ORISE
OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION

May 9, 2000

Mr. Mike Lopez
U.S. Department of Energy
Oakland Operations Office
1301 Clay Street 700N
Oakland, CA 94612-5208

SUBJECT: FINAL REPORT—VERIFICATION SURVEY OF BUILDING 4133, SANTA SUSANA FIELD LABORATORY, THE BOEING COMPANY, VENTURA COUNTY, CALIFORNIA

Dear Mr. Lopez:

Enclosed is the final report describing the procedures and results for the verification survey of Building 4133. Any comments provided on the draft report have been incorporated.

Please contact me at (865) 576-5073 or Eric Abelquist at (865) 576-3740 should you have any questions.

Sincerely,

Timothy J. Vitkus
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JRM:klp

Enclosure

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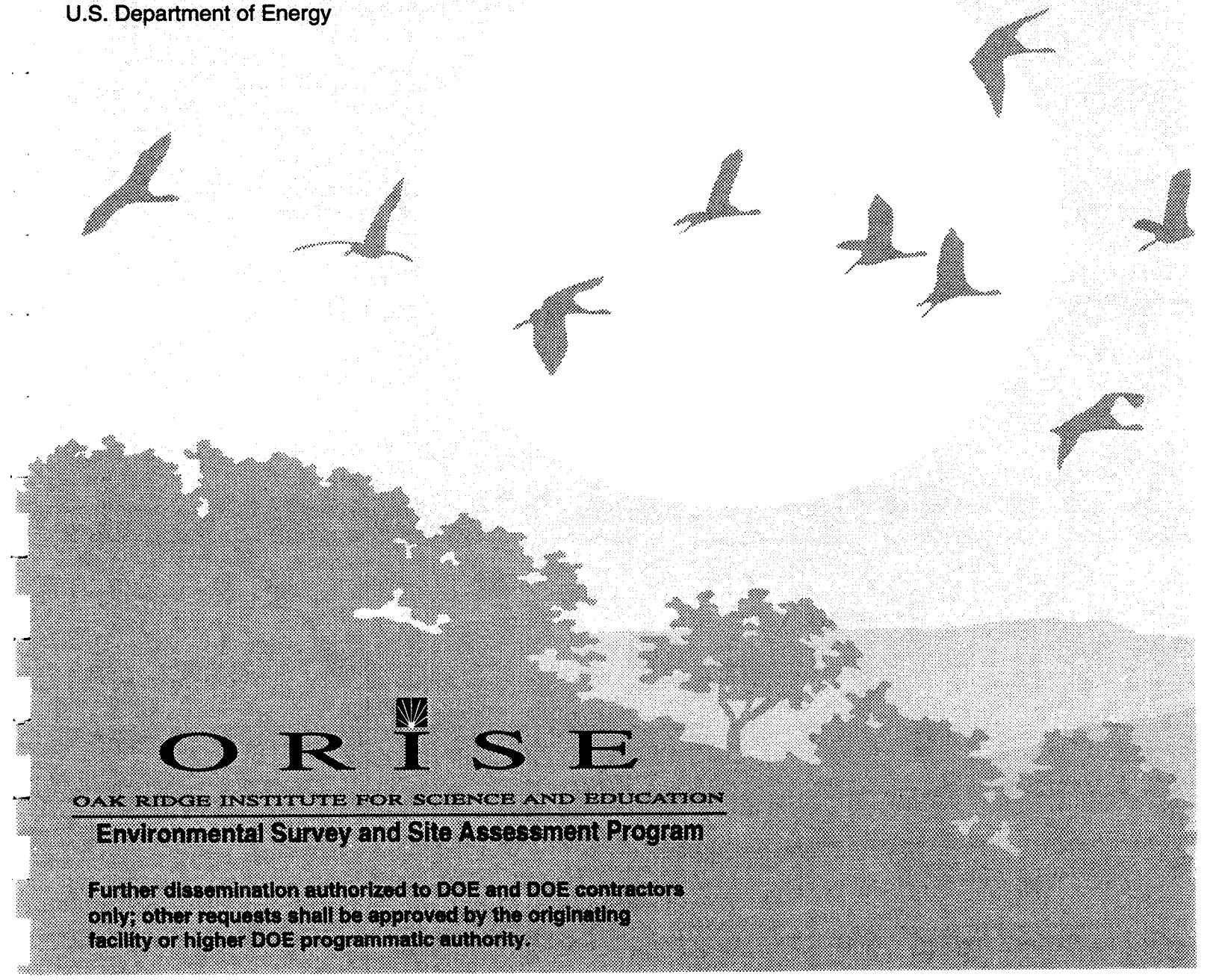
File/402

VERIFICATION SURVEY OF BUILDING 4133 SANTA SUSANA FIELD LABORATORY THE BOEING COMPANY VENTURA COUNTY, CALIFORNIA

J. R. MORTON

Prepared for the
Office of Site Closure
U.S. Department of Energy



ORISE
OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION
Environmental Survey and Site Assessment Program

The Oak Ridge Institute for Science and Education (ORISE) was established by the U.S. Department of Energy to undertake national and international programs in education, training, health, and the environment. ORISE and its programs are operated by Oak Ridge Associated Universities (ORAU) through a contract with the U.S. Department of Energy. Established in 1946, ORAU is a multiuniversity consortium.

VERIFICATION SURVEY OF BUILDING 4133 SANTA SUSANA FIELD LABORATORY THE BOEING COMPANY VENTURA COUNTY, CALIFORNIA

Prepared by

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Prepared for the
Office of Site Closure
U.S. Department of Energy

FINAL REPORT

APRIL 2000

This report is based on work performed under a contract with the U.S. Department of Energy.

VERIFICATION SURVEY
OF BUILDING 4133
SANTA SUSANA FIELD LABORATORY
THE BOEING COMPANY
VENTURA COUNTY, CALIFORNIA

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ABBREVIATIONS AND ACRONYMS

µrem/h	microrem per hour
µR/h	microroentgens per hour
AEC	Atomic Energy Commission
ASME	American Society of Mechanical Engineers
BKG	background
cm	centimeter
cm^2	square centimeter
cpm	counts per minute
D&D	decontamination and decommissioning
$DCGL_w$	derived concentration guideline level
DOE	U.S. Department of Energy
dpm/100 cm^2	disintegrations per minute per one hundred square centimeters
EML	Environmental Measurements Laboratory
ERDA	Energy Research and Development Administration
ϵ_i	instrument efficiency
ϵ_s	source efficiency
ESSAP	Environmental Survey and Site Assessment Program
ETEC	Energy Technology Engineering Center
ha	hectare
HWMF	Hazardous Waste Management Facility
ITP	Intercomparison Test Program
kg	kilogram
km	kilometer
m^2	square meters
MAPEP	Mixed Analyte Performance Evaluation Program
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MeV	million electron volts
mm	millimeter
M&O	Management and Operation
MDC	minimum detectable concentration
NaI	sodium iodide
NIST	National Institute of Standards and Technology
NRC	U.S. Nuclear Regulatory Commission
ORISE	Oak Ridge Institute for Science and Education
pCi/g	picocuries per gram
pCi/l	picocuries per liter
SSFL	Santa Susana Field Laboratory

VERIFICATION SURVEY
OF BUILDING 4133
SANTA SUSANA FIELD LABORATORY
THE BOEING COMPANY
VENTURA COUNTY, CALIFORNIA

INTRODUCTION AND SITE HISTORY

Rocketdyne Propulsion and Power of the Boeing Company (Rocketdyne), formerly Rockwell International Rocketdyne Division, operates the Santa Susana Field Laboratory (SSFL). The Energy Technology Engineering Center (ETEC) is that portion of the SSFL, operated for the U.S. Department of Energy (DOE), which performed testing of equipment, materials, and components for nuclear and energy related programs. Contract work for the Atomic Energy Commission (AEC) and the Energy Research and Development Administration (ERDA), predecessor agencies to the DOE, began in the early 1950's. Specific programs conducted for AEC/ERDA/DOE involved engineering, developing, testing, and manufacturing operations for nuclear reactor systems and components. Other SSFL activities have also been conducted for the National Aeronautics and Space Administration, the U.S. Department of Defense, and other government related or affiliated organizations and agencies. Some activities have been licensed by the U.S. Nuclear Regulatory Commission (NRC) and by the Radiologic Health Branch of the State of California Department of Health Services.

