BNL-NUREG-50855



# EVALUATION OF ISOTOPE MIGRATION LAND BURIAL WATER CHEMISTRY AT COMMERCIALLY OPERATED LOW-LEVEL RADIOACTIVE WASTE DISPOSAL SITES

PROGRESS REPORT No. 6

JULY - SEPTEMBER 1977

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NUCLEAR WASTE MANAGEMENT RESEARCH GROUP

DEPARTMENT OF NUCLEAR ENERGY BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK 11973

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## WATER CHEMISTRY AT COMMERCIALLY OPERATED LOW-LEVEL RADIOACTIVE WASTE DISPOSAL SITES

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MASTER

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PREPARED FOR THE UNITED STATES NUCLEAR REGULATORY COMMISSION
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UNDER CONTRACT No. EY-76-C-02-0016

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## Foreword

The burial of low-level radioactive wastes at commercially operated disposal sites began in 1962. At the present time, disposal sites exist in Maxey Flats, Kentucky; Beatty, Nevada; Sheffield, Illinois; Barnwell, South Carolina; West Valley, New York; and Richland, Washington. Projections have been made of the available capacity of these sites, and the results indicate that the current burial capacity of all six sites may be exceeded by 1990 when existing sites may have to be closed or enlarged or new sites will have to be established.

The U.S. Geological Survey (USGS) is collecting data for developing site selection criteria for the disposal of solid low-level radioactive waste. In support of USGS investigations, the U.S. Nuclear Regulatory Commission is funding Brookhaven National Laboratory (BNL) to perform analyses of soil, natural waters, and waste leachates that have accumulated in the trenches at the disposal sites.

The ability to make predictions of the rate of movement of various radionuclides along the ground water flow path is a significant factor in developing site selection criteria. Towards this goal BNL is conducting experiments to (a) define the source term of radionuclides and other solutes in the trench waters, (b) detect and characterize radionuclides along the flow paths of the ground water, and (c) describe physical, chemical, and biological processes that control the movement of buried radionuclides at the disposal sites.

## Summary

A survey of the Maxey Flats, Kentucky, low-level radioactive waste disposal site was conducted to obtain an overview of the radioactivity in the trench waters for the purpose of selecting specific trenches for comprehensive study. Water samples collected from trenches and wells were analyzed for specific conductance, pH, temperature, dissolved organic carbon, tritium, gross alpha, gross beta, and gamma radioactivities. The results indicate that there are large differences in the composition of trench waters at the site. Several trenches, that represent extreme and average values of the major parameters measured, have been tentatively selected for further study.

# I. INTRODUCTION

Previous reports of this program describe the development and testing of procedures for collecting, preparing, and analyzing trench waters.[1-5] Anoxic procedures were developed for collecting and filtering trench water samples to prevent precipitation of ferric hydroxide. Randomly selected trenches at the Maxey Flats, Kentucky, radioactive waste disposal site were sampled and analyzed for dissolved inorganic, organic, and radiochemical constituents.

It was decided that a more comprehensive study should be made of several selected trenches from each of the low-level radioactive waste disposal sites. Therefore, a survey of the low-level radioactive waste disposal sites was conducted during the summer of 1977 for the purpose of selecting specific trenches for future studies. Water samples were collected from trenches and wells from the Maxey Flats, Kentucky; West Valley, New York; and Sheffield, Illinois, low-level radioactive waste disposal sites (Figure 1). These water samples were analyzed for specific conductance, pH, temperature, dissolved organic carbon (DOC), tritium, gross alpha, beta, and gamma radioactivities. Since substantial amounts of organics had previously been found in trench waters from Maxey Flats,[5] DOC was included as one of the selection parameters. The results of the reconnaissance survey at the Maxey Flats, Kentucky, site are presented in this report.

## II. SAMPLE COLLECTION

### A. General

United States Geological Survey personnel conducting hydrogeological studies at the disposal sites collected the water samples for this survey study. Samples were obtained from all trenches and wells that contained water. Surface and ground water samples adjacent to the disposal sites were also collected. The detailed procedures adopted by USGS and BNL personnel for conducting the reconnaissance survey, as described in BNL-NUREG-22673, are given in the Appendix.

Briefly, trench water samples were obtained by lowering plastic tubing into established riser pipes in the trenches and lifting the water with a peristaltic pump. Well water samples were obtained with a bailer because the water levels in the wells were below the lift capability of a peristaltic pump. A 500 ml sample for radiochemical analysis and a 50 ml sample for organic analysis were collected from each sampling location.

Since the objective of this survey is to obtain an overview of the radioactivity and organics present in the trench waters, the anoxic collection method was not used.[3] The sample for radiochemical analysis was not filtered and was immediately acidified with 35 ml concentrated nitric acid to prevent iron hydroxide precipitation. The acidified sample was stored at ambient temperature in a polyethylene bottle. The radioactivity of this sample represents the total activity of the dissolved and suspended solids in the trench water.

The survey study procedure described in the Appendix requires that a 50 ml sample for DOC analysis be obtained by in-line filtration through a 0.45 micron silver membrane filter. Silver acts as a bactericide to prevent bacterial action from changing the organic nature of the sample in the interval between sampling and analysis. However, the in-line filtration was not accomplished

in the field due to clogging of the filter by very fine suspended material in the water. The pressure available from the peristaltic pump, after lifting the water from the trench, was insufficient for filtering. Instead, the DOC sample was obtained by filling the filtration unit directly from the outflow of the peristaltic pump and pressurizing the unit with a small portable nitrogen cylinder. A 50 ml sample was filtered into a glass bottle and was kept at $\sim 4^{o}C$ until the DOC analysis was completed.

B. Maxey Flats, Kentucky, Site

Water samples were collected from 46 trenches and 5 wells at the Maxey Flats, Kentucky, disposal site. Figure 2 shows the location of trenches and wells at Maxey Flats. Some trenches have one or more riser pipes for water removal which are identified by a riser number or letter following the trench number. Trench 34 has four riser pipes, trench 31 has risers in its east and west ends, and trenches 40, 43, and 44 have risers in the north and south ends. The "33L trench" is a group of side by side slit trenches each having one or more riser pipes.

New Tygon tubing was rinsed with approximately three gallons of trench water before a sample was collected. Due to a shortage of new tubing, it was necessary to sample trenches 33L-17, 33L-13, 1, 5S, and 23 in sequence with the same tubing. The outside of the used tubing was wiped clean before it was inserted into the next riser pipe, and the inside was then flushed with at least five gallons of trench water before the sample was collected.

Water samples from trenches 40N, 42, and 44N were collected with new PVC bailers which had been rinsed with 0.5 gallons of trench water before taking the sample. All on-site well water samples were taken with separate copper bailers. Trenches 12L, 13L, 28, 29, 33L-2, 33L-5, 33L-7, 33L-14, 33L-15, 34-2, 34-3, 40S, 41, 43N, and 43S were not sampled because of insufficient water or badly bent sump pipes.

Ten samples from wells and streams in the vicinity of the disposal site were also collected. Approximate locations of the off-site sampling positions in relation to the trench area at the disposal site are shown as circled numbers in Figure 3 and are described in Table 1. The off-site samples were taken in glass bottles except from location 5 which was obtained directly from the tap.

## III. ANALYSES

Measurements of specific conductance, pH, and temperature of each water sample were made by USGS personnel in the field at the time of collection. Analyses for DOC, tritium, gross alpha, gross beta, and gammas were performed at BNL.

### A. DOC

DOC analysis was determined on the filtered, non-acidified sample using the Beckman Total Carbon Analyzer* which measures both total and inorganic carbon. The organic carbon content is obtained by difference with a detection limit of approximately 2 mg/l.

### B. Tritium

Tritium, as HTO was determined on the filtered non-acidified sample. One ml of a distilled aliquot of water sample in 15 ml of liquid scintillation fluid was counted in a Beckman LS8100 liquid scintillation counter.* Trench water samples were counted for one minute, whereas well and stream samples were generally counted for ten minutes. With a background count of approximately 8 cpm, the detection limit for tritium is 8,000 pCi/l for trench water and 2,000 pCi/l for wells and streams. Since this study was intended to survey a large number of samples in a limited time, the detection limit is somewhat higher than commonly encountered in environmental monitoring studies.

### C. Gross Alpha-Gross Beta

Gross alpha and gross beta activities were measured on an aliquot of the acidified non-filtered water sample. A 3 ml aliquot of trench water was heated to dryness

* Mention of commercial products does not constitute endorsement or recommendation for use.

in a 50 mm planchette and counted with a Nuclear Chicago two-channel, low-level, proportional flow counter* for 10 minutes. Well and stream samples were concentrated from 50 ml to 3 ml, dried in a 50 mm planchette, and counted for 20 minutes. The alpha detection limits for these counting conditions are 200 pCi/l for trench water and 6 pCi/l for wells and streams. Beta detection limits for these conditions are 700 pCi/l for trench water and 30 pCi/l for wells and streams.

D. Gamma

The gamma activities of the acidified non-filtered samples were measured by scintillation counting with a NaI(Tl) detector. Gross gamma activity, without energy descrimination, was determined with a 76 x 76 mm NaI(Tl) well counter in a Searle 1185 gamma counting system.* A 10 ml aliquot of water sample was counted for 20 minutes in an energy window between 15 keV and $\infty$. This counting method was used to obtain relative gamma activities of a large number of trench water samples in a short period of time.

In addition to NaI(Tl) counting, these samples are being counted with a Ge(Li) high resolution gamma ray spectrometer system to identify and measure the individual gamma emitting radionuclides present. The results of the Ge(Li) gamma scans will be reported when all of the samples have been analyzed.

* Mention of commercial products does not constitute endorsement or recommendation for use.

## IV. RESULTS AND DISCUSSION

Field measurements of pH, temperature, and specific conductance of trench waters and on-site well samples are given in Table 2. These measurements were generally made immediately after collecting a sample. When there was a delay in making the measurements, the elapsed time is indicated in parenthesis after the temperature. Since the water temperature was not measured in-line, the value should not be taken as the actual ground water temperature. Values of specific conductance ranged from 400 to 38,500 micromhos/cm at 25°C. Since specific conductance is related to the amount of dissolved solids in the trench water, any iron hydroxide that precipitated before making the measurement would have caused a reduction of the measured value. The pH of the samples varied from pH 2.2 to 12.4 indicating differences in chemical composition of the trench waters.

