Rockwell International
Rocketdyne Division

SUPPORTING DOCUMENT

GO NO.	S/A NO.	PAGE 1 OF	TOTAL PAGES	REV LTR/CHG NO. SEE SUMMARY OF CHG	NUMBER
96212	12600	60	60	New	N704SRR990035

PROGRAM TITLE
Assessment Surveys and Release of Equipment from Building T064

3123

DOCUMENT TITLE
Radiological Assessment of the Building T064 Fenced-In Yard

DOCUMENT TYPE
Safety Review Report

KEY NOUNS
SSFL, radioactivity, survey, contamination measurements

ORIGINAL ISSUE DATE
December 23, 1993

REL. DATE
1-12-94 CJ

PREPARED BY/DATE | DEPT | MAIL ADDR
D. W. Kneff 12/22/93 | 642 | NA02
R. J. Tuttle 12/22/93 | 641 | T100
G. Subbaraman 12/21/93 | 030 | T038

IR&D PROGRAM? YES ☐ NO ☒
IF YES, ENTER TPA NO.

APPROVALS | DATE
P. H. Horton 12/23/93
P. D. Rutherford 12/22/93
G. G. Gaylord 12/22/93
A. Okuda 1/3/94

DISTRIBUTION

*	NAME	MAIL ADDR
	*G. T. Bryant	T100
	*G. G. Gaylord (5)	T038
	D. C. Gibbs	T038
	*J. M. Harris	KAPL
	*P. H. Horton	T009
	*D. W. Kneff (3)	NA02
	*V. Keshishian	FA88
	*S. R. Lafflam	AA24
	*R. D. Meyer	T038
	*B. M. Oliver	NA02
	*P. S. Olson	KAPL
	*P. D. Rutherford (2)	T100
	*G. Subbaraman (5)	T038
	*R. J. Tuttle	T100
	*P. H. Waite	T009
	*Decommissioning File	T100
	*RP & HPS Library	T100
	*Authorization 139	T100

ABSTRACT

A radiological survey was performed to assess the residual radioactivity in the 6580-ft^2 area of fenced-in yard surrounding Building T064 at the SSFL. Data were obtained by alpha and beta counting and gamma exposure rate measurements, and by laboratory analyses of surface material for radioactivity. Results show that residual radioactivity in the area is well below acceptance limits. The results also indicate consistency between the present data and data obtained from previous surveys of the fenced-in yard.

RESERVED FOR PROPRIETARY/LEGAL NOTICES

* COMPLETE DOCUMENT
NO ASTERISK, TITLE PAGE/SUMMARY OF CHANGE PAGE ONLY

FORM 734-C REV. 12-84

CONTENTS

TABLES

FIGURES

SUMMARY

PURPOSE. This Safety Review Report documents findings from a radiological assessment survey performed in the fenced-in portions of Building T064, located in Rockwell International's Santa Susana Field Laboratory (SSFL). The survey is part of an ongoing U.S. Department of Energy (DOE) environmental restoration program to decontaminate and decommission (D&D) SSFL facilities and work areas. The survey is intended to provide data on previously known or suspected radiological conditions and to assist in subsequent D&D operations.

BACKGROUND. Since the late 1950s, Building T064 and its fenced-in yard were utilized by Rockwell and its predecessor firms in support of a number of the U.S. Government's nuclear programs. In the early 1960s, a contamination incident involving radioactive mixed fission products from a reactor fuel-element shipping cask occurred in an area near the eastern portion of the fenced-in yard. The area was cleaned up in 1963. A general gamma survey in 1988 indicated contamination within the eastern fence line and in an adjacent area outside the fence. That area was cleaned up in 1989 by removing affected top soil, and it was concluded from the results of a subsequent 1989 survey that the remediated area is suitable for release for unrestricted use. The present work was performed to assess the entire fenced-in yard area for unrestricted release.

WORK PERFORMED. The 6580 ft^2 area comprising the fenced-in yard was gridded and surveyed for residual alpha-, beta-, and gamma-emitting radionuclides. Top-layer materials (asphalt and soil) were collected from randomly selected locations for analysis to identify and quantify specific radionuclides. The survey data and soil data have been analyzed and compared with acceptance limits and with previous survey data from the same location.

STATUS. The fenced-in yard continues to be unoccupied and unused for radiological or other purposes. Building T064 proper has undergone remediation and final survey.

CONCLUSION. Results of the present assessment survey indicate that the fenced-in yard is suitable for release for unrestricted use.

1. INTRODUCTION

Since the 1950s, Rockwell International and its predecessor companies have performed nuclear activities sponsored by the U. S. Department of Energy (DOE) and its predecessor agencies at the Santa Susana Field Laboratory (SSFL). Several facilities were constructed and operated at the SSFL to support programs involving nuclear materials. These programs have ended, but some of the facilities and work areas contain residual radioactive material. These facilities and areas are currently undergoing decontamination and decommissioning (D&D) to prepare them for future release for unrestricted use.

The D&D program is being performed under an established environmental restoration plan.[1] Included in this plan are surveys to assess the radiological conditions of the affected facilities and work areas. One such facility, designated Building T064, and including its surrounding yards, is undergoing environmental restoration and related radiological assessments. This facility was used previously to receive and temporarily store Source and Special Nuclear Materials, and more recently to store low-level radioactive waste waiting shipment for offsite disposal.

This report presents the findings from a radiological survey performed in the fenced-in portion of the yard immediately surrounding Building T064. The survey included performance of a variety of radioactivity measurements on the 6580 ft^2 area comprising the fenced-in yard, interpretation of the data, and data comparison against established acceptance limits and other data obtained from previous surveys.[2,3] The present report covers the in-situ alpha, beta, and gamma activity measurements, plus the laboratory analyses of soil and asphalt samples extracted from the site.

This report is organized as follows: Section 2 summarizes the background on the location, operating history, and previous surveys of the fenced-in yard; details may be found in References 2 and 3. Section 3 describes the procedures used for the survey and data reduction. Section 4 discusses the results, and Section 5 presents the conclusions of the survey. Appendix A includes tabulated data from the surveys, and Appendix B consists of a list of survey records resulting from this survey and maintained in the Building T064 D&D files.

2. BACKGROUND

2.1 LOCATION

Building T064 is located within Rockwell International's Santa Susana Field Laboratory (SSFL) in the Simi Hills of southeastern Ventura County, California, adjacent to the Los Angeles County line and approximately 29 miles northwest of downtown Los Angeles. A plan view of Building T064, formerly known as the "Source and Special Nuclear Material Storage Building," and its adjoining areas is shown in Figure 1. As indicated, T064 is totally fenced in with a chain-link fence. The area addressed in this report corresponds to about 6580 ft^2 of mostly asphaltic pavement and concrete dock surfaces, all inside the fence and entirely surrounding the building proper.

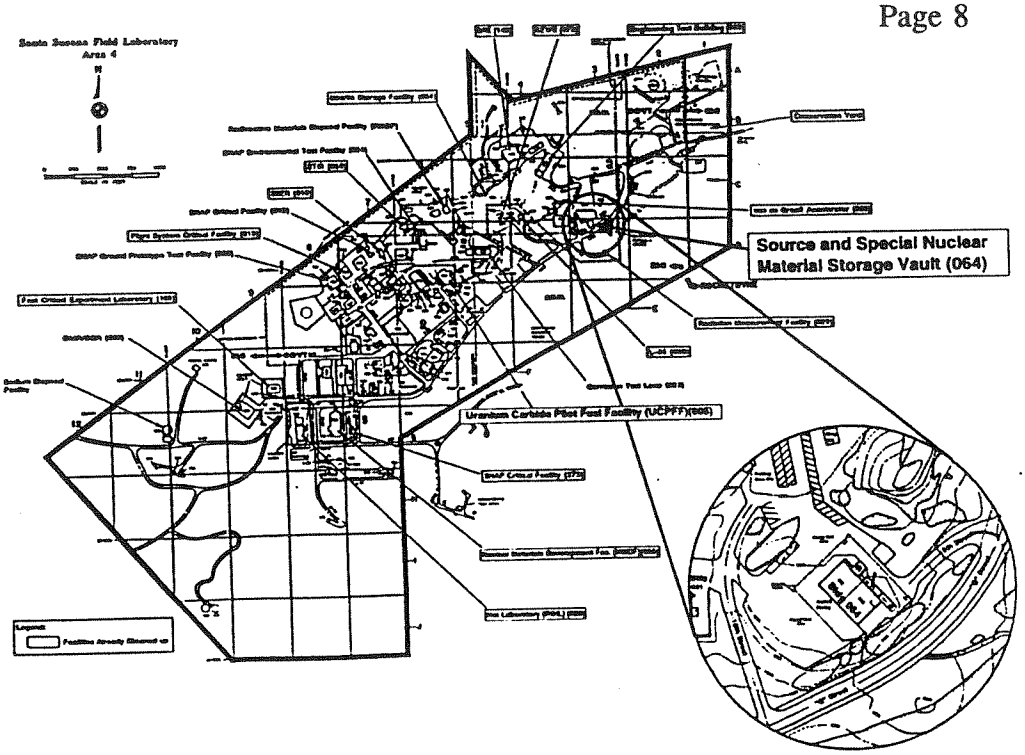
The formal reference to the location of Building T064 and the fenced-in yard, based on topographic maps of the U. S. Geological Survey (USGS), is Township T2N, Range R17W, Section 30, Calabasas Quadrangle. Figure 2 shows relevant portions of a 1967 edition of the USGS topographic map of the Calabasas Quadrangle where SSFL is located. A callout of the building location has been added.

Access to the fenced-in yard and the building is through two gates, one in the northeast corner, and the other in the southeast corner. These gates are also indicated in Figure 1.

Additional descriptions of the building, its surroundings, and topography, including both photographs and drawings, are provided in Refs. 2 and 3.

2.2 OPERATING HISTORY

Building T064 has been operated by Rockwell International and its predecessor companies since 1958 in support of the U.S. Department of Energy (DOE) and its predecessor agencies' nuclear programs. It was used actively through the mid-1970s for the storage of packaged items of Source Material (normal uranium, depleted uranium, and thorium) and Special Nuclear Material (enriched uranium, plutonium, and U-233).[2] The plutonium was temporarily stored in shipping containers prior to its shipment to its final destination. Since nuclear material was only stored there, there was no processing equipment within the building. Most of the major DOE nuclear projects have ended, and most of the material was sent to other DOE sites by 1980. Since then,



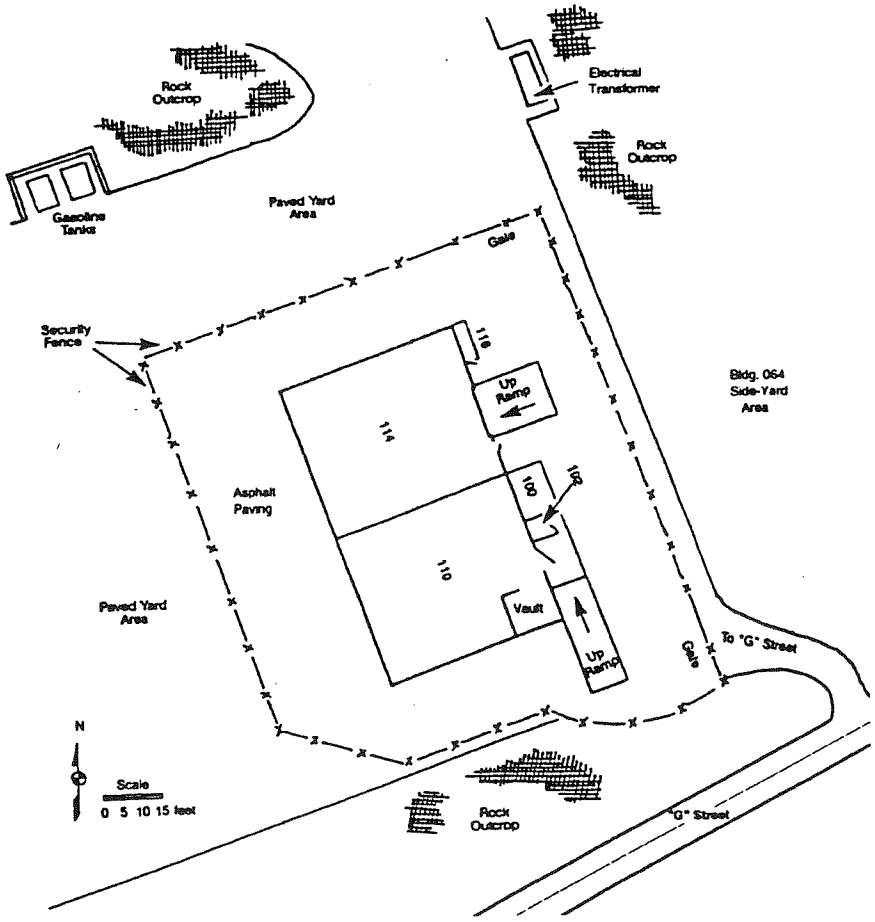


Figure 1. Source and Special Nuclear Material Storage Building, T064

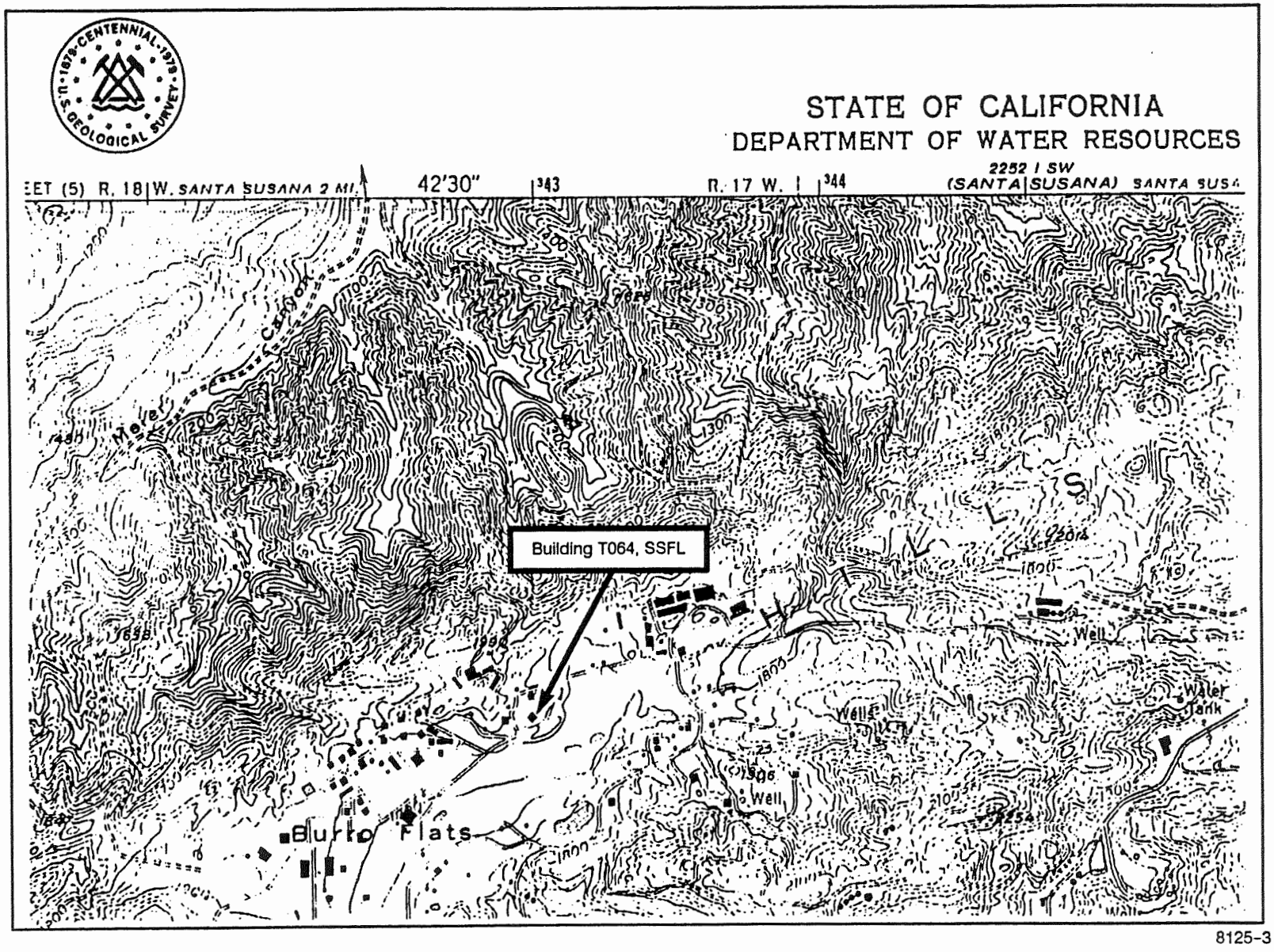


Figure 2. USGS Topographic Map of Portions of the Calabasas Quadrangle, with the SSFL in the Lower Left

the building has been used to store nonradioactive DOE components and supplies and low-level radioactive waste. The building was empty at the time of the 1992 fenced-in yard survey, with the exception of some limited uncontaminated debris and office furniture, and remains empty.

The fenced-in yard surrounding Building T064 was used on occasion for storing recoverable uranium scrap, irradiated fuel elements, and miscellaneous radioactive wastes. Spent fuel shipping casks and shipping trailers were also stored just outside the western fence line.

During the early 1960s a special lead-pig cask containing irradiated "Seawolf" fuel pins was stored in the east side of the fenced-in yard. The irradiated fuel pins had probably been transferred to the cask in a fuel storage pool at the site of their origin. Before shipping to the SSFL, the drain plug at the bottom of the cask should have been removed to drain the radioactive water, but was not. The shipping cask was stored in the fenced-in yard while still containing water. The drain plug eventually rusted out, and water leaked out to the yard surface. This water contained mixed fission products which contaminated the area. Following the identification of this leak in February 1963,[4] a large area (about 700 ft^2) of top soil was removed and transferred to the RMDF (Radioactive Materials Disposal Facility) for disposal. Radiation levels were then measured to range between 0.04 mrad/h (background) and 0.5 mrad/h, which was considered acceptable for the soil at that time. The yard was subsequently back-filled and repaved for continued use.

Additional details documenting this operating history are provided in Refs. 2 and 3.

2.3 RECENT RADIOLOGICAL SURVEYS AND REMEDIATION

A broad radiological survey plan was established in 1985 for all areas at the SSFL that were involved in operations with radioactive materials.[5] Building T064 and a surrounding 2-acre area were included in the survey plan, and a gamma activity survey was performed in 1988.

The results of the 1988 survey were used to identify a contaminated area of approximately 4000 ft^2, bordering and outside of the Building T064 eastern fence, as shown in Figure 3. Gamma exposure rates were measured to be higher than background in this area, and soil analysis for radionuclides showed ^{137}Cs concentrations higher than normal. Details are provided in Ref. 2. This broad-area survey did not identify any radiological contamination in the rest of the fenced-in yard.

