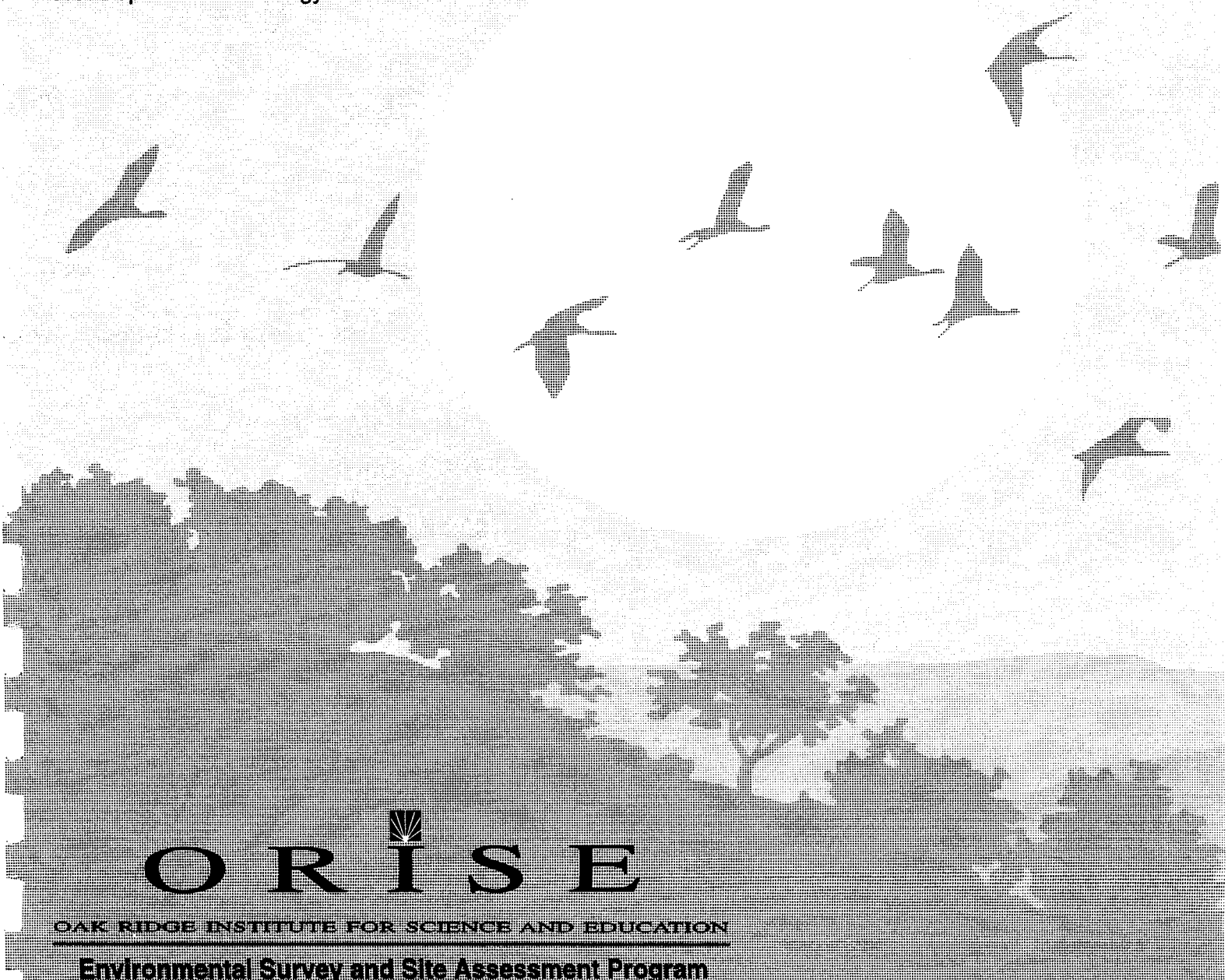
VERIFICATION SURVEY OF BUILDINGS T019 AND T024 SANTA SUSANA FIELD LABORATORY ROCKWELL INTERNATIONAL VENTURA COUNTY, CALIFORNIA

T. J. VITKUS and T. L. BRIGHT

Prepared for the Office of Environmental Restoration
U.S. Department of Energy



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

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Prepared by

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U.S. Department of Energy

FINAL REPORT

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OF
BUILDINGS T019 AND T024
SANTA SUSANA FIELD LABORATORY
ROCKWELL INTERNATIONAL
VENTURA COUNTY, CALIFORNIA

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ABBREVIATIONS AND ACRONYMS

μR/h	microroentgens per hour
AEC	Atomic Energy Commission
cm	centimeter
cm^2	square centimeter
cpm	counts per minute
DOE	Department of Energy
dpm/100 cm^2	disintegrations per minute per 100 square centimeters
EM	Environmental Restoration and Waste Management
EML	Environmental Measurement Laboratory
ERDA	Energy Research and Development Administration
ESSAP	Environmental Survey and Site Assessment Program
ETEC	Energy Technology Engineering Center
GM	Geiger-Mueller
ha	hectare
km	kilometer
m	meter
m^2	square meter
M&O	Management and Operation
NIST	National Institute of Standards and Technology
NaI	sodium iodide
ORISE	Oak Ridge Institute for Science and Education
pCi/g	picocuries per gram
PIC	Pressurized Ionization Chamber
RMDF	radioactive material disposal facility
SETF	SNAP Environmental Test Facility
SSFL	Santa Susana Field Laboratory
SNAP	Systems for Nuclear and Auxiliary Power
ZnS	zinc sulfide