Radionuclide and DOC concentrations of trench waters and on-site well samples are given in Table 3. Gross alpha, gross beta, and tritium concentrations are given in pCi/l; gross gamma is reported as relative cpm above background. The number in parenthesis represents the % counting uncertainty, 1.65 $\sigma$ for gross alpha/gross beta and 2 $\sigma$ for tritium. It should be noted that the radiochemical samples were not filtered, therefore, the reported radionuclide concentrations include the activity of any suspended material in the trench water samples. Tritium is present in all trenches and on-site wells, with the highest concentration, $5 \times 10^9$ pCi/l, in trench 27. Well 13E contains a considerable amount of tritium ($6.16 \times 10^6$ pCi/l). Gross beta was found in all trench samples and gross alpha was found in most trenches. Two of the five on-site wells, 8E and 12E contained small detectable amounts of gross alpha and gross beta. The presence of alpha and beta radioactivity in these wells is not necessarily a consequence of radionuclide migration from adjacent trenches, since Montgomery et al.[9] reported that disposal operations at

Maxey Flats have resulted in low-level contamination of test wells. DOC was found in all trenches except trench 22 and ranged in concentration from 7.4 mg/l to 5,820 mg/l.

The pH, specific conductance, DOC, tritium, gross alpha, gross beta, and gross gamma data from Tables 2 and 3 are presented in Figures 4-10 respectively showing the distribution of these parameters among the trenches. The bar graphs list the trench numbers that fall within ranges of the measured parameters. A summary of the ranges of these measurements is given in Table 4.

Field measurements of pH, temperature, and specific conductance of wells and streams in the vicinity of the Maxey Flats site are given in Table 5. Sample location numbers correspond to circled numbers in Figure 3. Specific conductance of these off-site waters are in a narrow range between 128 and 420 micromhos/cm at 25°C and are between one and two orders of magnitude lower than the on-site well waters. The pH of the off-site water samples are in a range between 4 and 7.

Radionuclide and DOC concentrations of off-site wells and streams are given in Table 6. Tritium was measured in all of these samples in a concentration range between $8.6 \times 10^3$ pCi/l to $3.8 \times 10^4$ pCi/l. Analyses of DOC in the on-site well waters were performed by USGS laboratories as part of a monitoring program of these wells. The value obtained from samples taken March 2, 1977, and April 26, 1977, are given in Table 3. The DOC measured in well 13E (13 mg/l) is slightly above the background levels found in the off-site water samples shown in Table 6.

Based on the data obtained from this reconnaissance survey of the Maxey Flats disposal site, trenches 2, 19, 26, 27, 33L-4, 33L-18, and 37 have been identified as candidates for further studies. These trenches represent extreme and average values of the major parameters measured in this study. The final selection

will depend upon availability of water in the trenches, location of new monitoring wells at the disposal site, and local ground water flow paths.

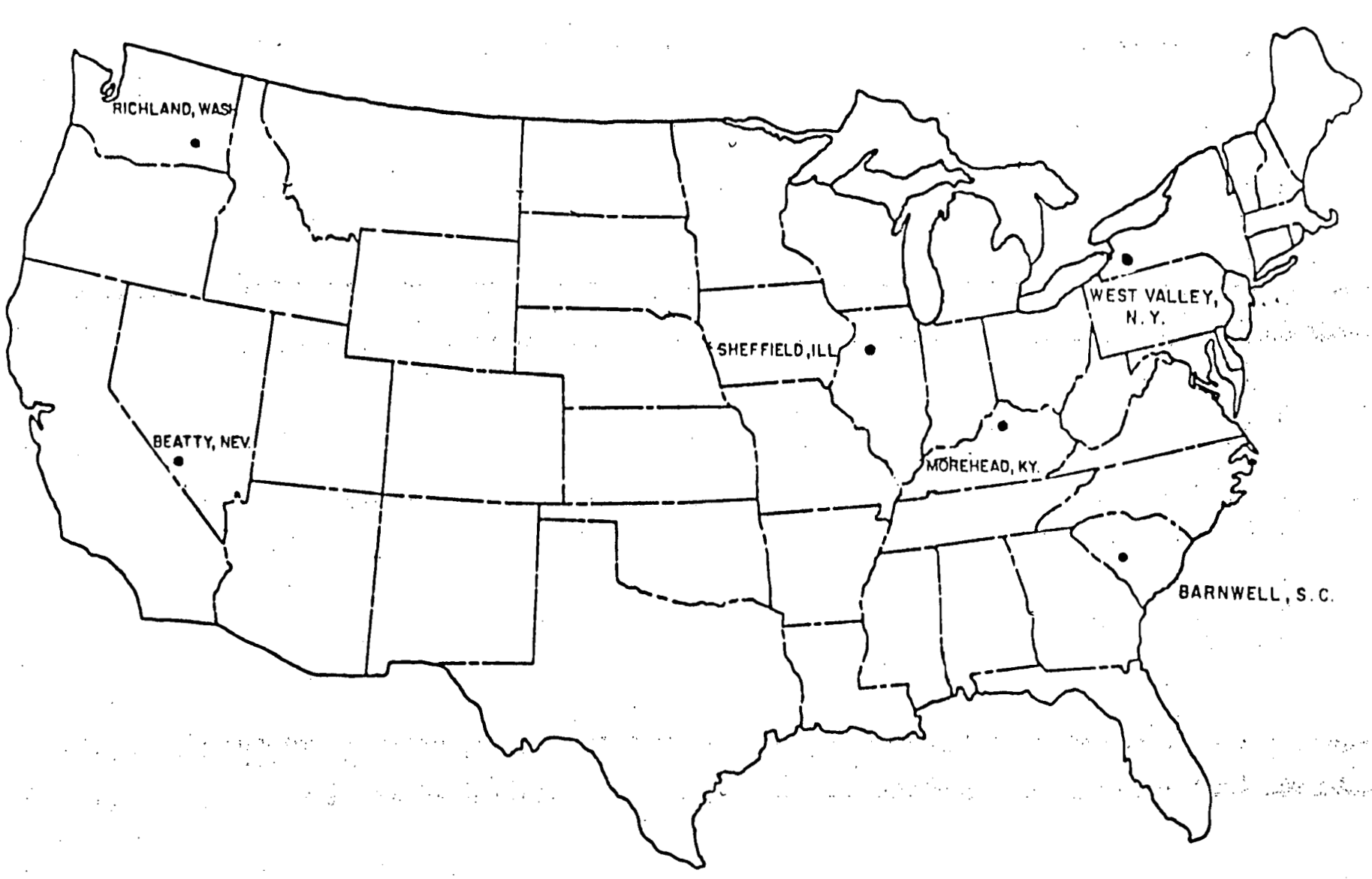
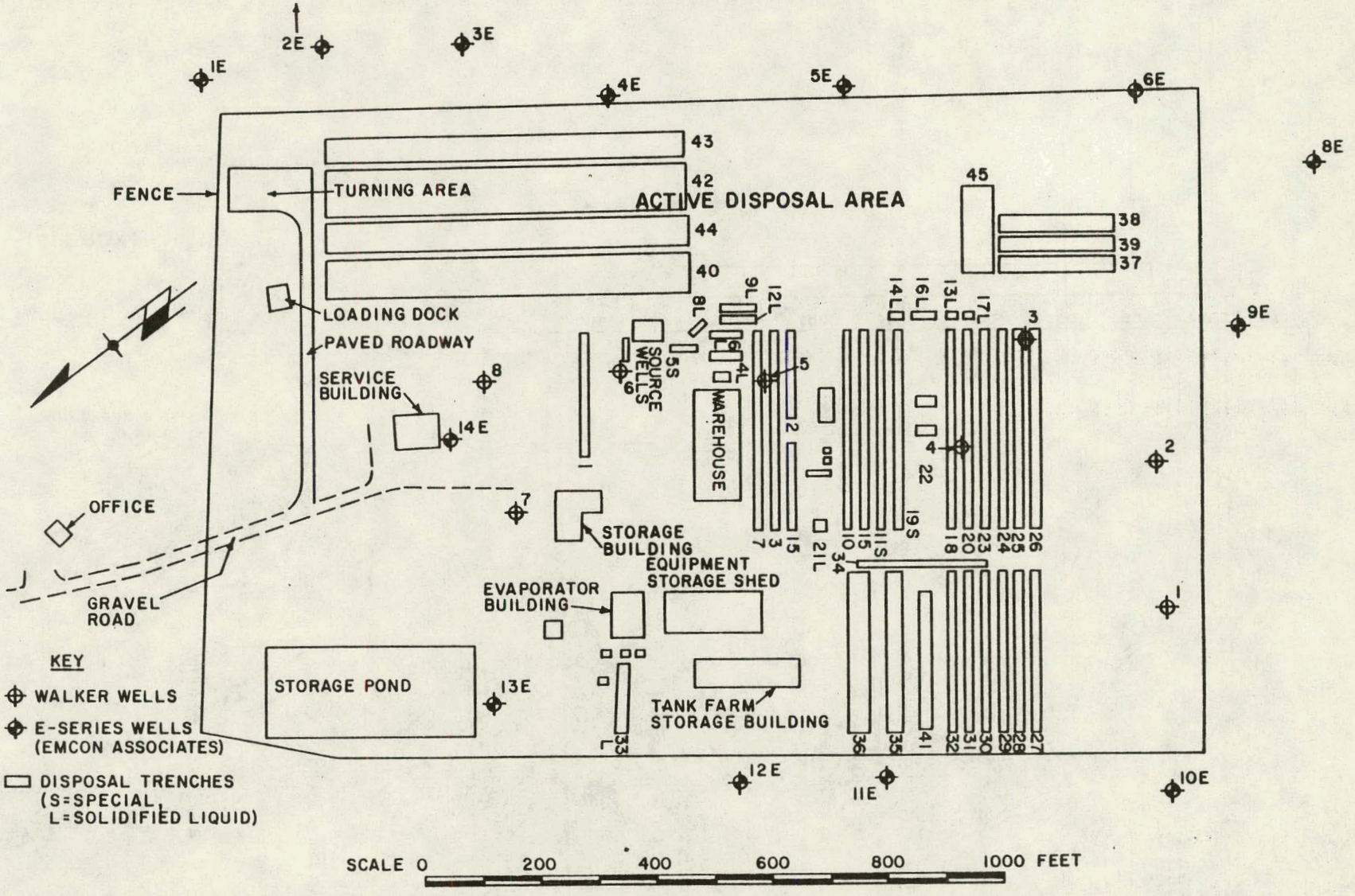



Figure 1. **Location of Commercial Radioactive Waste Disposal Sites in the United States** (adapted from Report WASH-1143).(6)




NOTE: SCALE APPLIES ONLY TO FENCELINE. POSITION AND DIMENSIONS OF TRENCHES ARE APPROXIMATE.

