and the moisture content was determined gravimetrically. The 1985 moisture content of the lysimeter was compared with its initial moisture content to estimate the recharge. There was an apparent net loss of moisture during the 13-yr experiment. There has been no detectable moisture accumulation in the bottom of the lysimeter since 1972. Thus, the recharge rate was $<0 \pm 0.2$ cm/yr (two sigma uncertainty) based on an error analysis of the moisture measurements over the 13-yr period.

Cesium-137 contaminated soil was placed in a 200 West Area solid-waste burial ground in 1970. After 10 yr, the distribution of ^{137}Cs was determined from core-drilled samples. There was no ^{137}Cs detected beneath the trench bottom that was above the background levels. Thus, there was no measurable downward recharge. However, ^{137}Cs was detected above the trench, most likely resulting from evapotranspiration-induced upward movement.

Based on the above observations, the conclusion was reached that there is little if any potential for downward movement of mixed waste contaminants in the upper vadose zone beneath the 200 Area Plateau under natural or undisturbed conditions.

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1.0 INTRODUCTION

A significant portion of the nuclear and hazardous waste inventory at the Hanford Site is stored in the vadose zone (unsaturated zone above the water table) on the 200 Area Plateau (Figure 1). The proportion of natural precipitation that percolates through the vadose zone to groundwater beneath the 200 Area Plateau is required to assess the long-term environmental impact of Hanford Site waste storage and disposal. Infiltrating precipitation (recharge) is the transport medium that may potentially carry a portion of this waste to the groundwater, and ultimately to the Columbia River and the surrounding population. The vadose zone varies in thickness from approximately 61 m (200 ft) in the 200 West Area to 91.4 m (300 ft) in the 200 East Area.

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The literature and data provided in this paper will be limited to studies and data concerning the Hanford Site 200 Area Plateau. There is a more extensive body of literature, largely published by Pacific Northwest Laboratory (PNL), that has been used to evaluate Hanford Site recharge processes (e.g., Gee and Heller 1985). However, these data and evaluations are <u>not</u> directly applicable to recharge on the 200 Area Plateau because of the locations from which much of the data were taken and the types of sediments studied. The above data were also collected in considerably different microclimates and from sediments that tend to be more homogeneous than the layered (varve like) strata of the 200 Area Plateau. The surface of the sites studied by PNL have generally been reworked by wind, resulting in a more homogenized sediment than the varve-like, strongly layered sediments noted above (Fecht et al. 1977; Routson and Fecht 1980).

Alternating fine and coarse textured sediments can have a profound effect on the movement of moisture through partially saturated sediments (Figure 2).

The tendency is for layering to limit the percolation rate of precipitation and to allow added time for evapotranspiration to further limit net recharge. Precipitation on the Hanford Site is 15.7 cm/yr (6.2 in/yr) based on 42 yr of record (Stone et al. 1972). Actual evapotranspiration was estimated to be 23.1 cm/yr (9.1 in/yr) (i.e., exceeds rainfall by 52%) (Gutknecht et al. 1980).

Natural recharge to groundwaters results from the infiltration and redistribution of natural precipitation in areas without artificial recharge (ground disposal) and surface-water sources. Percolation through sediments surrounding buried waste is the primary source for recharge from any waste-burial operation. The movement during redistribution is a continuous, cyclic process. The cycle is initiated with the infiltration of precipitation into the soil. This is followed by temporary storage and redistribution of water to deeper sediments. The final portion of the cycle is the removal of water from the sediments by evaporation, transpiration (plant withdrawal), and deep drainage (recharge) to the water table.

On the average, this cycle can be mathematically described by a quasi-steady-state in the deeper sediments. The moisture content in the deeper sediments (about 7 m at the Hanford Site) tends to remain constant (Jones 1978; Last et al. 1976). The travel time of deep-draining moisture to some depth, such as the water table, can be determined if the recharge rate and volumetric water content of the sediments are known (Heller et al. 1985). The volumetric water content is essentially the constant volume of vadose zone water divided by the volume of soil (expressed as a percentage) at which the soil drains. The moisture content of soil below about 7 m on the 200 Area Plateau, although slightly variable, tends to average about 6%. Dividing the recharge (cm/yr) by the volumetric water content (6%) will provide the depth (distance) moisture

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will travel per year (the velocity). Dividing the depth to groundwater by the velocity provides the time for moisture to travel from the surface or from the buried waste to groundwater. In mathematical form the governing equations are as follows:

$$V = r/\theta \quad (1)$$

and

$$T = D/V \quad (2)$$

where

V = velocity (cm/yr)

r = recharge rate (cm/yr)

θ = volumetric water content (mL/cm^3)

T = travel time to groundwater (yr)

D = depth to groundwater (cm).