VERIFICATION SURVEY
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ROCKWELL INTERNATIONAL
VENTURA COUNTY, CALIFORNIA

INTRODUCTION

Rockwell International's Rocketdyne Division operates the Santa Susana Field Laboratory (SSFL). The Energy Technology Engineering Center (ETEC) is that portion of the SSFL, operated for the Department of Energy (DOE), which performs 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 the engineering, development, testing, and manufacturing operations of nuclear reactor systems and components. Other SSFL activities have also been conducted for the National Aeronautics and Space Administration, the Department of Defense, and other government related or affiliated organizations and agencies. Some activities have been licensed by the Nuclear Regulatory Commission and by the State of California Radiological Health Branch of the 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 (in natural and enriched isotopic abundances), plutonium, Am-241, fission products (primarily Cs-137 and Sr-90), activation products (tritium [H-3], Co-60, Eu-152, Eu-154, Ni-63, Pm-147, Ta-182). Chemical contaminants, mainly chlorinated organic solvents, have also been identified in groundwater, primarily as a result of rocket engine testing.

Decontamination and decommissioning of contaminated facilities began in the late 1960's and continues as the remaining DOE program operations at ETEC have been terminated, effective

September 30, 1995. As part of this program, Rockwell/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 the 1980's. Environmental Management of DOE contaminated properties continues under the termination clause of the existing M&O contract. Surplus sodium facilities have been included in the current EM (Environmental Restoration and Waste Management) Program for stabilization and eventual clean-up.

Building T024 was constructed in 1960 to house the Systems for Nuclear and Auxiliary Power (SNAP) Environmental Test Facility (SETF). The facility was used for endurance tests of SNAP-10 reactors. Four such systems were tested in the facility between the years 1960 and 1971. Decontamination was initiated in 1977 and included removal of contaminated equipment and components. Project documentation does not indicate specific contaminants (Rockwell 1978). Surveys conducted following remediation included smear sampling for removable contamination, dose rate measurements, and soil sampling from an exterior area on the east end of Building T024 where liquid and gas holdup tanks were removed. With the exception of two power vaults, Rockwell/Rocketdyne released the facility from radiological controls associated with DOE orders concerning radiation protection of workers in 1978. The power vaults have remained under a surveillance and maintenance mode since that time.

Building T019 was constructed in 1962 and served as the SNAP System Nuclear Qualification Test Facility where SNAP reactors were tested, using fully encapsulated highly enriched uranium, at zero power until termination of the SNAP program in 1970. All SNAP components were then removed and a facility survey performed. Documentation indicated that there were no releases of the uranium fuel or fission products and that neutron activation of construction materials was negligible (Rockwell 1988). Rockwell/Rocketdyne also released the building from radiological controls and redesignated it as the ETEC Construction Staging and Computer Facility.

DOE's 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

conducted within Office of Environmental Restoration programs. The purpose of these independent verifications is to confirm that remedial actions have been effective in meeting established and supplemental 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 each of these facilities. This report describes the results of the verification surveys.

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 are conducted in Rockwell International-owned and DOE-owned facilities located within the 117 ha Area IV (Figure 2). The ETEC portion of Area IV consists of government-owned buildings that occupy 36 ha.

Building T019 is located on B Street in the north-central part of Area IV (Figure 2). Total area of the building is 595 m^2 divided among a high bay area that also includes a below-grade test cell, a low bay office-control center, and a vault (Figure 3). This vault was originally built for nuclear fuel element storage. Building construction is of steel framing and siding and a built-up roof.

Building T024 is located in the north-central portion of Area IV, northwest of 17th Street (Figure 2). The building consists of two levels, one at ground level containing a high bay area and support and equipment rooms. The second level is a subgrade basement, where the two power vaults are located that are currently in a surveillance and maintenance mode. Building construction is of aluminum siding, steel framing and some flooring, and concrete. Figure 4 shows the facility floor plan.

OBJECTIVE

The objective of the verification survey was to validate that cleanup procedures and survey methods used by Rockwell/Rocketdyne were adequate. Independent document reviews and measurement and sampling data provides assurance that the post-remediation data is sufficient, accurate, and demonstrates that remedial actions were accomplished in accordance with appropriate standards and guidelines, and that authorized limits were met.

DOCUMENT REVIEW

ESSAP has reviewed Rockwell/Rocketdyne's supporting documentation concerning each building or outdoor area's final status survey procedures and results. In addition, the current levels of residual contamination remaining in the Building T024 power vaults were to be evaluated.

PROCEDURES

ESSAP personnel conducted independent measurements and sampling at SSFL on September 11 through 14, 1995. Survey activities were performed in accordance with a site-specific survey plan (ORISE 1995), using procedures and instruments described in the ESSAP Survey Procedures and Quality Assurance Manuals and summarized in Appendices A and B.

SURVEY PROCEDURES

Reference System

Measurement and sampling locations were referenced to prominent building or site features, and recorded on representative area drawings.