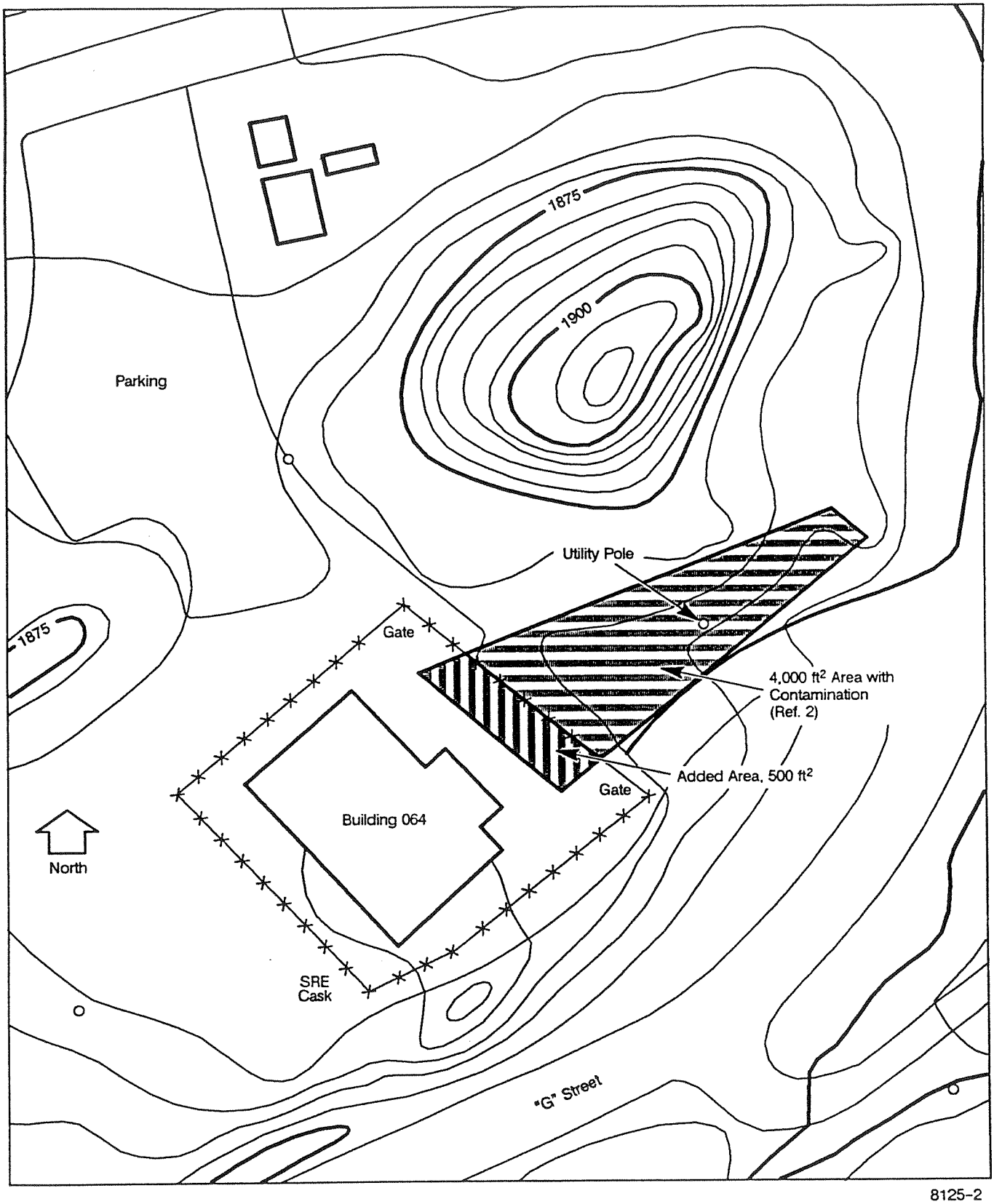


Figure 3. Building T064 Side Yard

The 1988 survey report recommended remedial action in the 4000-ft^2 area. Accordingly, in 1989, the top layer material was removed from contaminated sections of the 4000-ft^2 area plus an additional 500 ft^2 area inside and bordering the east fence, as shown in Figure 3. This 4500-ft^2 area is designated the Building T064 Side Yard. Figure 4 is a detailed drawing depicting these areas and locations from which subsequent radiological measurements were obtained. The remedial efforts and results of the subsequent radiological survey are documented in the 1990 report.(3)

Based on results from both of these surveys, and favorable comparisons with acceptance limits established by DOE Orders, guides, and other regulatory agencies, the 1990 report concluded that the area identified as the Side Yard was suitable for release for unrestricted use.

2.4 THE 1992 ASSESSMENT SURVEY

The 1992 survey of the entire fenced-in yard, documented in this report, was performed as a more detailed and updated radiological assessment of that area. No radiologically significant activities have occurred in the assessed area to suspect any re-contamination since the previous surveys. Therefore, no new remedial actions were undertaken nor were new findings of significance anticipated. However, the building proper is undergoing remediation, including the removal between the 1988 and 1992 surveys of stored boxes of contaminated soil from several SSFL remediation operations. Some slightly contaminated building components were removed from the building interior following the 1992 survey, but they provided no opportunity for yard contamination because they were first packaged inside the building. All of these items were identified as part of the 1988 survey.

During the present assessment survey, new grid locations were established in the fenced-in yard. Measurements were made on these grid surfaces for fixed alpha and beta radioactivity, and for gamma exposure rates at 1-m elevations from the surface. Asphalt samples (or soil, as applicable) were collected from selected grid locations for analysis of radioactivity concentrations.

The procedures used in obtaining the above data were similar to those used previously. They are summarized in Section 3.

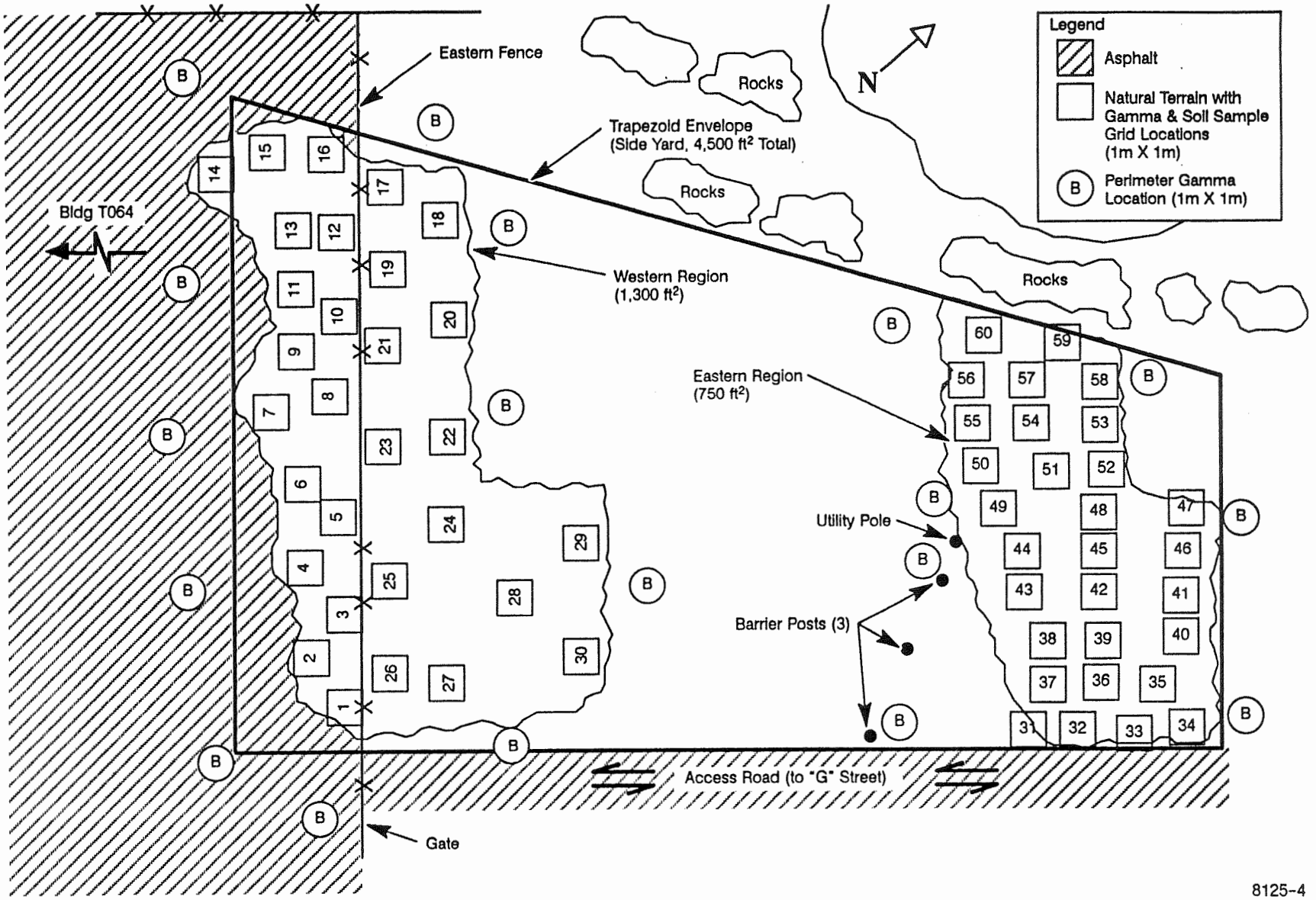


Figure 4. Building T064 Side Yard Decontamination and Survey Grid Locations

3. PROCEDURES

The survey area covered the entire 6580-ft^2 area of the fenced-in yard, following established procedures.[6] The survey grids, procedures, instrument calibration and checkouts, and data reduction and analyses are described below.

3.1 SURVEY GRID

A 3-m x 3-m grid pattern was established within the survey area, as shown in Figure 5. Measurements were made within the grid blocks to obtain alpha, beta, and gamma activity data. Asphalt and soil samples were subsequently collected from selected grid block locations for laboratory analyses of radioactivity. The grids covered mostly the asphaltic pavement, but also included concrete loading docks and a ramp, and soil surfaces from which the original asphalt had been removed by previous remediation activities, weathering, and erosion.

3.2 SURVEY PROCEDURES

3.2.1 Alpha and Beta Activity Measurements

Average alpha and beta surface activities were measured in a 1-m^2 area within each of the 9-m^2 grid blocks shown in Figure 5. As specified in DOE regulations,[7] this 1-m^2 area is the maximum area over which average measurements are to be made. The location of the 1-m^2 area within each grid block was left to the surveyor's judgment: it was to be selected as the area within the block most likely to have residual contamination. Such a selection procedure was expected to produce survey results biased toward the high end of the activity distribution over the survey area.

In order to facilitate the survey, the alpha and beta detectors were mounted on separate portable carts with the detector probe faces adjacent to the ground. Each selected square-meter survey area was scanned for alpha and beta activity, by moving each cart over the area for five minutes with a prescribed speed and survey pattern. These scans provided average 5-minute alpha and beta activity measurements over the 1-m^2 area. The detector, detector probe, date, and number of counts were recorded by location for each scan.

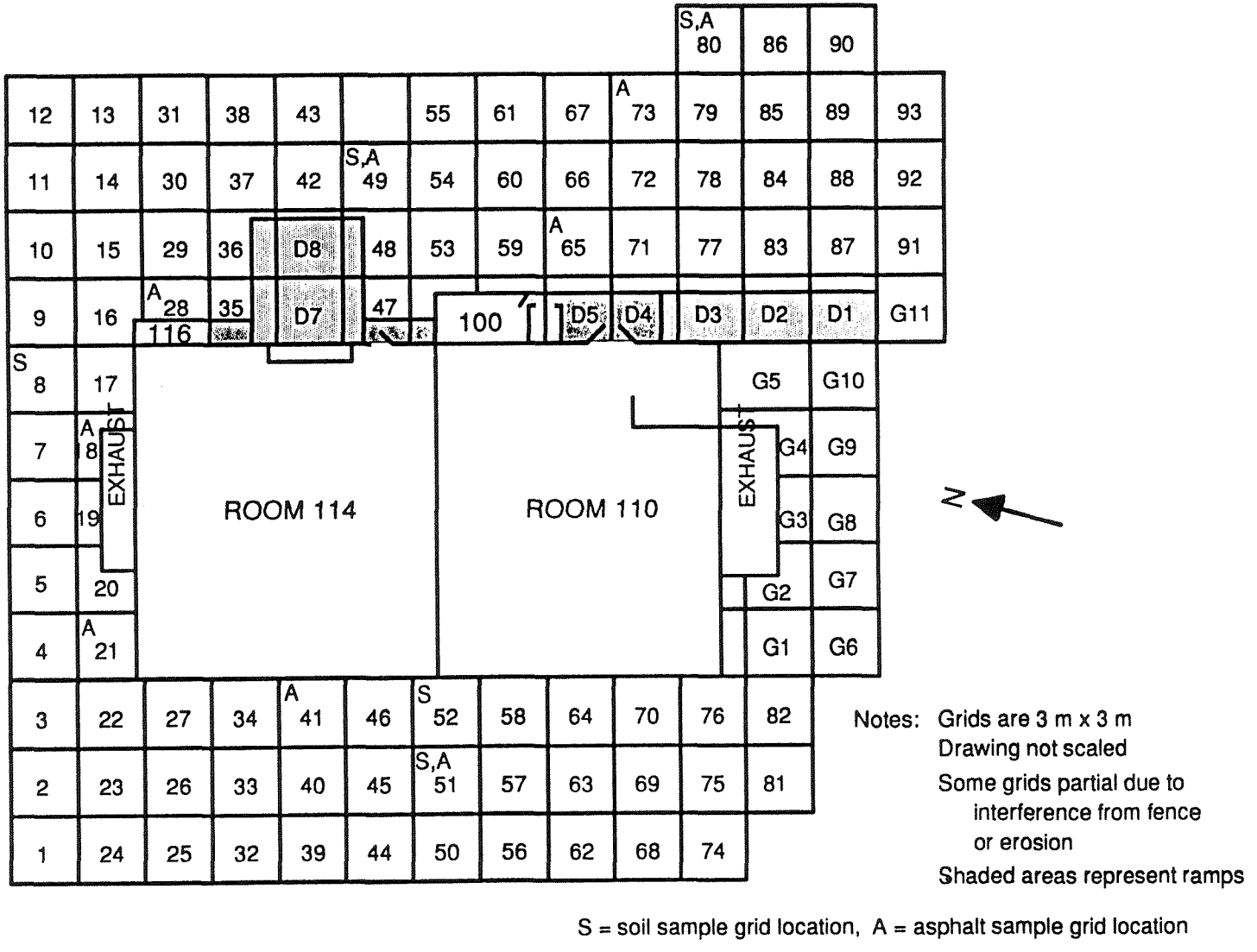


Figure 5. Fenced-In Yard Survey Grid Locations

The DOE regulations[7] also define limits for maximum allowable alpha and beta contamination, as described in Ref. 2. If a contamination spot is detected during the 5-minute scan for average activity, the surveyor typically performs an additional 5-minute stationary scan at that spot to check compliance with the regulatory limits, using the same equipment setup. In the present case, no such spots were detected.

3.2.2 Ambient Gamma Exposure Rate Measurements

A gamma exposure rate measurement was made 1 m from the surface in each of the 9-m^2 grid blocks shown in Figure 5. The particular location within the grid was chosen randomly. A tripod was used to support the gamma probe at the 1-m height. A 1-minute count was made at each location.

3.2.3 Surface Samples for Laboratory Analysis

Previous radiological survey procedures required that the surveyor obtain soil samples only if a gamma exposure rate measurement indicated radioactive contamination. Under such conditions, samples would be collected from that spot for analyses of gross alpha and beta activities using a 2-g sample, and for gamma spectrometry with a 450-ml sample. During the present survey, no such spots were indicated. However, for added conservatism, surface samples were collected for gamma spectrometry.

Samples of surface materials, collected to a depth of about 3 in. and weighing about 2 lb. each, were taken from 14 locations, as indicated in Figure 5. Most of the area is paved with asphalt, and 7 of these samples consisted of asphalt, 5 of soil, and two of a rock/soil mixture. Sample locations were identified and marked on the sample bags. The samples were crushed to smaller pieces as necessary and transferred to 450-ml Marinelli beakers for counting by gamma spectrometry. The samples were dry and thus were not subjected to the drying process usually required before spectrometry measurements.

3.3 INSTRUMENTS AND CALIBRATION

In general, the instruments used for this survey were the same as those used in previous surveys of this and other SSFL facilities. The instruments and the procedures used for their calibration are described in detail in previous survey reports (e.g., Ref. 2), and are summarized below.

3.3.1 Alpha and Beta Activity Measurements

Alpha contamination measurements were made using a Ludlum Model 43-1 alpha probe attached to a Ludlum Model 2220-ESG portable scaler. This large-diameter (9.5 cm) probe is sensitive only to alpha particles with energies exceeding about 1.5 MeV. The detector was calibrated using a ^{230}Th alpha source. The energy of ^{230}Th alpha particles (4.6 MeV) is similar to those of the isotopes handled in Building T064: ^{235}U, ^{234}U, and ^{238}U. A calibration check was performed three times daily using a ^{230}Th "check-source," and the background response of the detector was measured at the same time. The background measurements were made for both 1-minute and 5-minute counting periods, as specified in the instrument qualification report forms. The check-source response provided a measure of instrument stability during the survey period, and the daily average of the background response measurements was subtracted from the field measurements to obtain net alpha counts at the grid points.

The beta measurements were made using a Ludlum Model 44-9 beta probe attached to a Ludlum Model 2221-ESG portable scaler. The probe is a thin-window pancake Geiger-Müller tube. This detector is sensitive to both alpha and beta particles and is slightly sensitive to x rays and gamma rays, but is generally called a "beta detector" because it is used predominantly to measure beta activities. The detector was calibrated against a ^{99}Tc beta source. The energy of the ^{99}Tc beta particles (maximum 0.3 MeV) is close to those emitted by uranium daughter products. Use of this source for calibration will cause a slight overestimate of old mixed fission product activity. The measurements were made over the same areas used for the alpha surface activity measurements. Calibration checks and background measurements were obtained for the beta surveys in the same manner as for the alpha surveys.

3.3.2 Ambient Gamma Exposure Rate Measurements

The ambient gamma exposure rate measurements were made using a 1" x 1" NaI(Tl) scintillation crystal coupled to a photomultiplier tube, with pulse counting by a Ludlum Model 2220-ESG scaler. This detector assembly was mounted on a tripod such that the NaI(Tl) gamma detection volume was 1 meter from the yard surface. The detector is sensitive to nearly all directions (i.e., 4π geometry). The average "statistically significant activity" (SSA) detection limit (defined in Section 3.4.1 and discussed in Section 4.3) measured for this instrument during the survey period was 1.7 μR/h, which is well below the 5-μR/h acceptance limit adopted for this facility (Section 3.4.2).

The expression of the gamma counting results in units of μR/h for comparison to regulatory limits required a conversion from detector counts per minute (cpm) to exposure rate (μR/h). A conversion factor of 215 cpm = 1 μR/h was established for this detector by comparison with a Reuter Stokes High Pressure Ion Chamber. The instrument response is adjusted quarterly using a ^{137}Cs calibration source in the mR/h range. This instrument response was also checked three times daily during the survey using a ^{40}K check-source. The background detector response was also measured three times daily, for 1-minute and 5-minute counting periods.

