PDR

CONFIRMATORY SURVEY OF THE UNIVERSITY OF TEXAS TRIGA REACTOR AUSTIN, TEXAS

[DOCKET 50-192]

A. J. ANSARI AND J. L. PAYNE

Prepared for the
U. S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation

ORISE
OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION
Environmental Survey and Site Assessment Program
Energy/Environment Systems Division

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NOTICES

ORISE 93/G-9

CONFIRMATORY SURVEY OF THE UNIVERSITY OF TEXAS TRIGA REACTOR AUSTIN, TEXAS

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FINAL REPORT

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CONFIRMATORY SURVEY
OF THE
UNIVERSITY OF TEXAS TRIGA REACTOR
AUSTIN, TEXAS

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ABBREVIATIONS

cm^2	square centimeter
cpm	counts per minute
dpm/100 cm^2	disintegrations per minute/100 square centimeters
ft	foot
GM	Geiger-Mueller
kg	kilogram
kw	kilowatt
m	meter
m^2	square meter
NaI	Sodium Iodide
pCi/g	picocuries per gram
PIC	Pressurized Ionization Chamber
μR/h	microroentgens per hour
ZnS	Zinc Sulfide

ACRONYMS

AEC	Atomic Energy Commission
ASME	American Society of Mechanical Engineers
EPA	Environmental Protection Agency
EML	Environmental Measurement Laboratory
ESSAP	Environmental Survey and Site Assessment Program
MDA	Minimum Detectable Activity
NETL	Nuclear Engineering Teaching Laboratory
NIST	National Institute for Standards Technology
NRC	Nuclear Regulatory Commission
ORISE	Oak Ridge Institute for Science and Education
TRIGA	Training, Research, Isotopes, General Atomics

CONFIRMATORY SURVEY
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AUSTIN, TEXAS

INTRODUCTION AND SITE HISTORY

The University of Texas TRIGA reactor was originally licensed by the Atomic Energy Commission (AEC), predecessor to the U.S. Nuclear Regulatory Commission (NRC), for operation at 10 kW. The license was amended in 1968 for operation at 250 kW. In May 1985, The University of Texas requested authorization to dismantle the TRIGA reactor facility and to dispose of the component parts, in accordance with the plan submitted as part of the application to terminate the NRC license R-92 (Docket 50-192). In March 1987, the NRC issued the order to dismantle the reactor following shipment of the fuel offsite. At the time that the NRC order was issued, the reactor was still operating and remained in intermittent operation until May 1988, when it was permanently shut down.

The reactor fuel was transferred by the Nuclear Engineering Teaching Laboratory (NETL) staff to a new TRIGA research reactor facility (NRC License R-192), constructed approximately 11 kilometers from the main University campus in Austin. Following transfer of the fuel, the dismantling and decommissioning program was initiated. A preliminary radiological survey was conducted by both the NETL and Quadrex Corporation, a University of Texas contractor. The neutron-activated parts of the aluminum reactor pool liner, a portion of the concrete reactor shield structure, and other radioactive waste materials were shipped to Barnwell, South Carolina, a low-level disposal site.

The licensee and Quadrex Corporation, performed a final radiological survey, and the data were provided to the NRC in December 1992.[1] The primary contaminants at this facility, based on the licensee's analysis, were Co-60 and Eu-152 — products of neutron activation due to reactor operations. At the request of the U.S. Nuclear Regulatory Commission, Region IV Office, the Environmental Survey and Site Assessment Program (ESSAP) of Oak Ridge Institute for Science

and Education (ORISE) conducted confirmatory activities and additional radiological surveys at this facility. This report describes the procedures and results of those activities.

SITE DESCRIPTION

The reactor room (Room 131) is located on the first floor of Taylor Hall, on the campus of the University of Texas at Austin, Travis County, Texas (Figures 1 and 2). The reactor room has approximately 150 m^2 of floor space. The reactor pool is approximately 10 m deep and is located near the center of Room 131 (Figure 3). There is also a crawlspace underneath the reactor room with access to the bottom of the outer layer of the reactor pool and to the area where fuel storage pits were formerly located. The areas immediately adjacent to the reactor room were not included in the decommissioning plan for this reactor facility; however, at the request of the NRC, limited survey activities were performed in these areas.

At the time of the initial ESSAP survey of this facility, the reactor pool liner was still in place. The aluminum pool liner was subsequently removed, and the exposed concrete walls of the former reactor pool were surveyed by the licensee, prior to the ESSAP follow-up survey.

OBJECTIVES

The objectives of the confirmatory process are to provide independent document reviews and radiological data, for use by the NRC in evaluating the adequacy and accuracy of the licensee's radiological status report, relative to established guidelines.

DOCUMENT REVIEW

As part of the confirmatory activities ESSAP reviewed the licensee's radiological survey data.[1,2,3] Analytical procedures and methods utilized by the licensee were reviewed for adequacy and appropriateness. The data were reviewed for accuracy, completeness, and compliance with guidelines.

PROCEDURES

On April 5 and 6, 1993, ESSAP performed a confirmatory survey of the University of Texas TRIGA reactor located on the campus of the University of Texas at Austin. Subsequent to further remediations and removal of the reactor pool liner by the licensee, ESSAP performed a follow-up survey of the facility on June 1, 1993. The surveys were conducted in accordance with survey plans which were submitted to and approved by the NRC Region IV Office.[4,5]

REFERENCE GRID

The 1 m × 1 m alphanumeric reference grid system, established on the floor of the reactor room by the licensee, was used by ESSAP to reference measurement and sampling locations (Figure 3). Measurement locations on the wall and ceiling surfaces were referenced to the floor grid. Sampling locations from the crawlspace were also referenced to the reactor room floor grid. The reactor pool surfaces were not gridded.

SURFACE SCANS

Surface scans for alpha, beta, and gamma activity were performed on floors and lower walls (up to 2 m) in the reactor room, using large area gas proportional and NaI scintillation detectors, coupled to ratemeter-scalers and ratemeters with audible indicators. Beta and gamma surface scans were performed in the reactor pool area. Gamma scans were performed in accessible areas of the crawlspace underneath the reactor room. Cursory beta and gamma surface scans were performed in areas adjacent to the reactor room. Areas of elevated direct radiation, identified by scans, were marked for further investigation.

SURFACE ACTIVITY MEASUREMENTS

Direct measurements to determine total alpha and total beta surface activity were performed on 57 randomly selected grid blocks on the floor and lower walls in the reactor room. Measurements were performed at the center of each grid block. Six measurements were

performed on upper wall and ceiling surfaces. Thirty measurements were performed on the top edge, floor and walls of the reactor pool. Sixteen measurements were performed in areas adjacent to the reactor room. A smear sample for determining removable activity was obtained from each measurement location. Smear samples for determining H-3 and C-14 activity were collected from the center point of 14 randomly selected grid blocks in the reactor room. Measurement and sampling locations for total and removable activity are illustrated in Figures 3-6.