Surface Scans

Surface scans for alpha, beta, and gamma activity were performed over 50 to 100 percent of the accessible floors and lower walls (up to 2 m) within Buildings T019 and T024. Accessible overhead surfaces where material may have settled or accumulated were also scanned. Due to access difficulties and health and safety concerns, the Building T019 test vault could not be surveyed. Surface scans of the exterior walls and grounds were performed at locations where residual contamination may have accumulated (near exhaust vents, downspouts, driplines, etc.).

Scans were performed using gas proportional, ZnS, GM, and/or NaI scintillation detectors coupled to ratemeters or ratemeter-scalers with audible indicators. Locations of elevated direct radiation were marked for further investigation.

Surface Activity Measurements

Direct measurements for total alpha and total beta activity were performed at 44 (seven of which were performed within a 1 m^2 area) floor and wall locations in Building T019 and at 76 floor and wall locations in Building T024. In areas where elevated direct radiation was detected by surface scans, a set of five direct measurements were taken within a 1 m^2 area to determine the average residual activity. These measurements were performed at the center and at four points equidistant from the center and grid block corners.

Direct measurements were made using gas proportional, ZnS, and/or GM detectors coupled to ratemeter-scalers. A smear sample was collected from the location within each grid block corresponding to the highest total direct measurement and from each single-point measurement location for the determination of removable gross alpha and gross beta activity. Figures 3 and 4 show measurement and sampling locations.

Exposure Rate Measurements

Exposure rate measurements were made at two locations in Building T019 and four locations in Building T024, excluding the vaults. Exposure rate measurements were performed at 1 m above the surface using a pressurized ionization chamber (PIC). Figures 3 and 4 show exposure rate measurement locations.

SAMPLE ANALYSIS AND DATA INTERPRETATION

Samples and data were returned to ORISE's ESSAP laboratory in Oak Ridge, Tennessee for analysis and interpretation. Smears were analyzed for gross alpha and gross beta activity using a low background proportional counter. Smear results and direct measurement data were converted to units of disintegrations per minute per 100 square centimeters (dpm/100 cm^2). Exposure rates are reported in microroentgens per hour (μR/h).

FINDINGS AND RESULTS

DOCUMENT REVIEW

Based on the review of the project documents, it is ESSAP's opinion that the documentation was inadequate to satisfactorily demonstrate that each building or area meets the DOE guidelines for release to unrestricted use. Overall, the documentation for each building or area does not provide a clear description of the sequence of events necessary for demonstrating that the subject areas meet the requirements for release to unrestricted use. That is, the specification of contaminants present, selection of the appropriate guidelines, development of a sampling and analysis plan that provides adequate data for guideline interpretation, and presentation of the data in a manner that can be directly compared with the guidelines. The types of deficiencies noted in the reports included the following: all potential contaminants were not identified, final surveys were not designed to identify residual contamination of all suspected radionuclides, residual surface activity data was either absent or not reported in units of dpm/100 cm^2, radionuclide-specific sample analyses were not performed

(i.e., gross beta analysis of soil samples was performed and the data used for demonstrating compliance), appropriate guidelines were not always cited or unapproved site-specific guidelines were used. Comments on the documents were provided to DOE (ORISE 1996).

Surface Scans

Surface scans identified an area of elevated direct beta radiation in the garage portion of Building T019 and also within the fan room of Building T024. Because of the significant gamma radiation emanating from the radioactive waste materials stored at the SSFL's RMDF, surface scans of the exterior area surrounding Building T024 were inconclusive. All other surface scans for alpha, beta and gamma activity were within the range of ambient site background.

Surface Activity Levels

Surface activity levels for Buildings T019 and T024 are summarized in Table 1. For Building T019, surface activity levels were less than 55 dpm/100 cm^2 for alpha and ranged from less than 1,400 to 11,000 dpm/100 cm^2 for beta. The average surface activity level within the 1 m^2 area with the highest beta surface activity level was 5,900 dpm/100 cm^2. Surface activity levels in Building T024 (excluding the power vaults) were less than 55 dpm/100 cm^2 for alpha and ranged from less than 1,400 to 33,000 dpm/100 cm^2 for beta. Removable activity levels were less than 12 dpm/100 cm^2 for gross alpha and less than 16 dpm/100 cm^2 for gross beta for both buildings.

Exposure Rates

Exposure rate measurements are summarized in Table 2. Exposure rate measurements in Buildings T019 and T024 (excluding the power vaults) ranged from 10 to 13 μR/h. The Rockwell-determined average interior background exposure rate was approximately 8 μR/h.

COMPARISON OF RESULTS WITH GUIDELINES

Surface activity levels in each area were compared to the appropriate residual radioactive material guidelines specified in DOE Order 5400.5 for uranium and mixed fission and activation products. These guidelines are summarized in Appendix C. The applicable guidelines for uranium are as follows:

Total Activity

5,000 α dpm/100 cm^2, average in a 1 m^2 area

15,000 α dpm/100 cm^2, maximum in a 100 cm^2 area

Removable Activity

1000 α dpm/100 cm^2

and the guidelines for beta-gamma emitters are:

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

1,000 β-γ dpm/100 cm^2

The average beta-gamma total surface activity guideline was exceeded within a 1 m^2 area in Building T019 (Figure 3) and the maximum beta-gamma total surface activity guideline was exceeded within the hot gas compression room in Building T024 (Figure 4). With the exception of these two areas, all other total and removable activity levels were less than the guideline values.