3.3.3 Gamma Spectrometry of Soil Samples

Each 450-ml soil sample was placed in a Marinelli beaker and counted on a Canberra Industries, Inc. Series 80 Multichannel Analyzer (MCA). The MCA is an energy-sensitive spectrometer whose results can be used to determine the presence and quantities of specific radionuclides, including (but not limited to) ^{238}U, ^{235}U, ^{232}Th, ^{40}K and the characteristic fission and activation products ^{137}Cs, ^{60}Co, and ^{152}Eu. The spectrometer is calibrated routinely for both energy definition and counting efficiency. This calibration was performed using a Marinelli Beaker Standard Source and procedures described in the Canberra Operator's Manual, and encompassed a wide energy range.

A detailed description of the MCA is given in Appendix A of Ref. 2, and the calibration procedures are documented in Ref. 8.

3.4 DATA REDUCTION AND ANALYSES

3.4.1 Data Reduction

Procedures used for the reduction of raw data obtained from the survey are essentially the same as those used in previous surveys. They are summarized below for completeness.

The detector data obtained from the alpha and beta contamination surveys are total detector counts recorded over a 5-minute period at each location. Each total count was converted to a total count rate (counts per minute or cpm), by dividing it by the counting time for each measurement. The net (background-corrected) cpm was then obtained by subtracting the daily average background cpm derived from the corresponding background measurements. The net cpm was converted to disintegrations per minute (dpm) by multiplying it by an efficiency factor

for the detector. Finally, the dpm was converted to dpm/100 cm^2 by multiplying it by the ratio of 100 cm^2 to the area of the detector probe (71 cm^2 for the alpha probe and 20 cm^2 for the beta probe). The quantity dpm/100 cm^2, determined for each grid location, is the conventional unit of measure for total average alpha and beta contamination. The efficiency factors used to convert the alpha and beta activity data to dpm/100 cm^2 for the individual measurements are included in the spreadsheet calculations appended to this report (Appendix A). They were typically about 7 dpm/cpm for the alpha probes and 8 dpm/cpm for the beta probes.

The raw data for the 1-minute gamma survey measurements were recorded as ambient gamma exposure counts. These total counts were converted to total exposure rates in μR/h using the calibration-derived relationship 215 cpm = 1 μR/h. The net (background-subtracted) gamma exposure rates were then obtained by subtracting a 15.3-μR/h background from the ambient values. This 15.3-μR/h background value was previously established as a best estimate for the SSFL, as documented in Ref. 2. Separate calculations were also performed to derive net gamma exposure rates using the background measurements performed in conjunction with the survey. In that case a net exposure count rate was determined for each location by subtracting the average background count rate for the day of the measurement from the total count rate. This net count rate was then converted to a net exposure rate by dividing by 215.

Specific concentrations of radionuclides in the asphalt/soil samples were converted from MCA counts to pCi/g following procedures outlined in Ref. 2.

One of the statistical tests employed to determine whether activity measurements indicate the presence of contamination or are part of the natural background distribution is a detection limit test known as "statistically significant activity" (SSA). This test compares the net (background-subtracted) activity with the SSA limit, which is defined mathematically as follows:[9]

$$SSA = \frac{1.645\sqrt{2}\,\sigma_B}{T} .$$

Here σ_B is the standard deviation of the background count, T is the count time (in minutes), and the factor 1.645 is the normal deviate corresponding to the one-sided 95% confidence level. The parameter SSA is then expressed in cpm units. A conservative (lower-limit) estimate of the SSA can be obtained from a single background measurement by approximating σ_B with $\sqrt{B}$, where B is the number of background counts. If the net measured activity is greater than the SSA, that

measurement is greater than 95% of the expected distribution of background measurements. The SSA thus provides guidance for judging whether a given measurement is background or background plus a contaminant.

The SSA also provides a measure of the counting instrument response in the presence of background, and can be used to judge the suitability of the instrument for a given application. For example, the instrument's SSA must be well below the regulatory acceptance limit for facility release in order for the instrument to be an appropriate selection for final survey measurements.

3.4.2 Comparison with Regulatory Limits

The data in each measurement category (alpha, beta, gamma, and soil radioactivity) were examined separately to determine whether any of the measured values exceeded regulatory acceptance limits. These limits, as adopted for this work, are summarized in Table 1 and discussed individually below.

Table 1. Regulatory Acceptance Limits Adopted for this Work

Parameter	Acceptance Limit	Reference
Total average alpha activity	5000 dpm/100 cm^2 above background	10
Total average beta activity	5000 dpm/100 cm^2 above background	10
Gamma exposure rate (at 1 m from surface)	5 µR/h above background	11, 3
Soil activity concentration	3.2 pCi/g each for ^{137}Cs and ^{90}Sr (for residential use, including drinking water from wells)	12

The alpha and beta limits are taken from DOE Order 5400.5.[10] This guideline specifies allowable average total residual surface contamination limits of 5000 dpm/cm^2 each for (a) ^{nat}U, ^{235}U, ^{238}U, and associated decay products and alpha emitters, and (b) mixed fission product beta-gamma emitters.

For the gamma exposure rate, DOE guidelines[7,10] recommend a limit of 20 μR/h above background, based originally on facility screening applications. In contrast, the NRC Dismantling Order for the decommissioning of the Rockwell L-85 reactor required a limit of 5 μR/h above background.[11] For conservatism, Rocketdyne adopted the NRC 5 μR/h above-background limit for this and previous[3] survey applications. Note that this limit is an increase of only about 1/3 over the average background value (15.3 μR/h) for the SSFL site.

Generic limits are generally not available for radionuclide concentrations in soil, and a pathway analysis calculation is required to set limits on a site- and nuclide-specific basis. A pathway analysis was performed for the present work using the computer code RESRAD,[12] as used previously for the Building T064 side yard and described in some detail in that report.[3] For the present case, a residential land use scenario was assumed, with a radionuclide contamination area defined as the area of the fenced-in yard plus Building T064, and extending to a depth of 1 meter. The assumption of an infinite contamination depth produced no change in the results. The analysis was used to calculate allowed ^{137}Cs and ^{90}Sr single-radionuclide concentration limits for which the annual effective dose equivalent received by a plausible future user of the site would not exceed 10 mrem. The 10 mrem/y limit was adopted as an achievable goal and is lower than the DOE guideline of 100 mrem/y.[10]

The soil guideline is not a spot limit, but provides guidance for cleanup and serves as a basis for calculating the allowable maximum ("hot spot") contamination. The allowable hot spot contamination, in areas smaller than 25 m^2, is calculated as $\sqrt{100/A}*G$, where A is the hot spot area in m^2 and G is the guideline value. This adjusted guideline should not exceed 30*G.

The results of the RESRAD analysis gave single-radionuclide limits of 3.24 pCi/g for ^{137}Cs and 362 pCi/g for ^{90}Sr. If it is assumed that equal concentrations of these two radionuclides are present, the concentration limit for each radionuclide is 3.2 pCi/g in order to meet the 10 mrem/y limit. This value was adopted for the present work.

The survey data were analyzed statistically by methods used previously in final release surveys.[3] Cumulative probability plots were generated and a test statistic (TS) was obtained and compared with the above acceptance limit for each radiological parameter. The probability plot provides a comparison between the data distribution and a normal (Gaussian) distribution whose parameters are derived from the data. Overlaying the data with the normal distribution (represented by a straight, solid line on the plot) readily identifies "outlier" data values.

The test statistic is defined as follows:

$$TS = \bar{x} + ks,$$

where $\bar{x}$ is the mean of the measurement distribution and s is the estimated standard deviation. The value of k is determined from the sample size and two other statistical sampling coefficients that are related to the risk of accepting a lot, given that a fraction of the lot has rejectable items in it. The values chosen for these coefficients for the present survey correspond to assuring, with 90% confidence, that 90% of the area has residual contamination below 100% of the applicable limit (i.e., a 90/90/100 test). The test statistic typically corresponds to a cumulative probability of about 93%, depending upon the number of data points. This value is indicated on the cumulative probability plot as a dashed vertical line. For a survey data set to be accepted, the normal distribution (solid) line on the plot must pass below the intersection of the test statistic probability line and a horizontal line representing the acceptance limit for the measurements.

Results from this survey are presented and discussed in the next section. Detailed data generated using spreadsheet calculations are included in Appendix A. A list of survey records is included in Appendix B.

4. RESULTS AND DISCUSSION

The results of the Building T064 fenced-in yard assessment survey are summarized in Table 2. In general, the survey data show that residual radioactivity in the fenced-in yard corresponds to background levels. The data and their analysis are discussed in more detail below.

4.1 ALPHA ACTIVITY

Total alpha activities were measured in 101 grid locations, averaged over a 1-m^2 surface area at each location. Based on these measurements, the average measured activity was determined to be 3.4 ± 12.0 dpm/100 cm^2 above the 30.3 ± 12.3 dpm/100 cm^2 background, with a maximum of 51 dpm/100 cm^2. These values are negligible in comparison with the 5000-dpm/100 cm^2 acceptance limit.

Comparisons between the individual background-subtracted activity measurements and the daily SSA values, calculated conservatively as the square root of the daily average of the background measurements, indicate that 7 of the 101 measurements are above the SSA limit (Appendix A). Three of those measurements are above the 28.6 dpm/100 cm^2 average SSA calculated from the standard deviation of the full set of 5-minute background counts. The average SSA is significantly higher than the daily values, as it accounts for several other measurement variability factors (instrument drift, etc.) besides $\sqrt{B}$ counting statistics. Even this average SSA may be conservative, as the alpha and beta background counts were made at a single outdoor location. The SSA limits and all of the alpha activity measurements are two orders of magnitude below the acceptance limit, and one can conclude that the alpha detector is appropriate for these measurements and that the fenced-in yard is acceptably clean of alpha activity.

A cumulative probability plot for the total background-corrected alpha activity data is shown in Figure 6, where the vertical scale was chosen to include the 5000-dpm/100 cm^2 acceptance limit. All of the data and the test statistic corresponding to their distribution (TS = 21.0 dpm/100 cm^2) are shown graphically to have negligible values relative to this limit.

Figure 7 replots the same data with an expanded vertical (activity) axis to show the distribution in more detail. This figure shows that the data are consistent with a normal distribution with the exception of three to six outlier data points, all of which were flagged by the SSA comparisons. The highest four data points (and five of the highest six) are from locations on the Building T064

Table 2. Summary of Data from the Building T064 Fenced-In Yard Assessment Survey

Measurement (Units)	Number of Measurements[a]	Average	Standard Deviation	Minimum	Maximum	Test Statistic	Acceptance Limit
Total Average Alpha Activity ($dpm/100\ cm^2$)	101	3.4	12.0	-19.8	51	21.0	5000
Total Average Beta Activity ($dpm/100\ cm^2$)	112	239	328	-655	1209	717	5000
Gamma Exposure Rate above Background (μR/h) @ 1 m Above Surface							
(1) for 15.3-μR/h average SSFL background	112	-1.11	1.11	-4.74	3.47	0.50	5.00
(2) for daily background measurements[b]	112	1.17	1.23	-2.51	4.56	2.96	5.00
Soil Radionuclide Concentration (pCi/g)							
^{40}K	14	19.3	2.2	22.3	14.3	23.4	---
^{137}Cs	14	0.41	0.83	0.02	3.12	1.96	3.2
^{235}U	14	0.04	0.02	0.02	0.07	0.07	0.27

[a] See Appendix A for individual measurements and corresponding survey locations
[b] See background discussion in text (Section 4.3)

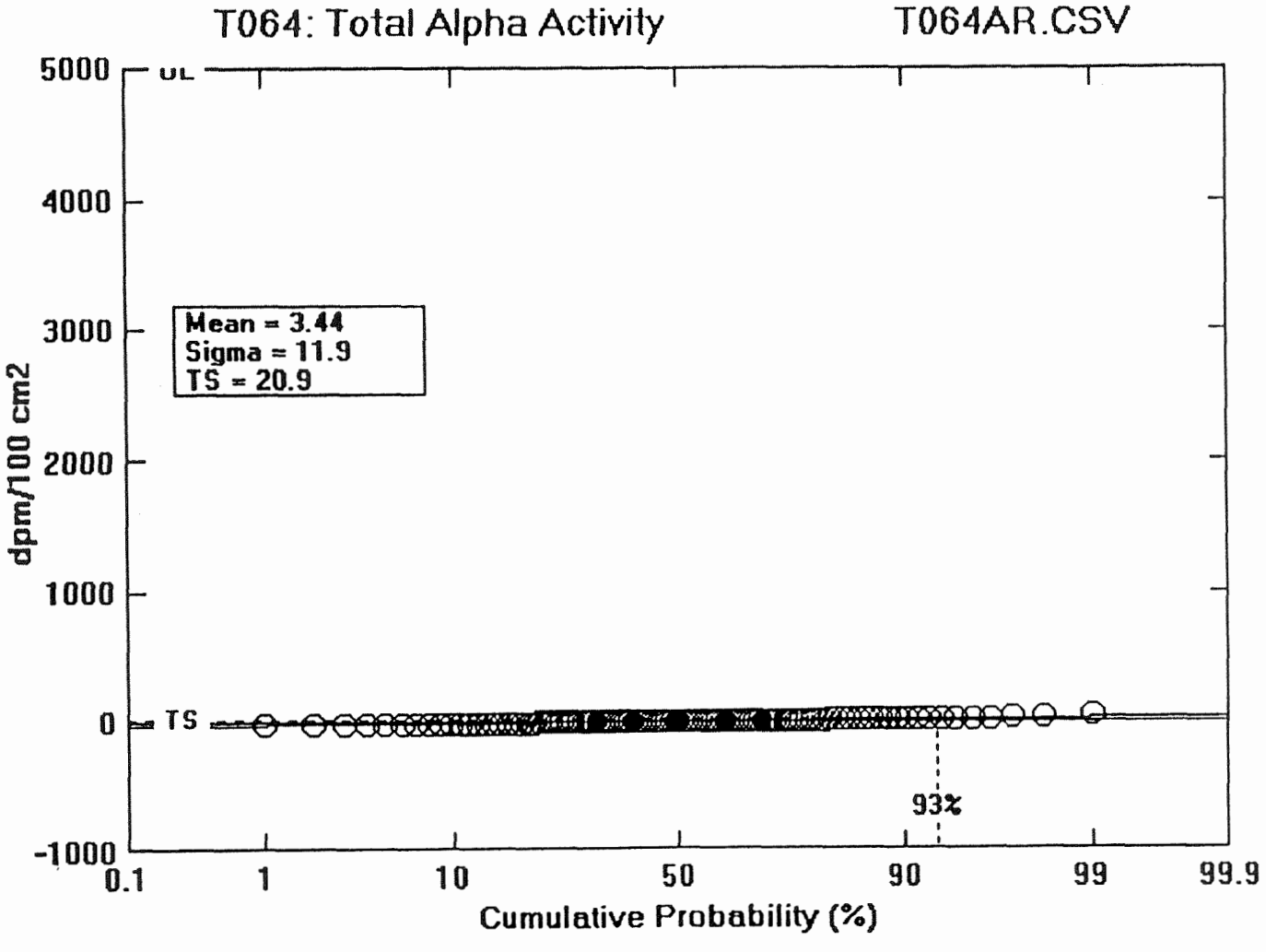


Figure 6. **Cumulative Probability Plot of Total Background-Corrected Alpha Activity Measurements in the Fenced-In Yard, with the Acceptance Limit as Maximum Ordinate**

ramp. Chapman observed similar outliers correlated with cement ramp locations during his 1988 survey of the building interior.[2] He attributed that increased activity to the possibility of naturally-occurring radionuclides in the concrete used for the ramps. The present data show that, with the exception of one grid location on the ramp (Location D7; see Appendix A), the alpha activities measured at the ramps are all slightly above the average, consistent with Chapman's observations.

4.2 BETA ACTIVITY

Total beta activities were measured in 112 locations. They were also averaged over a 1-m^2 surface area at each location, where the 1-m^2 area was generally the same as that used for the alpha measurements. The average background-subtracted beta activity was found to be 239 ± 328 dpm/100 cm^2, with a maximum of 1209 dpm/cm^2. All values were well below the 5000-dpm/cm^2 acceptance limit, indicating that the fenced-in yard is acceptably clean of beta activity.

Comparisons were also made between the individual background-subtracted beta activity measurements and the daily SSA values, the latter calculated as the square root of the daily average of the background measurements. The results indicate that 41 (37%) of the 112 measurements are above this conservative SSA limit (Appendix A), although significantly below the acceptance limit. A separate analysis of the background measurements taken during the survey (at a single location) gave an average background that is equivalent to a beta activity of 3336 ± 362 dpm/100 cm^2, and an average SSA of 842 dpm/100 cm^2 (above background). Only four values exceed this SSA limit. This average SSA is also well below the acceptance limit, validating the acceptability of the beta detector for these measurements.

A cumulative probability plot for the background-corrected beta activity data is shown in Figure 8, with the vertical scale chosen to include the 5000-dpm/cm^2 acceptance limit as the upper boundary. All of the data and the calculated test statistic (TS = 717 dpm/100 cm^2) are shown graphically to be well below this limit. The data are replotted in Figure 9 with an expanded vertical axis. These data behave as a normal distribution, with the exception of two to five outliers. These outliers, which were also flagged by comparisons with the average SSA limit, do not correspond to any specific type of location, in contrast to observations for the outlier alpha activities.