By rearranging equations 1 and 2, the recharge rate can be determined. Discussion and derivation of these equations are available in Heller et al. (1985).

Two principal data sources will be relied upon for estimating recharge. The first is a deep lysimeter study that has been continued for more than 13 yr (Jones 1978). The second data source is an evaluation of the radionuclide movement within a 200 West Area solid-waste burial ground, taken from sampling data. Both of these sources provide relatively long-term data (10 to 13 yr).

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2.0 MATERIALS AND METHODS

2.1 THE 200 EAST AREA LYSIMETER STUDY

In 1971, two large lysimeters were installed 1.6 km south of the 200 East Area (Figure 1). These lysimeters are approximately 3 m in diameter and 18 m deep. Both were equipped with instruments to evaluate possible vertical movement of sediment moisture. One lysimeter was left open at the bottom, while the other was sealed at approximately 18 m (Figure 3) (Hsieh et al. 1973). Any large amount of downward moisture movement was projected to result in an accumulation of recharge moisture in the lower portion of the closed-bottom lysimeter. Three 4.09-cm access tubes for neutron moisture probes were installed in each lysimeter to permit measurement of the moisture content at various depths. These lysimeters are described in detail in Hsieh et al. (1973). The open-bottom lysimeter was subsequently dismantled; therefore, will not be considered further in this report.

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When the sediment was packed in the lysimeter, the initial moisture content of the sediments was measured (Hsieh et al. 1973). After 13 yr the moisture content of the lysimeter sediment (soil) was remeasured, and recharge was calculated from the difference between current moisture content and initial moisture content using equations 1 and 2 (Figure 4). Samples were obtained by core drilling and hand sampling the lysimeter sediment. Samples were taken approximately every 1.5 m. Sediment samples were quickly placed in moisture cans, and the lid-can contact was wrapped with tape. Moisture content was determined by the method of Gardner (1965).

There has been some redistribution of moisture from the upper half of the lysimeter to the lower half of the lysimeter because surface sediments in 1971

were somewhat wetter than the deeper sediments. The 1985 moisture distribution was established as early as 1975 (Brownell 1975). The upper 3 m show a seasonal variation (Fromwell et al. 1975; Last et al. 1976; Jones 1978). The observed redistribution represents an approach to a study-state system and not recharge. However, because there is no measurable (net) accumulation of moisture in the lysimeter, recharge is estimated at 0 ± 0.2 cm/yr (two sigma uncertainty). Thus, the apparent upper-bound recharge rate is taken as <0.2 cm/yr.

Sparse vegetation was observed on the surface of the lysimeter in 1985. Over much of the lysimeter's 13-yr history, the surface of the lysimeter was unvegetated; but a limited number of cheat-grass plants (Bromous tectorium) (a shallow introduced annual grass) were observed in 1985. A portion of the precipitation was probably removed by transpiration.

A significantly greater amount of moisture would likely be removed on an undisturbed, lightly disturbed, or revegetated site (if there were any more moisture available). Conversely, on a totally unvegetated site, there would possibly be some measurable recharge.

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2.2 200 WEST AREA SOLID-WASTE BURIAL GROUND

In 1970, a radioactive spill into the surface soil occurred on the Hanford Site. The contaminated soil was buried beneath approximately 4.7 m of cover in the 200 West Area solid-waste burial ground. In 1980, as part of a solid-waste burial-ground study, the surrounding soil was core drilled and sampled to determine how deep the waste might have leached (Routson et al. 1981). Figure 5 is a representation of the measured ^{137}Cs activity as a function of depth. This figure shows that there was no measurable activity below the bottom of the burial trench. However, there was increased ^{137}Cs activity above the top of the waste. This suggests that the net movement of moisture was upward during the storage period, and that net recharge is zero, and probably negative, over the 10-yr burial period.