The DOE's exposure rate guideline is 20 μR/h above background, although Rockwell/Rocketdyne has elected to use a more restrictive guideline of 5 μR/h above background. Interior exposure rates at 1 meter above the surface were within these guidelines.

SUMMARY

The Environmental Survey and Site Assessment Program of the Oak Ridge Institute for Science and Education conducted verification activities for Buildings T019 and T024 at the Santa Susana Field Laboratory in Ventura County, California. Verification activities included document reviews and during the period September 9 through 12, 1995, ESSAP personnel visited the site and performed independent surface scans, surface activity measurements, and exposure rate measurements.

ESSAP's review identified a number of deficiencies in the final status documentation that was prepared for each building. Deficiencies noted included inadequate final status survey methods, no discussion of specific contaminants, inconsistent specification of all applicable guidelines and presentation of data that may be compared to the guidelines, absence of quantitative laboratory data, and absense of adequate figures documenting remediated areas and measurement and sampling locations.

The results of the independent verification determined that interior exposure rates were comparable to background levels and satisfied both the DOE and the more restrictive NRC exposure rate guideline. However, surface activity measurements and sampling identified residual fixed beta-gamma surface contamination in excess of the DOE guidelines in isolated locations in both Buildings T019 and T024. Because of the identification of residual contamination and documentation deficiencies, ESSAP was unable to verify Rockwell/Rocketdyne's conclusion that these areas of the buildings meet the DOE requirements for release to unrestricted use. ESSAP recommends final status documentation be revised to address deficiencies that were identified and provided to the DOE (ORISE 1996) and that additional decontamination and surveys be performed. In addition, because the Building T019 test vault could not be surveyed, ESSAP was unable to verify the radiological status of the test vault.

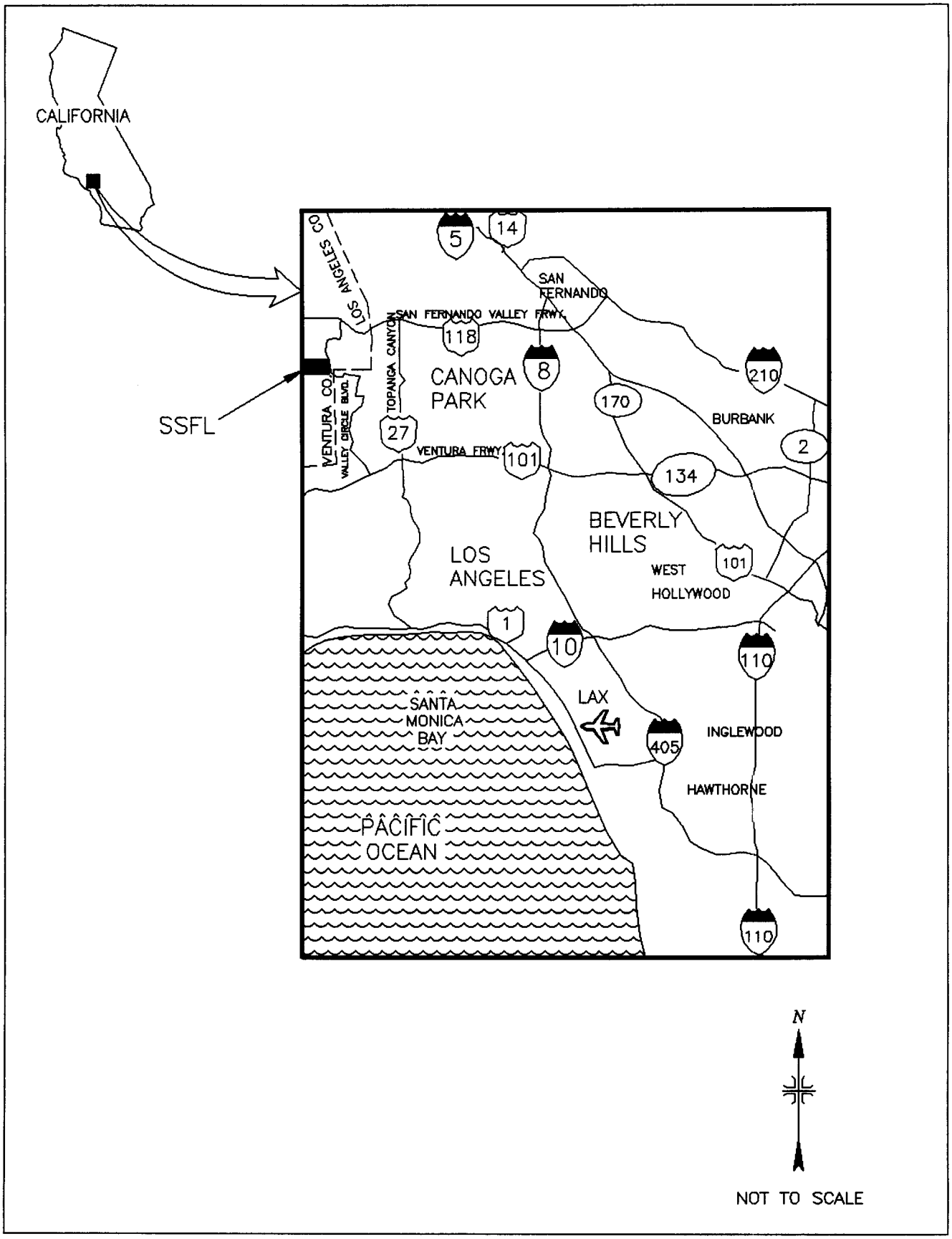


FIGURE 1: Los Angeles, California Area – Location of Santa Susana Field Laboratory Site