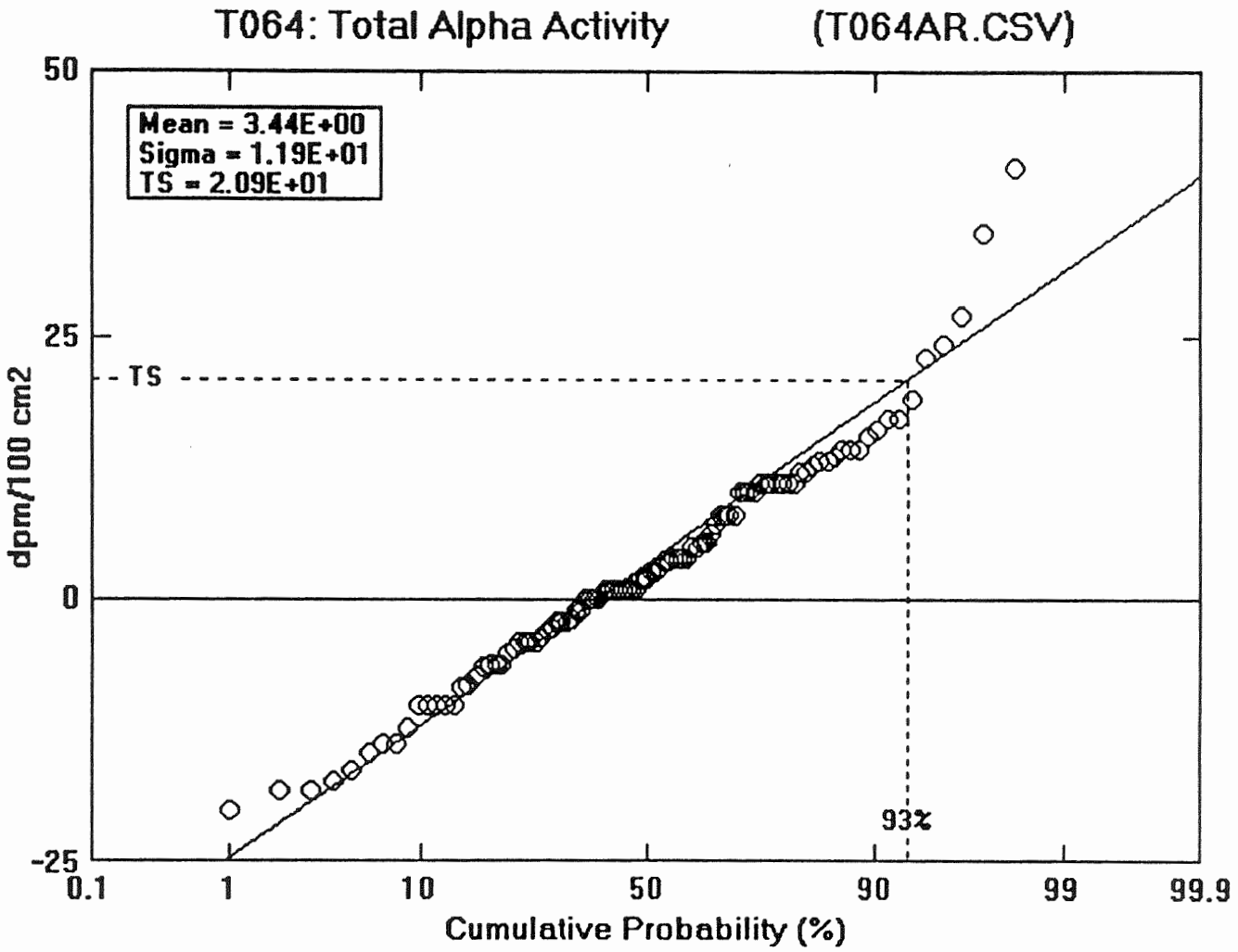


Figure 7. **Cumulative Probability Plot of Total Background-Corrected Alpha Activity Measurements in the Fenced-In Yard, with Expanded Ordinate Scale**

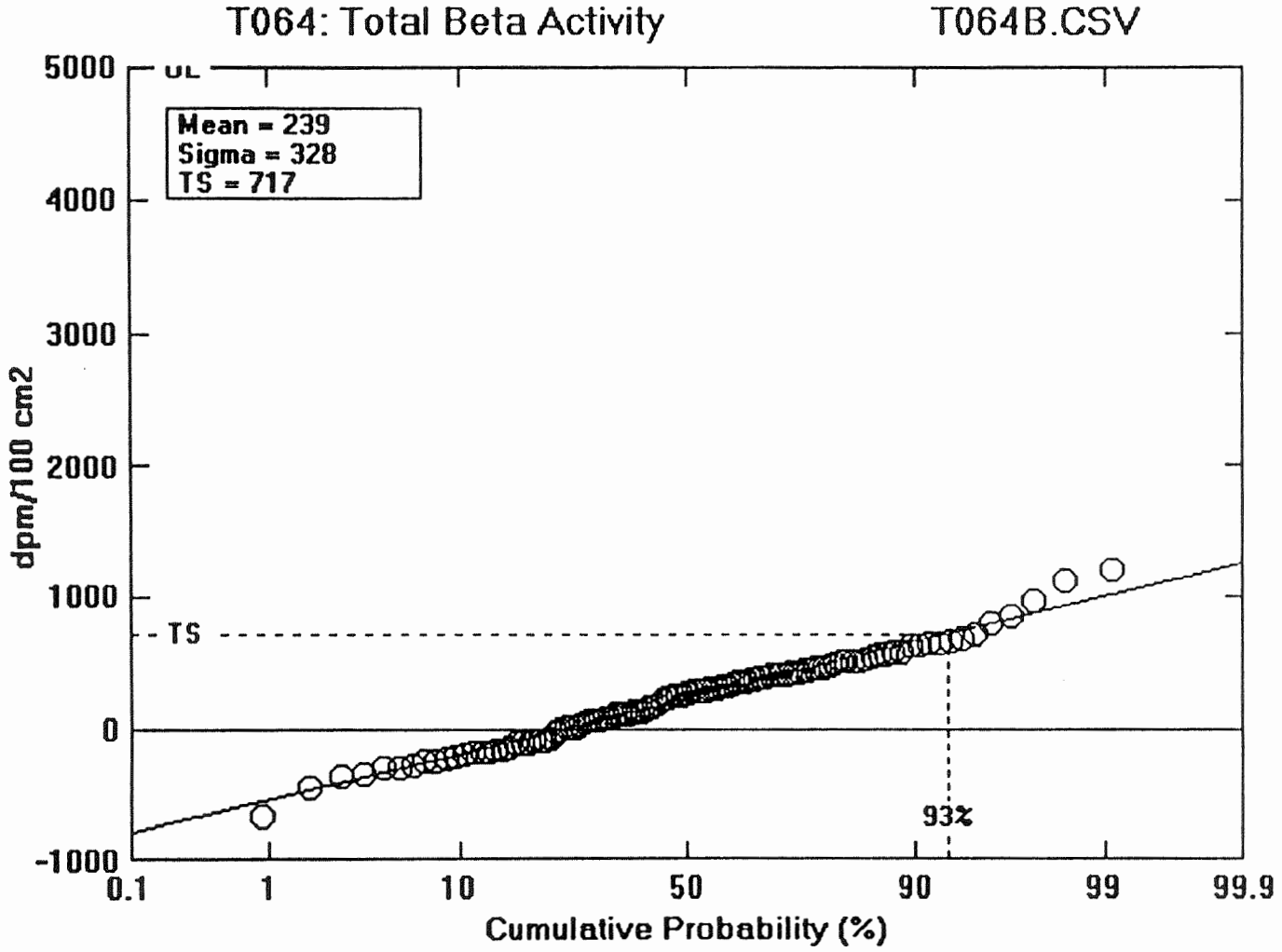


Figure 8. **Cumulative Probability Plot of Total Background-Corrected Beta Activity Measurements in the Fenced-In Yard, with the Acceptance Limit as Maximum Ordinate**

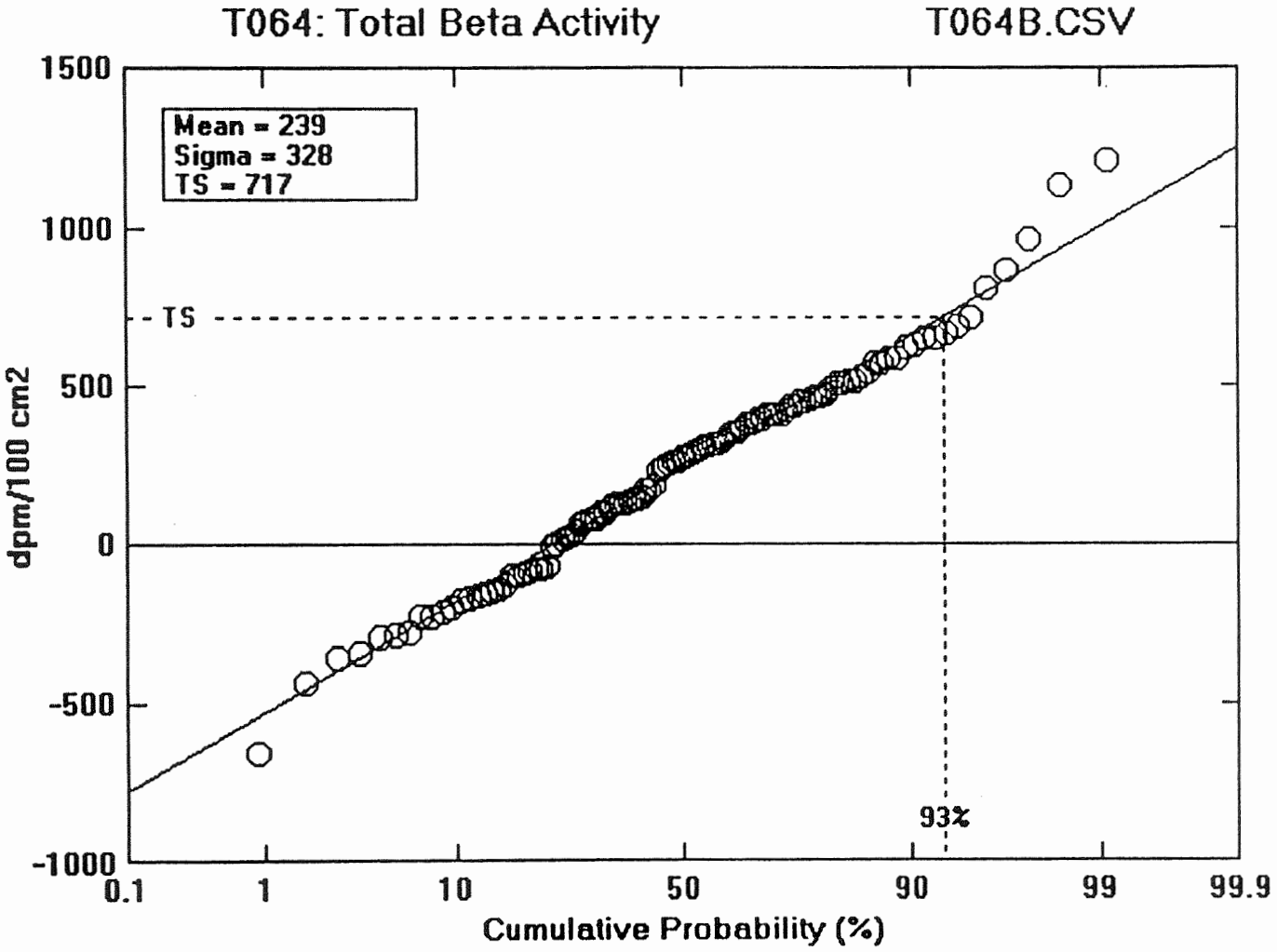


Figure 9. **Cumulative Probability Plot of Total Background-Corrected Beta Activity Measurements in the Fenced-In Yard, with Expanded Ordinate Scale**

4.3 GAMMA EXPOSURE RATES

Gamma exposure rate data were obtained from 112 locations. The background-corrected exposure rate at each location was determined by calculating the total exposure rate and then subtracting an average background value of 15.3 μR/h. This provided an average net exposure rate of -1.11 ± 1.11 μR/h and a maximum value of 3.47 μR/h. The corresponding cumulative probability plot is shown in Figure 10, and includes a calculated test statistic of TS = 0.50 μR/h. The exposure rate values and the test statistic are all below the 5 μR/h acceptance limit.

The 15.3-μR/h background used for these calculations was based on an average of previous measurements made at three different SSFL locations.[2,13] Such background measurements have shown a wide variation in exposure rate, depending upon location. For example, Chapman[2,13] noted during his 1988 survey that the background values measured in the Building 309 Area had a range of 3.4 μR/h, which approaches the adopted NRC limit of 5 μR/h. Because of this observed variability, the Building T064 Side Yard survey[3] established a background based on data from a portion of the surrounding 2-acre area that most closely matched the survey area physically and topographically. That background value (15.5 ± 0.8 μR/h) is consistent with the 15.3-μR/h value used here.

The present survey included three-times-daily background gamma measurements that were performed as instrument checks. Those measurements were all performed at a single location outside of, but in the vicinity of, the fenced-in yard that was known to be free of contamination. The analysis of those measurements gave an average background value of 12.8 ± 0.7 μR/h and an average SSA value of 1.7 μR/h. This background value is significantly lower than (but within the variation of) the established area average, which may be due to the use of a single, lower-activity counting location. SSA comparisons based on these lower-background measurements indicated that 80 (71%) of the activity measurements exceeded the daily SSA values and 37 (33%) exceeded the average SSA. One conclusion that could be made based on the average SSA is that the gamma detector performance is acceptable for this survey. An average net gamma exposure rate was also calculated using these background data, by subtracting the daily background readings from the individual survey measurements before converting to exposure rates. This yielded an average net exposure rate of 1.17 ± 1.23 μR/h. The individual net exposure rates are shown as a cumulative probability plot in Figure 11. Although the net calculated exposure rates are higher using these background data, they are all below the 5-μR/h acceptance limit.

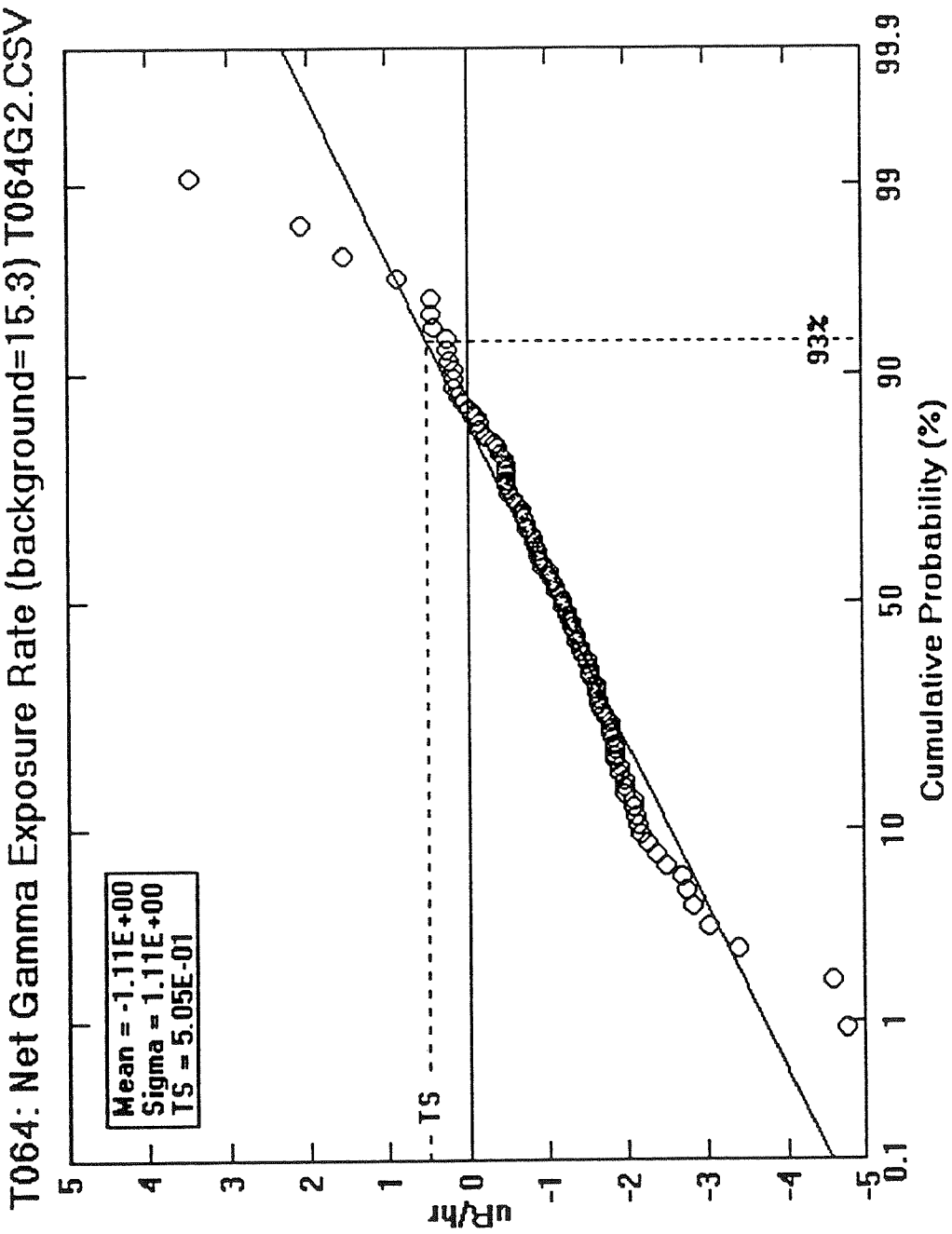


Figure 10. Cumulative Probability Plot of Background-Subtracted Gamma Exposure Rates in the Fenced-In Yard, for Background = 15.3 µR/h

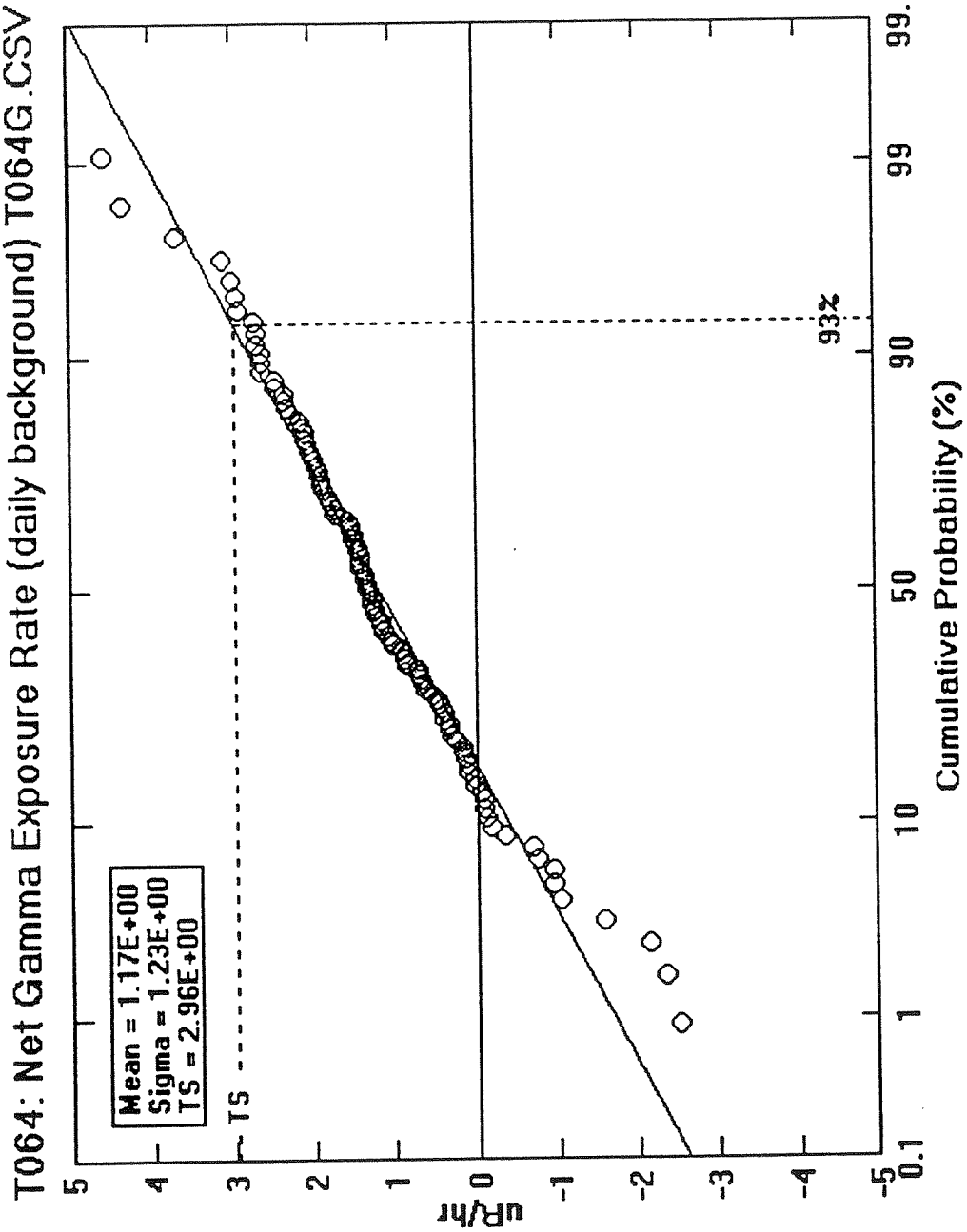


Figure 11. Cumulative Probability Plot of Background-Subtracted Gamma Exposure Rates in the Fenced-In Yard, Using Daily Background Measurements

The net exposure rates calculated using the adopted 15.3-μR/h average facility background were examined in more detail to look for possible trends. The probability plot in Figure 10 shows three outlier exposure values, at grid locations 17, 18, and G11 (see Figure 5). Two of the locations (17 and 18) were near a slightly contaminated building filter plenum[2] that was packaged and removed since the survey. The third location (G11) is in the vicinity of a rain gutter that may have accumulated some fallout material that settled on the building roof and was washed down by precipitation. All three values are below acceptance limits and no further action is warranted.