EXPOSURE RATE MEASUREMENT

Background exposure rate measurements were performed at 3 locations within Taylor Hall, having similar construction as the reactor room but without a history of radioactive materials use. Exposure rate measurements were performed at 1 m above the surface at 5 locations in the reactor room and 2 locations in the adjacent areas, using a pressurized ionization chamber (PIC). Measurement locations for Room 131 are shown in Figure 3.

SOIL SAMPLING

Three soil samples were collected from the crawlspace underneath the reactor room. The approximate locations of these samples relative to the floor grid in the reactor room are indicated in Figure 3. One sample was obtained near the northwest corner of the outer layer of the reactor pool. Two additional samples were obtained from former locations of fuel storage pits.

SAMPLE ANALYSIS AND DATA INTERPRETATION

Samples and survey data were returned to the ESSAP Oak Ridge laboratory for analyses and interpretation. Smears were analyzed for gross alpha and gross beta or H-3/C-14 activity. Direct measurement and smear data were converted to units of disintegrations per minute per 100 cm^2 (dpm/100 cm^2), and exposure rate measurements were reported in microroentegens per hour (μR/h). Soil and concrete samples were analyzed by gamma spectrometry. Spectra were reviewed for U-235, U-238, Co-60, and Eu-152 and any other identifiable photopeaks. Soil and

concrete sample results were reported in units of picocuries per gram (pCi/g). Additional information concerning major instrumentation, sampling equipment, and analytical procedures is provided in Appendices A and B. Results were compared to NRC guidelines which are provided in Appendix C.

FINDINGS AND RESULTS

DOCUMENT REVIEW

ESSAP reviewed the licensee's radiological survey data and comments were provided to the NRC.[5,6,7] In ESSAP's opinion, the licensee's measurements of removable alpha and beta activity, exposure rate measurements, and the survey performed subsequent to removal of the reactor pool liner provide an adequate description of the radiological condition of the facility. However, because of the methodology used in determining total surface activity in the reactor room, the licensee's data are not directly comparable to the NRC surface contamination guidelines.

Confirmatory activities are, by definition, limited to those types of measurements, performed by the licensee, which are adequate to demonstrate compliance with applicable NRC guidelines. ESSAP's measurements of removable surface activity and exposure rate in the reactor room and the survey of the reactor pool can be considered confirmatory activities. Although ESSAP's measurements of total surface activity in the reactor room and the surveys performed in the adjacent areas are not "confirmatory", they will be of use to the NRC in the overall evaluation of the radiological status of the facility.

SURFACE SCANS

Alpha, beta, and gamma surface scans of the reactor room floor and lower walls identified several locations of elevated beta radiation near or at the top edge of the reactor pool. These locations were marked for further investigation. Cursory scans in areas adjacent to the reactor room identified one location in room 125 with elevated beta activity. This location was also marked for further investigation.

SURFACE ACTIVITY LEVELS

In the reactor room, results of total activity measurements, performed on randomly selected grid blocks on the floor and lower walls, were all less than the detection limits of the procedure which were 69 dpm/100 cm^2 and 1700 dpm/100 cm^2 for alpha and beta, respectively. Removable activity levels at all but two of these locations were less than the minimum detectable activity of the procedure which were 12 dpm/100 cm^2 for alpha, 17 dpm/100 cm^2 for beta, 6 dpm/100 cm^2 for H-3, and 5 dpm/100 cm^2 for C-14. Removable beta activity at grid blocks L,1 and C,2 were 18 and 19 dpm/100 cm^2, respectively.

Surface scans had identified several locations of elevated beta radiation near the reactor pool. The results of surface activity measurements, performed at those locations prior to and after remediation by the licensee, are summarized in Table 1. Prior to remediations, the total surface activity measurements were <66 dpm/100 cm^2 for alpha and ranged from 11,000 to 46,000 dpm/100 cm^2 for beta. After the remediations, the total surface activity measurements ranged from <68 to 120 dpm/100 cm^2 for alpha and <1,300 to 5,200 dpm/100 cm^2 for beta. The removable activity levels, before and after the remediation, were <12 dpm/100 cm^2 for alpha and ranged from <17 to 22 dpm/100 cm^2 for beta. The size of the area with 5,200 dpm/100 cm^2 (#9, Figure 4) was less than 100 cm^2.

Results of total activity measurements on the floor and walls of the reactor pool were all less than the detection limits of the procedure which were 68 dpm/100 cm^2 and 1,300 dpm/100 cm^2 for alpha and beta, respectively. Removable activity levels were <12 dpm/100 cm^2 for alpha and ranged from <20 to 22 dpm/100 cm^2 for beta.

Results of surface activity levels in areas adjacent to the reactor room are summarized in Table 2. At one location in Room 125 (W4,S4), identified by surface scans, the beta activity was 47,000 dpm/100 cm^2. A portion of the wood floor was removed by NETL staff while ESSAP was on site. The beta activity from the follow-up measurement taken at this location was <1500 dpm/100 cm^2. Results of total activity measurements at other locations were less than the detection limits of the procedure which were 69 dpm/100 cm^2 and 1500 dpm/100 cm^2

for alpha and beta, respectively. Removable activity levels were less than the minimum detectable activity of the procedure which were 12 dpm/100 cm^2 and 17 dpm/100 cm^2 for alpha and beta, respectively.

EXPOSURE RATES

Background exposure rate was 11 μR/h. Exposure rate measurements at 5 locations in the reactor room and 2 locations in the adjacent areas ranged from 9 to 13 μR/h (Table 3).

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES

Radionuclide concentrations in crawlspace soil samples are presented in Table 4. In all three samples, the concentrations of Co-60 and Eu-152 were <0.1 and <0.2 pCi/g, respectively. The concentrations of U-235 ranged from 0.1 to 0.2 pCi/g. The concentrations of U-238 ranged from 1.2 to 1.7 pCi/g.

COMPARISON OF RESULTS WITH GUIDELINES

The NRC guidelines for surface contamination and residual concentrations of radionuclides in soil, established for license termination or release of a facility for unrestricted use, are presented in Appendix C.[8,9] The major contaminants identified by the licensee, prior to remediation, were Co-60 and Eu-152. The applicable guidelines are those for beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 are:

Total Activity

5,000 dpm /100 cm^2, averaged over a 1 m^2 area

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

Removable Activity

1000 dpm /100 cm^2

The surface contamination guidelines for uranium are:

<u>Total Activity</u>

5,000 dpm α/100 cm^2, total, averaged over a 1 m^2 area

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

<u>Removable Activity</u>

1,000 dpm α/100 cm^2

All surface activity measurements were within the guideline levels.

The NRC guideline for exposure rate at 1 m above surface is 5 μR/h above background.[10] All exposure rates measured in this survey were within this limit.