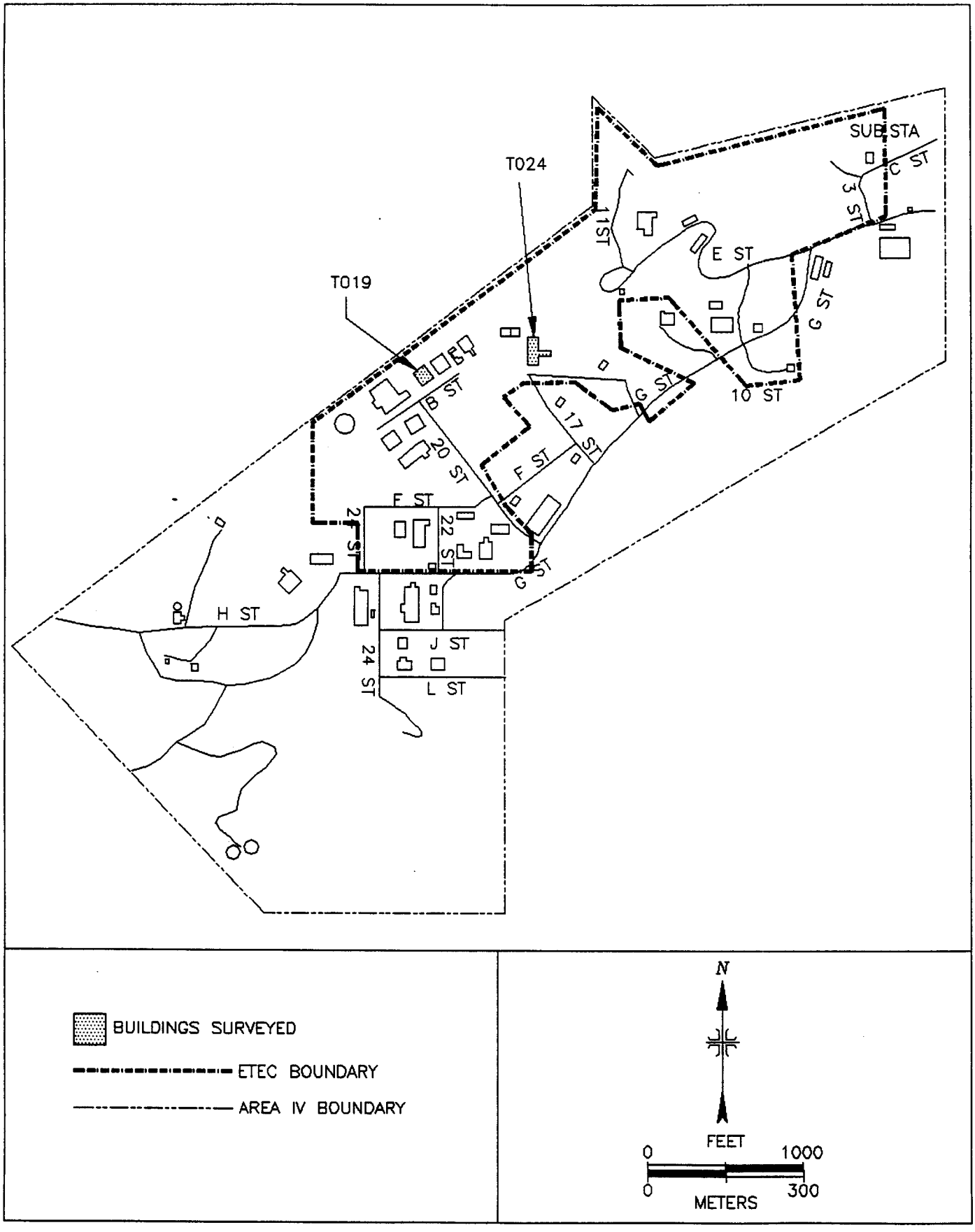


FIGURE 2: Santa Susana Field Laboratory Area IV, Plot Plan – Location of Surveyed Areas