Comparisons between the other gamma activity measurements and previous site survey measurements[2] show that the present data are consistent with previous results.

4.4 RESIDUAL RADIOACTIVITY IN SOIL/ASPHALT

The fourteen soil and asphalt samples were analyzed for 18 specific radionuclides by gamma spectrometry. The net activity measurements for those radionuclides were consistent with natural background activities with the exception of a few slightly elevated ^{137}Cs activities. The average measured ^{137}Cs activity was 0.41 ± 0.83 pCi/g, and all values were below the adopted 3.2 pCi/g acceptance limit.

The radiological activity measurements for the three radionuclides ^{40}K, ^{137}Cs, and ^{235}U are summarized in Appendix A and plotted in Figure 12. ^{40}K was the only significant activity measured (19.3 ± 2.2 pCi/g), and that activity is due to natural potassium in the soil. Figure 13 replots the ^{137}Cs and ^{235}U results with an expanded activity scale and provides a comparison with the ^{137}Cs acceptance criterion. This figure shows graphically that the soil activity concentration criterion is met for all ^{137}Cs measurements.

Cumulative probability plots for the ^{40}K, ^{137}Cs, and ^{235}U data are shown in Figures 14, 15, and 16, respectively. These plots indicate that the ^{40}K and ^{235}U (0.04 ± 0.02 pCi/g) activities generally follow normal probability distributions, as expected from naturally distributed radionuclides. The ^{137}Cs probability distribution flags as outliers the three elevated data points in Figure 13, but these values and the test statistic calculated for the distribution (1.96 pCi/g) meet the adopted acceptance criterion.

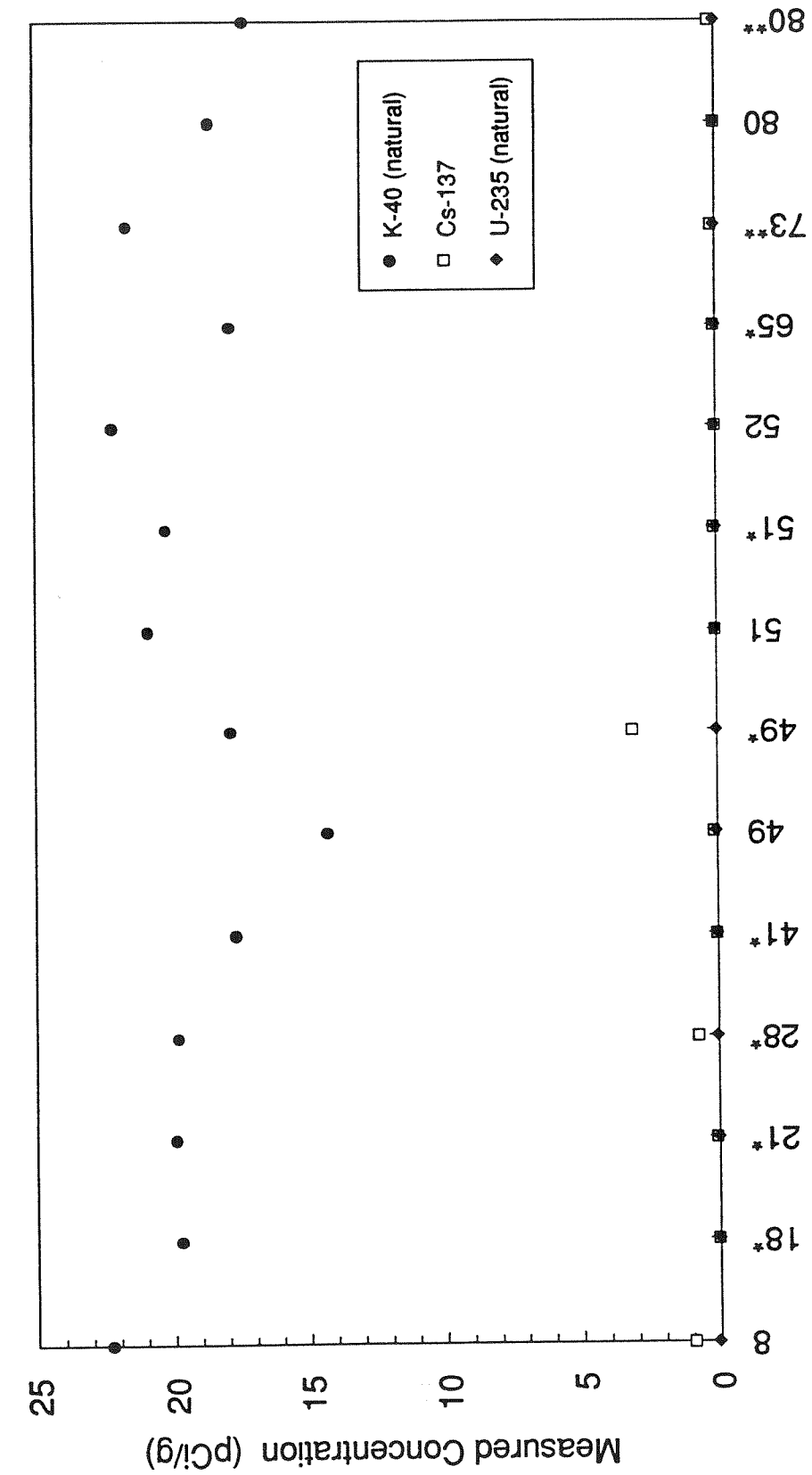


Figure 12. ^{40}K, ^{137}Cs, and ^{235}U Activity Measurements for the Soil and Asphalt Samples from the Fenced-In Yard

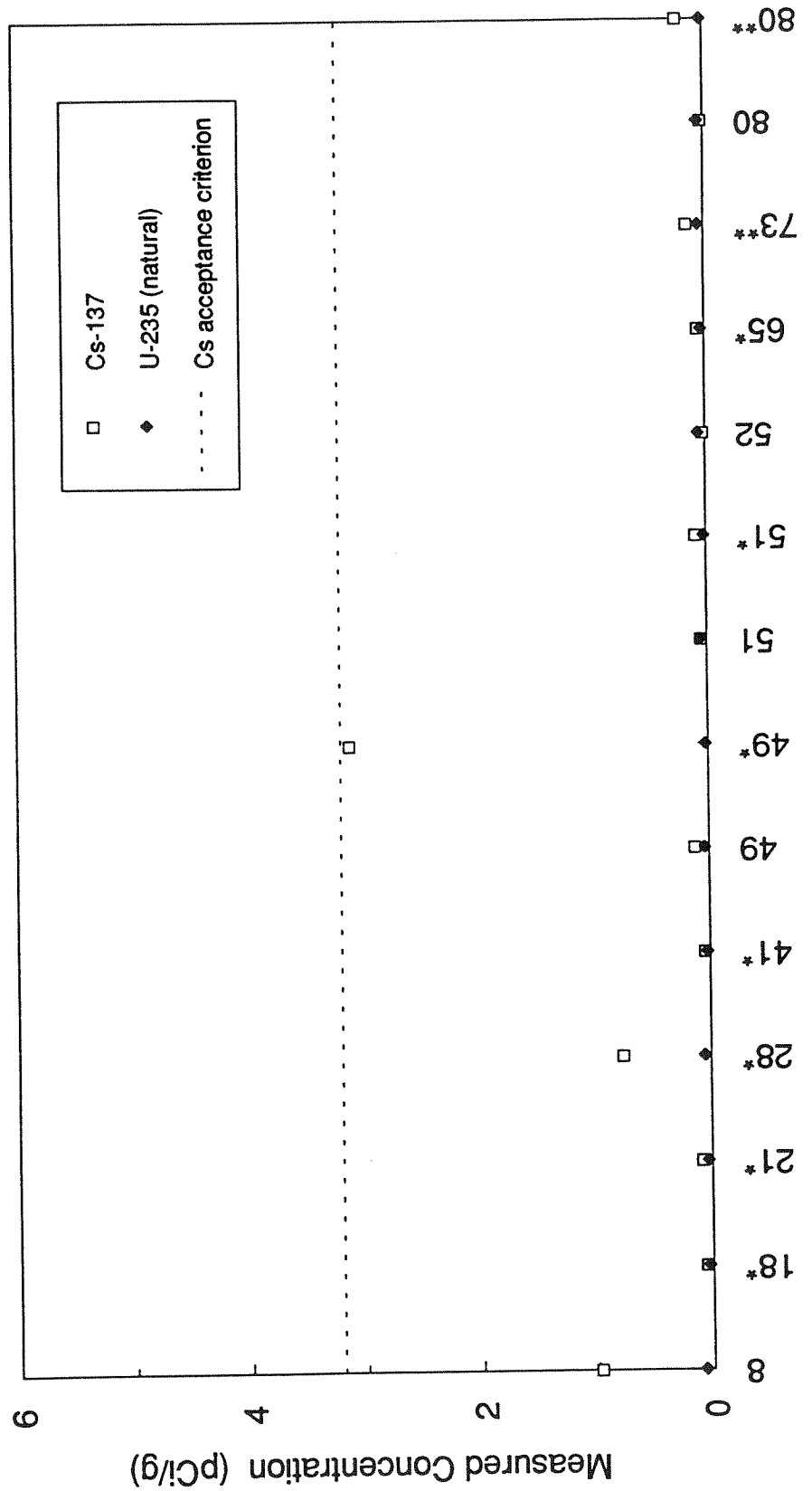


Figure 13. ^{137}Cs and ^{235}U Activity Measurements from the Soil and Asphalt Samples from the Fenced-In Yard, Overlaid with the ^{137}Cs Acceptance Criterion

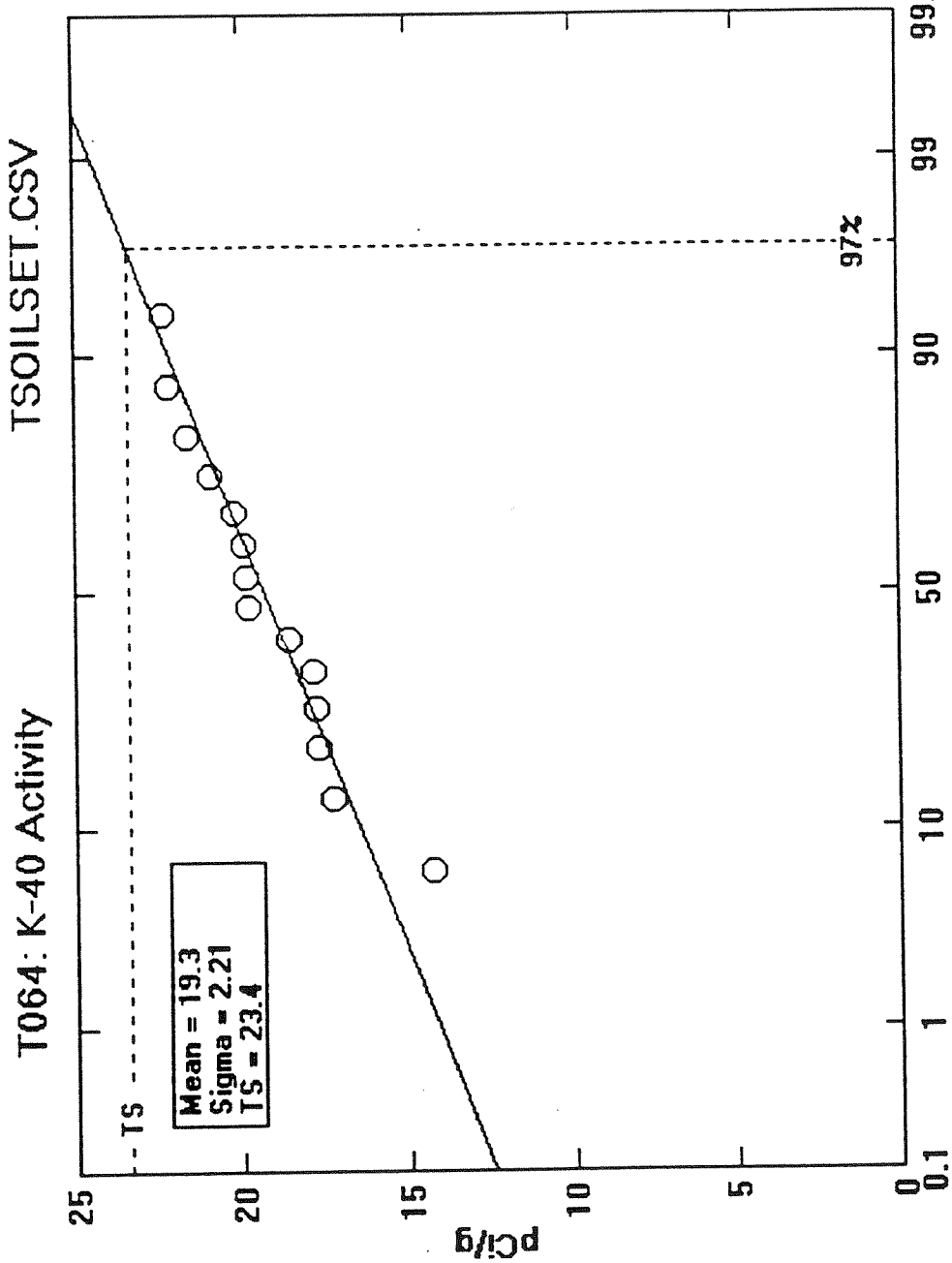


Figure 14. Cumulative Probability Plot of ^{40}K Activity Measurements from the Fenced-In Yard Soil and Asphalt Samples

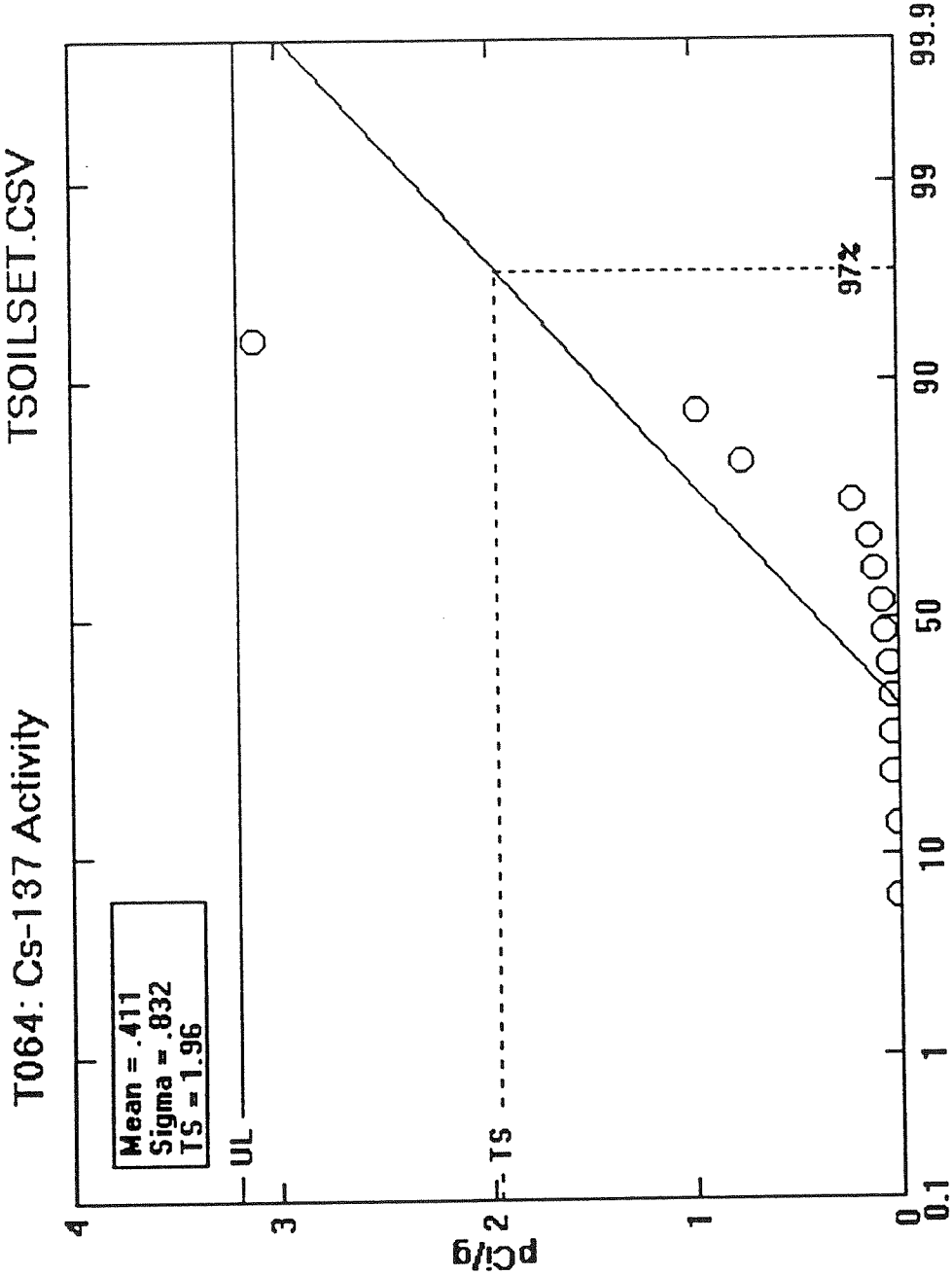


Figure 15. Cumulative Probability Plot of ^{137}Cs Activity Measurements from the Fenced-In Yard Soil and Asphalt Samples