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3.0 SUMMARY AND CONCLUSIONS

A review and evaluation was made to estimate the recharge rate for two areas on the Hanford Site 200 Area Plateau. Several previous studies found that the recharge rate approached zero within the error of the moisture measurement. In this evaluation, recharge was found to be 0 ± 0.2 cm/yr based on a 13-yr period of moisture accumulation in the Hanford Site 200 East Area closed-bottom lysimeter. Field recharge was further evaluated using radionuclide depth distribution data from a decade-old burial trench. Waste transport in a solid-waste burial trench appeared to be upward, suggesting zero or negative recharge. Thus, the field observation was in good agreement with the lysimeter study, confirming that recharge is small and probably approaches zero under the environmental conditions that prevailed at these two sites on the 200 Area Plateau during the period of observation. However, note that a

significant potential for recharge may exist at disturbed sites or where vegetation and fine-textured soils have been removed and/or replaced with course-textured soils or gravel. The signifitance of this paper is that there is little if any potential for downward movement of mixed waste contaminants in the upper vadose zone under natural or undisturbed conditions. Current waste management practices and closure plans for waste cleanup should strive to maintain and/or enhance this natural, beneficial feature on the 200 Area Plateau at the Hanford Site.

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Figure 1. Hanford Site Map Showing the Location of the 200 Areas Plateau and 200 East Area Lysimeter.

Figure 2. Typical Horizontal and Vertical Movement of Liquids in Hanford Formation Sediments Under Partially Saturated Conditions. Taped Area Outlines Location of Water Addition.

Figure 3. Elevation View of the 200 East Lysimeter.

Figure 4. Cross-Section View of Hanford 200 East Area Closed-Bottom Lysimeter.

Figure 5. Gravimetric Moisture Content Distribution for 1985 (Dashed Curve) and 1972 in the 200 East Area Closed-Bottom Lysimeter. Soil Surface Was Not Sampled.

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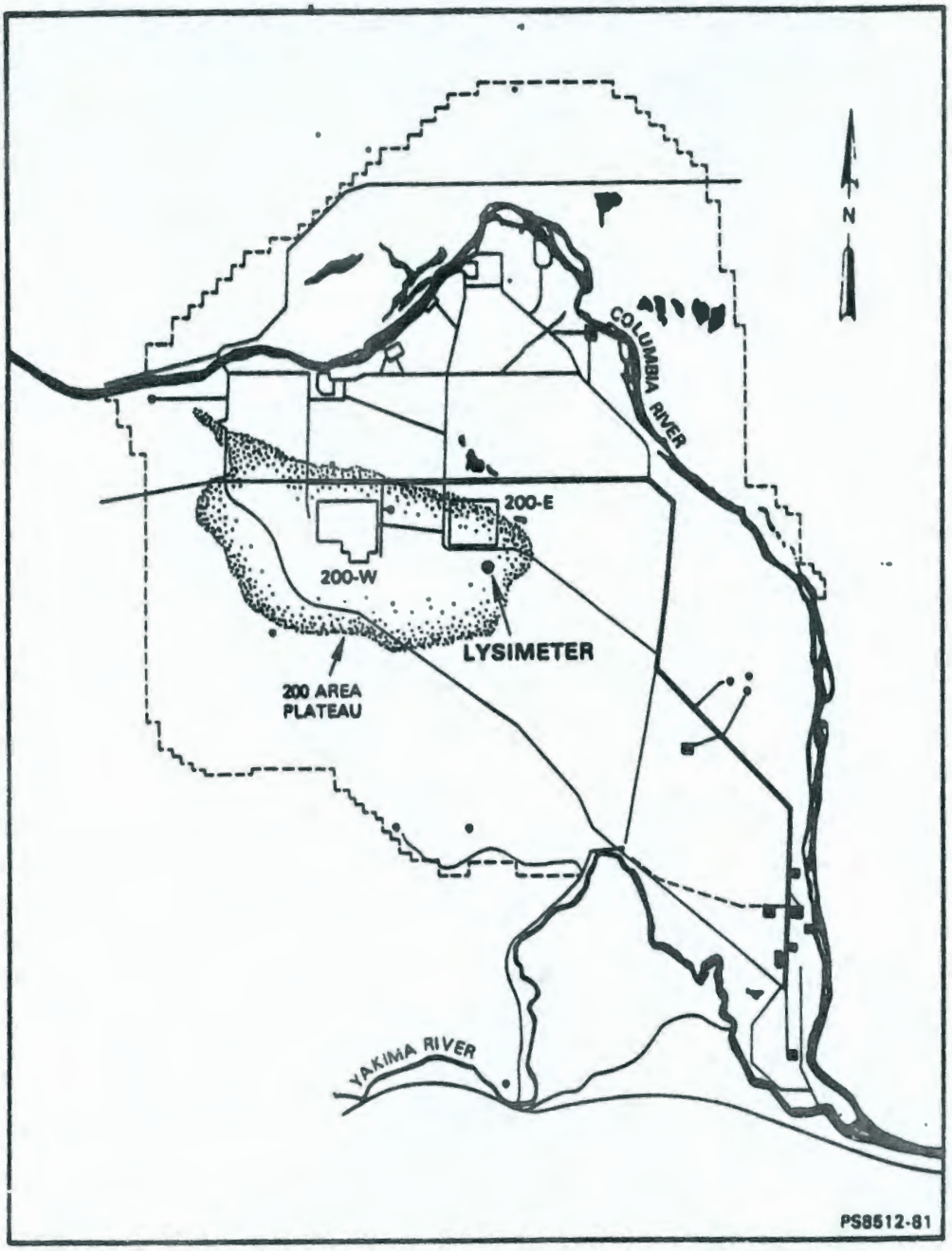