The soil concentration guideline for enriched uranium is 30 pCi/g.[9] Based on a U-234:U-235 ratio of 30 to 1, the highest total uranium concentration in the samples collected (crawlspace, underneath grid block H4) is 7.9 pCi/g which is well below the 30 pCi/g limit.

There are no specific concentration guidelines for Co-60 and Eu-152 in soil.

SUMMARY

On April 5 and 6, 1993, ESSAP conducted confirmatory activities and additional radiological surveys of the University of Texas TRIGA reactor on the campus of the University of Texas at Austin, Texas. Confirmatory survey activities included document reviews, surface scans, measurements of removable surface activity, and exposure rate measurements in the reactor room. Additional survey activities included cursory scans of the areas immediately adjacent to the reactor room, measurements of total surface activity in the reactor room and adjacent areas, and soil sampling in the crawlspace.

Several locations were identified in the reactor room with elevated beta activity. These locations were near or at the edge of the reactor pool. Subsequently, the reactor pool liner was removed by the licensee and the locations of elevated activity were remediated and surveyed. At the request of the NRC, Region IV Office, ESSAP surveyed the remediated areas and the reactor pool floor and walls on June 1, 1993. The follow-up confirmatory measurements support the licensee's conclusion that the radiological condition of the reactor room satisfies NRC's guidelines for release to unrestricted use.

The survey activities in areas immediately adjacent to the reactor room identified one location in room 125 with 47,000 beta dpm/100 cm^2. This area (approximately 50 cm^2) was effectively remediated while ESSAP was on site. The results of total and removable activity at other measurement locations in the adjacent areas were within applicable NRC guidelines. These adjacent areas were not included in the decommissioning activities, and it is not clear whether the activity found was due to reactor-related operations.