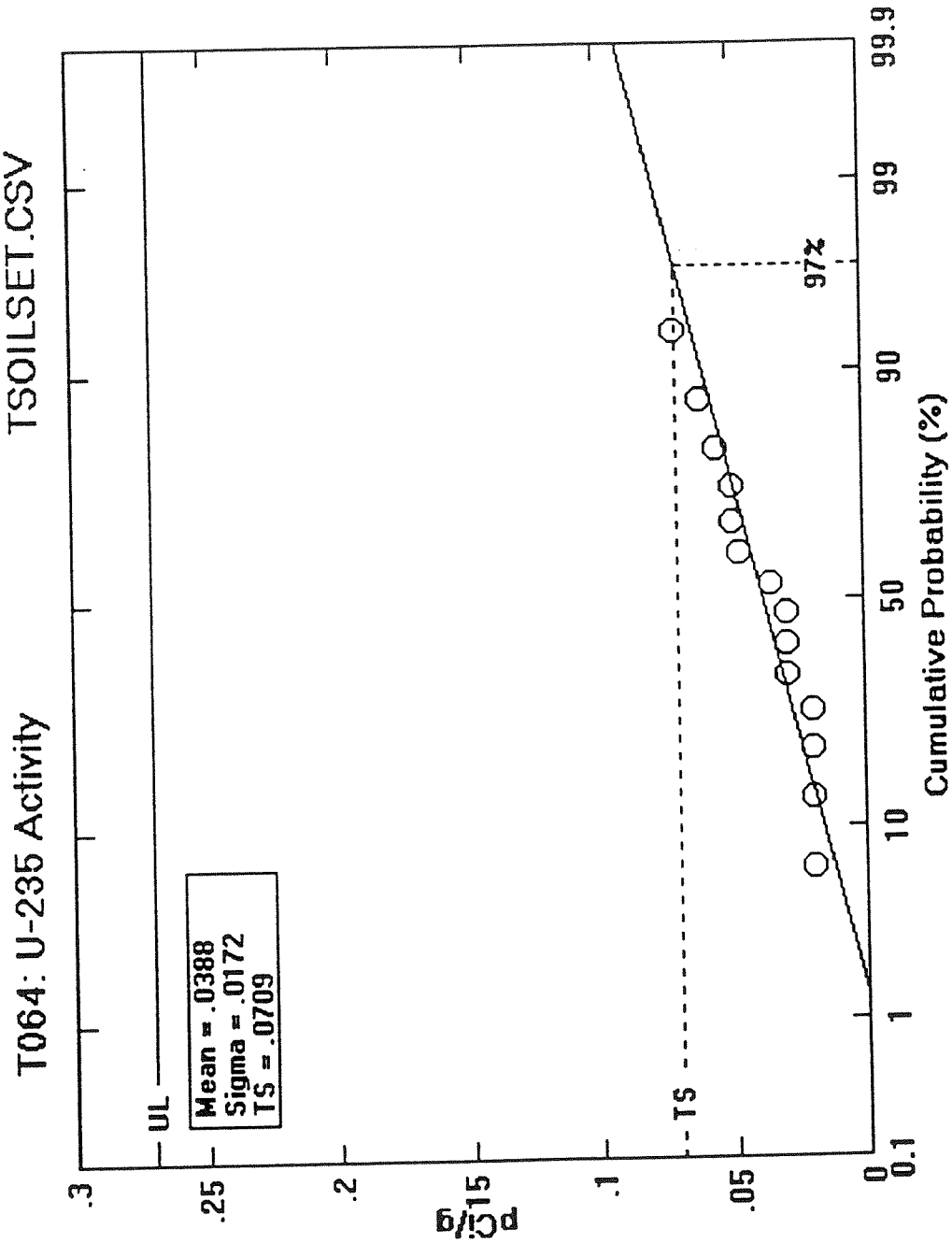


Figure 16. Cumulative Probability Plot of ^{235}U Activity Measurements from the Fenced-In Yard Soil and Asphalt Samples

Since ^{235}U, as measured by gamma spectrometry, is an indicator of ^{234}U and ^{238}U, depending upon enrichment of the possible contaminant, an equivalent acceptance limit must be developed to recognize these other radionuclides. The guideline for ^{235}U in highly enriched uranium (HEU, 93% ^{235}U by mass) is 0.27 pCi ^{235}U/g. This is about five times the activity concentration in natural soil due to the natural uranium, and so is readily detected. For normal uranium, the ^{235}U guideline is 0.50 pCi ^{235}U/g. Since HEU could have been a contaminant here, the lower guideline is applied.

5. CONCLUSIONS

The 6580 ft^2 area comprising the fenced-in yard that surrounds SSFL Building T064 was surveyed to assess its present radiological condition. The area was divided into grid blocks, alpha activity, beta activity, and gamma exposure rate measurements were made, and samples of soil and asphalt were taken for laboratory analysis to measure concentration levels of man-made residual radioactivity.

The resulting analysis data were compared with acceptance limits for facility release and with previous data where possible. The specific and general conclusions from this work follow.

5.1 SPECIFIC CONCLUSIONS

1. The average value for the 101 1-m^2-averaged, background-subtracted alpha surface activity measurements in the fenced-in yard is 3.4 ± 12.0 dpm/100 cm^2, the maximum measured area-averaged value is 51 dpm/100 cm^2, and the test statistic for the distribution is 21.0 dpm/100 cm^2. All values are well below the acceptance limit of 5000 dpm/100 cm^2.

2. The average value for the 112 1-m^2-averaged, background-subtracted beta surface activity measurements in the fenced-in yard is 239 ± 328 dpm/cm^2, the maximum measured area-averaged value is 1209 dpm/100 cm^2, and the test statistic for the distribution is 717 dpm/100 cm^2. All values are well below the acceptance limit of 5000 dpm/100 cm^2.

3. The average measured value for the background-subtracted gamma exposure rate is -1.11 ± 1.11 µR/h, based on an assumed background rate of 15.3 µR/h for the SSFL facility. The maximum measured gamma exposure rate (3.47 µR/h) and the test statistic for the measured exposure rate distribution (0.50 µR/h) are both below the 5-µR/h acceptance limit for facility release. Reanalyzing the data using the lower background rates obtained from daily instrument checks at a single location raises the calculated background-subtracted exposure rates, but those values are also all below the acceptance limit.

4. The measured soil concentrations of 18 specific radionuclides in the 14 soil and asphalt samples are consistent with natural background concentrations with the exception of a few slightly elevated ^{137}Cs measurements. The average measured ^{137}Cs activity is 0.41 ± 0.83 pCi/g, and all values are below the adopted 3.2 pCi/g acceptance limit.

5.2 OVERALL CONCLUSION

The fenced-in yard remains acceptably clean of radioactive contamination, and meets the criteria for release for unrestricted use.

REFERENCES

1. Richards, C. D., et. al., "ETEC Environmental Restoration Program Management Plan," Energy Technology Engineering Center, Report ER-AN-0002 (October 25, 1991).

2. Chapman, J. A., "Radiological Survey of the Source and Special Nuclear Material Storage Vault-Bldg T64," Energy Technology Engineering Center, Report GEN-ZR-0005 (August 19, 1988).

3. Subbaraman, G., and Oliver, B. M., "Final Decontamination and Radiological Survey of the Building T064 Side Yard," Rockwell International, Safety Review Report N704SRR990031 (October 30, 1990).

4. Badger, F. H., "Contamination Incident SS Fault, Santa Susana," North American Aviation Internal Letter to R. M. Hill dated November 11, 1963.

5. Badger, F. H., and Tuttle, R. J., "Radiological Survey Plan for SSFL," Rockwell International, Safety Review Report 154SRR000001 (September 25, 1985).

6. Richards, C. D., "Building 064 Radiologic Survey and Sampling," Energy Technology Engineering Center, Report SSWA-SOP-0001 (February 28, 1992).

7. _____ , "Guidelines for Residual Radioactivity at FUSRAP and Remote SFMP Sites," U.S. Department of Energy (February 1985).

8. Kittinger, W. D., Badger, F. H., and Moore, J. D., "Quality Control and General Operating Procedure for Gamma Spectroscopy Using Canberra Multichannel Analyzers," Rockwell International, Rocketdyne Division, Supporting Document N001OP000028 (June 1991).

9. Rutherford, P. D., "Sodium Disposal Facility Closure - Radiological Acceptance Criteria for Soil Segregation," Rockwell International, Energy Technology Engineering Center, Report 886-XT-0001 (February 25, 1992).

10. _____ , "Residual Radioactive Material," Chapter IV of U.S. Department of Energy Order 5400.5 (February 8, 1990).

11. _____ , "Order Authorizing Dismantling of Facility and Disposition of Component Parts," U.S. Nuclear Regulatory Commission, Docket 50-375 (February 22, 1983).

12. Gilbert, T. L., et al., "A Manual for Implementing Residual Radioactive Material Guidelines," Argonne National Laboratory, Report ANL/ES-160 (DOE/CH/8901) (June 1989.

13. Chapman, J. A., "Radiological Survey of Shipping/Receiving and Old Accelerator Area - Buildings T641 and T030," Energy Technology Engineering Center, Report GEN-ZR-0007 (August 19, 1988).

APPENDIX A

SURVEY DATA SPREADSHEETS

The following spreadsheet tables provide the input data for the individual survey measurements, the calculations performed to derive background-corrected exposure rates (gamma) and radiological activity levels (alpha, beta), and a summary of the soil/asphalt radiological concentration measurements for ^{40}K, ^{137}Cs, and ^{235}U. Also included are the spreadsheet tables used to derive average gamma, alpha, and beta background values from the individual background counts performed during the survey period.

Alpha Activity Data T064R2.xls 2/18/93

Detector area (Aalpha) = 71 cm^2

Grid Point	Meas. Date	Total Cts. (5 min)	Total (T) cpm	Bkgd (B) cpm	Daily SSA	SSA Test (T-B-SSA)	Net cpm (T - B)	Convers. dpm/cpm	dpm/ 100 cm2 (- bkgd)	dpm/ 100 cm2 (w/bkgd)
1	2/18/92	20	4.0	4.3	2.2	LTD*	-0.3	6.4	-2.7	36.1
2	2/18/92	21	4.2	4.3	2.2	LTD	-0.1	6.4	-0.9	37.9
3/1	2/18/92	29	5.8	4.3	2.2	LTD	1.5	6.4	13.5	52.3
3/2	2/18/92	23	4.6	4.3	2.2	LTD	0.3	6.4	2.7	41.5
4	2/18/92	11	2.2	4.2	2.2	LTD	-2.0	6.4	-18.0	19.8
5	2/18/92	17	3.4	4.2	2.2	LTD	-0.8	6.4	-7.2	30.6
6	2/18/92	19	3.8	4.2	2.2	LTD	-0.4	6.4	-3.6	34.3
7	2/18/92	13	2.6	4.2	2.2	LTD	-1.6	6.4	-14.4	23.4
8	2/18/92	20	4.0	4.2	2.2	LTD	-0.2	6.4	-1.8	36.1
9	2/18/92	21	4.2	4.2	2.2	LTD	0.0	6.4	0.0	37.9
10	2/18/92	10	2.0	4.2	2.2	LTD	-2.2	6.4	-19.8	18.0
11	2/19/92	25	5.0	4.9	2.2	LTD	0.1	6.4	0.9	45.1
12	2/19/92	17	3.4	4.9	2.2	LTD	-1.5	6.4	-13.5	30.6
13	2/19/92	15	3.0	4.9	2.2	LTD	-1.9	6.4	-17.1	27.0
14	2/19/92	33	6.6	4.9	2.2	LTD	1.7	6.4	15.3	59.5
15	2/19/92	22	4.4	4.9	2.2	LTD	-0.5	6.4	-4.5	39.7
16	2/19/92	17	3.4	4.9	2.2	LTD	-1.5	6.4	-13.5	30.6
17	2/19/92	23	4.6	4	2.2	LTD	0.6	6.4	5.4	41.5
18	2/19/92	26	5.2	4	2.2	LTD	1.2	6.4	10.8	46.9
19	2/19/92	26	5.2	4	2.2	LTD	1.2	6.4	10.8	46.9
20	2/19/92	23	4.6	4	2.2	LTD	0.6	6.4	5.4	41.5
21	2/19/92	22	4.4	4	2.2	LTD	0.4	6.4	3.6	39.7
22	2/19/92	26	5.2	4	2.2	LTD	1.2	6.4	10.8	46.9
23	2/19/92	27	5.4	4	2.2	LTD	1.4	6.4	12.6	48.7
24	2/19/92	22	4.4	4	2.2	LTD	0.4	6.4	3.6	39.7
25	4/22/92	15	3.0	2.8	1.8	LTD	0.2	7.1	2.0	30.0
26	4/22/92	9	1.8	2.8	1.8	LTD	-1.0	7.1	-10.0	18.0
27	4/22/92	16	3.2	2.8	1.8	LTD	0.4	7.1	4.0	32.0
28	4/16/92	30	6.0	5.3	2.4	LTD	0.7	6.4	6.3	54.1
29	4/16/92	36	7.2	5.3	2.4	LTD	1.9	6.4	17.1	64.9
30	4/16/92	28	5.6	5.3	2.4	LTD	0.3	6.4	2.7	50.5
31	4/16/92	27	5.4	5.3	2.4	LTD	0.1	6.4	0.9	48.7
32	4/22/92	6	1.2	2.8	1.8	LTD	-1.6	7.1	-16.0	12.0
33	4/22/92	12	2.4	2.8	1.8	LTD	-0.4	7.1	-4.0	24.0
34	4/22/92	5	1.0	2.8	1.8	LTD	-1.8	7.1	-18.0	10.0
35	4/16/92	40	8.0	5.3	2.4	0.3	2.7	6.4	24.3	72.1
36	4/16/92	37	7.4	5.3	2.4	LTD	2.1	6.4	18.9	66.7
37	4/16/92	27	5.4	5.3	2.4	LTD	0.1	6.4	0.9	48.7
38	4/16/92	23	4.6	5.3	2.4	LTD	-0.7	6.4	-6.3	41.5
39	4/22/92	11	2.2	2.8	1.8	LTD	-0.6	7.1	-6.0	22.0
40	4/22/92	9	1.8	2.8	1.8	LTD	-1.0	7.1	-10.0	18.0
41	4/22/92	8	1.6	2.8	1.8	LTD	-1.2	7.1	-12.0	16.0
42	4/16/92	27	5.4	5.3	2.4	LTD	0.1	6.4	0.9	48.7
43	4/16/92	22	4.4	5.3	2.4	LTD	-0.9	6.4	-8.1	39.7
44	4/22/92	11	2.2	2.8	1.8	LTD	-0.6	7.1	-6.0	22.0
45	4/22/92	21	4.2	2.8	1.8	LTD	1.4	7.1	14.0	42.0

Alpha Activity Data/2

Grid Point	Meas. Date	Total Cts. (5 min)	Total (T) cpm	Bkgd (B) cpm	Daily SSA	SSA Test (T-B-SSA)	Net cpm (T - B)	Convers. dpm/cpm	dpm/ 100 cm2 (- bkgd)	dpm/ 100 cm2 (w/bkgd)
46	4/22/92	19	3.8	2.8	1.8	LTD	1.0	7.1	10.0	38.0
47	4/16/92	27	5.4	5.3	2.4	LTD	0.1	6.4	0.9	48.7
48	4/17/92	11	2.2	2	1.6	LTD	0.2	7.1	2.0	22.0
49	4/17/92	17	3.4	2	1.6	LTD	1.4	7.1	14.0	34.0
50	4/22/92	14	2.8	2.8	1.8	LTD	0.0	7.1	0.0	28.0
51	4/22/92	13	2.6	2.8	1.8	LTD	-0.2	7.1	-2.0	26.0
52	4/22/92	9	1.8	2.8	1.8	LTD	-1.0	7.1	-10.0	18.0
53	4/17/92	14	2.8	2	1.6	LTD	0.8	7.1	8.0	28.0
54	4/17/92	15	3.0	2	1.6	LTD	1.0	7.1	10.0	30.0
56	4/22/92	9	1.8	2.8	1.8	LTD	-1.0	7.1	-10.0	18.0
57	4/22/92	11	2.2	2.8	1.8	LTD	-0.6	7.1	-6.0	22.0
58	4/22/92	9	1.8	2.8	1.8	LTD	-1.0	7.1	-10.0	18.0
59	4/17/92	18	3.6	2	1.6	LTD	1.6	7.1	16.0	36.0
60	4/17/92	14	2.8	2	1.6	LTD	0.8	7.1	8.0	28.0
61	4/17/92	16	3.2	2	1.6	LTD	1.2	7.1	12.0	32.0
62	4/22/92	14	2.8	2.8	1.8	LTD	0.0	7.1	0.0	28.0
63	4/23/92	9	1.8	2	1.4	LTD	-0.2	7.1	-2.0	18.0
64	4/23/92	8	1.6	2	1.4	LTD	-0.4	7.1	-4.0	16.0
65	4/17/92	8	1.6	2	1.6	LTD	-0.4	7.1	-4.0	16.0
66	4/17/92	15	3.0	2	1.6	LTD	1.0	7.1	10.0	30.0
67	4/17/92	12	2.4	2	1.6	LTD	0.4	7.1	4.0	24.0
68	4/23/92	11	2.2	2	1.4	LTD	0.2	7.1	2.0	22.0
69	4/23/92	14	2.8	2	1.4	LTD	0.8	7.1	8.0	28.0
70	4/23/92	9	1.8	2	1.4	LTD	-0.2	7.1	-2.0	18.0
71	4/17/92	6	1.2	2	1.6	LTD	-0.8	7.1	-8.0	12.0
72	4/17/92	12	2.4	2	1.6	LTD	0.4	7.1	4.0	24.0
73	4/20/92	12	2.4	1.7	1.4	LTD	0.7	7.1	7.0	24.0
74	4/23/92	17	3.4	2	1.4	LTD	1.4	7.1	14.0	34.0
75	4/23/92	8	1.6	2	1.4	LTD	-0.4	7.1	-4.0	16.0
76	4/23/92	15	3.0	2	1.4	LTD	1.0	7.1	10.0	30.0
77	4/20/92	8	1.6	1.7	1.4	LTD	-0.1	7.1	-1.0	16.0
78	4/20/92	14	2.8	1.7	1.4	LTD	1.1	7.1	11.0	28.0
79	4/20/92	14	2.8	1.7	1.4	LTD	1.1	7.1	11.0	28.0
80	4/20/92	14	2.8	1.7	1.4	LTD	1.1	7.1	11.0	28.0
81	4/23/92	14	2.8	2	1.4	LTD	0.8	7.1	8.0	28.0
82	4/23/92	12	2.4	2	1.4	LTD	0.4	7.1	4.0	24.0
83	4/20/92	6	1.2	1.7	1.4	LTD	-0.5	7.1	-5.0	12.0
84	4/20/92	9	1.8	1.7	1.4	LTD	0.1	7.1	1.0	18.0
85	4/20/92	15	3.0	1.7	1.4	LTD	1.3	7.1	13.0	30.0
86	4/20/92	11	2.2	1.7	1.4	LTD	0.5	7.1	5.0	22.0
87	4/20/92	10	2.0	1.7	1.4	LTD	0.3	7.1	3.0	20.0
88	4/20/92	7	1.4	1.7	1.4	LTD	-0.3	7.1	-3.0	14.0
89	4/20/92	11	2.2	1.7	1.4	LTD	0.5	7.1	5.0	22.0
90	4/20/92	9	1.8	1.7	1.4	LTD	0.1	7.1	1.0	18.0
91	4/20/92	17	3.4	1.7	1.4	0.3	1.7	7.1	17.0	34.0
92	4/20/92	9	1.8	1.7	1.4	LTD	0.1	7.1	1.0	18.0
93	4/20/92	15	3.0	1.7	1.4	LTD	1.3	7.1	13.0	30.0
D1	4/21/92	29	5.8	1.7	1.4	2.7	4.1	7.1	41.0	58.0