Numerous buildings and land areas became radiologically contaminated as a result of the various operations which included ten reactors, seven criticality test facilities, fuel fabrication, reactor and fuel disassembly, laboratory work, and on-site storage of nuclear material. Potential radioactive contaminants identified at the site are uranium (predominantly in enriched isotopic abundances), plutonium, Am-241, fission products (primarily Cs-137 and Sr-90), and activation products (tritium [H-3], Co-60, Eu-152, Eu-154, and Ni-63). Chemical contaminants, mainly chlorinated organic solvents, have also been identified in groundwater, primarily as a result of rocket engine testing.

Decontamination and decommissioning (D&D) of contaminated facilities began in the late 1960's, but accelerated in the 1990's, as the remaining DOE program operations at ETEC were terminated. As part of this D&D program, Rocketdyne performed decommissioning and final status surveys of

a number of facilities that supported the various nuclear-related ETEC operations during the latter part of the 1950's and continuing through to the present. Environmental management of DOE contaminated properties continues under the termination clause of the existing Management and Operation (M&O) contract. A facility that was recently addressed was Building 4133.

Building 4133, known as the Hazardous Waste Management Facility (HWMF), was built to treat non-radioactive sodium and NaK from non-radioactive test loops and secondary sodium loops. Although this facility was not considered a radioactive facility and did not handle any radioactive material, Rocketdyne performed a final status radiological survey because an earlier facility, used for similar purposes, had become radiologically contaminated in the 1960's and 70's. The survey of Building 4133 was, therefore, performed to confirm the absence of radiological contamination.

DOE's Office of Site Closure—previously the Office of Environmental Restoration, Northwestern Area Programs—is responsible for oversight of a number of remedial actions that have been, or will be conducted at the SSFL. It is the policy of DOE to perform independent (third party) verification of remedial action activities. The purpose of these independent verification activities is to confirm that remedial actions have been effective in meeting established and site-specific guidelines and that the documentation accurately and adequately describes the radiological conditions at the site. The Environmental Survey and Site Assessment Program (ESSAP) of the Oak Ridge Institute for Science and Education (ORISE) was designated as the organization responsible for this task at SSFL, and was requested to verify the current radiological status of Building 4133.

SITE DESCRIPTION

The SSFL is located in the Simi Hills of southeastern Ventura County, California, approximately 47 kilometers (km [29 miles]) northwest of downtown Los Angeles (Figure 1). The site is comprised of approximately 1,090 hectares (ha[2,700 acres]) and is divided into four administrative areas (Areas I through IV) and a Buffer Zone. DOE operations were conducted in Boeing/Rocketdyne-owned facilities located within the 117 ha Area IV. The ETEC portion of Area IV consists of government-owned buildings that occupy 36 ha.

included those areas where slight contamination may have existed, but at levels less than the $DCGL_W$. Class 3 survey units included areas where no contamination existed during the building's history. All surveyed units within the Building 4133 facility were designated as Class 2.

Reference System

Measurement and sampling locations were referenced to the existing grid established by Rocketdyne. Any measurements or sampling on ungridded surfaces were referenced to the floor and lower wall grids or prominent building features.

Surface Scans

Surface scans for gamma and beta activity were performed on 25 to 50 percent of building surfaces. Scans were performed using NaI scintillation and gas proportional detectors coupled to ratemeters or ratemeter-scalers with audible indicators. GM detectors were also used to survey locations that were difficult to access using the larger hand-held gas proportional detectors. Particular attention was given to cracks and joints in the floor and walls, ledges, drains, ducts, and other locations where material may have accumulated.

Surface Activity Measurements

Construction material-specific surface activity measurements were used for correcting gross surface activity measurements (NRC 1998). Direct measurements for beta surface activity were performed at a total of 13 locations within Building 4133 (Figures 4 through 6). One smear sample for the determination of removable activity was collected at each direct measurement location. Direct measurements were made using gas proportional detectors coupled to ratemeter-scalers.

Exposure Rate Measurements

Exposure rates were measured at one meter above the surface at two locations within Building 4133 using a microrem meter (Figures 4 and 5). The Rocketdyne-determined background exposure rates measurements were used for comparison.

EXTERIOR SURVEY PROCEDURES

The following procedures were applicable for the survey of the exterior portions of the Building 4133 facility.

Reference System

Measurement and sampling locations were referenced to the grid established by Rocketdyne.

Surface Scans

Surface scans for gamma activity were performed over 100 percent of the exterior areas using NaI scintillation detectors coupled to ratemeters with audible indicators. In addition, surface scans for beta activity were performed over approximately 50 percent of the paved portions of the Building 4133 exterior area and the T-1 Tank Pit. Beta scans were performed using large-area gas proportional detectors coupled to ratemeter-scalers with audible indicators.

Surface Activity Measurements

Construction material-specific surface activity measurements were used for correcting gross surface activity measurements (NRC 1998). Direct measurements for beta surface activity were performed at a total of four locations within the T-1 Tank Pit (Figure 7). One smear sample for the determination of removable activity was collected at each direct measurement location. Direct measurements were made using gas proportional detectors coupled to ratemeter-scalers.

Exposure Rate Measurements

Exposure rates at one meter above the surface were measured at three soil sample locations using a microrem meter (Figure 3). Background exposure rates, used for comparison, were performed during a previous site survey (ORISE 1996).

Soil Sampling

Surface (0-15 cm) soil samples were collected from a total of three locations within Building 4133 exterior soil areas (Figure 3). Background soil samples collected during a previous site survey were used for comparison purposes (ORISE 1996).

SAMPLE ANALYSIS AND DATA INTERPRETATION

Samples and data were returned to ORISE's ESSAP laboratory in Oak Ridge, Tennessee for analysis and interpretation. Sample analyses were performed in accordance with the ORISE/ESSAP Laboratory Procedures Manual (ORISE 1999b). Soil samples were analyzed by gamma spectrometry and results reported in picocuries per gram (pCi/g). The radionuclides of interest were mixed fission and activation products, primarily Cs-137; however, gamma spectra were reviewed for other identifiable photopeaks. Smears were analyzed for gross alpha and gross beta activity using a low-background proportional counter. Smear data and direct measurement data were converted to units of disintegrations per minute per one hundred square centimeters (dpm/100 cm^2). Exposure rates were reported in units of microroentgens per hour (μR/h). The data generated were compared with Rocketdyne documentation and the DOE generic and site-specific guidelines established for release for unrestricted use.

FINDINGS AND RESULTS

DOCUMENT REVIEW

ESSAP's review of Rocketdyne's preliminary draft procedure and field data indicated that most procedures and methods used by Rocketdyne were appropriate and that data indicated that surface activity and soil concentration levels were below unrestricted release criteria.

INTERIOR

Surface Scans

Surface scans did not identify any locations of direct radiation in excess of ambient background levels.

Surface Activity Levels

Results of the total and removable surface activity levels are summarized in Table 1. Total beta surface activity levels ranged from -900 to 2,300 dpm/100 cm^2. Removable surface activity levels ranged from 0 to 3 dpm/100 cm^2 for alpha and from -4 to 6 dpm/100 cm^2 for beta.