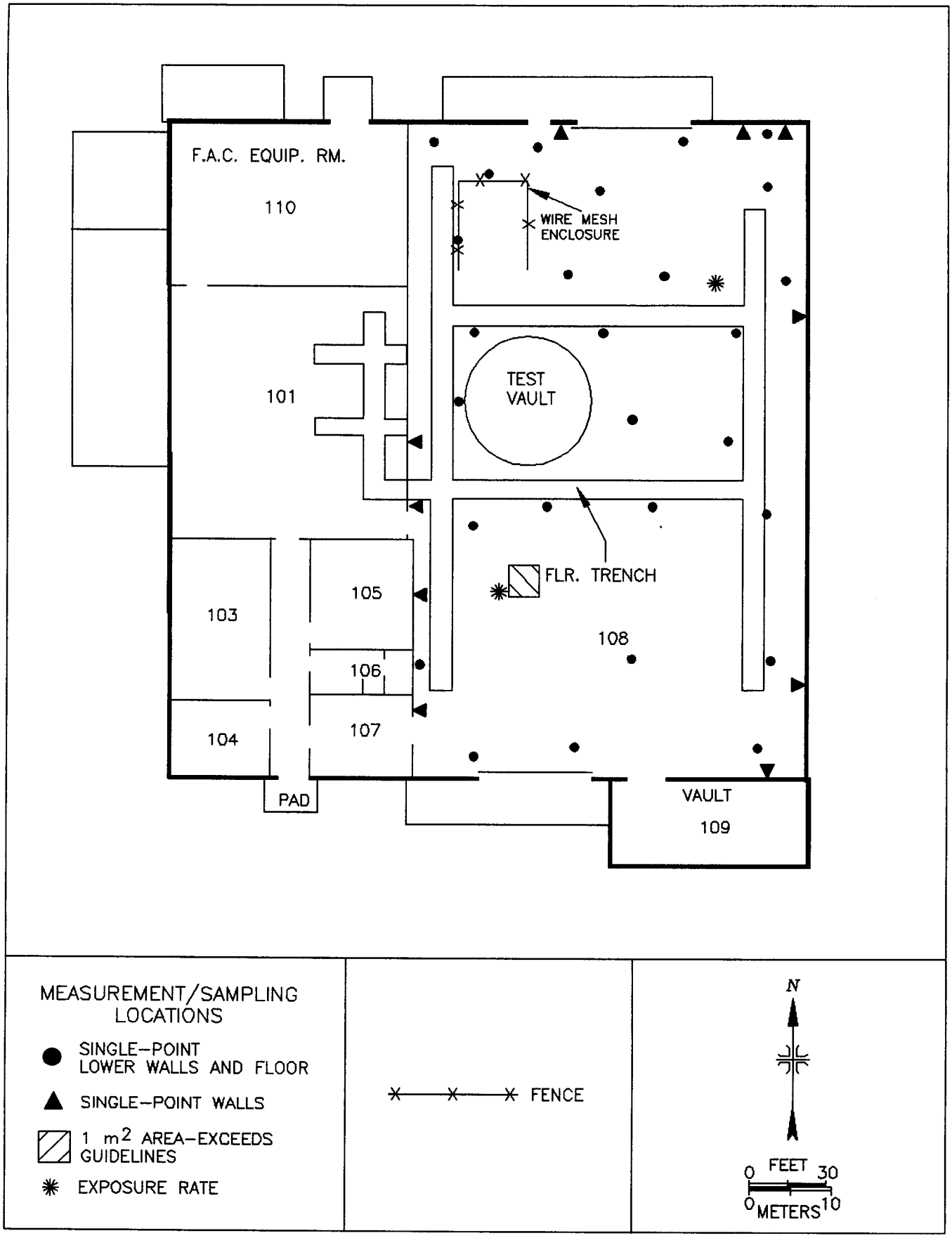
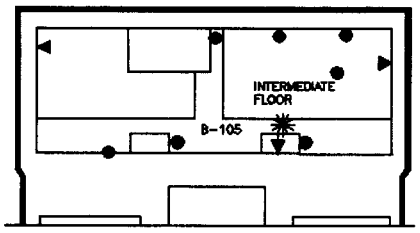
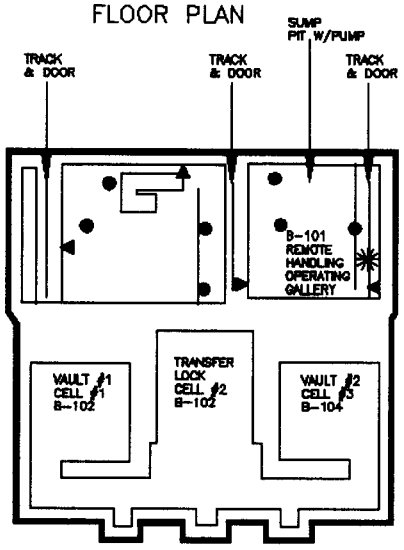