Alpha Activity Data/3

Grid Point	Meas. Date	Total Cts. (5 min)	Total (T) cpm	Bkgd (B) cpm	Daily SSA	SSA Test (T-B-SSA)	Net cpm (T - B)	Convers. dpm/cpm	dpm/ 100 cm2 (- bkgd)	dpm/ 100 cm2 (w/bkgd)
D2	4/21/92	22	4.4	1.7	1.4	1.3	2.7	7.1	27.0	44.0
D3	4/21/92	34	6.8	1.7	1.4	3.7	5.1	7.1	51.0	68.0
D4	4/21/92	26	5.2	1.7	1.4	2.1	3.5	7.1	35.0	52.0
D5	4/21/92	14	2.8	1.7	1.4	LTD	1.1	7.1	11.0	28.0
D6	4/21/92	20	4.0	1.7	1.4	0.9	2.3	7.1	23.0	40.0
D7	4/23/92	10	2.0	2	1.4	LTD	0.0	7.1	0.0	20.0
D8	4/23/92	16	3.2	2	1.4	LTD	1.2	7.1	12.0	32.0
								ave =	3.44	32.00
								std dev =	11.95	13.71

* LTD = "Less Than Detectable" (below SSA limit)

Alpha Counter Background Response:

Date	Total counts/shift time Start	Mid	End	Total Ct. Time (m)	Bkgd cpm	Convers. dpm/cpm	dpm/ 100 cm2	
4/16/92	42	34	35	21	5.3	6.4	47.65	Group ave:
4/17/92	16	11	16	21	2.0	7.1	20.48	6.84
4/20/92	12	10	13	21	1.7	7.1	16.67	dpm/100 cm2
4/21/92	11	13		14	1.7	7.1	17.14	
4/22/92	24	16	19	21	2.8	7.1	28.10	
4/23/92	13	16	14	21	2.0	7.1	20.48	
2/18/92	24	19	23	15	4.4	6.4	39.66	
2/18/92 A	24	19		10	4.3			
2/18/92 P		19	23	10	4.2			
2/19/92	26	23	17	15	4.4	6.4	39.66	
2/19/92 A	26	23		10	4.9			
2/19/92P		23	17	10	4.0			

Alpha Individual Background Counting Data T064BKR2.xls 2/19/93

Detector Area (Aalpha) = 71 cm^2

Date	Period	Counts	Time (min)	Ct. Rate (cpm)	Convers. dpm/cpm	dpm/ 100 cm2
2/18/92	am	24	5	4.8	6.4	43.3
2/18/92	mid	19	5	3.8	6.4	34.3
2/18/92	pm	23	5	4.6	6.4	41.5
2/19/92	am	26	5	5.2	6.4	46.9
2/19/92	mid	23	5	4.6	6.4	41.5
2/19/92	pm	17	5	3.4	6.4	30.6
4/16/92	am	33	5	6.6	6.4	59.5
4/16/92	mid	26	5	5.2	6.4	46.9
4/16/92	pm	21	5	4.2	6.4	37.9
4/17/92	am	13	5	2.6	7.1	26.0
4/17/92	mid	10	5	2	7.1	20.0
4/17/92	pm	13	5	2.6	7.1	26.0
4/20/92	am	9	5	1.8	7.1	18.0
4/20/92	mid	8	5	1.6	7.1	16.0
4/20/92	pm	11	5	2.2	7.1	22.0
4/21/92	am	8	5	1.6	7.1	16.0
4/21/92	mid	11	5	2.2	7.1	22.0
4/22/92	am	20	5	4	7.1	40.0
4/22/92	mid	12	5	2.4	7.1	24.0
4/22/92	pm	14	5	2.8	7.1	28.0
4/23/92	am	7	5	1.4	7.1	14.0
4/23/92	mid	11	5	2.2	7.1	22.0
4/23/92	pm	10	5	2	7.1	20.0

ave =	16.0	***ave alpha =***	30.27
std. dev. =	7.2	***std dev =***	12.27
ave/minute =	3.2	***SSA =***	28.55
SSA =	3.4		

Daily Average 5-Minute Count SSAs (for Individual Data Comparisons):

Date	Ave 5-min Count	SSA (cpm)
2/18/92	22.00	2.2
2/19/92	22.00	2.2
4/16/92	26.67	2.4
4/17/92	12.00	1.6
4/20/92	9.33	1.4
4/21/92	9.50	1.4
4/22/92	15.33	1.8
4/23/92	9.33	1.4

Beta Activity Data

Detector area (Abeta) = 20 cm^2

Grid Point	Meas. Date	Total Cts. (5 min)	Total (T) cpm	Bkgd (B) cpm	Daily SSA	SSA Test (T-B-SSA)	Net cpm (T - B)	Convers. dpm/cpm	dpm/ 100 cm2 (- bkgd)	dpm/ 100 cm2 (w/bkgd)
1	2/18/92	386	77.2	84	9.5	LTD	-6.8	8.4	-286	3242
2	2/18/92	422	84.4	84	9.5	LTD	0.4	8.4	17	3545
3/1	2/18/92	393	78.6	84	9.5	LTD	-5.4	8.4	-227	3301
3/2	2/18/92	368	73.6	84	9.5	LTD	-10.4	8.4	-437	3091
4	2/18/92	403	80.6	84	9.5	LTD	-3.4	8.4	-143	3385
5	2/18/92	440	88	84	9.5	LTD	4	8.4	168	3696
6	2/18/92	409	81.8	84	9.5	LTD	-2.2	8.4	-92	3436
7	2/18/92	425	85	84	9.5	LTD	1	8.4	42	3570
8	2/18/92	453	90.6	84	9.5	LTD	6.6	8.4	277	3805
9	2/18/92	423	84.6	84	9.5	LTD	0.6	8.4	25	3553
10	2/18/92	405	81	84	9.5	LTD	-3	8.4	-126	3402
11	2/19/92	417	83.4	82	9.7	LTD	1.4	8.4	59	3503
12	2/19/92	425	85	82	9.7	LTD	3	8.4	126	3570
13	2/19/92	418	83.6	82	9.7	LTD	1.6	8.4	67	3511
14	2/19/92	427	85.4	82	9.7	LTD	3.4	8.4	143	3587
15	2/19/92	448	89.6	82	9.7	LTD	7.6	8.4	319	3763
16	2/19/92	441	88.2	82	9.7	LTD	6.2	8.4	260	3704
17	2/19/92	421	84.2	88	9.7	LTD	-3.8	8.4	-160	3536
18	2/19/92	475	95	88	9.7	LTD	7	8.4	294	3990
19	2/19/92	416	83.2	88	9.7	LTD	-4.8	8.4	-202	3494
20	2/19/92	510	102	88	9.7	4.3	14	8.4	588	4284
21	2/19/92	487	97.4	88	9.7	LTD	9.4	8.4	395	4091
22	2/19/92	362	72.4	88	9.7	LTD	-15.6	8.4	-655	3041
23	2/19/92	419	83.8	88	9.7	LTD	-4.2	8.4	-176	3520
24	2/19/92	407	81.4	88	9.7	LTD	-6.6	8.4	-277	3419
25	4/21/92	395	79	81	9.5	LTD	-2	7.9	-79	3121
26	4/21/92	450	90	81	9.5	LTD	9	7.9	356	3555
27	4/21/92	447	89.4	81	9.5	LTD	8.4	7.9	332	3531
28	4/17/92	449	89.8	78	9.1	2.7	11.8	7.9	466	3547
29	4/17/92	442	88.4	78	9.1	1.3	10.4	7.9	411	3492
30	4/17/92	423	84.6	78	9.1	LTD	6.6	7.9	261	3342
31	4/17/92	428	85.6	78	9.1	LTD	7.6	7.9	300	3381
32	4/21/92	446	89.2	81	9.5	LTD	8.2	7.9	324	3523
33	4/21/92	404	80.8	81	9.5	LTD	-0.2	7.9	-8	3192
34	4/21/92	415	83	81	9.5	LTD	2	7.9	79	3279
35	4/17/92	438	87.6	78	9.1	0.5	9.6	7.9	379	3460
36	4/17/92	420	84	78	9.1	LTD	6	7.9	237	3318
37	4/17/92	390	78	78	9.1	LTD	0	7.9	0	3081
38	4/17/92	402	80.4	78	9.1	LTD	2.4	7.9	95	3176
39	4/21/92	437	87.4	81	9.5	LTD	6.4	7.9	253	3452
40	4/21/92	428	85.6	81	9.5	LTD	4.6	7.9	182	3381
41	4/21/92	457	91.4	81	9.5	0.9	10.4	7.9	411	3610
42	4/17/92	411	82.2	78	9.1	LTD	4.2	7.9	166	3247
43	4/17/92	440	88	78	9.1	0.9	10	7.9	395	3476
44	4/22/92	470	94	78	9.1	6.9	16	7.9	632	3713
45	4/22/92	472	94.4	78	9.1	7.3	16.4	7.9	648	3729

Beta Activity Data/2

Grid Point	Meas. Date	Total Cts. (5 min)	Total (T) cpm	Bkgd (B) cpm	Daily SSA	SSA Test (T-B-SSA)	Net cpm (T - B)	Convers. dpm/cpm	dpm/ 100 cm2 (- bkgd)	dpm/ 100 cm2 (w/bkgd)
46	4/22/92	462	92.4	78	9.1	5.3	14.4	7.9	569	3650
47	4/17/92	436	87.2	78	9.1	0.1	9.2	7.9	363	3444
48	4/17/92	445	89	78	9.1	1.9	11	7.9	435	3516
49	4/17/92	533	106.6	78	9.1	19.5	28.6	7.9	1130	4211
50	4/22/92	442	88.4	78	9.1	1.3	10.4	7.9	411	3492
51	4/22/92	444	88.8	78	9.1	1.7	10.8	7.9	427	3508
52	4/22/92	454	90.8	78	9.1	3.7	12.8	7.9	506	3587
53	4/17/92	429	85.8	78	9.1	LTD	7.8	7.9	308	3389
54	4/17/92	445	89	78	9.1	1.9	11	7.9	435	3516
56	4/22/92	449	89.8	78	9.1	2.7	11.8	7.9	466	3547
57	4/22/92	450	90	78	9.1	2.9	12	7.9	474	3555
58	4/22/92	492	98.4	78	9.1	11.3	20.4	7.9	806	3887
59	4/17/92	512	102.4	78	9.1	15.3	24.4	7.9	964	4045
60	4/17/92	455	91	78	9.1	3.9	13	7.9	514	3595
61	4/17/92	480	96	78	9.1	8.9	18	7.9	711	3792
62	4/22/92	454	90.8	78	9.1	3.7	12.8	7.9	506	3587
63	4/23/92	441	88.2	81	9.4	LTD	7.2	7.9	284	3484
64	4/23/92	442	88.4	81	9.4	LTD	7.4	7.9	292	3492
65	4/17/92	402	80.4	78	9.1	LTD	2.4	7.9	95	3176
66	4/17/92	472	94.4	78	9.1	7.3	16.4	7.9	648	3729
67	4/17/92	543	108.6	78	9.1	21.5	30.6	7.9	1209	4290
68	4/23/92	440	88	81	9.4	LTD	7	7.9	277	3476
69	4/23/92	457	91.4	81	9.4	1	10.4	7.9	411	3610
70	4/23/92	434	86.8	81	9.4	LTD	5.8	7.9	229	3429
71	4/17/92	455	91	78	9.1	3.9	13	7.9	514	3595
72	4/17/92	469	93.8	78	9.1	6.7	15.8	7.9	624	3705
73	4/20/92	442	88.4	91	10.1	LTD	-2.6	7.9	-103	3492
74	4/23/92	415	83	81	9.4	LTD	2	7.9	79	3279
75	4/23/92	462	92.4	81	9.4	2	11.4	7.9	450	3650
76	4/23/92	462	92.4	81	9.4	2	11.4	7.9	450	3650
77	4/20/92	445	89	91	10.1	LTD	-2	7.9	-79	3516
78	4/20/92	436	87.2	91	10.1	LTD	-3.8	7.9	-150	3444
79	4/20/92	426	85.2	91	10.1	LTD	-5.8	7.9	-229	3365
80	4/20/92	446	89.2	91	10.1	LTD	-1.8	7.9	-71	3523
81	4/23/92	479	95.8	81	9.4	5.4	14.8	7.9	585	3784
82	4/23/92	445	89	81	9.4	LTD	8	7.9	316	3516
83	4/20/92	428	85.6	91	10.1	LTD	-5.4	7.9	-213	3381
84	4/20/92	433	86.6	91	10.1	LTD	-4.4	7.9	-174	3421
85	4/20/92	410	82	91	10.1	LTD	-9	7.9	-356	3239
86	4/20/92	471	94.2	91	10.1	LTD	3.2	7.9	126	3721
87	4/20/92	518	103.6	91	10.1	2.5	12.6	7.9	498	4092
88	4/20/92	434	86.8	91	10.1	LTD	-4.2	7.9	-166	3429
89	4/20/92	471	94.2	91	10.1	LTD	3.2	7.9	126	3721
90	4/20/92	473	94.6	91	10.1	LTD	3.6	7.9	142	3737
91	4/20/92	469	93.8	91	10.1	LTD	2.8	7.9	111	3705
92	4/20/92	474	94.8	91	10.1	LTD	3.8	7.9	150	3745
93	4/20/92	442	88.4	91	10.1	LTD	-2.6	7.9	-103	3492
D1	4/21/92	407	81.4	81	9.5	LTD	0.4	7.9	16	3215

Beta Activity Data/3

Grid Point	Meas. Date	Total Cts. (5 min)	Total (T) cpm	Bkgd (B) cpm	Daily SSA	SSA Test (T-B-SSA)	Net cpm (T - B)	Convers. dpm/cpm	dpm/ 100 cm2 (- bkgd)	dpm/ 100 cm2 (w/bkgd)
D2	4/21/92	489	97.8	81	9.5	7.3	16.8	7.9	664	3863
D3	4/21/92	422	84.4	81	9.5	LTD	3.4	7.9	134	3334
D4	4/21/92	420	84	81	9.5	LTD	3	7.9	119	3318
D5	4/21/92	362	72.4	81	9.5	LTD	-8.6	7.9	-340	2860
D6	4/21/92	368	73.6	81	9.5	LTD	-7.4	7.9	-292	2907
D7	4/23/92	394	78.8	81	9.4	LTD	-2.2	7.9	-87	3113
D8	4/23/92	474	94.8	81	9.4	4.4	13.8	7.9	545	3745
G1	4/24/92	453	90.6	81	9.5	0.1	9.6	7.9	379	3579
G2	4/24/92	477	95.4	81	9.5	4.9	14.4	7.9	569	3768
G3	4/24/92	463	92.6	81	9.5	2.1	11.6	7.9	458	3658
G4	4/24/92	492	98.4	81	9.5	7.9	17.4	7.9	687	3887
G5	4/24/92	436	87.2	81	9.5	LTD	6.2	7.9	245	3444
G6	4/24/92	449	89.8	81	9.5	LTD	8.8	7.9	348	3547
G7	4/24/92	514	102.8	81	9.5	12.3	21.8	7.9	861	4061
G8	4/24/92	450	90	81	9.5	LTD	9	7.9	356	3555
G9	4/24/92	472	94.4	81	9.5	3.9	13.4	7.9	529	3729
G10	4/24/92	444	88.8	81	9.5	LTD	7.8	7.9	308	3508
G11	4/24/92	454	90.8	81	9.5	0.3	9.8	7.9	387	3587
								ave =	238.55	3540.39
								std dev =	328.42	257.80

Beta Counter Background Response:

Date	Total counts/shift time Start	Mid	End	Total Ct. Time (m)	Bkgd cpm	Convers. dpm/cpm	dpm/ 100 cm2	
4/17/92	558	548	540	21	78	7.9	3096	Group ave:
4/20/92	764	557	589	21	91	7.9	3593	3313
4/21/92	555	558	583	21	81	7.9	3190	dpm/100 cm2
4/22/92	540	565	542	21	78	7.9	3098	
4/23/92	557	575	576	21	81	7.9	3213	
4/24/92	556		572	14	81	7.9	3183	
2/18/92	418	418	417	15	84	8.4	3508	
2/18/92 A	418	418		10	84			
2/18/92 P		418	417	10	84			
2/19/92	415	405	473	15	86	8.4	3620	
2/19/92 A	415	405		10	82			
2/19/92P		405	473	10	88			

Beta Individual Background Counting Data

Detector Area (Abeta) = 20 cm^2

Date	Period	Counts	Time (min)	Ct. Rate (cpm)	Convers. dpm/cpm	dpm/ 100 cm2
2/18/92	am	418	5	83.6	8.4	3511
2/18/92	mid	418	5	83.6	8.4	3511
2/18/92	pm	417	5	83.4	8.4	3503
2/19/92	am	415	5	83	8.4	3486
2/19/92	mid	405	5	81	8.4	3402
2/19/92	pm	473	5	94.6	8.4	3973
4/17/92	am	385	5	77	7.9	3042
4/17/92	mid	390	5	78	7.9	3081
4/17/92	pm	377	5	75.4	7.9	2978
4/20/92	am	587	5	117.4	7.9	4637
4/20/92	mid	402	5	80.4	7.9	3176
4/20/92	pm	418	5	83.6	7.9	3302
4/21/92	am	417	5	83.4	7.9	3294
4/21/92	mid	409	5	81.8	7.9	3231
4/21/92	pm	424	5	84.8	7.9	3350
4/22/92	am	392	5	78.4	7.9	3097
4/22/92	mid	383	5	76.6	7.9	3026
4/22/92	pm	378	5	75.6	7.9	2986
4/23/92	am	402	5	80.4	7.9	3176
4/23/92	mid	404	5	80.8	7.9	3192
4/23/92	pm	406	5	81.2	7.9	3207
4/24/92	am	412	5	82.4	7.9	3255
4/24/92	pm	420	5	84	7.9	3318
	ave =	415.3			***ave beta =***	3336
	std. dev. =	42.5			***std dev =***	362
	ave/minute =	83.1			***SSA =***	842
	SSA =	19.8				

Daily Average 5-Minute Count SSAs (for Individual Data Comparisons):

Date	Ave 5-min Count	SSA (cpm)
2/18/92	417.67	9.5
2/19/92	431.00	9.7
4/17/92	384.00	9.1
4/20/92	469.00	10.1
4/21/92	416.67	9.5
4/22/92	384.33	9.1
4/23/92	404.00	9.4
4/24/93	416.00	9.5