Figure 2. Sketch of Maxey Flats Radioactive Waste Disposal Site (updated from sketch by EMCON Associates).[7]

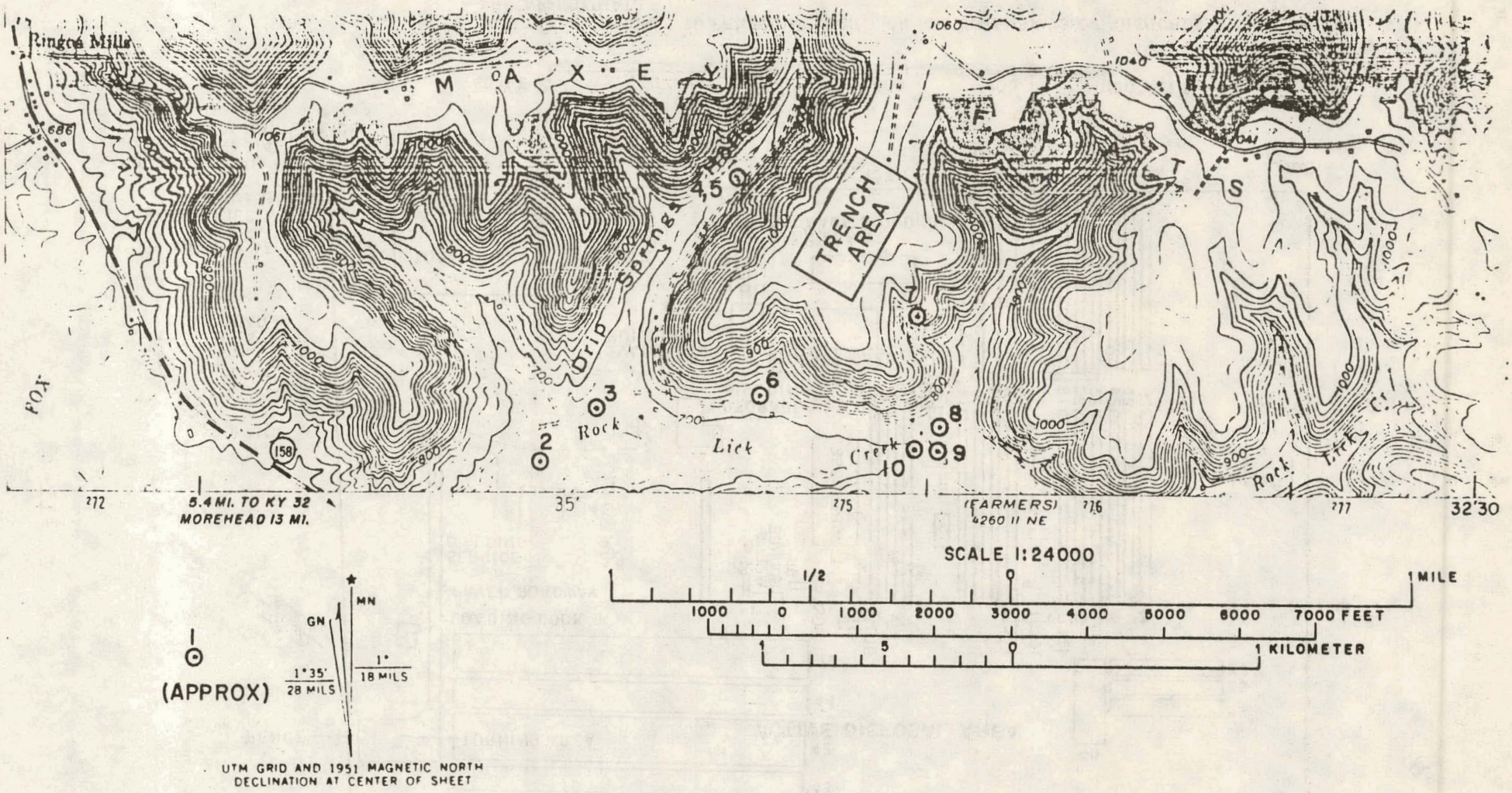



Figure 3. Approximate Sampling Locations Near the Maxey Flats, Kentucky, Disposal Site (adapted from topographical map, United States Geological Survey).(8)

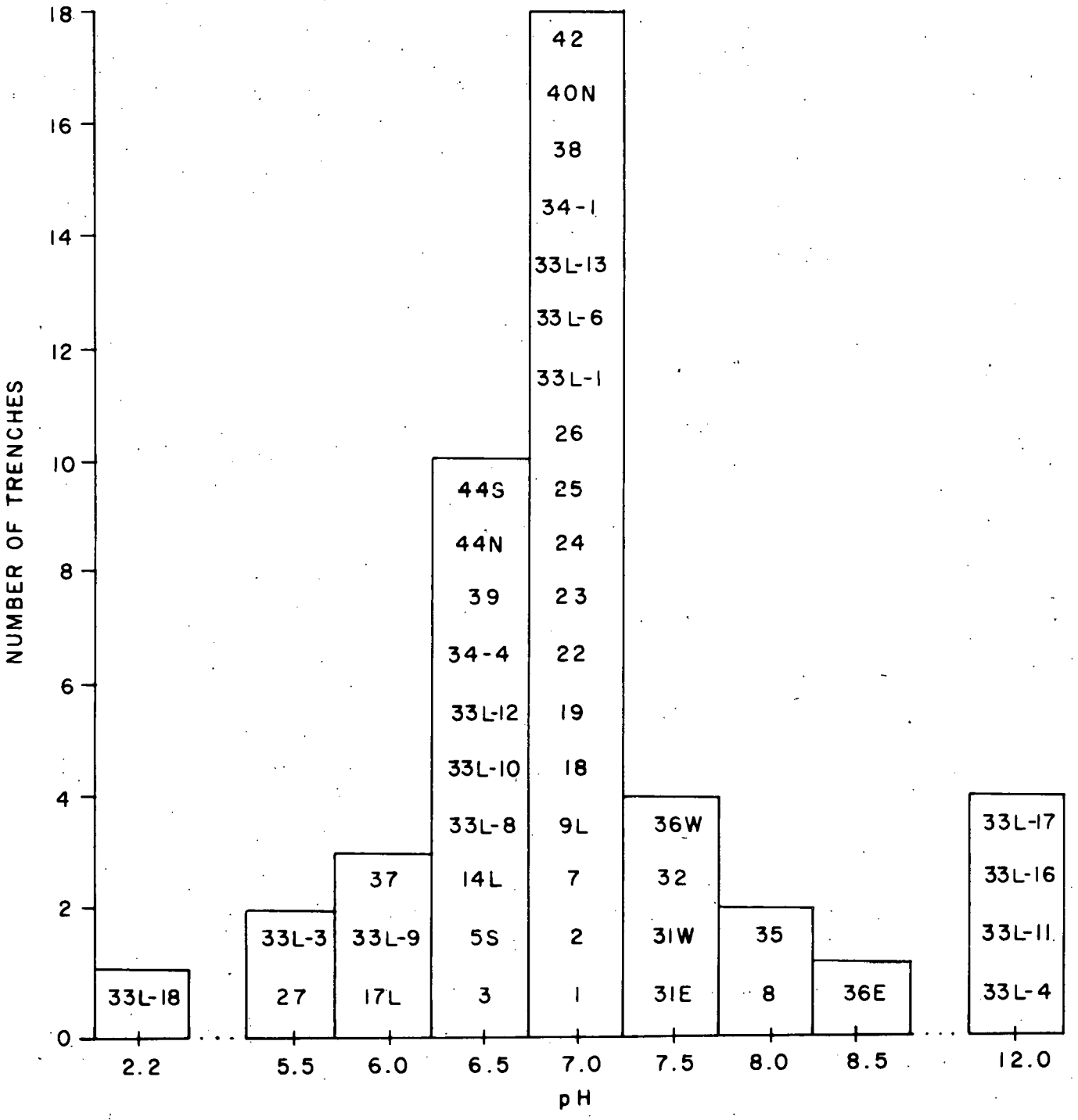



Figure 4. Distribution of pH Values Among Trench Waters at Maxey Flats, Kentucky, Disposal Site.