Exposure Rates

Exposure rates are summarized in Table 2. Rocketdyne-determined background exposure rates for Area IV SSFL structures averaged 8 μR/h, while ESSAP site exposure rates, including background, ranged from 7 to 9 μR/h.

EXTERIOR

Surface Scans

Surface scans for beta and gamma activity did not identify any locations of direct radiation in excess of ambient background levels.

Surface Activity Levels

Results of the total and removable surface activity levels of the T-1 Tank behind Building 4133 are summarized in Table 1. Total beta surface activity levels ranged from -440 to 770 dpm/100 cm^2. Removable surface activity levels ranged from 0 to 1 dpm/100 cm^2 for alpha and from -2 to 6 dpm/100 cm^2 for beta.

Exposure Rates

Exposure rates are summarized in Table 2. Background exterior exposure rates for SSFL averaged 14 μR/h, while ESSAP site exposure rates, including background, ranged from 15 to 17 μR/h.

Radionuclide Concentrations in Soil

Concentrations of radionuclides in soil samples collected from the exterior portions of Building 4133 are provided in Table 3. The radionuclide concentrations were as follows: less than 0.1 pCi/g for Am-241, 0.3 to 0.6 pCi/g for Cs-137, 0.7 to 0.9 pCi/g for Ra-226, 1.1 pCi/g for Th-228, less than 9.5 pCi/g for Th-230, 0.9 to 1.3 pCi/g for Th-232, less than 0.3 pCi/g for U-235, and less than 0.1 to 0.8 pCi/g for U-238.

COMPARISON OF RESULTS WITH GUIDELINES

Surface activity levels were compared to the appropriate residual radioactive material guidelines specified in DOE Order 5400.5 for mixed fission products (DOE 1990). The applicable guidelines are as follows:

Total Activity

5,000 β-γ dpm/100 cm^2, average in a 1 m^2 area

15,000 β-γ dpm/100 cm^2, maximum in a 100 cm^2 area

Removable Activity

1000 β-γ dpm /100 cm^2

All residual surface activity levels satisfied these guidelines.

The applicable site-specific soil guidelines are provided in Table 4 and have been approved by both the DOE and State of California (DOE 1996 and State of California 1996). Individual soil results were within these guidelines.

The DOE's exposure rate guideline is 20 μR/h above background (DOE 1990), although Rocketdyne has elected to use a more restrictive guideline of 5 μR/h above background. All exposure rates were below this guideline.

SUMMARY

On October 28, 1999, the Environmental Survey and Site Assessment Program performed verification surveys of the Building 4133 facility at the Santa Susana Field Laboratory. Verification activities included document reviews, surface scans, surface activity measurements, exposure rate measurements, and soil sampling.

All total and removable surface activity levels satisfied the DOE average and maximum guidelines for release for unrestricted use. All soil samples and exposure rate measurements were less than the guideline levels. The ESSAP survey results, therefore, verify the Rocketdyne conclusion that Building 4133 satifies the criteria for release for unrestricted use.

FIGURES

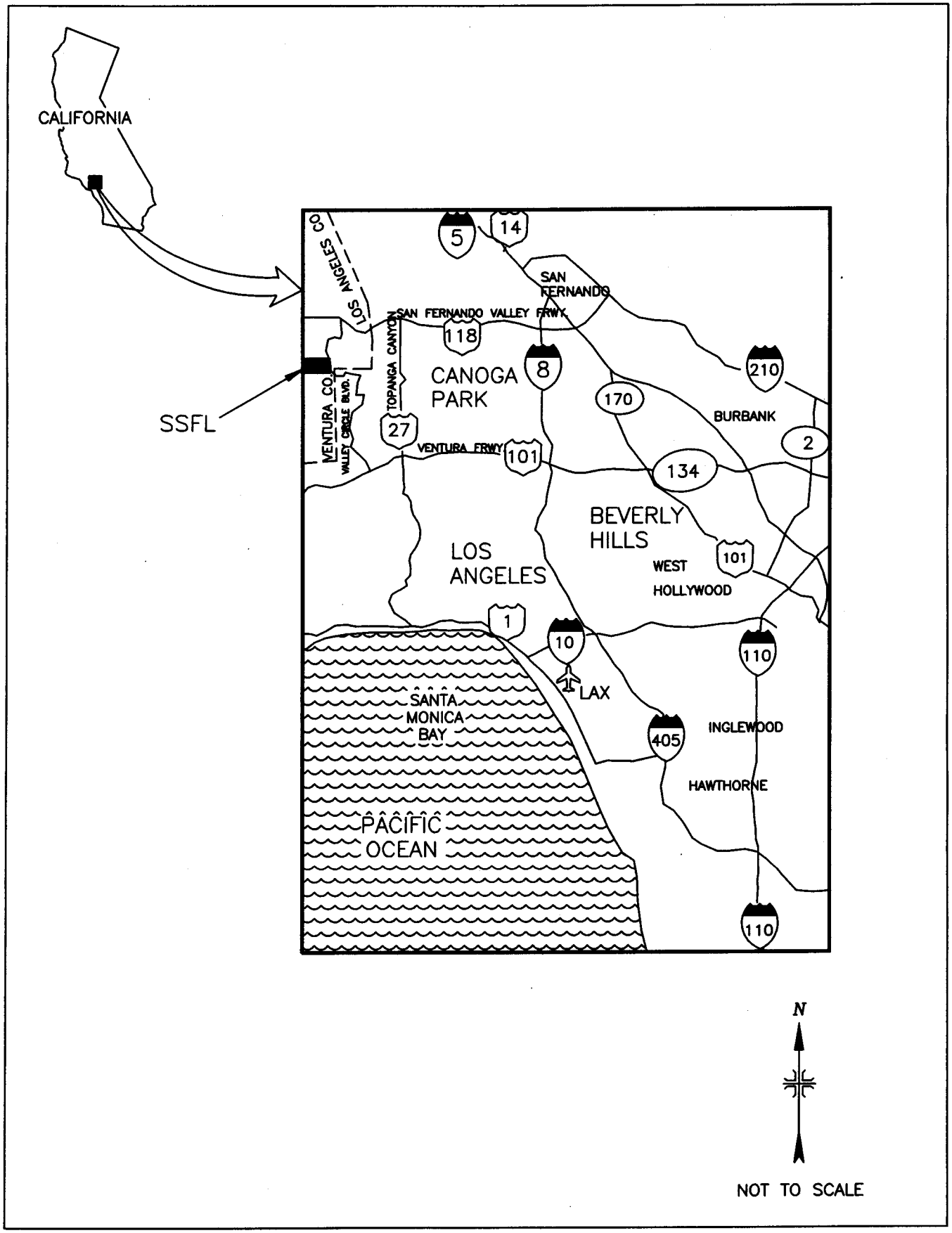

FIGURE 1: Los Angeles California Area – Location of Santa Susana Field Laboratory Site