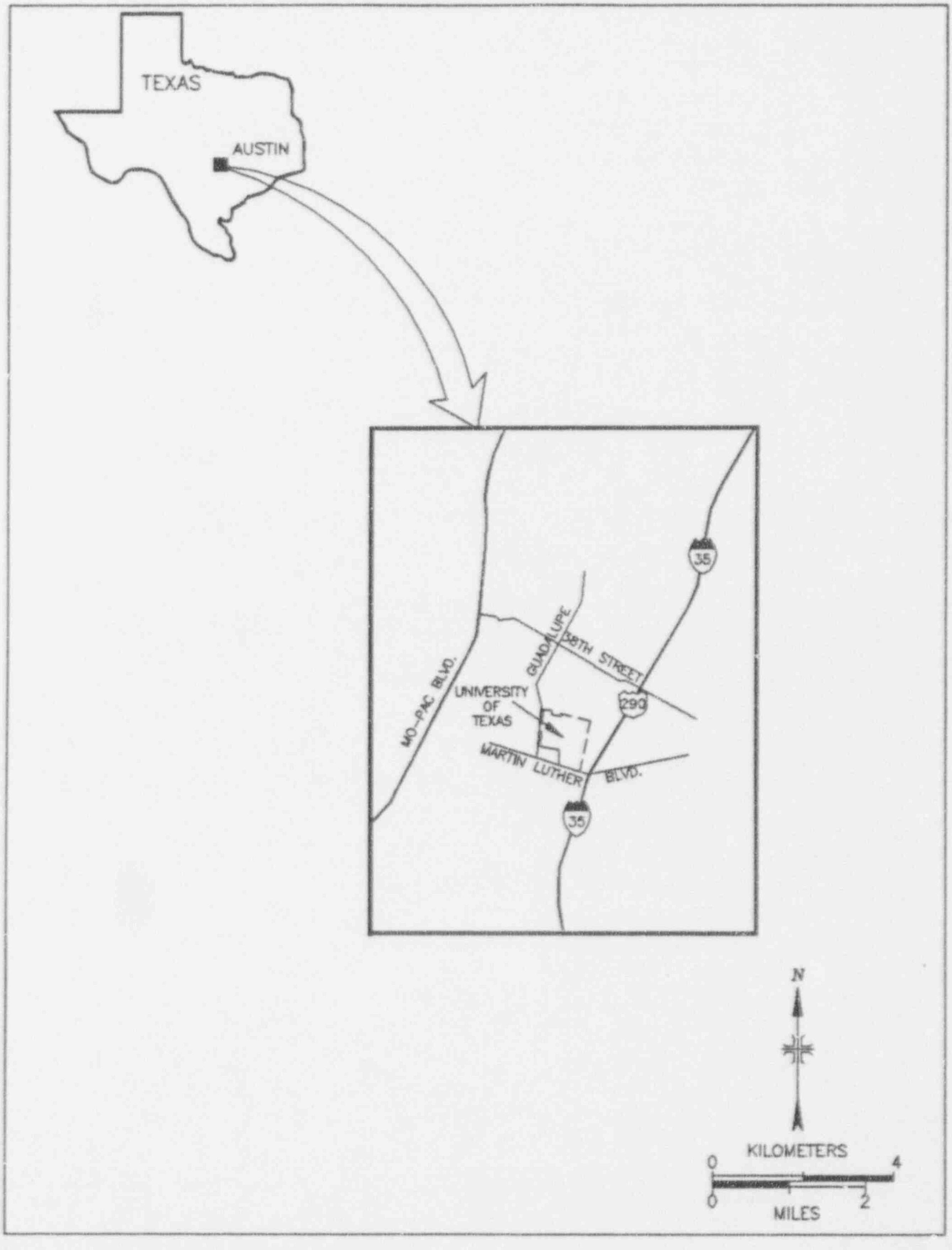

FIGURE 1: Austin, Texas Area – Location of the University of Texas

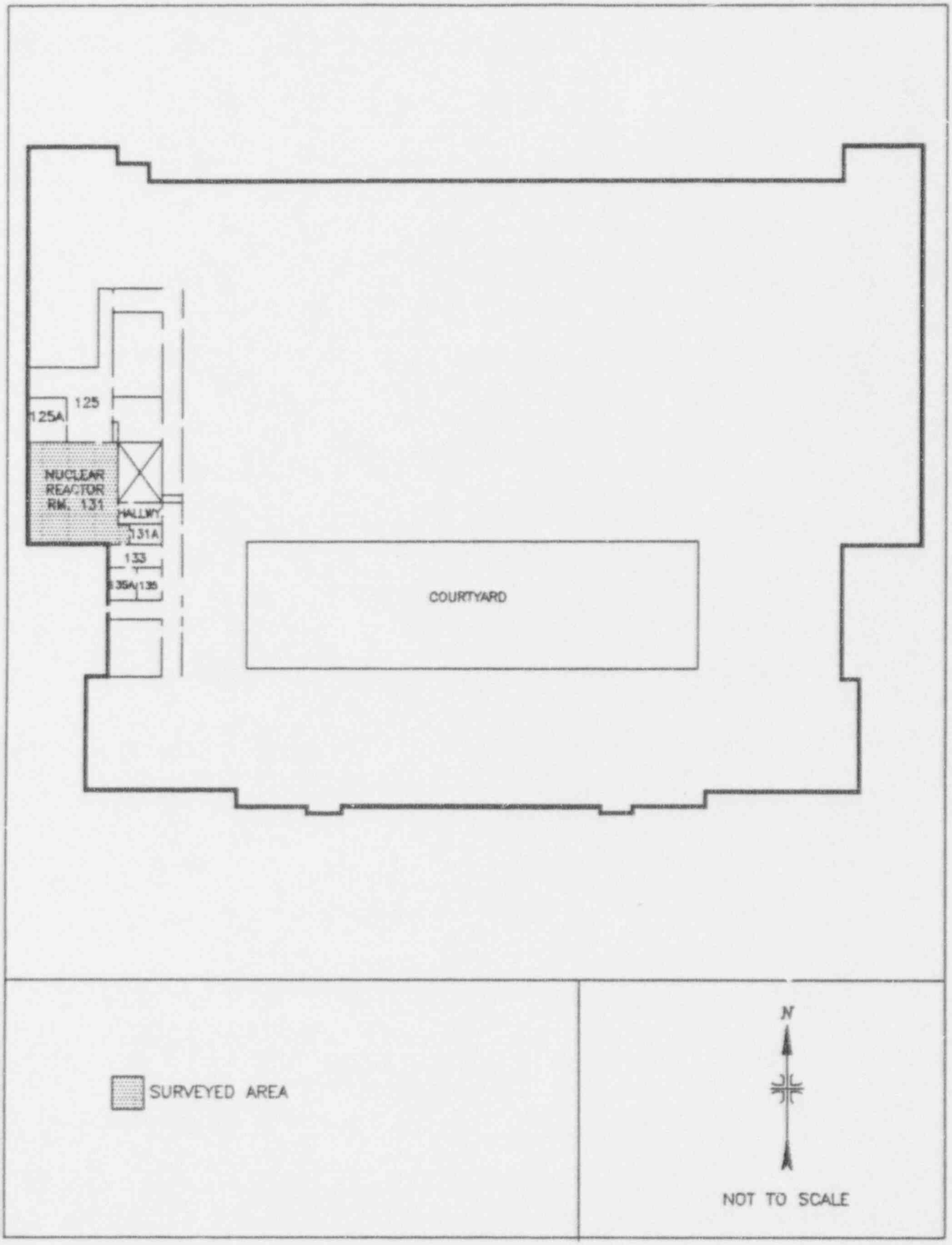

FIGURE 2: Taylor Hall, First Floor – Location of the Reactor Room 131

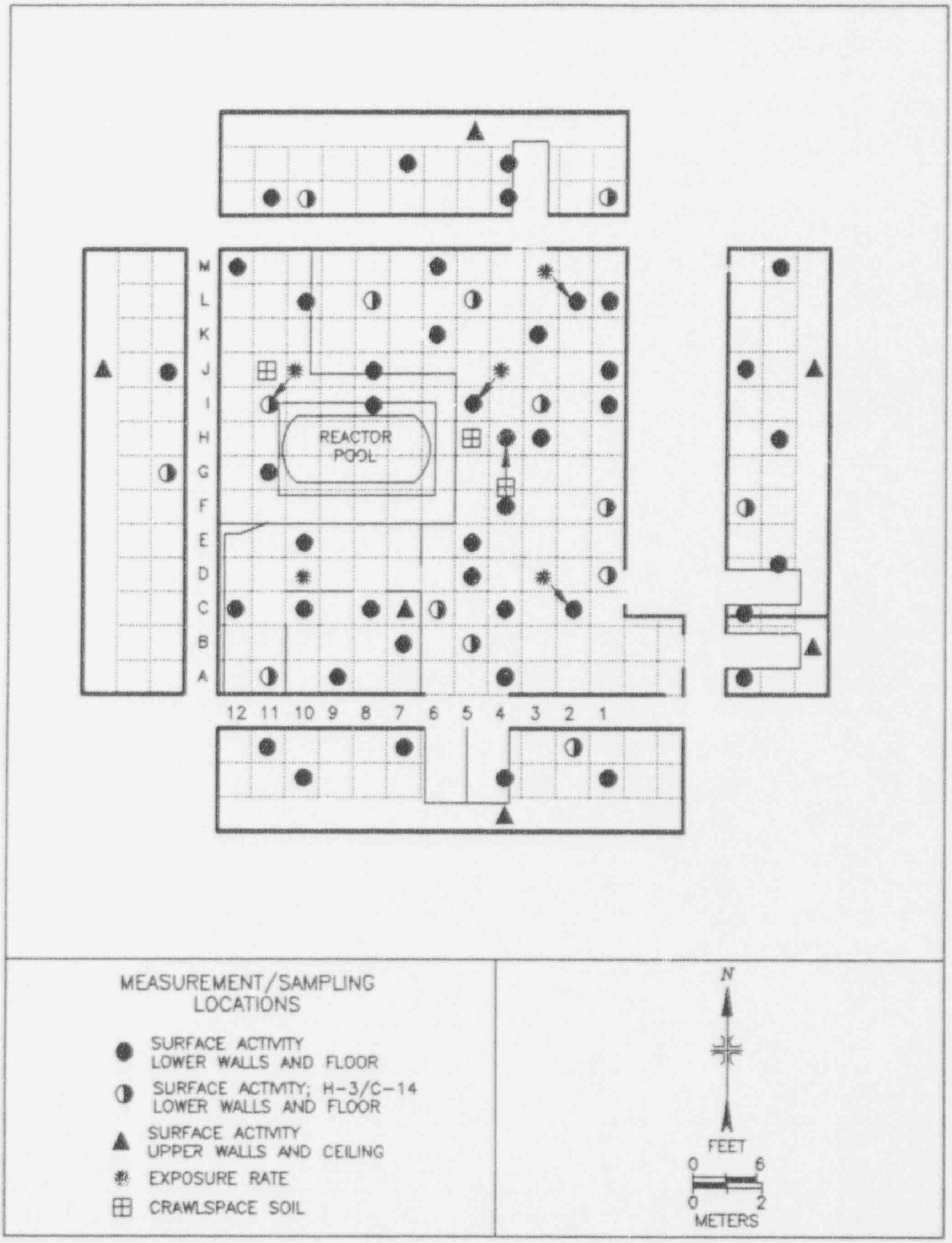

FIGURE 3: Room 131, Reactor Room – Measurement and Sampling Locations

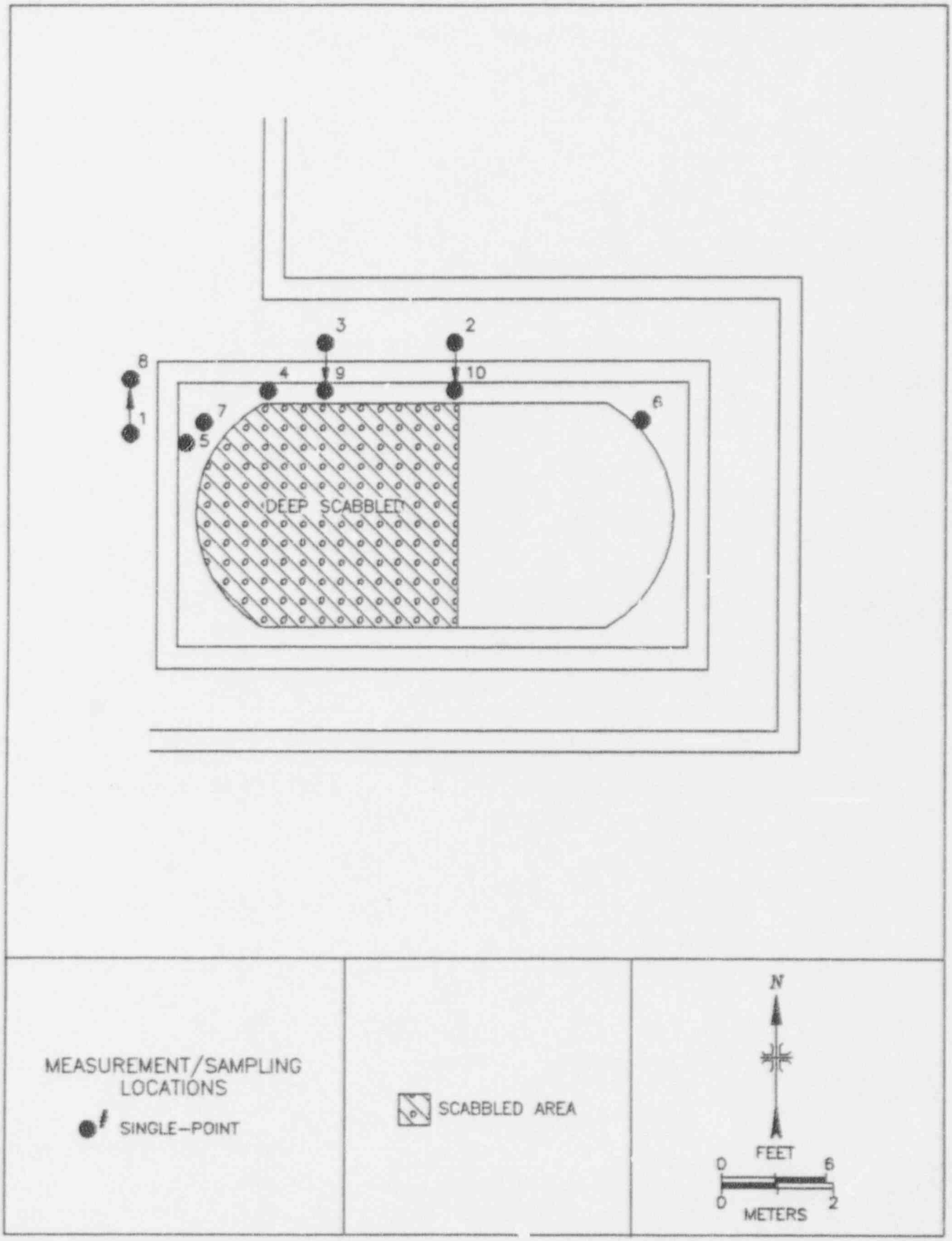

FIGURE 4: Top Edge of the Reactor Pool – Measurement and Sampling Locations

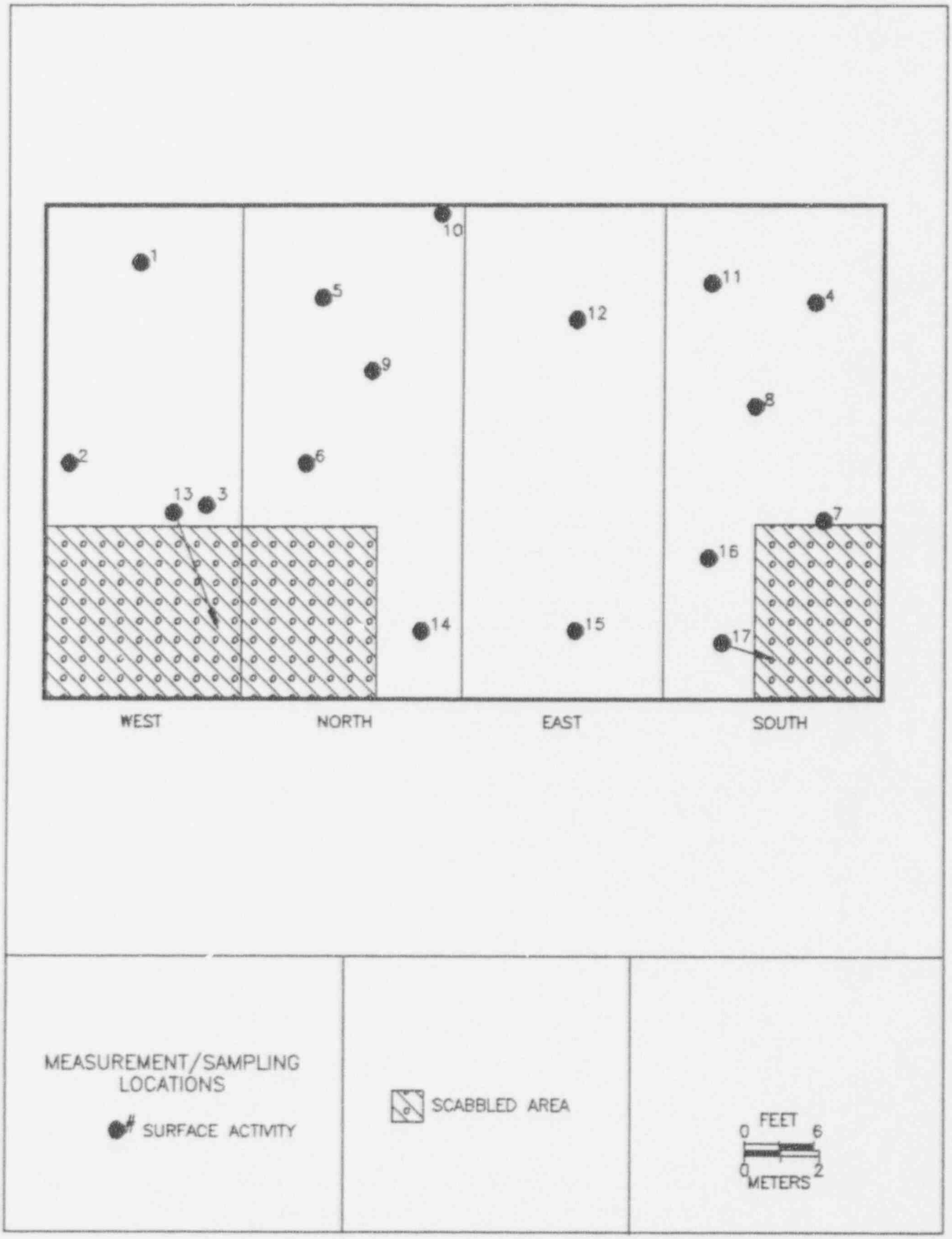

FIGURE 5: Walls of the Reactor Pool – Measurement and Sampling Locations

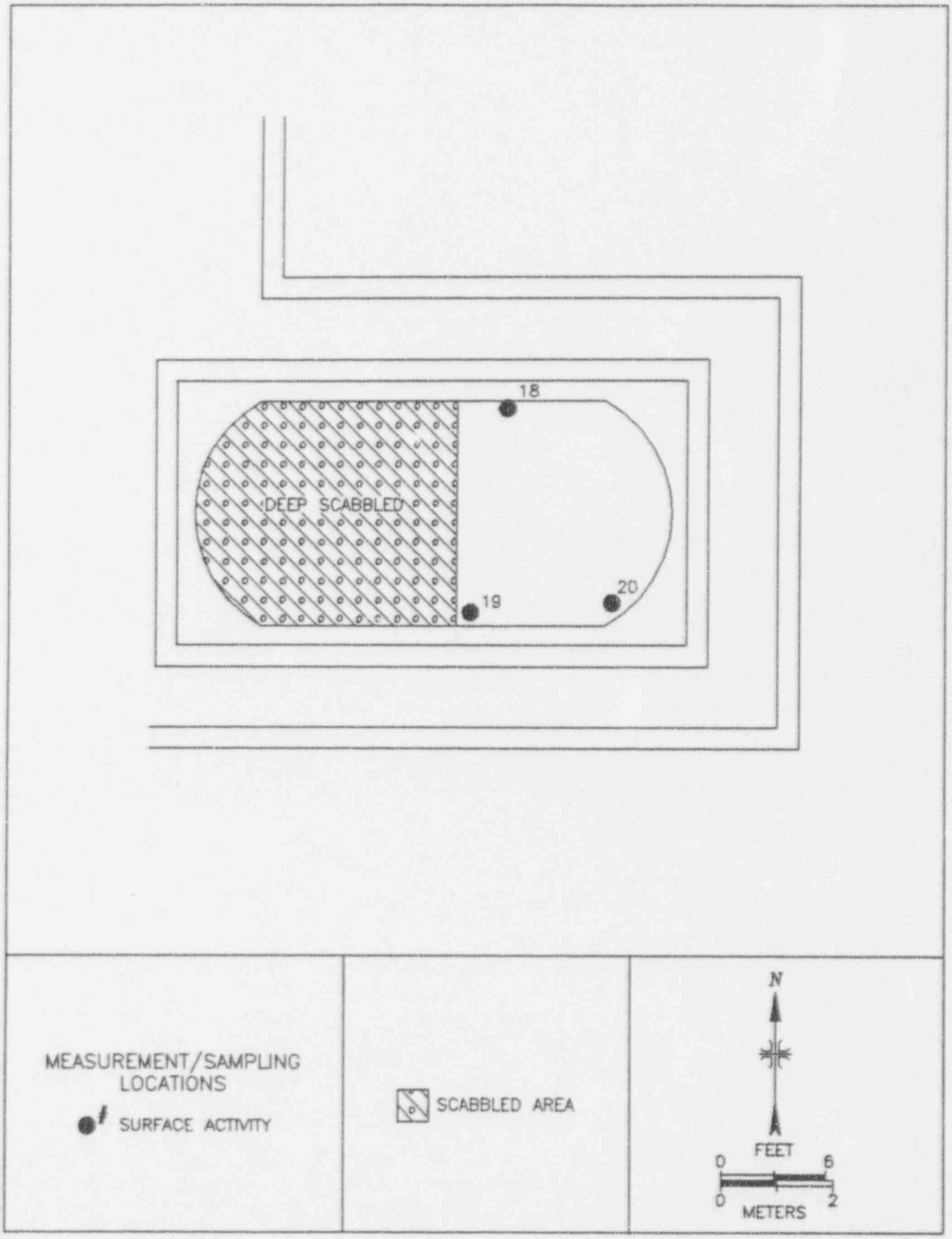

FIGURE 6: Floor of the Reactor Pool – Measurement and Sampling Locations

TABLE 1

SUMMARY OF SURFACE ACTIVITY MEASUREMENTS
LOCATIONS OF ELEVATED DIRECT RADIATION
UNIVERSITY OF TEXAS TRIGA REACTOR