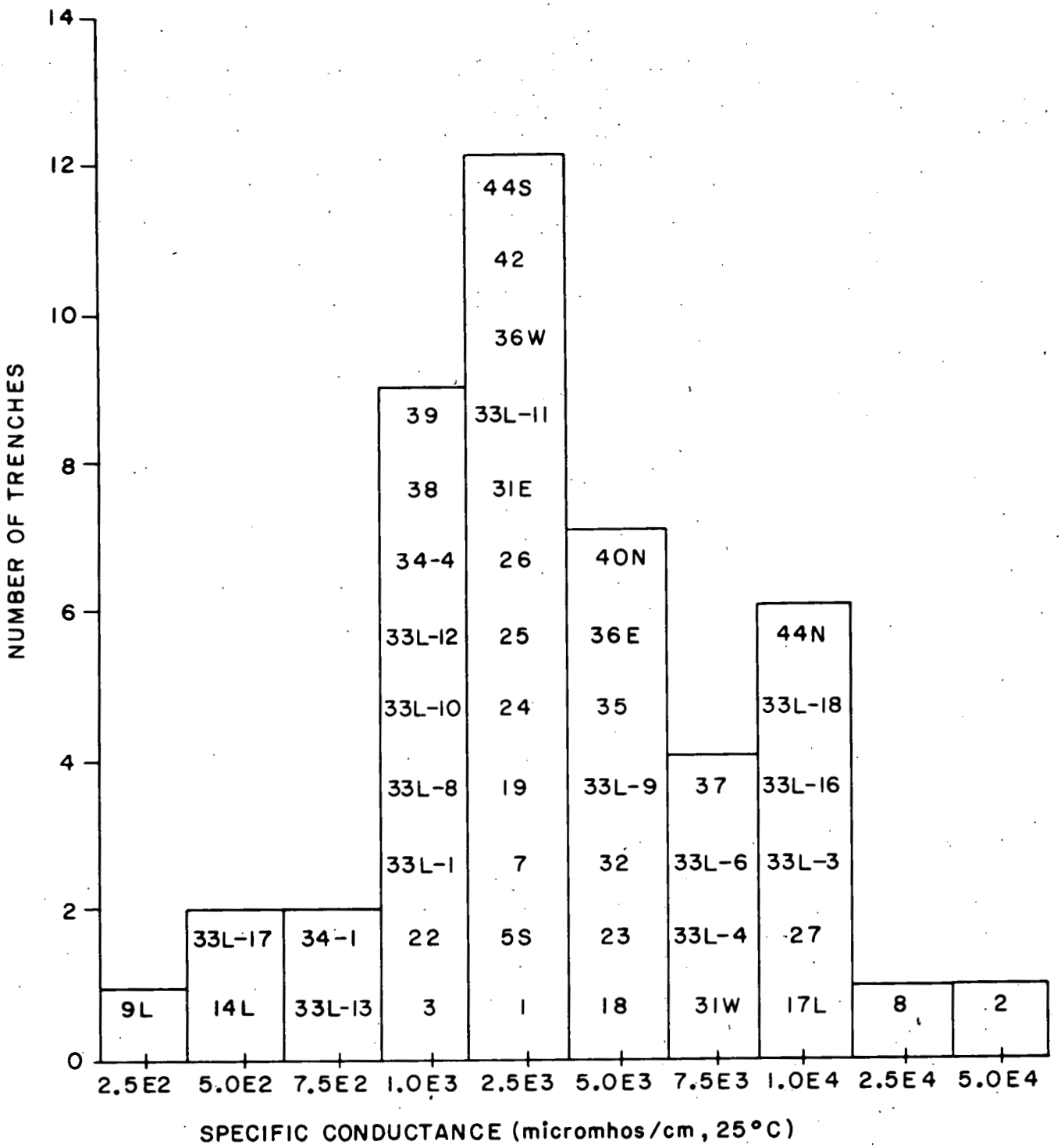



Figure 5. Distribution of Specific Conductance Values Among Trench Waters at Maxey Flats, Kentucky, Disposal Site.

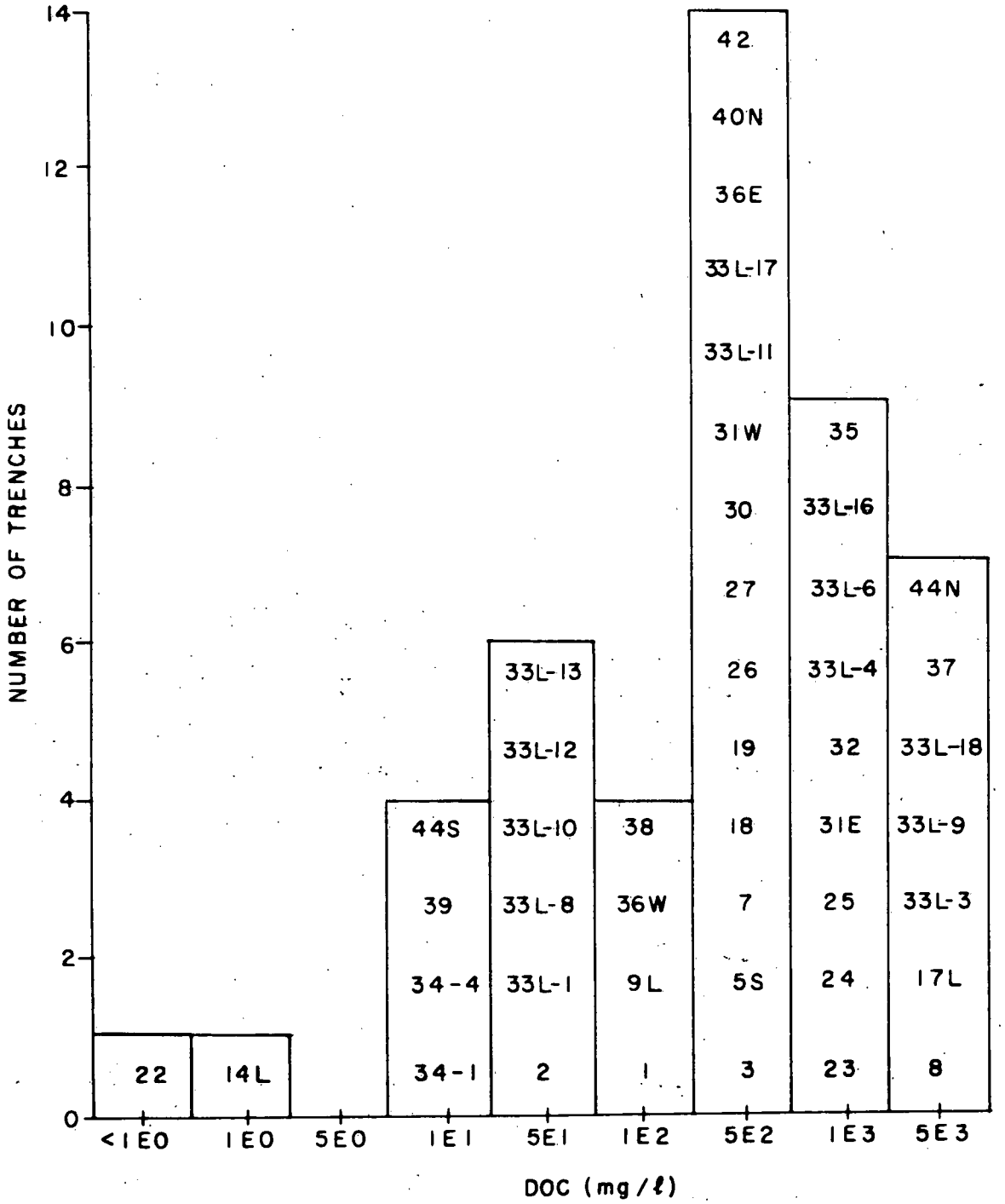



Figure 6. Distribution of DOC Values Among Trench Waters at Maxey Flats, Kentucky, Disposal Site.

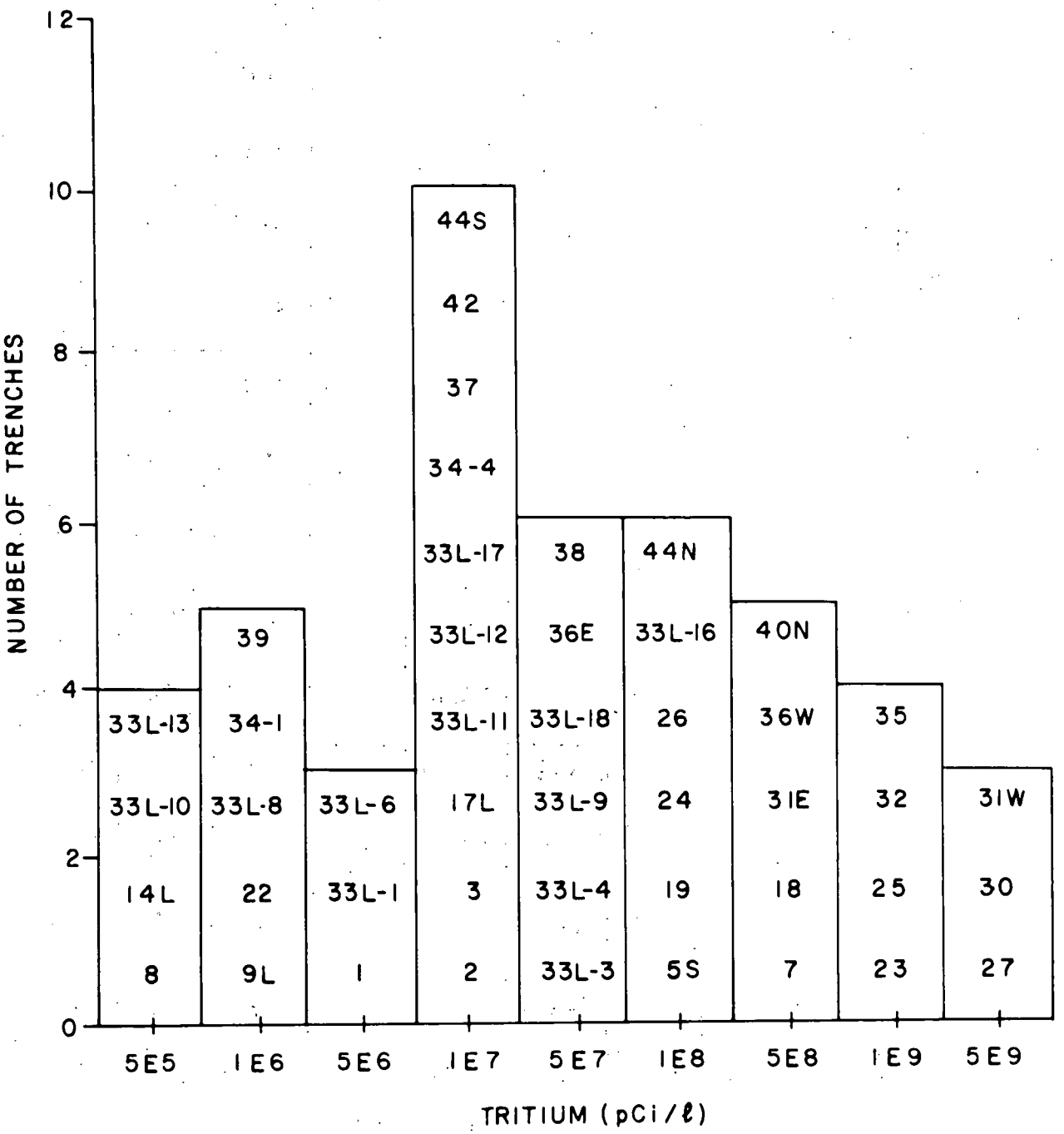



Figure 7. Distribution of Tritium Values Among Trench Waters at Maxey Flats, Kentucky, Disposal Site.