Gamma Exposure Rate Data

conversion=1/kgam
kgam = 215

* Indiv. bkgd subtraction

** Ave. bkgd (bgam) subtraction,
bgam = 15.3 µR/h

Grid Point	Meas. Date	Total (T) cpm	Bkgd (B) cpm	Daily SSA	SSA Test (T-B-SSA)	Net cpm (T - B)	Net Rate * (µR/h)	Total Rate (µR/h)	Net Rate** (µR/h)
1	2/18/92	2564	2901	127.5	LTD	-337	-1.57	11.93	-3.37
2	2/18/92	2864	2901	127.5	LTD	-37	-0.17	13.32	-1.98
3/1	2/18/92	2822	2901	127.5	LTD	-79	-0.37	13.13	-2.17
3/2	2/18/92	2880	2901	127.5	LTD	-21	-0.10	13.40	-1.90
4	2/18/92	2914	3065	127.5	LTD	-151	-0.70	13.55	-1.75
5	2/18/92	3085	3065	127.5	LTD	20	0.09	14.35	-0.95
6	2/18/92	3048	3065	127.5	LTD	-17	-0.08	14.18	-1.12
7	2/18/92	3136	3065	127.5	LTD	71	0.33	14.59	-0.71
8	2/18/92	3386	3065	127.5	193.5	321	1.49	15.75	0.45
9	2/18/92	2843	3065	127.5	LTD	-222	-1.03	13.22	-2.08
10	2/18/92	2864	3065	127.5	LTD	-201	-0.93	13.32	-1.98
11	2/19/92	3214	2903	128.1	182.9	311	1.45	14.95	-0.35
12	2/19/92	2936	2903	128.1	LTD	33	0.15	13.66	-1.64
13	2/19/92	2983	2903	128.1	LTD	80	0.37	13.87	-1.43
14	2/19/92	2937	2903	128.1	LTD	34	0.16	13.66	-1.64
15	2/19/92	3039	2903	128.1	7.9	136	0.63	14.13	-1.17
16	2/19/92	3183	2903	128.1	151.9	280	1.30	14.80	-0.50
17	2/19/92	3622	3098	128.1	395.9	524	2.44	16.85	1.55
18	2/19/92	4035	3098	128.1	808.9	937	4.36	18.77	3.47
19	2/19/92	3104	3098	128.1	LTD	6	0.03	14.44	-0.86
20	2/19/92	3099	3098	128.1	LTD	1	0.00	14.41	-0.89
21	2/19/92	3185	3098	128.1	LTD	87	0.40	14.81	-0.49
22	2/19/92	2893	3098	128.1	LTD	-205	-0.95	13.46	-1.84
23	2/19/92	2937	3098	128.1	LTD	-161	-0.75	13.66	-1.64
24	2/19/92	2641	3098	128.1	LTD	-457	-2.13	12.28	-3.02
25	4/21/92	2877	2810	122.2	LTD	67	0.31	13.38	-1.92
26	4/21/92	2994	2810	122.2	61.8	184	0.86	13.93	-1.37
27	4/21/92	3239	2810	122.2	306.8	429	2.00	15.07	-0.23
28	4/16/92	3009	2600	118.4	290.6	409	1.90	14.00	-1.30
29	4/16/92	2867	2600	118.4	148.6	267	1.24	13.33	-1.97
30	4/16/92	2892	2600	118.4	173.6	292	1.36	13.45	-1.85
31	4/16/92	2981	2600	118.4	262.6	381	1.77	13.87	-1.43
32	4/21/92	2941	2810	122.2	8.8	131	0.61	13.68	-1.62
33	4/21/92	3111	2810	122.2	178.8	301	1.40	14.47	-0.83
34	4/21/92	3376	2810	122.2	443.8	566	2.63	15.70	0.40
35	4/16/92	2889	2600	118.4	170.6	289	1.34	13.44	-1.86
36	4/16/92	2703	2600	118.4	LTD	103	0.48	12.57	-2.73
37	4/16/92	2684	2600	118.4	LTD	84	0.39	12.48	-2.82
38	4/16/92	2904	2600	118.4	185.6	304	1.41	13.51	-1.79
39	4/21/92	2959	2810	122.2	26.8	149	0.69	13.76	-1.54
40	4/21/92	3113	2810	122.2	180.8	303	1.41	14.48	-0.82
41	4/21/92	3296	2810	122.2	363.8	486	2.26	15.33	0.03
42	4/16/92	2900	2600	118.4	181.6	300	1.40	13.49	-1.81
43	4/16/92	2898	2600	118.4	179.6	298	1.39	13.48	-1.82
44	4/22/92	2963	2679	120.0	164	284	1.32	13.78	-1.52
45	4/22/92	3324	2679	120.0	525	645	3.00	15.46	0.16

Gamma Exposure Rate Data/2

Grid Point	Meas. Date	Total (T) cpm	Bkgd (B) cpm	Daily SSA	SSA Test (T-B-SSA)	Net cpm (T - B)	Net Rate * (µR/h)	Total Rate (µR/h)	Net Rate** (µR/h)
46	4/22/92	3344	2679	120.0	545	665	3.09	15.55	0.25
47	4/16/92	2715	2600	118.4	LTD	115	0.53	12.63	-2.67
48	4/17/92	2954	2777	121.6	55.4	177	0.82	13.74	-1.56
49	4/17/92	3186	2777	121.6	287.4	409	1.90	14.82	-0.48
50	4/22/92	3141	2679	120.0	342	462	2.15	14.61	-0.69
51	4/22/92	3255	2679	120.0	456	576	2.68	15.14	-0.16
52	4/22/92	3473	2679	120.0	674	794	3.69	16.15	0.85
53	4/17/92	2756	2777	121.6	LTD	-21	-0.10	12.82	-2.48
54	4/17/92	3021	2777	121.6	122.4	244	1.13	14.05	-1.25
56	4/22/92	3129	2679	120.0	330	450	2.09	14.55	-0.75
57	4/22/92	3055	2679	120.0	256	376	1.75	14.21	-1.09
58	4/22/92	3308	2679	120.0	509	629	2.93	15.39	0.09
59	4/17/92	2831	2777	121.6	LTD	54	0.25	13.17	-2.13
60	4/17/92	3180	2777	121.6	281.4	403	1.87	14.79	-0.51
61	4/17/92	3143	2777	121.6	244.4	366	1.70	14.62	-0.68
62	4/22/92	3131	2679	120.0	332	452	2.10	14.56	-0.74
63	4/23/92	3160	2759	123.4	277.6	401	1.87	14.70	-0.60
64	4/23/92	3258	2759	123.4	375.6	499	2.32	15.15	-0.15
65	4/17/92	3062	2777	121.6	163.4	285	1.33	14.24	-1.06
66	4/17/92	3016	2777	121.6	117.4	239	1.11	14.03	-1.27
67	4/17/92	3095	2777	121.6	196.4	318	1.48	14.40	-0.90
68	4/23/92	3032	2759	123.4	149.6	273	1.27	14.10	-1.20
69	4/23/92	3164	2759	123.4	281.6	405	1.88	14.72	-0.58
70	4/23/92	3182	2759	123.4	299.6	423	1.97	14.80	-0.50
71	4/17/92	2921	2777	121.6	22.4	144	0.67	13.59	-1.71
72	4/17/92	2956	2777	121.6	57.4	179	0.83	13.75	-1.55
73	4/20/92	3111	2743	121.5	246.5	368	1.71	14.47	-0.83
74	4/23/92	3068	2759	123.4	185.6	309	1.44	14.27	-1.03
75	4/23/92	3093	2759	123.4	210.6	334	1.55	14.39	-0.91
76	4/23/92	3208	2759	123.4	325.6	449	2.09	14.92	-0.38
77	4/20/92	2934	2743	121.5	69.5	191	0.89	13.65	-1.65
78	4/20/92	2893	2743	121.5	28.5	150	0.70	13.46	-1.84
79	4/20/92	2958	2743	121.5	93.5	215	1.00	13.76	-1.54
80	4/20/92	3176	2743	121.5	311.5	433	2.01	14.77	-0.53
81	4/23/92	3030	2679	123.4	227.6	351	1.63	14.09	-1.21
82	4/23/92	3180	2679	123.4	377.6	501	2.33	14.79	-0.51
83	4/20/92	2926	2743	121.5	61.5	183	0.85	13.61	-1.69
84	4/20/92	2805	2743	121.5	LTD	62	0.29	13.05	-2.25
85	4/20/92	2992	2743	121.5	127.5	249	1.16	13.92	-1.38
86	4/20/92	3130	2743	121.5	265.5	387	1.80	14.56	-0.74
87	4/20/92	3015	2743	121.5	150.5	272	1.27	14.02	-1.28
88	4/20/92	2966	2743	121.5	101.5	223	1.04	13.80	-1.50
89	4/20/92	3067	2743	121.5	202.5	324	1.51	14.27	-1.03
90	4/20/92	2974	2743	121.5	109.5	231	1.07	13.83	-1.47
91	4/20/92	3050	2743	121.5	185.5	307	1.43	14.19	-1.11
92	4/20/92	3005	2743	121.5	140.5	262	1.22	13.98	-1.32
93	4/20/92	3001	2743	121.5	136.5	258	1.20	13.96	-1.34
D1	4/21/92	2833	2810	122.2	LTD	23	0.11	13.18	-2.12

Gamma Exposure Rate Data/3

Grid Point	Meas. Date	Total (T) cpm	Bkgd (B) cpm	Daily SSA	SSA Test (T-B-SSA)	Net cpm (T - B)	Net Rate * (µR/h)	Total Rate (µR/h)	Net Rate** (µR/h)
D2	4/21/92	2839	2810	122.2	LTD	29	0.13	13.20	-2.10
D3	4/21/92	2780	2810	122.2	LTD	-30	-0.14	12.93	-2.37
D4	4/21/92	2902	2810	122.2	LTD	92	0.43	13.50	-1.80
D5	4/21/92	2305	2810	122.2	LTD	-505	-2.35	10.72	-4.58
D6	4/21/92	2271	2810	122.2	LTD	-539	-2.51	10.56	-4.74
D7	4/23/92	3029	2759	123.4	146.6	270	1.26	14.09	-1.21
D8	4/23/92	2997	2759	123.4	114.6	238	1.11	13.94	-1.36
G1	4/23/92	3283	2759	123.4	400.6	524	2.44	15.27	-0.03
G2	4/23/92	3322	2759	123.4	439.6	563	2.62	15.45	0.15
G3	4/23/92	3085	2759	123.4	202.6	326	1.52	14.35	-0.95
G4	4/23/92	3174	2759	123.4	291.6	415	1.93	14.76	-0.54
G5	4/23/92	3324	2759	123.4	441.6	565	2.63	15.46	0.16
G6	4/23/92	3200	2759	123.4	317.6	441	2.05	14.88	-0.42
G7	4/23/92	3381	2759	123.4	498.6	622	2.89	15.73	0.43
G8	4/23/92	3341	2759	123.4	458.6	582	2.71	15.54	0.24
G9	4/23/92	3337	2759	123.4	454.6	578	2.69	15.52	0.22
G10	4/23/92	3262	2759	123.4	379.6	503	2.34	15.17	-0.13
G11	4/23/92	3740	2759	123.4	857.6	981	4.56	17.40	2.10
						ave =	1.17	14.19	
						std dev =	1.23	1.11	

Gamma Counter Background Response:

Date	Total counts/shift time Start	Mid	End	Total Ct. Time (m)	Bkgd cpm
4/16/92	17633	18403	18558	21	2600
4/17/92	19805		19069	14	2777
4/20/92	19281	19204	19128	21	2743
4/21/92	19681	19664	19656	21	2810
4/22/92	18354	18961	18938	21	2679
4/23/92	19561	19085	19300	21	2759
2/18/92	2886	2916	3214	3	3005
2/18/92 A	2886	2916		2	2901
2/18/92 P		2916	3214	2	3065
2/19/92	2901	2904	3291	3	3032
2/19/92 A	2901	2904		2	2903
2/19/92P		2904	3291	2	3098

Gamma Individual Background Counting Data

Conversion Factor (kgam) = 215

Date	Period	Total Counts	Time (min)	Ct. Rate (cpm)	Exp. Rate (μR/h)
2/18/92	am	2886	1	2886	13.42
2/18/92	mid	2916	1	2916	13.56
2/18/92	pm	3214	1	3214	14.95
2/19/92	am	2901	1	2901	13.49
2/19/92	mid	2904	1	2904	13.51
2/19/92	pm	3291	1	3291	15.31
4/16/92	am	2530	1	2530	11.77
4/16/92	am	2527	1	2527	11.75
4/16/92	mid	2659	1	2659	12.37
4/16/92	mid	2578	1	2578	11.99
4/16/92	pm	2614	1	2614	12.16
4/16/92	pm	2626	1	2626	12.21
4/17/92	am	2832	1	2832	13.17
4/17/92	am	2748	1	2748	12.78
4/17/92	pm	2722	1	2722	12.66
4/17/92	pm	2626	1	2626	12.21
4/20/92	am	2723	1	2723	12.67
4/20/92	am	2728	1	2728	12.69
4/20/92	mid	2737	1	2737	12.73
4/20/92	mid	2736	1	2736	12.73
4/20/92	pm	2687	1	2687	12.50
4/20/92	pm	2743	1	2743	12.76
4/21/92	am	2719	1	2719	12.65
4/21/92	am	2791	1	2791	12.98
4/21/92	mid	2756	1	2756	12.82
4/21/92	mid	2681	1	2681	12.47
4/21/92	pm	2798	1	2798	13.01
4/21/92	pm	2802	1	2802	13.03
4/22/92	am	2713	1	2713	12.62
4/22/92	am	2568	1	2568	11.94
4/22/92	mid	2579	1	2579	12.00
4/22/92	mid	2693	1	2693	12.53
4/22/92	pm	2732	1	2732	12.71
4/22/92	pm	2683	1	2683	12.48
4/23/92	am	2906	1	2906	13.52
4/23/92	am	2795	1	2795	13.00
4/23/92	mid	2772	1	2772	12.89
4/23/92	mid	2785	1	2785	12.95
4/23/92	pm	2835	1	2835	13.19
4/23/92	pm	2790	1	2790	12.98
	ave =	2758		***avegam =***	12.83
	std dev =	153		***std dev =***	0.71
	SSA =	357		***SSA =***	1.66

Gamma Individual Background Counting Data/2

Daily Average 5-Minute Count SSAs (for Individual Data Comparisons):

Date	Ave 1-min Count	SSA (cpm)
2/18/92	3005	127.5
2/19/92	3032	128.1
4/16/92	2589	118.4
4/17/92	2732	121.6
4/20/92	2726	121.5
4/21/92	2758	122.2
4/22/92	2661	120.0
4/23/92	2814	123.4

Summary of Soil/Asphalt Radiological Concentration Measurements T-SOIL2.xls 3/12/93

Grid Location	Sample Type	Measured Activity	2-Sigma Uncertainty	Analytical Background	SSA	Net Activity	
40K Activity (pCi/g):							
8	soil	22.46	0.27	0.17	0.04	22.29	
49	soil	14.45	0.32	0.15	0.06	14.30	
51	soil	21.08	0.15	0.19	0.03	20.89	
52	soil	22.37	0.40	0.21	0.07	22.16	
80	soil	18.70	0.39	0.17	0.07	18.53	
18	asphalt	19.89	0.36	0.15	0.08	19.74	
21	asphalt	20.09	0.42	0.16	0.10	19.93	
28	asphalt	19.98	0.48	0.15	0.11	19.83	
41	asphalt	17.83	0.36	0.16	0.09	17.67	
49	asphalt	17.99	0.45	0.15	0.11	17.84	
51	asphalt	20.38	0.49	0.17	0.13	20.21	Average:
65	asphalt	17.98	0.58	0.17	0.15	17.81	19.29
73	rock/soil	21.76	0.41	0.17	0.10	21.59	Std. Dev.:
80	rock/soil	17.41	0.52	0.16	0.14	17.25	2.21
137Cs Activity (pCi/g):							
8	soil	0.97	0.02	0.00	0.00	0.97	
49	soil	0.12	0.01	0.00	0.00	0.12	
51	soil	0.05	0.01	0.00	0.00	0.05	
52	soil	0.02	0.01	0.00	0.00	0.02	
80	soil	0.02	0.01	0.00	0.01	0.02	
18	asphalt	0.05	0.01	0.00	0.01	0.05	
21	asphalt	0.08	0.02	0.00	0.01	0.08	
28	asphalt	0.76	0.03	0.00	0.01	0.76	
41	asphalt	0.04	0.01	0.00	0.01	0.04	
49	asphalt	3.12	0.05	0.00	0.01	3.12	
51	asphalt	0.09	0.02	0.00	0.01	0.09	Average:
65	asphalt	0.06	0.02	0.00	0.01	0.06	0.41
73	rock/soil	0.15	0.02	0.00	0.01	0.15	Std. Dev.:
80	rock/soil	0.23	0.02	0.00	0.01	0.23	0.83
235U Activity (pCi/g):							
8	soil	0.08	0.007	0.01	0.00	0.071	
49	soil	0.04	0.006	0.00	0.00	0.036	
51	soil	0.06	0.006	0.01	0.00	0.056	
52	soil	0.07	0.009	0.01	0.00	0.062	
80	soil	0.05	0.008	0.01	0.00	0.048	
18	asphalt	0.04	0.01	0.01	0.01	0.03	
21	asphalt	0.04	0.02	0.01	0.01	0.03	
28	asphalt	0.06	0.10	0.01	0.01	0.05	
41	asphalt	0.03	0.01	0.01	0.01	0.02	
49	asphalt	0.03	0.01	0.01	0.01	0.02	
51	asphalt	0.03	0.01	0.01	0.01	0.02	Average:
65	asphalt	0.04	0.02	0.01	0.01	0.03	0.04
73	rock/soil	0.06	0.01	0.01	0.01	0.05	Std. Dev.:
80	rock/soil	0.03	0.01	0.01	0.01	0.02	0.02

APPENDIX B

LIST OF ITEMS IN THE BUILDING T064 FENCED-IN YARD RADIOLOGICAL SURVEY FILE

The following table provides an annotated list of the records generated during this survey and maintained in the Building T064 decontamination and decommissioning files.

ITEMS IN THE BUILDING T064 FENCED-IN YARD RADIOLOGICAL SURVEY FILE

1. Richards, C. D., "Building 064 Radiologic Survey and Sampling," Energy Technology Engineering Center, Report SSWA-SOP-0001 (February 28, 1992). *(The procedures and sampling plan used for this fenced-in yard survey.)*

2. Original radiation survey report forms (Form 732-A, Rev 1-91) used to record the fenced-in yard alpha, beta, and gamma survey counting measurements.

3. Radiation Protection and Health Physics Services Daily Instrument Qualification reports that record the daily instrument checks and background measurements performed during the survey periods.

4. Copies of the Building 064 Operations Log pages that document personnel activities during the February 1992 survey measurement period.

5. MicroSoft EXCEL spreadsheets that tabulate the survey data and perform the analyses converting the measurements to activity and exposure rate units.

6. Data records documenting the soil and asphalt radionuclide concentration measurements.

7. D. W. Kneff, R. J. Tuttle, and G. Subbaramaṅ, "Radiological Assessment of the Building T064 Fenced-In Yard," Rockwell International, Rocketdyne Division Supporting Document N704SRR990035 (December 1993). *(This final survey report.)*