AUSTIN, TEXAS

Location #[a]	Total Activity (dpm/100 cm²)		Removable Activity (dpm/100 cm²)	
	Alpha	Beta	Alpha	Beta
Prior to Removal of Reactor Pool Liner				
1	<66	46,000	<12	<17
2	<66	29,000	<12	<17
3	<66	21,000	<12	22
4	<66	19,000	<12	<17
5	<66	28,000	<12	<17
6	<66	11,000	<12	<17
After Removal of Reactor Pool Liner				
7	120	2500	<12	<20
8	<68	<1300	<12	<20
9	<68	5200	<12	<20
10	<68	2500	<12	<20

[a] Refer to Figure 4.

TABLE 2

SUMMARY OF SURFACE ACTIVITY MEASUREMENTS
AREAS ADJACENT TO THE REACTOR ROOM
UNIVERSITY OF TEXAS TRIGA REACTOR
AUSTIN, TEXAS

Location[a]	Total Activity (dpm/100 cm²)		Removable Activity (dpm/100 cm²)	
	Alpha	Beta	Alpha	Beta
Room 125				
W2,S2	<69	<1500	<12	<17
W4,S4	<69	<1500[b]	<12	<17
W7, S1	<69	<1500	<12	<17
Doorway to Room 125 A	<69	<1500	<12	<17
Doorway to Room 131	<69	<1500	<12	<17
Room 125 A				
Center of Room	<69	<1500	<12	<17
Hallway				
W2, S0	<69	<1500	<12	<17
Doorway to Room 131	<69	<1500	<12	<17
Room 131 A				
Center of Room	<69	<1500	<12	<17
Room 133				
W6, S1	<69	<1500	<12	<17
W0, S0	<69	<1500	<12	<17
W2, S2	<69	<1500	<12	<17
Room 135				
Center of Room	<69	<1500	<12	<17
Doorway to the Hall	<69	<1500	<12	<17
Room 135 A				
Center of Room	<69	<1500	<12	<17
Doorway to Room 133	<69	<1500	<12	<17

[a]These areas were not gridded. A description of the measurement location is provided. When coordinates are given, they designate the distance in meters from the northeast corner of the room. For example, "W2, S2" in Room 125 indicates a measurement location at 2 m west and 2 m south of the northeast corner of Room 125.