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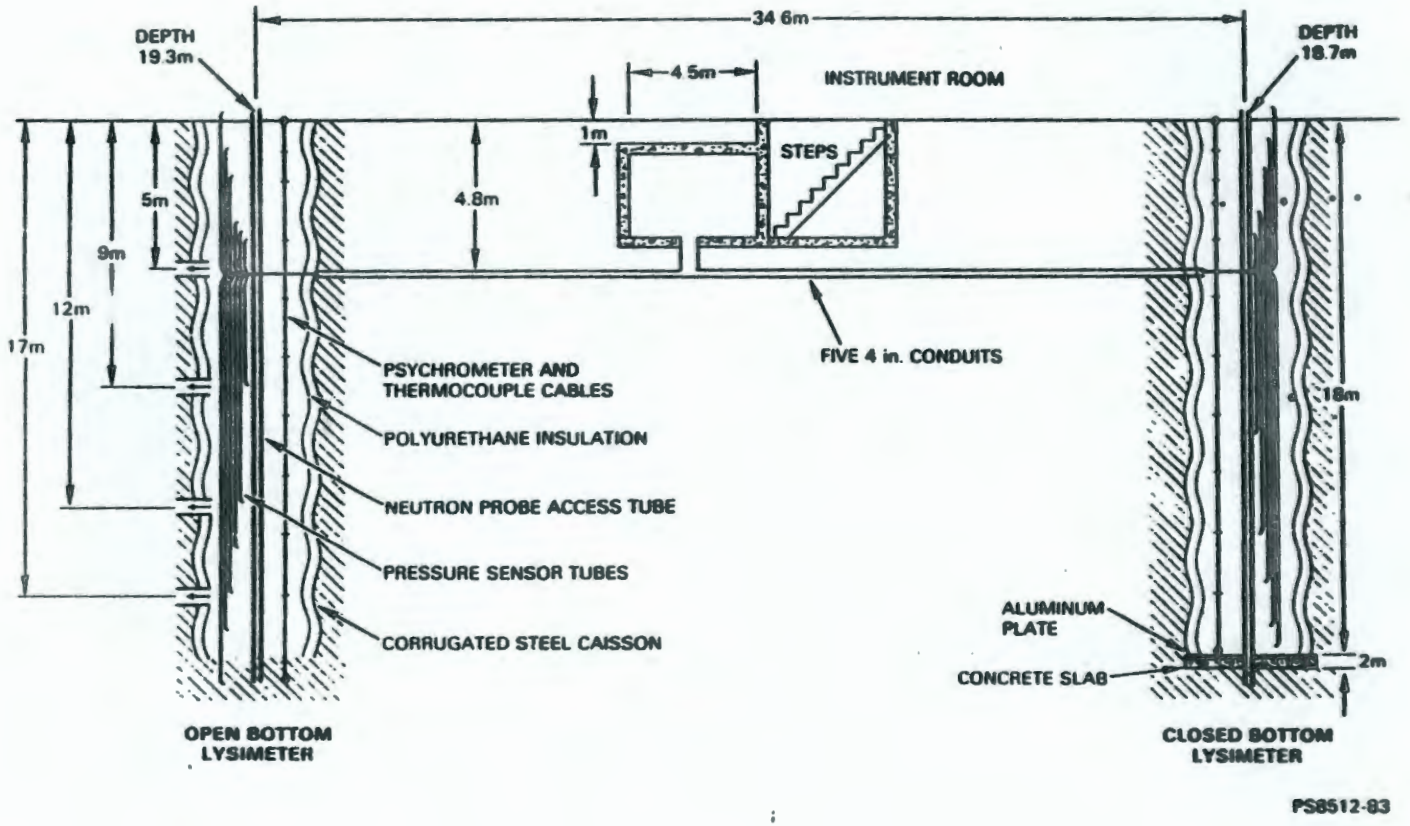