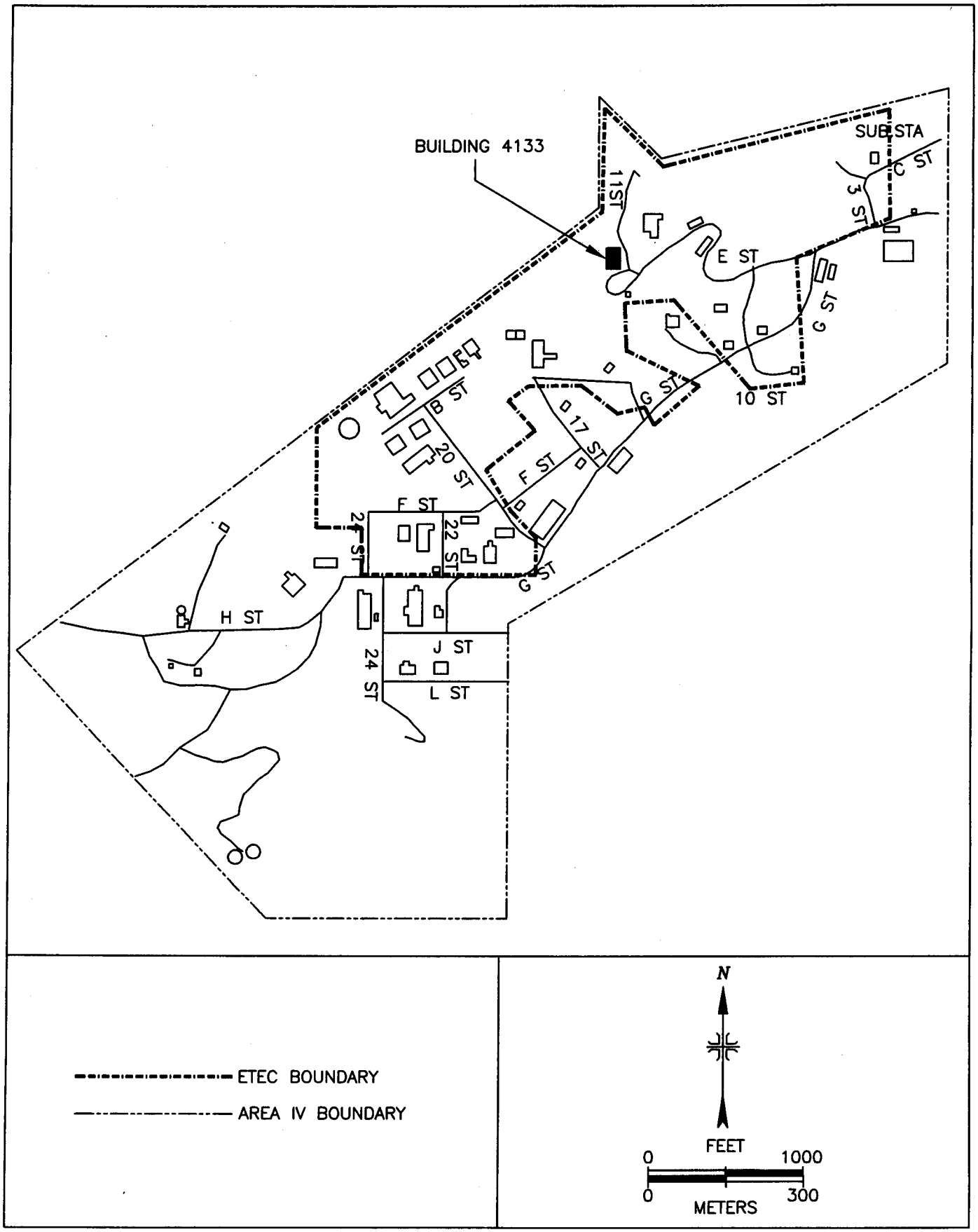

FIGURE 2: Santa Susana Field Laboratory Area IV, Plot Plan – Location of Building 4133