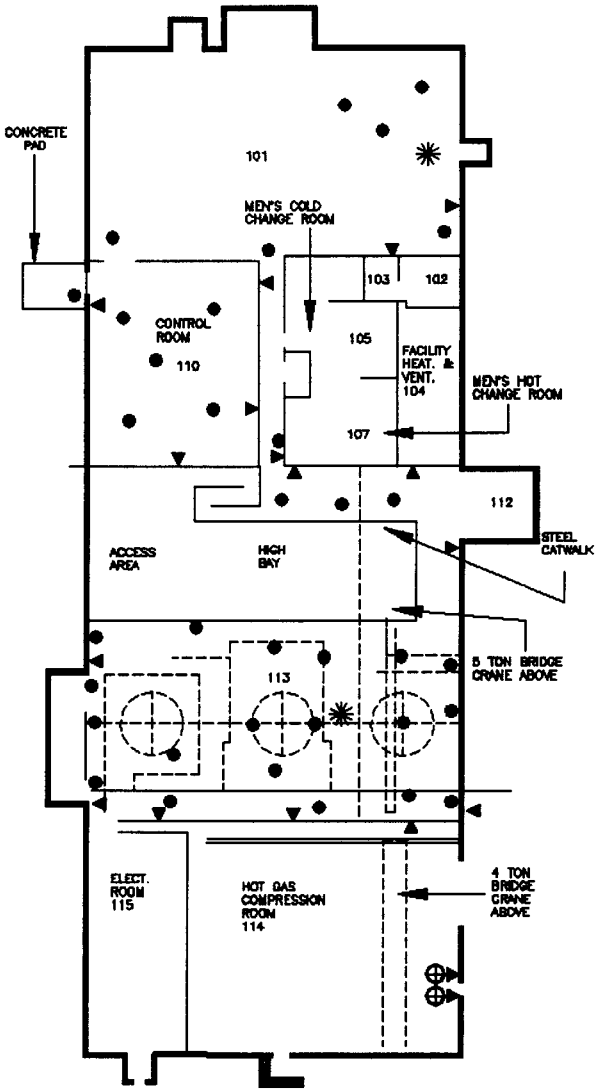
FIGURE 3: Building T019 – Floor Plan and Measurement and Sampling Locations



INTERMEDIATE FLOOR PLAN



BASEMENT PLAN



FIRST FLOOR PLAN

MEASUREMENT/SAMPLING LOCATIONS

- SINGLE-POINT FLOORS
- SINGLE-POINT WALLS AND EQUIPMENT
- EXPOSURE RATE
- SINGLE-POINT FLOOR-EXCEEDS GUIDELINES

NOT TO SCALE

FIGURE 4: Building T024 – Floor Plan and Measurement and Sampling Locations

TABLE 1

SUMMARY OF SURFACE ACTIVITY LEVELS
BUILDINGS T019 AND T024
SANTA SUSANA FIELD LABORATORY
ROCKWELL INTERNATIONAL
VENTURA COUNTY, CALIFORNIA

Location[a]	Number Of Measurement Locations	Total Activity Range (dpm/100 cm²)		Removable Activity Range (dpm/100 cm²)	
		Single Measurement			
	Single-Pt.	Alpha[b]	Beta[c]	Alpha[d]	Beta[e]
T019					
Floor	34	<55	<1,400 - 11,000[f]	<12	<16
Lower Wall	10	<55	<1,000 - 1,400	<12	<16
T024					
Floor	51	<55	<1,400 - 33,000	<12	<16
Lower Wall	23	<55	<900 - <1,400	<12	<16
Equipment	2	NA	<1,000	<12	<16

[a]Refer to Figures 3 and 4.
[b]Guidelines = 5,000 α dpm/100 cm² average in a 1 m² area and 15,000 α dpm/100 cm² maximum.
[c]Guidelines = 5,000 β-γ dpm/100 cm² average in a 1 m² area and 15,000 β-γ dpm/100 cm² maximum.
[d]Guidelines = 1,000 γ dpm/100 cm² average in a 1 m² area and 15,000 α dpm/100 cm² maximum.
[e]Guidelines = 1,000 β-γ dpm/100 cm² average in a 1 m² area and 15,000 α dpm/100 cm² maximum.
[f]Average surface activity in the surrounding 1 m² at this measurement location was 5,900 dpm/100 cm².

TABLE 2

EXPOSURE RATES
BUILDINGS T019 AND T024
SANTA SUSANA FIELD LABORATORY
ROCKWELL INTERNATIONAL
VENTURA COUNTY, CALIFORNIA

Location[a]	Number of Measurements	Exposure Rate Ranges at 1 m Above Surface (μR/h)
T019	2	10 to 11
T024	4	11 to 13

[a]Refer to Figures 3 and 4.

REFERENCES

Oak Ridge Institute for Science and Education (ORISE). Verification Survey Plan for the Interim Storage Facility; Buildings T030, T024, T019, T013; An Area Northwest of Buildings T059, T019, T013, and T012; and A Storage Yard West of Buildings T626 and T038; Santa Susana Field Laboratory, Rockwell International, Ventura County, CA. Oak Ridge, TN; September 6, 1995.

ORISE. Comments on the Final Status Survey Documentation for the Interim Storage Facility; Buildings T013, T019, T024, T030, and T641; The Storage Yard West of Buildings T626 and T038; and The NW Area; Santa Susana Field Laboratory, Ventura County, CA. Oak Ridge, TN; January 11, 1996.

Rockwell International. Radiological Survey Results - Release to Unrestricted Use, Building T024, SSFL. Ventura County, CA; November 28, 1978.

Rockwell International. Radiological Survey of Buildings T019 and T013; An Area Northwest of T059, T019, T013, and T012; and A Storage Yard West of Buildings T626 and T038. Ventura County, CA; August 26, 1988.

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 authors or their employers.