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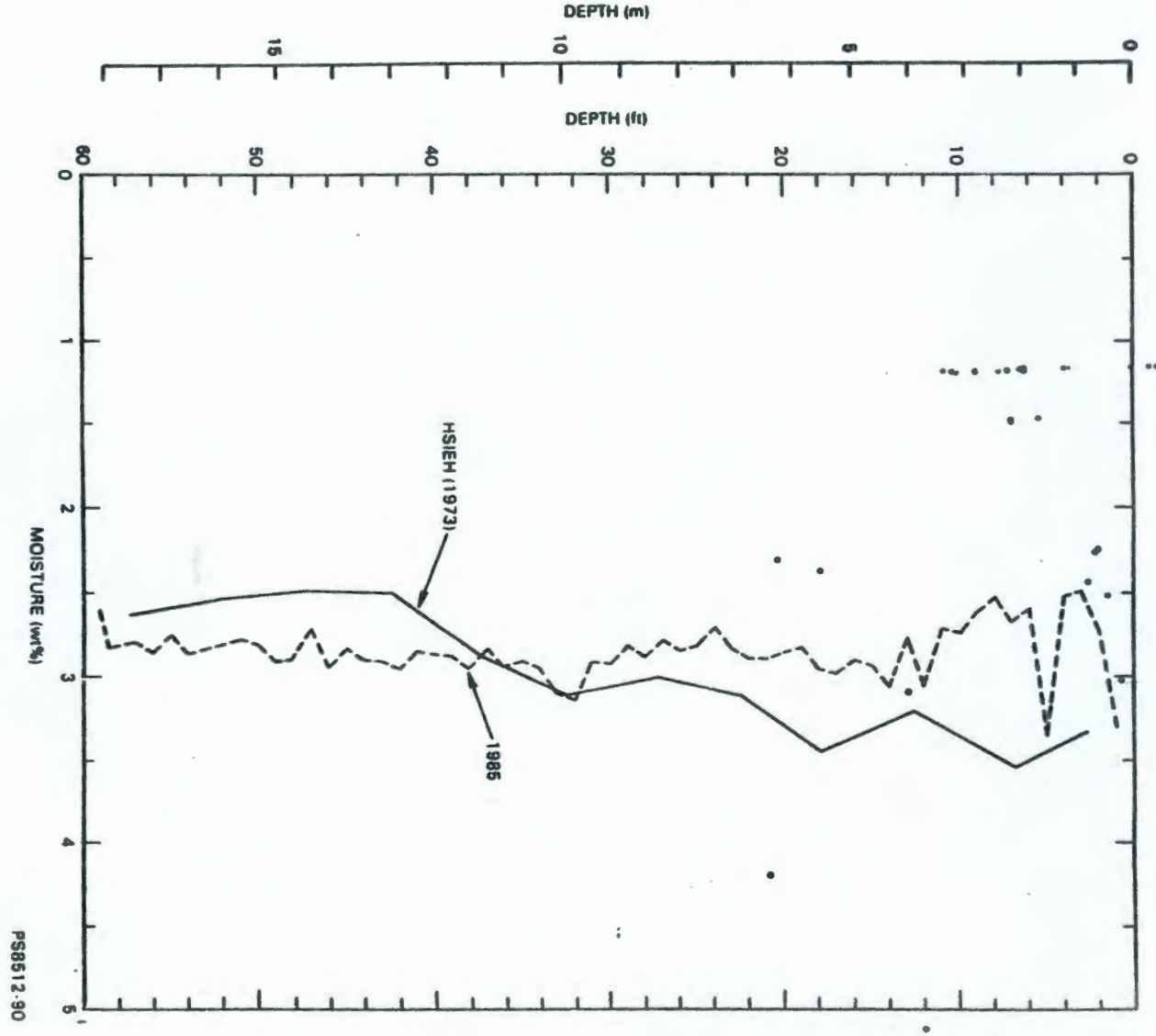