[b]This measurement was taken after removal of a portion of the wood floor by NETL while ESSAP was on site. Prior to this remediation the beta activity was 47,000 dpm/100 cm².

TABLE 3

EXPOSURE RATE MEASUREMENTS
UNIVERSITY OF TEXAS TRIGA REACTOR
AUSTIN, TEXAS

Location	Exposure Rate (μR/h)
Facility Exposure Rates[a]	
Room 131, Grid Block I5	10
Room 131, Grid Block I11	11
Room 131, Grid Block L2	10
Room 131, Grid Block C2	10
Room 131, Grid Block D10	11
Office, S.E. Corner of Room 131	13
Room 125, Center of Room	9
Background Exposure Rates	
Hallway in front of Room 133	11
Taylor Hall Entrance Hallway	11
Hallway between Room 131 and Main Hallway	11

[a] Refer to Figures 2 and 3.

TABLE 4

RADIONUCLIDE CONCENTRATIONS IN CRAWLSPACE SOIL SAMPLES UNIVERSITY OF TEXAS TRIGA REACTOR AUSTIN, TEXAS

Location in Crawlspace[b]	Radionuclide Concentrations (pCi/g)[a]			
	Co-60	Eu-152	U-235	U-238
Grid Block H4	<0.1	<0.2	0.2 ± 0.1	1.7 ± 1.1
Grid Block H5	<0.1	<0.2	0.1 ± 0.1	1.2 ± 1.0
Grid Block J11	<0.1	<0.2	0.1 ± 0.1	1.3 ± 1.1

[a]Uncertainties represent the 95% confidence level, based only on counting statistics.
[b]Locations listed here designate the grid block on the reactor room floor corresponding to the approximate locations of soil sample collected from crawlspace underneath the floor. Refer to Figure 4.

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2. Quadrex Corporation, "Project Report for Decontamination and Survey for Unconditional Release of the Reactor Room in Taylor Hall at the University of Texas," January 15, 1993.

3. Letter from T. Bauer (University of Texas) to Document Control Desk (NRC), Reference: "Inspection Report 50-192/93-01, Confirmation Survey, Removal of Pool Liner," May 3, 1993.

4. Oak Ridge Institute for Science and Education, "Radiological Survey Plan for the University of Texas TRIGA Reactor, Austin, Texas," March 30, 1993.

5. Letter from A. Ansari (ORISE) to B. Murray (NRC, Region IV), Reference: "Confirmatory Survey of the Reactor Pool Area, University of Texas," May 25, 1993.

6. Letter from A. Jaberabonansari (ORISE) to B. Murray (NRC, Region IV), Reference: "Final Status Survey of the University of Texas TRIGA Reactor," March 19, 1993.

7. Letter from A. Jaberabonansari (ORISE) to B. Murray (NRC, Region IV), Reference: "Comments on Quadrex Corporation Project Report for Decontamination and Survey of the Reactor Room in Taylor Hall at the University of Texas," March 24, 1993.

8. U.S. Nuclear Regulatory Commission, "Termination of Operating Licenses for Nuclear Reactors," Regulatory Guide 1.86, Washington D.c., June 1974.

9. U.S. Nuclear Regulatory Commission, "Disposal of Onsite Storage of Thorium and Uranium Wastes from Past Operations," 46 FR 52061, Washington, D.C., October 23, 1981.

10. U.S. Nuclear Regulatory Commission, Office of Nuclear Safety and Safeguards, "Review Plan: Evaluating Decommissioning Plans for Licenses Under 10 CFR Parts 30, 40, and 70," Washington, D.C. 1991.

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
Effective Area, 15.5 cm²
(Eoerline, Santa Fe, NM)

Eberline ZnS Scintillation Detector
Model AC-3-7
Effective Area, 59 cm²
(Eberline, Santa Fe, NM)

Ludlum Gas Proportional Detector
Model 43-37
Effective Area, 550 cm²
(Ludlum Measurements, Inc., Sweetwater, TX)

Ludlum Gas Proportional Detector
Model 43-68
Effective Area, 100 cm^2
(Ludlum Measurements, Inc.,
Sweetwater, TX)

Reuter-Stokes Pressurized Ionization Chamber
Model RSS-111
(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

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
3100 Vax 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
3100 Vax Workstation
(Canberra, Meriden, CT)

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

Tri-Carb Liquid Scintillation Analyzer
Model 1900CA
(Packard Instrument Co., Meriden, CT)

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 smaller area (100 cm^2) hand-held gas proportional 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-Beta	—	gas proportional detectors with ratemeter-scalers
Gamma	—	NaI scintillation detectors with ratemeters

Surface Activity Measurements

Measurements of total alpha and beta activity levels were performed using ZnS scintillation and GM detectors with ratemeters-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. The alpha activity background countrates for the ZnS scintillation detectors averaged 1 cpm for each detector. Alpha efficiency factors ranged from 0.18 to 0.19 for the ZnS scintillation detectors. The beta activity background count rates for the GM detectors ranged from 57 to 61 cpm. Beta efficiency factors ranged from

0.15 to 0.16 for the GM detector. The effective windows for the ZnS scintillation and GM detectors were 59 cm^2 and 15.5 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, obtained from each measurement location, were placed in labeled envelopes with the location and other pertinent information recorded. In addition, at 14 measurement locations, smear samples for H-3/C-14 analysis were obtained. These smears were placed in labeled glass vials and capped.

Exposure Rate Measurements

Measurements of gamma exposure rates were performed at 1 m above surface using a pressurized ionization chamber (PIC).

Miscellaneous Samples

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

Removable Activity

Gross Alpha/Beta

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

Liquid Scintillation

Smears were counted in a liquid scintillation counter for low-energy beta activity to determine H-3 and C-14 activity.

Miscellaneous Samples

Gamma Spectrometry

Solid Samples

Samples of solid material (soil) were dried, mixed, crushed, and/or homogenized as necessary, and a portion sealed in 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. Energy peaks used for determination of radionuclides of concern were:

Co-60	1.173 MeV
Eu-152	0.344 MeV

U-235	0.186 MeV
U-238	0.063 MeV from Th-234*

*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 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 4.66 times the standard deviation of the background count. 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 radionuclide in samples, the detection limits differ from sample to sample and instrument to instrument.

CALIBRATION AND QUALITY ASSURANCE

Analytical and field survey activities were conducted in accordance with procedures from the following ESSAP documents:

- Survey Procedures Manual, Revision 7 (May 1992)
- Laboratory Procedures Manual, Revision 7 (April 1992)
- Quality Assurance Manual, Revision 5 (May 1992)

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.