DIRECT RADIATION MEASUREMENT

Instruments

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

Eberline "Rascal" Ratemeter-Scaler
Model PRS-1
(Eberline, Santa Fe, NM)

Ludlum Floor Monitor
Model 239-1
(Ludlum Measurements, Inc.,
Sweetwater, TX)

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

Detectors

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

Eberline ZnS Scintillation Detector
Model AC-3-7
Physical Area, 74 cm^2
(Eberline, Santa Fe, NM)

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

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

Reuter-Stokes Pressurized Ion Chamber
Model RSS-112
(Reuter-Stokes, Cleveland, OH)

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

LABORATORY ANALYTICAL INSTRUMENTATION

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 probes slowly over the surface; the distance between the probe 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, 74 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:

Alpha	-	gas proportional detector with ratemeter-scaler
	-	ZnS scintillation detector with ratemeter-scaler
Beta	-	gas proportional detector with ratemeter-scaler
	-	GM detector with ratemeter-scaler
Gamma	-	NaI scintillation detector with ratemeter

Surface Activity Measurements

Measurements of total alpha and total beta activity levels were performed using ZnS scintillation and GM detectors with ratemeter-scalers.

Count rates (cpm), which were integrated over 1 minute in a static position, were converted to activity levels (dpm/100 cm^2) by dividing the net rate by the 4π efficiency and correcting for the active area of the detector. Because different building materials (poured concrete, concrete block, steel, etc.) can have very different background levels, average background counts 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 GM detectors averaged 95 cpm for concrete, 36 cpm for sheet rock, 33 cpm for structural steel, 96 cpm for cinder block, and 92 cpm for asphalt. Alpha background count rates for the ZnS detectors averaged 7 cpm for concrete, 1 cpm for sheet rock, 2 cpm for structural steel, 3 cpm for cinder block, and 2 cpm for asphalt. Net count rates were determined by subtracting the appropriate material background from the gross count rate for each measurement location. Beta efficiency factors ranged from 0.17 to 0.18 for the GM detector calibrated to Tc-99. The beta minimum detectable activities (MDA) for the GM detectors varied by material and ranged from 870 to 1,400 dpm/100 cm^2. Alpha efficiency factors ranged from 0.18 to 0.19 for the ZnS detectors calibrated to Pu-239 and MDAs ranged from 50 to 100 dpm/100 cm^2. The physical window areas for the GM and ZnS detectors were 20 cm^2 and 74 cm^2, respectively.

Removable Activity Measurements

Removable 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 gamma exposure rates were performed using a pressurized ionization chamber (PIC). The instrument was adjusted to one meter above the surface and allowed to stabilize. The measurement was read directly in $\mu R/h$.

ANALYTICAL PROCEDURES

Removable Activity

Gross Alpha/Beta

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

UNCERTAINTIES AND DETECTION LIMITS

The uncertainties associated with the analytical data presented in the tables of this report represent the 95% confidence level for that data. These uncertainties were calculated based on both the gross sample count levels and the associated background count levels. Additional uncertainties, associated with sampling and measurement procedures, have not been propagated into the data presented in this report.

Detection limits, referred to as minimum detectable activity (MDA), were based on 2.71 plus 4.65 times the standard deviation of the background count [$2.71 + 4.65\sqrt{BKG}$]. When the activity was determined to be less than the MDA of the measurement procedure, the result was reported as less than MDA. 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 standard/sources were available. In cases where they were not available, standards of an industry recognized organization were used. Calibration of pressurized ionization chambers was performed by the manufacturer.

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, Revision 9 (April 1995)
- Laboratory Procedures Manual, Revision 9 (January 1995)
- Quality Assurance Manual, Revision 7 (January 1995)

The procedures contained in these manuals were developed to meet the requirements of DOE Order 5700.6C 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 EPA and EML laboratory Quality Assurance Programs.
- Training and certification of all individuals performing procedures.
- Periodic internal and external audits.

APPENDIX C

RESIDUAL RADIOACTIVE MATERIAL GUIDELINES SUMMARIZED FROM DOE ORDER 5400.5

APPENDIX C

RESIDUAL RADIOACTIVE MATERIAL GUIDELINES SUMMARIZED FROM DOE ORDER 5400.5

BASIC DOSE LIMITS

The basic 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.

STRUCTURE GUIDELINES

Indoor/Outdoor Structure Surface Contamination

Radionuclides[a]	Allowable Total Residual Surface Contamination (dpm/100 cm^2)[b] Average[c,d]	Maximum[d,e]	Removable[f]
Transuranics, Ra-226, Ra-228, Th-230 Th-228, Pa-231, Ac-227, I-125, I-129[g]	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[h]	5,000β-γ	15,000β-γ	1,000β-γ

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.

SOIL GUIDELINES

Radionuclides	Soil Concentration (pCi/g) Above Background[i,j,k]
Uranium and mixed fission and activation products	Soil guidelines are calculated on a site-specific basis, using the DOE manual developed for this use.

[a] 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.

[b] 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.

[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. It is not necessary to use wiping techniques to measure removable contamination levels, if direct scan surveys indicate that total residual surface contamination levels are within the limits for removable contamination.

[g] Guidelines for these radionuclides are not given in DOE Order 5400.5; however, these guidelines are considered applicable until guidance is provided.

[h] This category of radionuclides includes mixed fission products, including the Sr-90 which is present in them. It does not apply to Sr-90, which has been separated from the other fission products, or mixtures where the Sr-90 has been enriched.

[i] 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").

[j] 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.

[k] 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, DOE/CH/8901. 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.