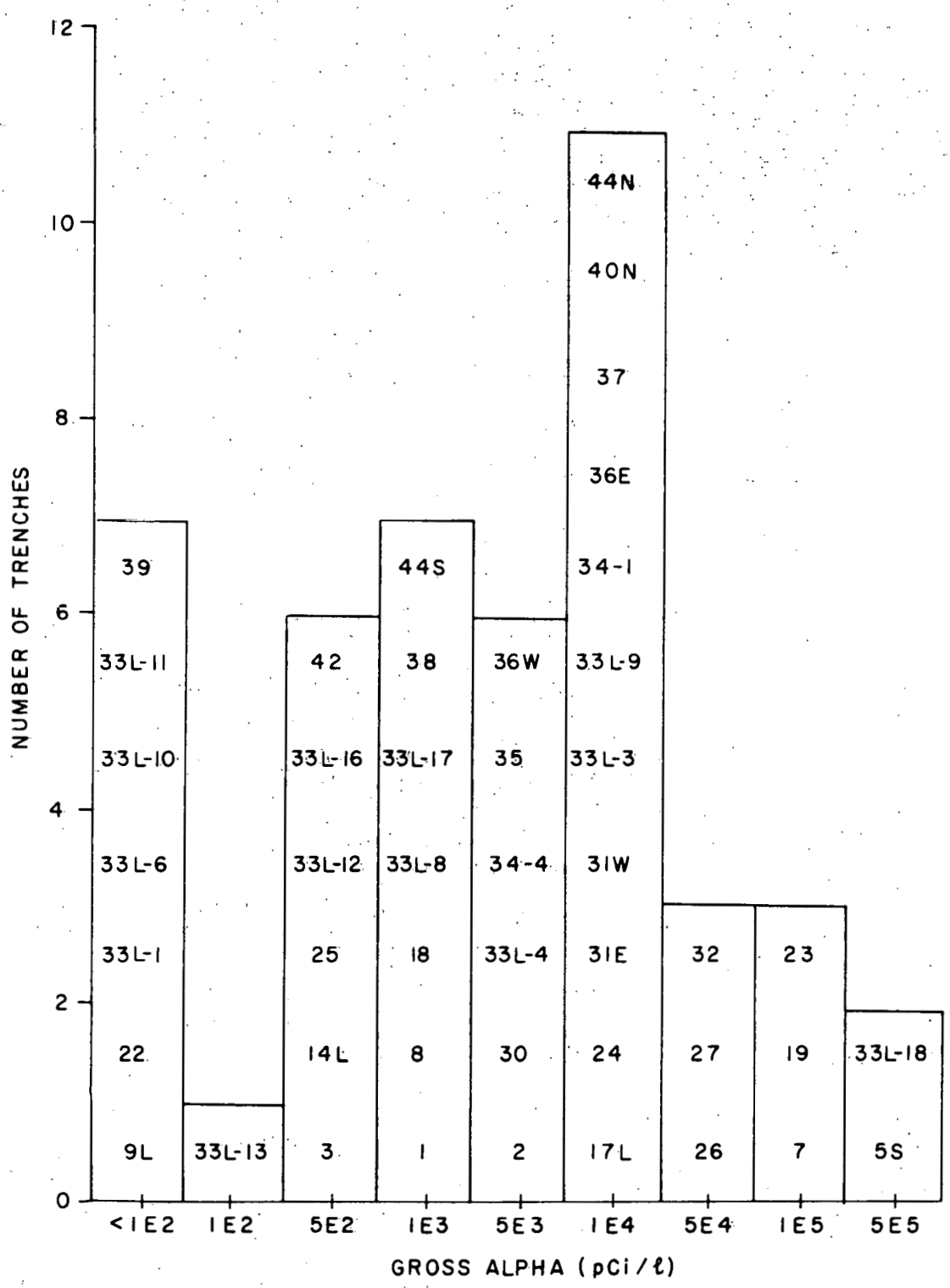



Figure 8. Distribution of Gross Alpha Values Among Trench Waters at Maxey Flats, Kentucky, Disposal Site.

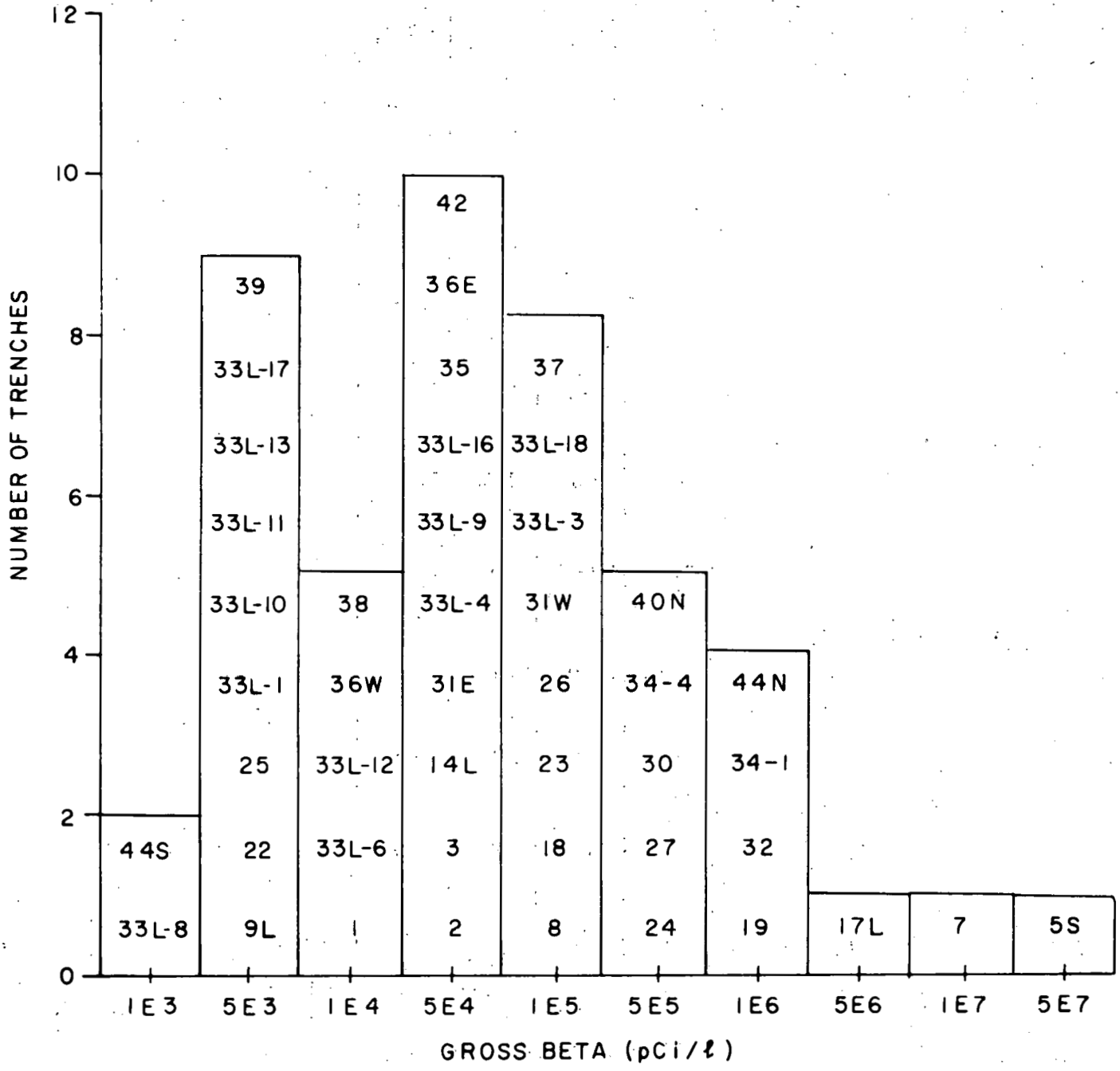



Figure 9. Distribution of Gross Beta Values Among Trench Waters at Maxey Flats, Kentucky, Disposal Site.