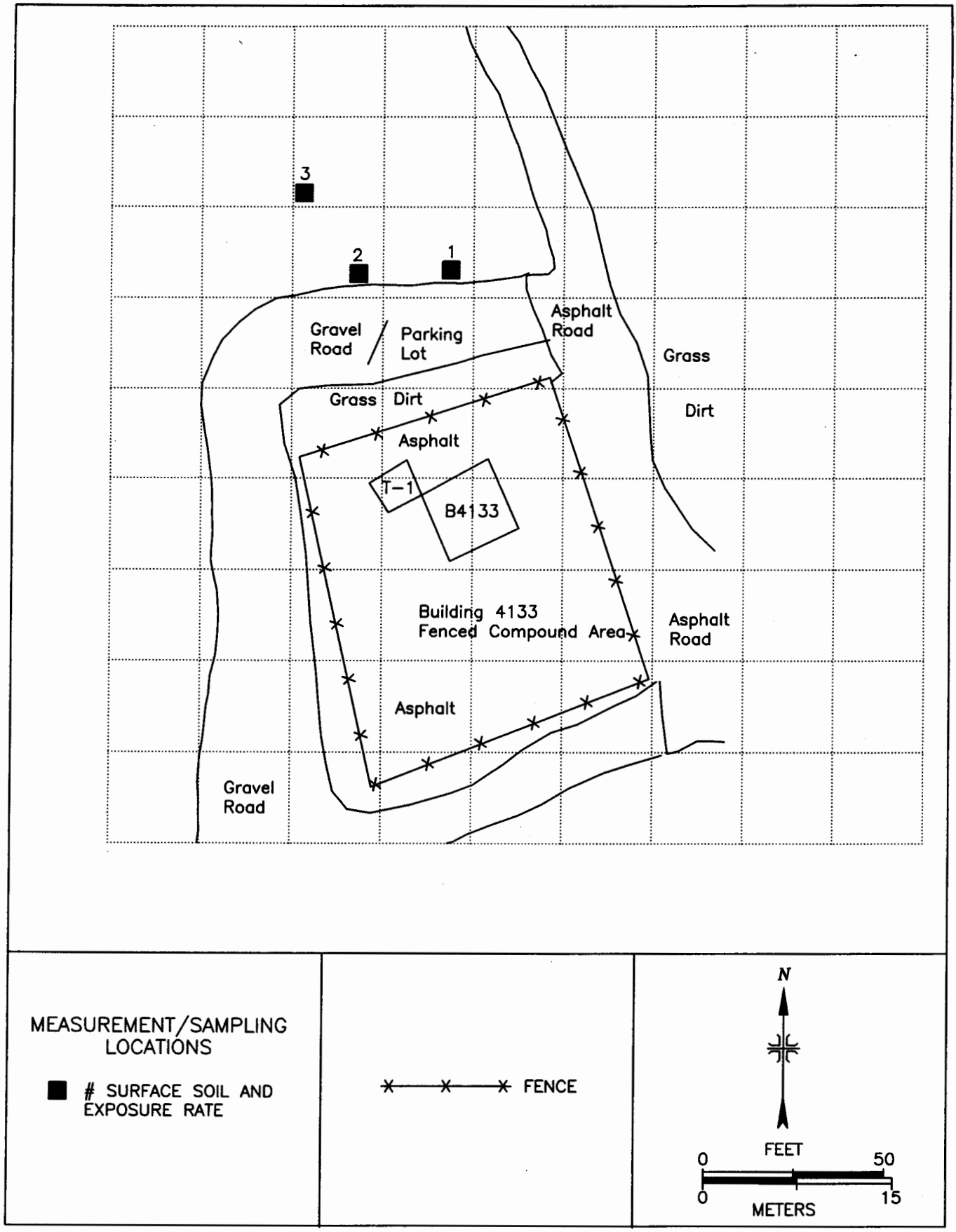

FIGURE 3: Building 4133, Exterior – Measurement and Sampling Locations

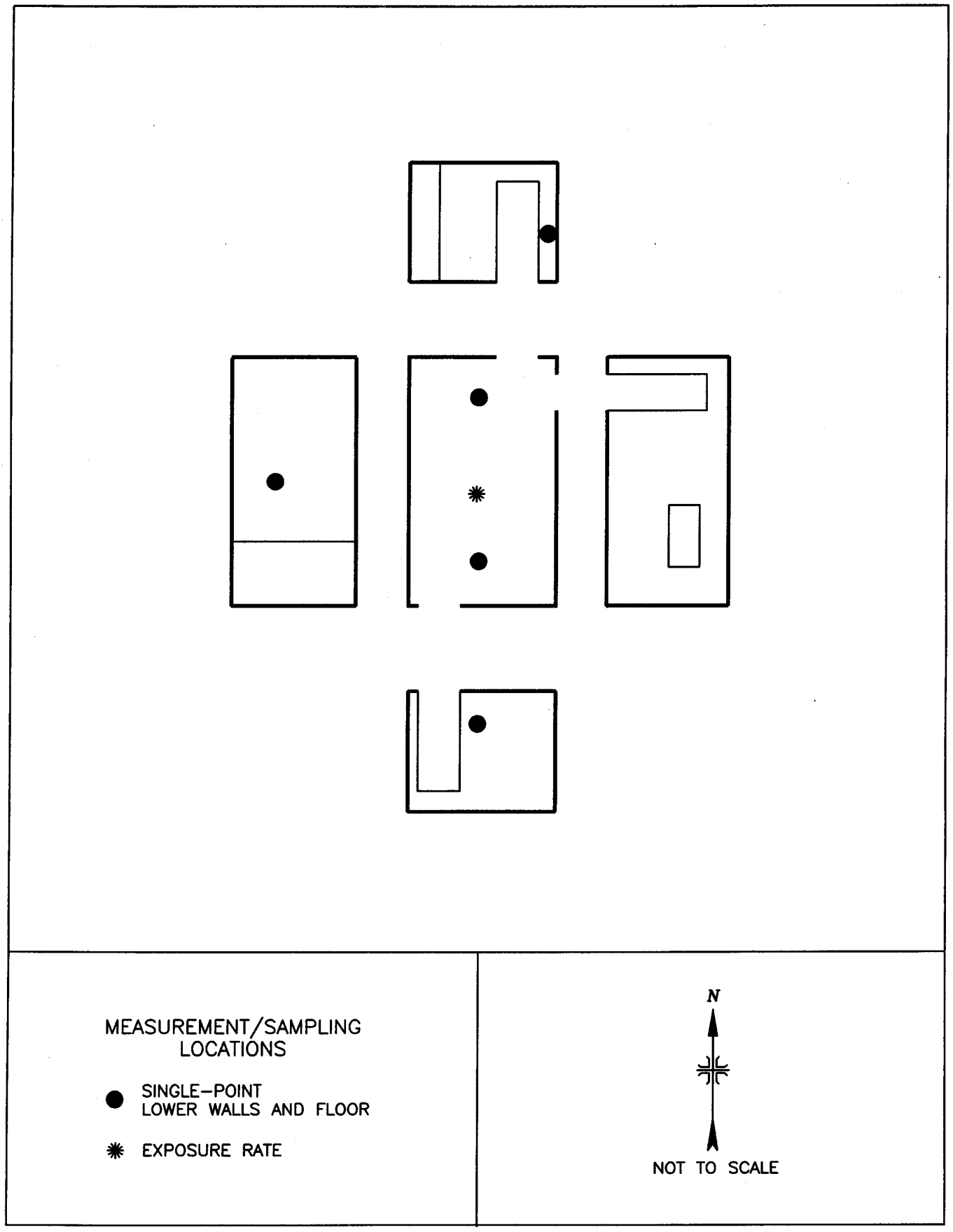

FIGURE 4: Building 4133, Office – Measurement and Sampling Locations

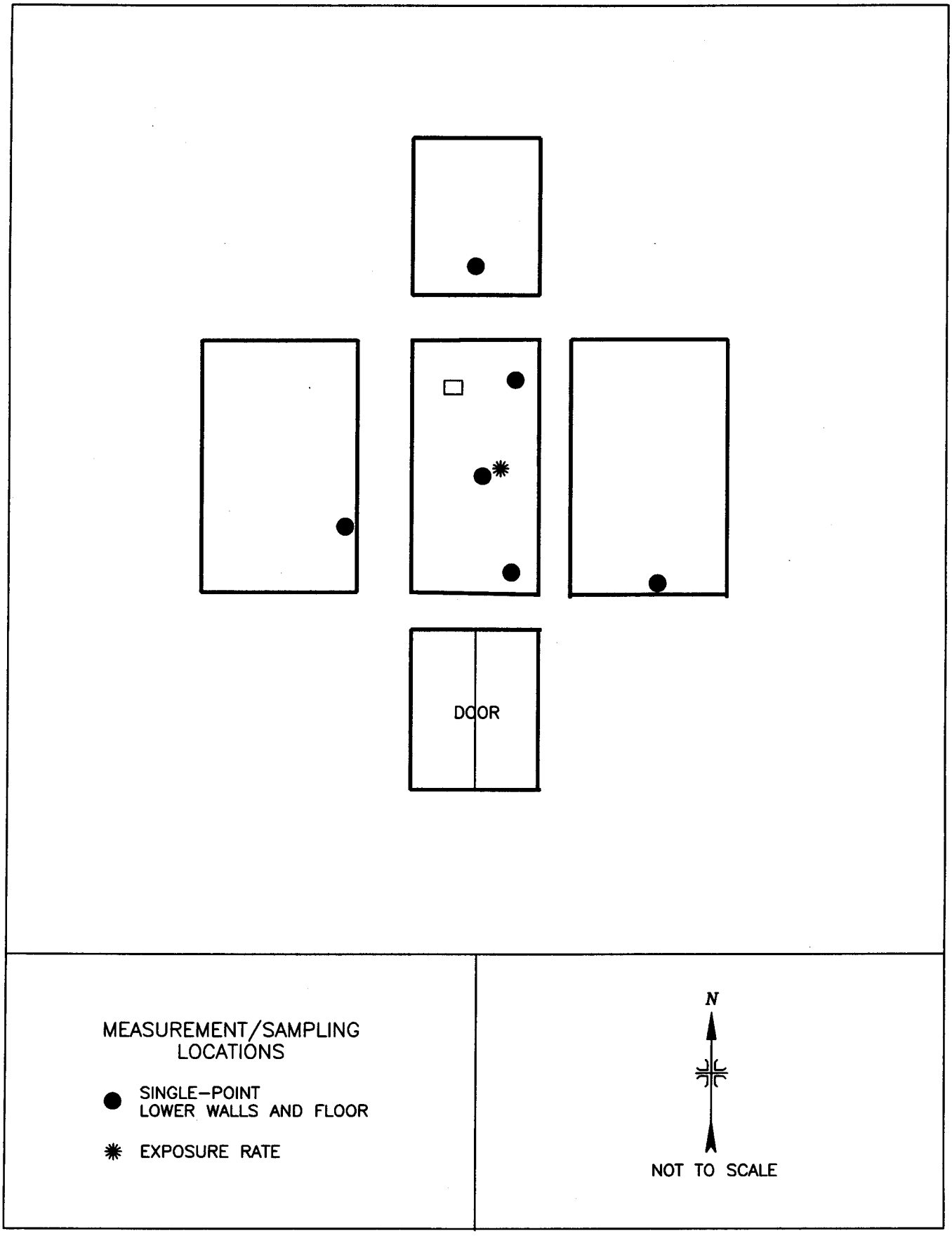

FIGURE 5: Building 4133, Treatment Room – Measurement and Sampling Locations

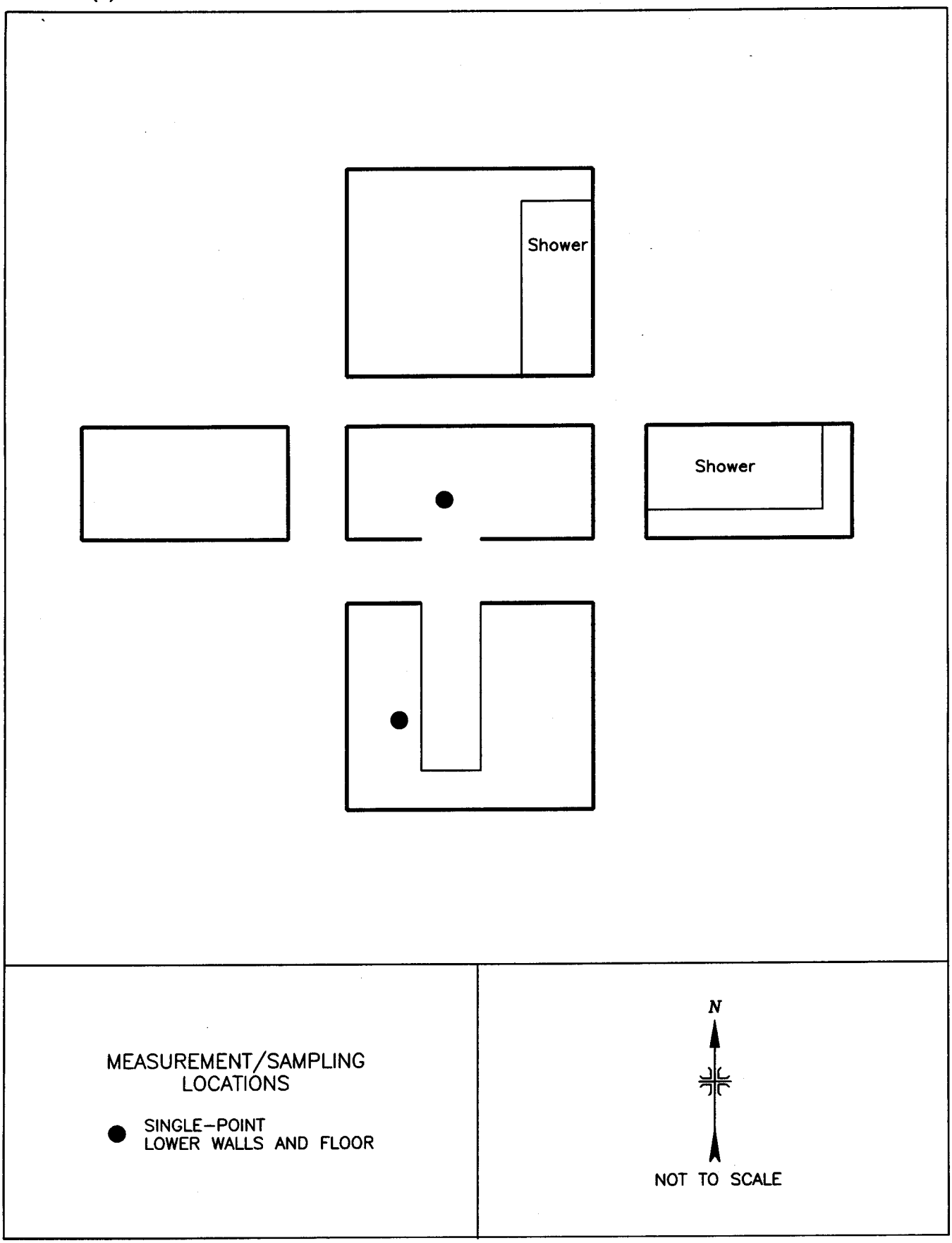

FIGURE 6: Building 4133, Restroom – Measurement and Sampling Locations

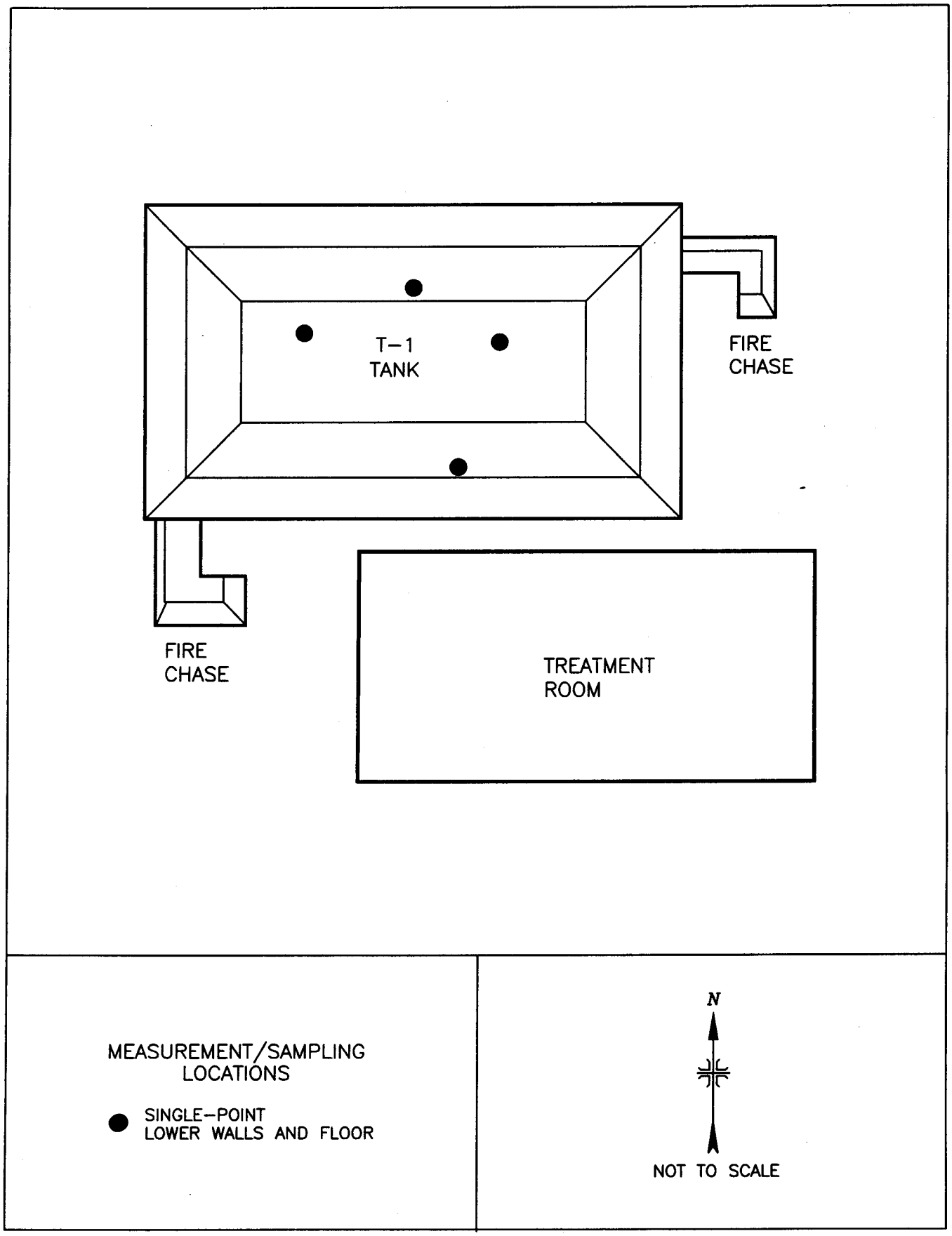

FIGURE 7: Building 4133, T-1 Tank – Measurement and Sampling Locations

TABLES

TABLE 1

SUMMARY OF SURFACE ACTIVITY LEVELS
BUILDING 4133
SANTA SUSANA FIELD LABORATORY
THE BOEING COMPANY
VENTURA COUNTY, CALIFORNIA

Location[a]	Number of Measurement Locations	Total Activity Range (dpm/100 cm^2)	Removable Activity Range (dpm/100 cm^2)[b]	
	Single-point	Beta	Alpha	Beta
Treatment Room	6	-900 to 1,800	0 to 1	-4 to 4
Office	5	-370 to 2,300	0	-3 to 2
Restroom	2	-420 to 2,200	1 to 3	-1 to 6
T1 Tank	4	-440 to 770	0 to 1	-2 to 6

[a] Refer to Figures 4 through 7.
[b] MDC for the procedure is 12 dpm/100 cm^2 for alpha and 16 dpm/100 cm^2 for beta.