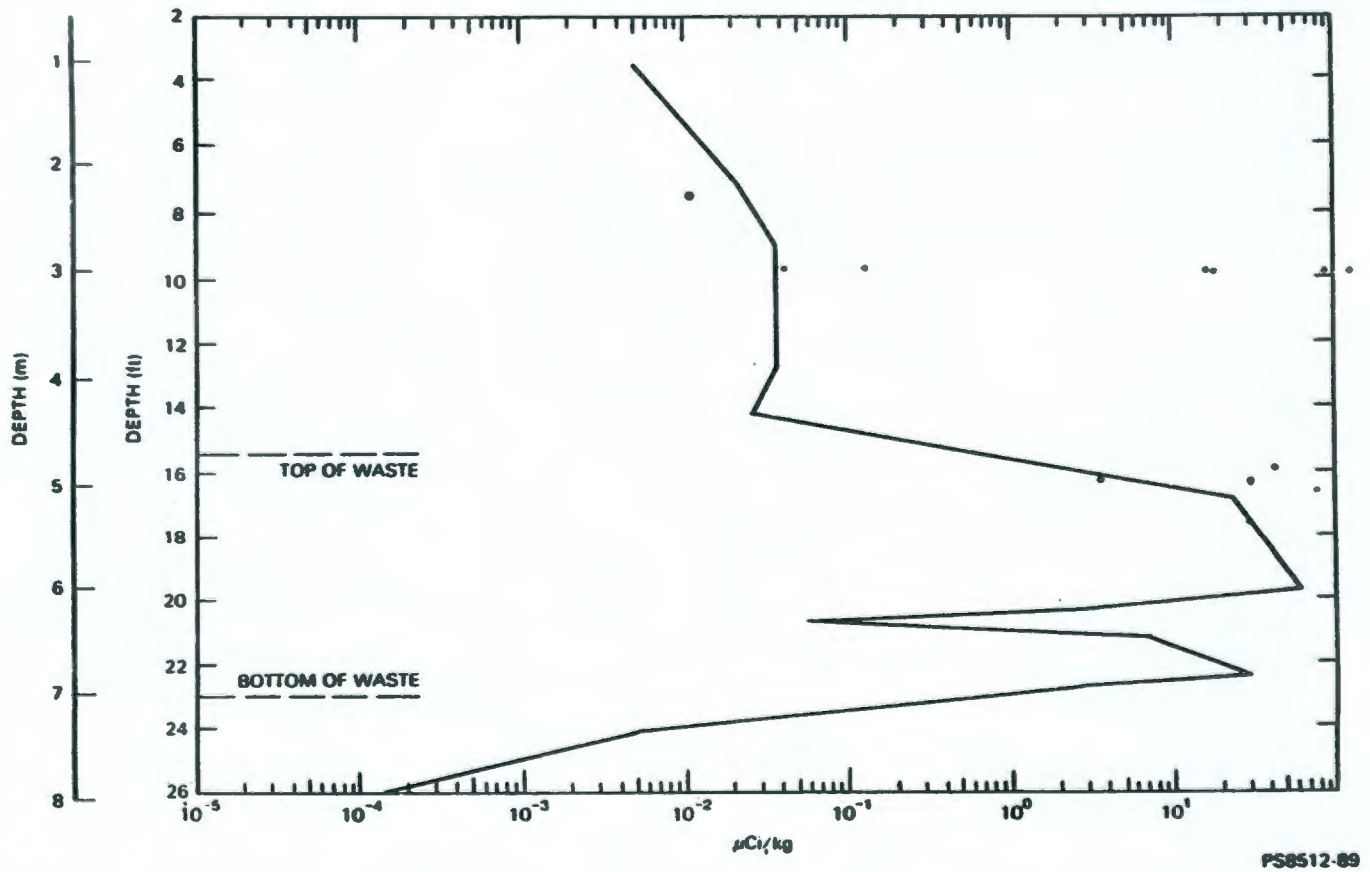
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