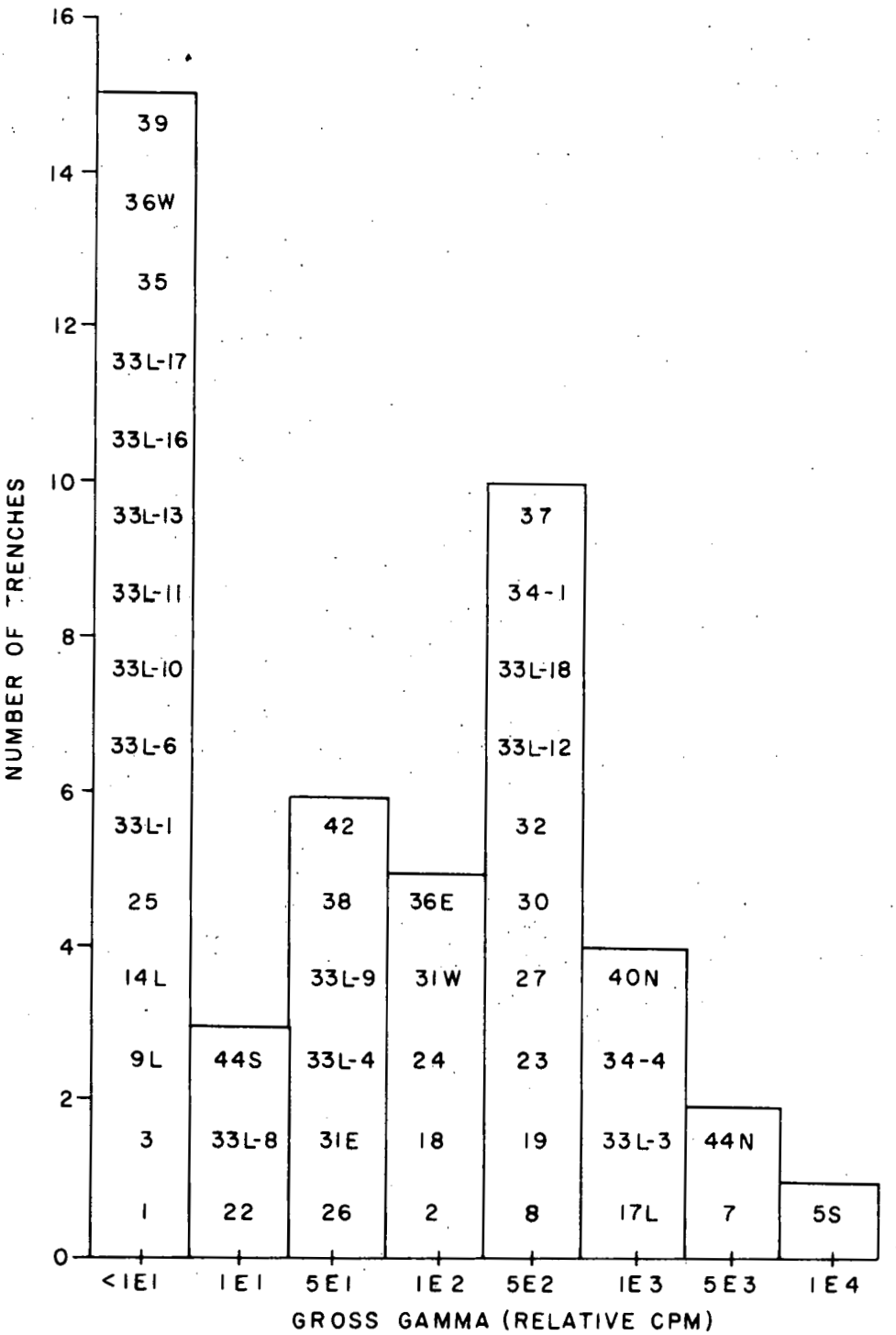



Figure 10. Distribution of Gross Gamma Values Among Trench Waters at Maxey Flats, Kentucky, Disposal Site.

Table 1

Sampling Locations Near the Maxey Flats, Kentucky, Disposal Site

| Position Number* | Location |
|---|---|
| 1 | Fox Creek below Rock Lick Creek |
| 2 | Rock Lick Creek at USGS gaging station |
| 3 | Drip Springs Hollow at Rock Lick Road |
| 4 | Drip Springs Hollow at McRoberts house |
| 5 | McRoberts well in Drip Springs Hollow |
| 6 | Skaggs well-south end of site |
| 7 | KDHR point 13 in site main drainage |
| 8 | No-Name Hollow at bridge |
| 9 | Rock Lick Creek above No-Name Hollow |
| 10 | Rock Lick Creek below No-Name Hollow |

* Position numbers correspond to circled locations in Figure 3.

Table 2

Field Measurements of Water Samples from Maxey Flats, Kentucky, Disposal Site, Survey Study 1977

| Sampling Location | Date Sampled | pH | Temperature (°C) | Specific Conductance (micromhos/cm at 25°C) |
|---|---|---|---|---|
| Trench 1 | 6/16/77 | 7.0 | 21.0 (15)[a] | 2.30 E3[c] |
| Trench 2 | 6/9/77 | 7.1 | 17.0 (30) | 3.85 E4 |
| Trench 3 | 6/6/77 | 6.6 | 22.0 --[b] | 1.75 E3 |
| Trench 5S | 6/16/77 | 6.6 | 23.0 (12) | 1.83 E3 |
| Trench 7 | 6/6/77 | 7.1 | 28.0 -- | 2.33 E3 |
| Trench 8 | 6/6/77 | 8.2 | 25.0 -- | 2.68 E4 |
| Trench 9L | 6/6/77 | 7.0 | 25.0 -- | 2.78 E2 |
| Trench 14L | 6/7/77 | 6.5 | 25.5 -- | 4.23 E2 |
| Trench 17L | 6/7/77 | 5.8 | 22.5 -- | 1.32 E4 |
| Trench 18 | 6/9/77 | 7.2 | 16.5 (25) | 4.35 E3 |
| Trench 19S | 6/9/77 | 6.8 | 18.0 (35) | 2.32 E3 |
| Trench 22 | 6/7/77 | 7.0 | 20.0 -- | 9.42 E2 |
| Trench 23 | 6/16/77 | 7.2 | 23.0 (13) | 5.20 E3 |
| Trench 24 | 6/8/77 | 6.9 | 15.5 -- | 3.38 E3 |
| Trench 25 | 6/8/77 | 6.9 | 15.0 -- | 2.36 E3 |
| Trench 26 | 6/8/77 | 7.0 | 14.5 -- | 2.72 E3 |
| Trench 27 | 6/8/77 | 5.7 | 16.5 -- | 1.63 E4 |
| Trench 30 | 6/9/77 | --- | --- | --- |

Table 2 (Cont'd)

Field Measurements of Water Samples from Maxey Flat, Kentucky, Disposal Site, Survey Study 1977

| Sampling Location | Date Sampled | pH | Temperature (°C) | Specific Conductance (micromhos/cm at 25°C) |
|---|---|---|---|---|
| Trench 31E | 6/9/77 | 7.4 | 17.0 (25) | 3.18 E3 |
| Trench 31W | 6/9/77 | 7.6 | 17.0 (30) | 7.46 E3 |
| Trench 32 | 6/8/77 | 7.3 | 17.0 -- | 5.55 E3 |
| Trench 33L-1 | 6/16/77 | 7.2 | 22.0 (10) | 1.09 E3 |
| Trench 33L-3 | 6/16/77 | 5.3 | 19.5 (10) | 1.22 E4 |
| Trench 33L-4 | 6/9/77 | 12.4 | 16.0 (15) | 7.23 E3 |
| Trench 33L-6 | 6/16/77 | 7.0 | 19.5 (7) | 8.19 E3 |
| Trench 33L-8 | 6/14/77 | 6.6 | 19.5 -- | 1.06 E3 |
| Trench 33L-9 | 6/14/77 | 5.8 | 16.5 -- | 6.49 E3 |
| Trench 33L-10 | 6/16/77 | 6.6 | 19.0 (13) | 1.26 E3 |
| Trench 33L-11 | 6/16/77 | 12.0 | 19.0 (7) | 3.00 E3 |
| Trench 33L-12 | 6/16/77 | 6.7 | 19.0 (10) | 1.50 E3 |
| Trench 33L-13 | 6/16/77 | 6.9 | 19.0 (8) | 7.62 E2 |
| Trench 33L-16 | 6/9/77 | 12.4 | 18.0 -- | 9.14 E3 |
| Trench 33L-17 | 6/16/77 | 12.2 | 20.0 (12) | 4.00 E2 |
| Trench 33L-18 | 6/16/77 | 2.2 | 19.0 (19) | 1.10 E4 |
| Trench 34-1 | 6/7/77 | 7.0 | 18.5 -- | 7.55 E2 |
| Trench 34-4 | 6/7/77 | 6.7 | 17.0 -- | 1.38 E3 |
| Trench 35 | 6/8/77 | 7.9 | 16.0 -- | 5.50 E3 |

Table 2 (Cont'd)

Field Measurements of Water Samples from Maxey Flats, Kentucky, Disposal Site, Survey Study 1977

| Sampling Location | Date Sampled | pH | Temperature (°C) | Specific Conductance (micromhos/cm at 25°C) |
|---|---|---|---|---|
| Trench 36E | 6/8/77 | 8.6 | 16.0 -- | 5.80 E3 |
| Trench 36W | 6/8/77 | 7.3 | 16.0 -- | 2.84 E3 |
| Trench 37 | 6/9/77 | 6.1 | 16.5 (20) | 8.66 E3 |
| Trench 38 | 6/7/77 | 6.9 | 16.0 -- | 1.67 E3 |
| Trench 39 | 6/7/77 | 6.3 | 17.5 -- | 1.53 E3 |
| Trench 40N | 6/17/77 | 7.2 | 20.0 (10) | 6.33 E3 |
| Trench 42 | 6/17/77 | 7.1 | 20.0 (10) | 2.83 E3 |
| Trench 44N | 6/17/77 | 6.4 | 19.0 -- | 1.16 E4 |
| Trench 44S | 6/17/77 | 6.6 | 19.5 (10) | 2.32 E3 |
| Well 5E | 6/10/77 | 7.5 | 16.0 -- | 1.12 E4 |
| Well 8E | 6/10/77 | 7.0 | 16.0 -- | 1.20 E3 |
| Well 12E | 6/10/77 | 7.1 | 15.0 -- | 1.81 E3 |
| Well 13E | 6/10/77 | 7.4 | 15.5 -- | 2.10 E3 |
| Well 14E | 6/10/77 | 6.9 | 16.0 -- | 1.83 E3 |

(a) Number in ( ) is minutes between sampling and measurements.

(b) -- indicates no delay in measurements.