TABLE 2

EXPOSURE RATES
BUILDING 4133
SANTA SUSANA FIELD LABORATORY
THE BOEING COMPANY
VENTURA COUNTY, CALIFORNIA

Location[a]	Exposure Rate at 1m (μR/h)
Treatment Room	7
Office	9
Exterior Areas	15 to 17

[a]Refer to Figures 3 through 5.

TABLE 3

RADIONUCLIDE CONCENTRATIONS IN SOIL
BUILDING 4133
SANTA SUSANA FIELD LABORATORY
ROCKWELL INTERNATIONAL
VENTURA COUNTY, CALIFORNIA

Location[a]	Radionuclide Concentrations (pCi/g)							
	Am-241	Cs-137	Ra-226	Th-228	Th-230	Th-232	U-235	U-238
1	<0.1	0.3 ± 0.1[b]	0.7 ± 0.2	1.1 ± 0.3	<9.5	0.9 ± 0.2	<0.3	<0.1
2	<0.1	0.6 ± 0.1	0.9 ± 0.1	1.1 ± 0.1	<5.4	1.2 ± 0.2	<0.1	0.8 ± 0.5
3	<0.1	0.6 ± 0.1	0.8 ± 0.1	1.1 ± 0.1	<5.4	1.3 ± 0.2	<0.2	0.7 ± 0.5

[a] Refer to Figure 3.
[b] Uncertainties are total propagated uncertainties at the 95% confidence level.

TABLE 4

GENERIC LIMITS FOR SOIL AND WATER (REFERENCE N001SRR140127)[a] SANTA SUSANA FIELD LABORATORY VENTURA COUNTY, CALIFORNIA

Radionuclide	Soil Guidelines (pCi/g)	Water (pCi/l)
Am-241	5.44	1.5
Co-60	1.94	200
Cs-134	3.33	75
Cs-137	9.20	110
Eu-152	4.51	840
Eu-154	4.11	570
Fe-55	629,000	9,000
H-3	31,900	20,000[b]
K-40	27.6	290
Mn-54	6.11	2,000
Na-22	2.31	480
Ni-59	151,000	26,000
Ni-63	55,300	9,500
Pu-238	37.2	1.7
Pu-239	33.9	1.6
Pu-240	33.9	1.6
Pu-241	230	80
Pu-242	35.5	1.6
Ra-226	5[d] and 15[d]	4.1
Sr-90	36.0	8[b]
Th-228	5[d] and 15[d]	6.8

TABLE 4 (Continued)

GENERIC LIMITS FOR SOIL AND WATER (REFERENCE N001SRR140127)[a] SANTA SUSANA FIELD LABORATORY VENTURA COUNTY, CALIFORNIA

Radionuclide	Soil Guidelines (pCi/g)	Water (pCi/l)
Th-232	5[d] and 15[d]	2.0
U-234	30[c]	
U-235	30[c]	total uranium 20[b]
U-238	35[c]	
Gross alpha (not including radon and uranium)	---	15[b]
Gross beta	---	50[b]

[a]Reference taken from Rocketdyne/Boeing 96ETEC-DRF-0374, Enclosure A, June 28, 1996.
[b]State of California Maximum Contaminant Levels, CCR Title 22.
[c]Generally more conservative NRC limits for uranium isotopes are proposed.
[d]DOE Order 5400.5 limits are proposed (5 pCi/g averaged over first 15 cm of soil depth and 15 pCi/g averaged over 15 cm layers below the top 15 cm).

REFERENCES

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U.S. Department of Energy. Memorandum from S. Robinson to R. Liddle, "Sitewide Limits for Release of Facilities Without Radiological Restrictions", September 17, 1996.

U.S. Nuclear Regulatory Commission. Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions. NUREG-1507. Washington, DC; June 1998.

APPENDIX A

MAJOR INSTRUMENTATION

APPENDIX A

MAJOR INSTRUMENTATION

The display of a specific product is not to be construed as an endorsement of the product or its manufacturer by the author or his employer.

DIRECT RADIATION MEASUREMENT

Instruments

Eberline Pulse Ratemeter
Model PRM-6
(Eberline, Santa Fe, NM)

Ludlum Ratemeter-Scaler
Model 2221
(Ludlum Measurements, Inc.,
Sweetwater, TX)

Detectors

Bicron Micro-Rem Meter
(Bicron Corporation, Newburg, OH)

Eberline GM Detector
Model HP-260
Physical Probe, 20 cm^2
(Eberline, Santa Fe, NM)

Ludlum Gas Proportional Detector
Model 43-37
Physical Probe, 550 cm^2
(Ludlum Measurements, Inc.,
Sweetwater, TX)

Ludlum Gas Proportional Detector
Model 43-68
Physical Probe, 126 cm^2
(Ludlum Measurements, Inc.,
Sweetwater, TX)

Victoreen NaI Scintillation Detector
Model 489-55
3.2 cm x 3.8 cm Crystal
(Victoreen, Cleveland, OH)

LABORATORY ANALYTICAL INSTRUMENTATION

High Purity Extended Range Intrinsic Detectors
Model No: ERVDS30-25195
(Tennelec, Oak Ridge, TN)
Used in conjunction with:
Lead Shield Model G-11
(Nuclear Lead, Oak Ridge, TN) and
Multichannel Analyzer
DEC Alpha Workstation
(Canberra, Meriden, CT)

High Purity Extended Range Intrinsic Detector
Model No. GMX-45200-5
(ORTEC)
used in conjunction with:
Lead Shield Model SPG-16-K8
(Nuclear Data)
Multichannel Analyzer
DEC Alpha Workstation
(Canberra, Meriden, CT)

High Purity Germanium Detector
Model GMX-23195-S, 23% Eff.
(EG&G ORTEC, Oak Ridge, TN)
Used in conjunction with:
Lead Shield Model G-16
(Gamma Products, Palos Hills, IL) and
Multichannel Analyzer
DEC Alpha Workstation
(Canberra, Meriden, CT)

Low-Background Gas Proportional Counter
Model LB-5100-W
(Oxford, Oak Ridge, TN)

APPENDIX B

SURVEY AND ANALYTICAL PROCEDURES

APPENDIX B
SURVEY AND ANALYTICAL PROCEDURES

SURVEY PROCEDURES

Surface Scans

Surface scans were performed by passing the detectors slowly over the surface; the distance between the detector and the surface was maintained at a minimum—nominally about 1 cm. A large surface area, gas proportional floor monitor was used to scan the floors of the surveyed areas. Other surfaces were scanned using small area (20 cm^2 or 126 cm^2) hand-held detectors. Identification of elevated levels was based on increases in the audible signal from the recording and/or indicating instrument. Combinations of detectors and instruments used for the scans were:

Beta - gas proportional detector with ratemeter-scaler

Beta-Gamma - GM detector with ratemeter-scaler

Gamma - NaI scintillation detector with ratemeter

Surface Activity Measurements

Measurements of total beta activity levels were performed using gas proportional detectors with portable ratemeter-scalers.