(c) E3 ≡ x $10^3$

Table 3

Radionuclide and DOC Concentrations in Water Samples
From Maxey Flats, Kentucky, Disposal Site, Survey Study 1977

| Sampling Location | Gross Alpha (pCi/ℓ) | Gross Beta (pCi/ℓ) | Tritium (pCi/ℓ) | Gross Gamma (relative cpm) | DOC (mg/ℓ) |
|---|---|---|---|---|---|
| Trench 1 | 1.38 E3 (34)[a] | 1.17 E4 (14)[a] | 3.73 E6 (3.5)[a] | <1 E1 | 1.03 E2 |
| Trench 2 | 6.40 E3 (14) | 3.38 E4 (12) | 1.86 E7 (1.6) | 1.22 E2 | 5.0 E1 |
| Trench 3 | 5.26 E2 (57) | 2.84 E4 (8.0) | 1.30 E7 (1.9) | <1 E1 | 2.60 E2 |
| Trench 5S | 4.81 E5 (1.8) | 5.70 E7 (<1) | 1.51 E8 (<1) | 1.56 E4 | 3.60 E2 |
| Trench 7 | 7.40 E4 (4.8) | 8.77 E6 (<1) | 3.60 E8 (<1) | 2.96 E3 | 3.23 E2 |
| Trench 8 | 1.38 E3 (34) | 8.86 E4 (4.4) | 6.42 E5 (8.4) | 7.44 E2 | 6.03 E3 |
| Trench 9L | <2 E2 | 2.32 E3 (36) | 7.89 E5 (7.6) | <1 E1 | 2.48 E2 |
| Trench 14L | 7.07 E2 (49) | 2.43 E4 (8.4) | 2.51 E5 (13) | <1 E1 | 7.4 E0 |
| Trench 17L | 1.54 E4 (9.8) | 3.18 E6 (<1) | 8.89 E6 (2.3) | 1.03 E3 | 5.56 E3 |
| Trench 18 | 1.58 E3 (29) | 1.60 E5 (3.4) | 4.46 E8 (<1) | 1.88 E2 | 4.57 E2 |
| Trench 19S | 1.82 E5 (3.0) | 9.56 E5 (2.2) | 8.38 E7 (<1) | 2.79 E2 | 4.03 E2 |
| Trench 22 | <2 E2 | 3.34 E3 (27) | 1.76 E6 (5.1) | 1.1 E1 | <1 E0 |
| Trench 23 | 9.33 E4 (4.3) | 1.95 E5 (3.9) | 1.04 E9 (<1) | 2.61 E2 | 8.00 E2 |

Table 3 (Cont'd)

Radionuclide and DOC Concentrations in Water Samples
From Maxey Flats, Kentucky, Disposal Site, Survey Study 1977

| Sampling Location | Gross Alpha (pCi/ℓ) | Gross Beta (pCi/ℓ) | Tritium (pCi/ℓ) | Gross Gamma (relative cpm) | DOC (mg/ℓ) |
|---|---|---|---|---|---|
| Trench 24 | 1.15 E4 (12) | 4.57 E5 (1.9) | 1.85 E8 (<1) | 1.43 E2 | 1.10 E3 |
| Trench 25 | 6.04 E2 (51) | 5.29 E3 (29) | 8.01 E8 (<1) | <1 E1 | 9.56 E2 |
| Trench 26 | 2.75 E4 (7.0) | 1.14 E5 (4.7) | 1.13 E8 (<1) | 5.9 E1 | 6.83 E2 |
| Trench 27 | 8.58 E4 (4.4) | 5.73 E5 (1.9) | 4.79 E9 (<1) | 4.25 E2 | 7.01 E2 |
| Trench 30 | 3.67 E3 (21) | 2.74 E5 (2.4) | 7.41 E9 (<1) | 6.78 E2 | 3.50 E2 |
| Trench 31E | 2.26 E4 (8.6) | 5.75 E4 (7.3) | 4.76 E8 (<1) | 7.0 E1 | 1.65 E3 |
| Trench 31W | 9.29 E3 (13) | 1.33 E5 (4.0) | 4.67 E9 (<1) | 2.22 E2 | 7.04 E2 |
| Trench 32 | 2.76 E4 (7.8) | 1.25 E6 (<1) | 1.94 E9 (<1) | 3.88 E2 | 8.94 E2 |
| Trench 33L-1 | <2 E2 | 2.97 E3 (31) | 3.71 E6 (3.5) | <1 E1 | 6.2 E1 |
| Trench 33L-3 | 1.23 E4 (11) | 1.71 E5 (3.1) | 4.56 E7 (1.0) | 9.04 E2 | 4.46 E3 |
| Trench 33L-4 | 3.91 E3 (20) | 6.72 E4 (5.3) | 5.90 E7 (1.3) | 2.5 E1 | 1.72 E3 |
| Trench 33L-6 | <2 E2 | 7.90 E3 (17) | 7.18 E6 (2.5) | <1 E1 | 8.60 E2 |
| Trench 33L-8 | 1.49 E3 (33) | 1.45 E3 (74) | 1.32 E6 (5.1) | 2.2 E1 | 3.9 E1 |

Table 3 (Cont'd)

Radionuclide and DOC Concentrations in Water Samples
From Maxey Flats, Kentucky, Disposal Site, Survey Study 1977

| Sampling Location | Gross Alpha (pCi/ℓ) | Gross Beta (pCi/ℓ) | Tritium (pCi/ℓ) | Gross Gamma (relative cpm) | DOC (mg/ℓ) |
|---|---|---|---|---|---|
| Trench 33L-9 | 1.77 E4 (9.1) | 2.75 E4 (12.5) | 2.55 E7 (1.3) | 5.3 E1 | 4.11 E3 |
| Trench 33L-10 | <2 E2 | 6.76 E3 (18) | 7.44 E5 (7.8) | <1 E1 | 4.3 E1 |
| Trench 33L-11 | <2 E2 | 3.18 E3 (30) | 2.20 E7 (1.4) | <1 E1 | 4.40 E2 |
| Trench 33L-12 | 6.04 E2 (52) | 1.12 E4 (13) | 2.40 E7 (1.3) | 4.72 E2 | 5.7 E1 |
| Trench 33L-13 | <2 E2 | 4.20 E3 (26) | 5.69 E5 (8.9) | <1 E1 | 2.7 E1 |
| Trench 33L-16 | 4.00 E2 (59) | 6.70 E4 (4.8) | 1.34 E8 (<1) | <1 E1 | 1.02 E3 |
| Trench 33L-17 | 1.86 E3 (30) | 7.05 E3 (20) | 1.40 E7 (2.6) | <1 E1 | 3.24 E2 |
| Trench 33L-18 | 6.39 E5 (1.5) | 1.61 E5 (11) | 5.01 E7 (<1) | 6.56 E2 | 5.82 E3 |
| Trench 34-1 | 1.11 E4 (12) | 1.77 E6 (1.2) | 1.91 E6 (4.9) | 6.71 E2 | 2.5 E1 |
| Trench 34-4 | 3.85 E3 (20) | 2.75 E5 (2.3) | 9.93 E6 (2.2) | 1.67 E3 | 2.5 E1 |
| Trench 35 | 3.47 E3 (20) | 3.68 E4 (7.3) | 2.39 E9 (<1) | <1 E1 | 8.10 E2 |
| Trench 36W | 5.68 E3 (15) | 1.02 E4 (20) | 5.31 E8 (<1) | <1 E1 | 1.08 E2 |
| Trench 36E | 9.52 E3 (12) | 2.82 E4 (10) | 5.14 E7 (<1) | 8.7 E1 | 2.90 E2 |

Table 3 (Cont'd)

Radionuclide and DOC Concentrations in Water Samples
From Maxey Flats, Kentucky, Disposal Site, Survey Study 1977

| Sampling Location | Gross Alpha (pCi/ℓ) | Gross Beta (pCi/ℓ) | Tritium (pCi/ℓ) | Gross Gamma (relative cpm) | DOC (mg/ℓ) |
|---|---|---|---|---|---|
| Trench 37 | 8.20 E3 (14) | 9.36 E4 (4.5) | 9.82 E6 (2.2) | 2.85 E2 | 2.98 E3 |
| Trench 38 | 1.27 E3 (32) | 1.91 E4 (10) | 3.33 E7 (1.2) | 2.5 E1 | 1.65 E2 |
| Trench 39 | <2 E2 | 4.06 E3 (24) | 7.54 E5 (7.8) | <1 E1 | 1.7 E1 |
| Trench 40N | 1.25 E4 (11) | 3.40 E5 (2.2) | 6.64 E8 (<1) | 1.02 E3 | 4.43 E2 |
| Trench 42 | 4.05 E2 (66) | 3.01 E4 (7.5) | 1.57 E7 (1.7) | 3.4 E1 | 3.32 E2 |
| Trench 44N | 8.80 E3 (14) | 9.97 E5 (1.3) | 1.03 E3 (<1) | 6.20 E3 | 2.98 E3 |
| Trench 44S | 8.28 E2 (45) | 2.00 E3 (48) | 1.36 E7 (1.8) | 2.1 E1 | 5.6 E1 |
| Well 5E | <6 E0 | <3 E1 | 1.80 E3 (4.0) | <1 E1 | 3.3, 3.1[b] |
| Well 8E | 6.34 E1 (27) | 2.13 E2 (21) | 1.41 E4 (18) | <1 E1 | 3.5, 5.3[b] |
| Well 12E | 5.41 E1 (30) | 1.77 E2 (24) | 1.80 E4 (15) | <1 E1 | 6.0, 2.7[b] |
| Well 13E | <6 E0 | <3 E1 | 6.12 E6 (<1) | <1 E1 | 13, 13[b] |
| Well 14E | <6 E0 | <3 E1 | 2.44 E4 (12) | <1 E1 | 2.2, 2.7[b] |

(a) Number in ( ) = % counting uncertainty,
1.65σ for alpha and beta, 2σ for tritium.

(b) DOC analyses performed by USGS labs on samples taken 3/2/77 and 4/26/77.

Table 4

Ranges of Measurements of Water Samples from Maxey Flats, Kentucky, Disposal Site, Survey Study 1977

| Measurement | Range |
|---|---|
| pH | 2.2 - 12.4 |
| Specific conductance (micromhos/cm at 25°C) | 4.0 E2 - 3.9 E4 |
| DOC (mg/l) | <1 E0 - 5.8 E3 |
| Gross alpha (pCi/l) | <1 E2 - 6.4 E5 |
| Gross beta (pCi/l) | 8.3 E2 - 5.7 E7 |
| Gross gamma (relative cpm) | <1 E1 - 1.6 E4 |
| Tritium (pCi/l) | 2.5 E5 - 7.4 E9 |

Table 5

Field Measurements of Water Samples from Vicinity of Maxey Flats, Kentucky, Disposal Site, Survey Study 1977

| | Sampling Location | Date Sampled | pH | Temperature (°C) | Specific Conductance (micromhos/cm at 25°C) |
|---|---|---|---|---|---|
| 1. | Fox Creek below Rock Lick Creek (Stream) | 6/15/77 | 7.0 | 22.5 --[b] | 2.10 E2[c] |
| 2. | Rock Lick Creek at USGS gaging station (Stream) | 6/15/77 | 6.7 | 24.5 -- | 1.86 E2 |
| 3. | Drip Springs Hollow at Rock Lick Road (Stream) | 6/15/77 | 6.6 | 22.5 -- | 1.83 E2 |
| 4. | Drip Springs Hollow at McRoberts House (Stream) | 6/15/77 | 5.6 | 25.0 -- | 1.85 E2 |
| 5. | McRoberts well in Drip Springs Hollow (Dug well) | 6/15/77 | 4.9 | 19.0 -- | 2.40 E2 |
| 6. | Skaggs Well - south end of site (Dug well) | 6/15/77 | 4.0 | 20.5 -- | 3.45 E2 |
| 7. | KDHR point 13 in site main drainage (Stream) | 6/15/77 | 5.0 | 21.0 (10)[a] | 4.28 E2 |
| 8. | No-Name Hollow at bridge (Stream) | 6/15/77 | 5.6 | 23.0 -- | 1.62 E2 |
| 9. | Rock Lick Creek above No-Name Hollow (Stream) | 6/15/77 | 5.8 | 24.0 (10) | 1.28 E2 |
| 10. | Rock Lick Creek below No-Name Hollow (Stream) | 6/15/77 | 6.1 | 26.5 (10) | 1.33 E2 |

(a) Number in ( ) is minutes between sampling and measurements.

(b) -- indicates no delay in measurements.

(c) E2 ≡ x $10^2$

Table 6

Radionuclide and DOC Concentrations in Water Samples from Vicinity of Maxey Flats, Kentucky, Disposal Site, Survey Study 1977

| | Sampling Location | Gross Alpha (pCi/ℓ) | Gross Beta (pCi/ℓ) | Tritium (pCi/ℓ) | Gross Gamma (relative cpm) | DOC (mg/ℓ) |
|---|---|---|---|---|---|---|
| 1. | Fox Creek below Rock Lick Creek | <1 E1 | <4 E1 | 8.55 E3 (17)[a] | <1 E1 | 2.9 |
| 2. | Rock Lick Creek at USGS gaging station | <1 E1 | <4 E1 | 2.18 E4 (13) | <1 E1 | 4.3 |
| 3. | Drip Springs Hollow at Rock Lick Road | <1 E1 | <4 E1 | 2.40 E4 (12) | <1 E1 | <3.5 |
| 4. | Drip Springs Hollow at McRoberts house | <1 E1 | <4 E1 | 2.33 E4 (12) | <1 E1 | 1.8 |
| 5. | McRoberts well in Drip Springs Hollow | <1 E1 | <4 E1 | 1.40 E4 (15) | <1 E1 | <1 |
| 6. | Skaggs Well - south end of site | <1 E1 | 8.5 E1 (52)[a] | 1.54 E4 (14) | <1 E1 | 1.3 |
| 7. | KDHR point 13 in site main drainage | <1 E1 | 1.25 E2 (39) | 2.92 E4 (11) | <1 E1 | <2 |
| 8. | No-Name Hollow at bridge | <1 E1 | 1.66 E2 (31) | 3.83 E4 (10) | <1 E1 | 3.3 |
| 9. | Rock Lick Creek above No-Name Hollow | <1 E1 | <4 E1 | 1.99 E4 (13) | <1 E1 | <1.5 |
| 10. | Rock Lick Creek below No-Name Hollow | <1 E1 | <4 E1 | 1.37 E4 (15) | <1 E1 | <2 |

(a) Number in ( ) = % counting uncertainty, 1.65σ for beta and 2σ for tritium

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## Appendix

## Procedure for Survey Study

### 1.0 EQUIPMENT AND SUPPLIES

The equipment needed for sampling consists of items supplied by BNL and USGS.

#### 1.1 Items Supplied by BNL

Polyethylene bottles (500 ml)*
DOC bottles from USGS Central Labs, Denver, Colorado (∿ 60 ml)
Glass bottles (1 liter)*
pH paper (range pH 1-2.5)
Plastic bags (water tight)
Masking tape
Insulated ice chest
Metal cans
Aluminum foil
Scotch tape
Hose clamps
Plastic squeeze bottles

#### 1.2 Items Supplied by USGS

Peristaltic Pump
Tygon tubing, laboratory grade R3603**, 5/8" x 3/8" and 3/8" x 1/4" sizes
Bailer
Nitric Acid ($HNO_3$), reagent grade (Conc)
Pipette or graduated cylinder
Radiation survey meter

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* All items cleaned at BNL. Do not make substitutions.

** Tygon tubing R3603 is available in various sizes compatable with the peristaltic pump available at the burial site. A possible source is: Norton Plastics and Synthetics Division, P.O. Box 350, Akron, Ohio 44309, Tel. (216) 633-3224.

1.2 Items Supplied by USGS (Cont'd)

Protective clothing (disposable gloves, shoe covering, etc.)
Marking pen
pH meter and electrodes
Conductivity meter and cell
Thermometer
Ice
Shipping crate
Absorbent material, e.g., vermiculite
In-line stainless steel filter assembly with 3-way valve
47 mm, 0.45 micron silver membrane filters
Acetone
Distilled water

## 2.0 COLLECTION PROCEDURE

All trenches and wells from which water can be obtained should be sampled. A radiochemical sample and an organic sample will be collected from each sampling location.

### 2.1 Trench Sampling

1. Prior to collecting a trench sample, purge with trench water to clean the lines. NEW TYGON TUBING SHOULD BE USED FOR EACH TRENCH TO AVOID CROSS CONTAMINATING THE SAMPLES.
2. Rinse a one liter glass bottle with some trench water prior to collecting approximately one liter of water sample. A hose clamp can be used to regulate the flow rate.
3. Record the sample source and collection date on each bottle used. Cover all written labels with transparent tape to protect the label from water.

#### 2.1.1 Radiochemical Sample

1. Dispense 5 ml of reagent grade concentrated nitric acid into a 500 ml polyethylene bottle followed by 100 ml of trench water (from 2.1 step 2), 30 ml of concentrated nitric acid, and trench water (from 2.1 step 2) to approximately 400 ml (total volume). Shake the contents of the glass bottle before pouring into the polyethylene bottle.

2. Shake the contents of the polyethylene bottle and test the acidified sample with pH paper supplied. If the color is not red (pH < 1) add an additional 5 ml of concentrated nitric acid, shake, and test again. A maximum of 100 ml of nitric acid should be added.

3. Fill the polyethylene bottle to the neck with trench water.

4. Do not cap the acidified sample bottle until all effervescence has ceased.

5. Record the total amount of nitric acid to the sample on the bottle label.

2.1.2 Organic Sample

1. Prior to collecting the organic sample, the in-line filtration assembly must be carefully cleaned by washing with detergent and brush, rinsing with water, rinsing with acetone (use a squeeze bottle), rinsing with water, and finally rinsing with distilled water.
IT IS IMPERATIVE THAT CAREFUL ATTENTION BE GIVEN TO RINSING THE FILTER ASSEMBLY WITH SUFFICIENT WATER TO REMOVE ALL TRACES OF DETERGENT AND ACETONE.
Any residue will adversely affect the DOC measurement.

2. Attach the stainless steel filter assembly containing a new silver membrane filter by clamping a short peice of 3/8" x 1/4" tygon tubing into the 5/8" x 3/8" tubing

attached to the peristaltic pump and connecting to the inlet port of the filter.

3. Set the three-way valve on the filter assembly to bypass the silver membrane filter and purge some trench water to waste.

4. Set the three-way valve to allow flow through the silver membrane filter and filter some trench water to waste.

5. Remove the cap of the DOC bottle and carefully peel back the aluminum foil cover. Place the cap and aluminum foil cover on a piece of clean aluminum foil to avoid contaminating the cover.

6. Place the discharge tube of the filter assembly (3/8" x 1/4" tygon tubing) in the bottom of the DOC bottle and filter trench water through the silver membrane filter to the shoulder of the bottle.

7. Seal the bottle with the aluminum foil cover and cap.

8. Secure the DOC bottle in a plastic bag by folding the top of the bag several times and bending over the tabs. Remove as much air as possible before sealing the bag.

9. This sample must be kept on ice and in the dark until it is analyzed for DOC at BNL.

10. The temperature, pH, and conductivity of the remainder of the sample in the glass bottle are measured in the field. Temperature is to be measured immediately after collection.

11. Waste water from pumping the trenches and wells should be collected in suitable containers and disposed of in a manner approved by site managers.

12. Discard the remainder of the trench water, bottle, and tygon tubing as prescribed by the site managers.

2.2 Water Well Sampling

1. Wells should be developed if possible, before sampling.

2. A bailer is used to raise the water sample if the water level is too low for a peristaltic pump. A separate bailer should be used for each well to eliminate the possibility of cross contaminating well samples.

3. The bailer should be bounced in the well to mix the standing water and to obtain a water sample containing bottom sediment.

4. Rinse a one liter glass bottle with some well water prior to collecting approximately one liter of water sample.

5. Labels for well samples should indicate the kind of well casing, the kind of bailer used, and the duration of time water sat in the well before sampling.

2.2.1 Radiochemical Sample

Shake the contents of the well sample in the one liter glass bottle and take an aliquot for radiochemical sample as in 2.1.1 steps 1-5.

2.2.2 Organic Sample

1. Allow the remaining well sample in the one liter glass bottle to settle for approximately 15 minutes.
2. Connect the in-line filter assembly to a short length of tygon tubing and attach to the peristaltic pump.
3. Filter the settled well water into a DOC bottle as in 2.1.2 steps 1-12.

2.3 Stream Sampling

Stream samples should be collected and processed similar to well samples.

## 3.0 PACKAGING PROCEDURE

### 3.1 Radiochemical Sample

1. Seal the 500 ml polyethylene bottle containing acidified sample in a plastic bag using the twist ties supplied.
2. Place each bagged 500 ml plastic bottle into a metal can and fill the void space with absorbent material, such as vermiculite, prior to sealing.
3. Each can must have a radioactivity label which includes sample identification and radiation level at the surface of the can.
4. The sealed cans may be packed in any convenient shipping carton.
5. The radioactivity at the surface of the shipping carton must be less than 0.5 mr/hr, as required by the Department of Transportation regulations.
6. No refrigeration is required for the acidified samples in the 500 ml plastic bottles.

### 3.2 Organic Sample

1. Place each bagged DOC bottle into a metal can and fill the void space with ice prior to sealing.
2. Label each can as in 3.1 step 3.
3. The sealed cans must be stored in an insulated ice chest filled with ice to maintain $\sim 4^{o}C$ until they arrive at BNL.
4. The ice chest may be packed in any convenient shipping carton.

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