Because different building materials (poured concrete, brick, wood, steel, etc.) may have different background levels, average background count rates were determined for each material encountered in the surveyed area at a location of similar construction and having no known radiological history. The beta activity background count rates for the gas proportional detectors averaged 332 cpm for concrete block and floors, 302 for drywall, and 303 cpm for metal.

Count rates (cpm), which were integrated over one minute in a static position, were converted to

activity levels (dpm/100 cm^2) by dividing the net rate by the total efficiency ($\epsilon_i \times \epsilon_s$) and correcting for the active area of the detector. The 2π instrument efficiency factor (ϵ_i) was 0.39 for the gas proportional detectors calibrated to Tc-99. The source efficiency factor (ϵ_s) was 0.25. Therefore, the total efficiency factor for the beta detectors was 0.10. The beta minimum detectable concentrations (MDC) ranged from 660 to 690 dpm/100 cm^2, depending on the surface material. The physical probe area for the gas proportional detectors was 126 cm^2.

Removable Activity Measurements

Removable gross alpha and gross beta activity levels were determined using numbered filter paper disks, 47 mm in diameter. Moderate pressure was applied to the smear and approximately 100 cm^2 of the surface was wiped. Smears were placed in labeled envelopes with the location and other pertinent information recorded.

Exposure Rate Measurements

Measurements of dose equivalent rates (μrem/h) were performed at 1 m above the surface using a Bicron *microrem* meter. Although the instrument displays data in μrem/h—the conversion to μR/h is essentially unity.

Soil Sampling

Approximately 1 kg of soil was collected at each sample location. Collected samples were placed in a plastic bag, sealed, and labeled in accordance with ESSAP survey procedures.

ANALYTICAL PROCEDURES

Gross Alpha/Beta

Smears were counted on a low-background gas proportional system for gross alpha and gross beta activity.

Gamma Spectroscopy

Samples of soil were dried, mixed, crushed, and/or homogenized as necessary, and a portion sealed in a 0.5-liter Marinelli beaker or other appropriate container. The quantity placed in the beaker was chosen to reproduce the calibrated counting geometry. Net material weights were determined and the samples counted using intrinsic germanium detectors coupled to a pulse height analyzer system. Background and Compton stripping, peak search, peak identification, and concentration calculations were performed using the computer capabilities inherent in the analyzer system. All photopeaks associated with the radionuclides of concern were reviewed for consistency of activity. Energy peaks used for determining the activities of radionuclides of concern were:

Am-241	0.059 MeV
Ra-226	0.351 MeV from Pb-214*
Th-228	0.239 MeV from Pb-212*
Th-230	0.067 MeV
Th-232	0.911 MeV from Ac-228*
U-235	0.143 MeV (or 0.186 MeV)
U-238	0.063 MeV from Th-234* (or 1.001 MeV from Pa-234 m)*
Cs-137	0.662 MeV

*Secular equilibrium assumed.

Spectra were also reviewed for other identifiable photopeaks.

UNCERTAINTIES AND DETECTION LIMITS

The uncertainties associated with the analytical data presented in the tables of this report represent total propagated uncertainty at the 95% confidence level. These uncertainties were calculated based on both the gross sample count levels and the associated background count levels. Detection limits, referred to as minimum detectable concentration (MDC), were based on 3 plus 4.65 times the standard deviation of the background count [$3 + (4.65\sqrt{BKG})$]. Because of variations in background levels, measurement efficiencies, and contributions from other radionuclides in samples, the detection limits differ from sample to sample and instrument to instrument.

CALIBRATION AND QUALITY ASSURANCE

Calibration of all field and laboratory instrumentation was based on standards/sources, traceable to NIST, when such standards/sources were available. In cases where they were not available, standards of an industry-recognized organization were used.

Analytical and field survey activities were conducted in accordance with procedures from the following documents of the Environmental Survey and Site Assessment Program:

- Survey Procedures Manual, (January 1998)
- Laboratory Procedures Manual, (October 1999)
- Quality Assurance Manual, (May 1998)

The procedures contained in these manuals were developed to meet the requirements of DOE Order 414.1A and ASME NQA-1 for Quality Assurance and contain measures to assess processes during their performance.

Quality control procedures include:

- Daily instrument background and check-source measurements to confirm that equipment operation is within acceptable statistical fluctuations.
- Participation in and EML, ITP, and MAPEP laboratory Quality Assurance Programs.
- Training and certification of all individuals performing procedures.
- Periodic internal and external audits.

APPENDIX C

SUMMARY OF DEPARTMENT OF ENERGY RESIDUAL RADIOACTIVE MATERIAL GUIDELINES

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BASIC DOSE LIMITS

The basic dose limit for the annual radiation dose (excluding radon) received by an individual member of the general public is 100 mrem/yr. In implementing this limit, DOE applies as low as reasonably achievable principles to set site-specific guidelines.

EXTERNAL GAMMA RADIATION

The average level of gamma radiation inside a building or habitable structure on a site that has no radiological restriction on its use shall not exceed the background level by more than 20 μR/h and will comply with the basic dose limits when an appropriate-use scenario is considered.

SURFACE CONTAMINATION GUIDELINES

	Allowable Total Residual Surface Contamination (dpm/100 cm^2)[a]		
Radionuclides[b]	Average[c,d]	Maximum[d,e]	Removable[d,f]
Transuranics, Ra-226, Ra-228, Th-230 Th-228, Pa-231, Ac-227, I-125, I-129	100	300	20
Th-Natural, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000	3,000	200
U-Natural, U-235, U-238, and associated decay products	5,000α	15,000α	1,000α
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above	5,000β-γ	15,000β-γ	1,000β-γ

[a] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute measured by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[b] Where surface contamination by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides should apply independently.

[c] Measurements of average contamination should not be averaged over an area of more than 1 m^2. For objects of less surface area, the average should be derived for each such object.

[d] The average and maximum dose rates associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at a depth of 1 cm.

[e] The maximum contamination level applies to an area of not more than 100 cm^2.

[f] The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping an area of that size with dry filter or soft absorbent paper, applying moderate pressure, and measuring the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of surface area less than 100 cm^2 is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. The numbers in this column are maximum amounts.

SOIL GUIDELINES

Radionuclides	**Soil Concentration (pCi/g) Above Background[a,b,c]**
Radium-226, Radium-228, Thorium-230, Thorium-232	5 pCi/g, averaged over the first 15 cm of soil below the surface; 15 pCi/g, averaged over 15-cm-thick layers of soil more than 15 cm below the surface.
Others	Calculated on a site-specific basis, using the DOE manual developed for this use.

[a] These guidelines take into account ingrowth of radium-226 from thorium-230 or thorium-232 and radium-228 and assume secular equilibrium. If either Th-230 and Ra-226 or Th-232 and Ra-228 are both present, not in secular equilibrium, the guidelines apply to the higher concentration. If other mixtures of radionuclides occur, the concentrations of individual radionuclides shall be reduced so that (1) the dose for the mixtures will not exceed the basic dose limit, or (2) the sum of ratios of the soil concentration of each radionuclide to the allowable limit for that radionuclide will not exceed 1 ("unity").

[b] These guidelines represent allowable residual concentrations above background averaged across any 15-cm-thick layer to any depth and over any contiguous 100 m^2 surface area.

[c] If the average concentration in any surface or below-surface area, less than or equal to 25 m^2, exceeds the authorized limit of guideline by a factor of $(100/A)^{½}$, where A is the area or the elevated region in square meters, limits for "hot spots" shall also be applicable. Procedures for calculating these hot spot limits, which depend on the extent of the elevated local concentrations, are given in the DOE Manual for Implementing Residual Radioactive Materials Guidelines. In addition, every reasonable effort shall be made to remove any source of radionuclide that exceeds 30 times the appropriate limit for soil, irrespective of the average concentration in the soil.