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 was used. Calibration or pressurized ionization chambers was performed by the manufacturer.

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

REGULATORY GUIDE 1.86, TERMINATION OF OPERATING LICENSES FOR NUCLEAR REACTORS

AND

GUIDELINES FOR RESIDUAL CONCENTRATIONS OF THORIUM AND URANIUM WASTES IN SOIL

U.S. ATOMIC ENERGY COMMISSION

REGULATORY GUIDE

DIRECTORATE OF REGULATORY STANDARDS

June 1974

REGULATORY GUIDE 1.86

TERMINATION OF OPERATING LICENSES FOR NUCLEAR REACTORS

A. INTRODUCTION

Section 50.51, "Duration of license, renewal," of 10 CFR Part 50, "Licensing of Production and Utilization Facilities," requires that each license to operate a production and utilization facility be issued for a specified duration. Upon expiration of the specified period, the license may be either renewed or terminated by the Commission. Section 50.82, "Applications for termination of licenses," specifies the requirements that must be satisfied to terminate an operating license, including the requirement that the dismantlement of the facility and disposal of the component parts not be inimical to the common defense and security or to the health and safety of the public. This guide describes methods and procedures considered acceptable by the Regulatory staff for the termination of operating licenses for nuclear reactors. The advisory Committee on Reactor Safeguards has been consulted concerning this guide and has concurred in the regulatory position.

B. DISCUSSION

When a licensee decides to terminate his nuclear reactor operating license, he may, as a first step in the process, request that his operating license be amended to restrict him to possess but not operate the facility. The advantage to the licensee of converting to such a possession-only license is reduced surveillance requirements in that periodic surveillance of equipment important to the safety of reactor operation is no longer required. Once this possession-only license is issued, reactor operation is not permitted. Other activities from the reactor and placing it in storage (either onsite or offsite) may be continued.

A licensee having a possession-only license must retain, with the Part 50 license, authorization for special nuclear material (10 CFR Part, 70, "Special Nuclear Material"), byproduct material (10 CFR Part 30, "Rules of General Applicability to Licensing of Byproduct Material"), and source material (10 CFR Part 40, "Licensing of Source Material"), until the fuel, radioactive components, and sources are removed from the facility. Appropriate administrative controls and facility requirements are imposed by the Part 50 license and the technical specifications to assure that proper surveillance is performed and that the reactor facility is maintained in a safe condition and not operated.

A possession-only license permits various options and procedures for decommissioning, such as mothballing, entombment, or dismantling. The requirements imposed depend on the option selected.

Section 50.82 provides that the licensee may dismantle and dispose of the component parts of a nuclear reactor in accordance with existing regulations. For research reactors and critical facilities, this has usually meant the disassembly of a reactor and its shipment organization for further use. The site from which a reactor has been removed must be decontaminated, as necessary, and inspected by the Commission to determine whether unrestricted access can be approved. In the case of nuclear power reactors, dismantling has usually been accomplished by shipping fuel offsite, making the reactor inoperable, and disposing of some of the radioactive components.

USAEC REGULATORY GUIDES

Regulatory Guides are issued to describe and make available to the public methods acceptable to the AEC regulatory staff of implementing specific parts of the Commission's regulations, to originate techniques used by the staff in evaluating specific problems or postulated accidents, or to provide guidance to applicants. Regulatory Guides are not substitutes for regulations and compliance with them is not required. Methods and solutions different from those set out in the guides will be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a permit or license by the Commission.

Published guides will be revised periodically, as appropriate, to accommodate comments and to reflect new information or experience.

Copies of published guides may be obtained by request indicating the division desired to the U.S. Atomic Energy Commission, Washington, D.C. 20545. Attention: Director of Regulatory Standards. Comments and suggestions for improvements in these guides are encouraged and should be sent to the Secretary of the Commission, U.S. Atomic Energy commission, Washington, D.C. 20545. Attention: Chief, Public Proceedings Staff.

The guides are issued in the following ten broad divisions.

1. Power Reactors
2. Research and test Reactors
3. Fuels and Materials Facilities
4. Environmental and Siting
5. Materials and Plan Protection
6. Products
7. Transportation
8. Occupational Health
9. Antitrust Review
10. General

Radioactive components may be either shipped off-site for burial at an authorized burial ground or secured on the site. Those radioactive materials remaining on the site must be isolated from the public by physical barriers or other means to prevent public access to hazardous levels of radiation. Surveillance is necessary to assure the long term integrity of the barriers. The amount of surveillance required depends upon (1) the potential hazard to the health and safety of the public from radioactive material remaining on the site and (2) the integrity of the physical barriers. Before areas may be released for unrestricted use, they must have been decontaminated or the radioactivity must have decayed to less than prescribed limits (Table 1).

The hazard associated with the returned facility is evaluated by considering the amount and type of remaining contamination, the degree of confinement of the remaining radioactive materials, the physical security provided by the confinement, the susceptibility to release of radiation as a result of natural phenomena, and the duration of required surveillance.

C. REGULATORY POSITION

1. APPLICATION FOR A LICENSE TO POSSESS BUT NOT OPERATE (POSSESSION-ONLY LICENSE)

A request to amend an operating license to a possession-only license should be made to the Director of Licensing, U.S. Atomic Energy Commission, Washington, D.C. 20545. The request should include the following information:

a. A description of the current status of the facility.

b. A description of measures that will be taken to prevent criticality or reactivity changes and to minimize releases of radioactivity from the facility.

c. Any proposed changes to the technical specifications that reflect the possession-only facility status and the necessary disassembly/retirement activities to be performed.

d. A safety analysis of both the activities to be accomplished and the proposed changes to the technical specifications.

e. An inventory of activated materials and their location in the facility.

2. ALTERNATIVES FOR REACTOR RETIREMENT

Four alternatives for retirement of nuclear reactor facilities are considered acceptable by the Regulatory staff. These are:

a. Mothballing. Mothballing of a nuclear reactor facility consists of putting the facility in a state of protective storage. In general, the facility may be left intact except that all fuel assemblies and the radioactive fluids and waste should be removed from the site. Adequate radiation monitoring, environmental surveillance, and appropriate security procedures should be established under a possession-only license to ensure that the health and safety of the public is not endangered.

b. In-Place Entombment. In-place entombment consists of sealing all the remaining highly radioactive or contaminated components (e.g., the pressure vessel and reactor internals) within a structure integral with the biological shield after having all fuel assemblies, radioactive fluids and wastes, and certain selected components shipped offsite. The structure should provide integrity over the period of time in which significant quantities (greater than Table 1 levels) of radioactivity remain with the material in the entombment. An appropriate and continuing surveillance program should be established under a possession-only license.

c. Removal of Radioactive. Components and Dismantling. All fuel assemblies, radioactive fluids and waste, and other materials having activities above accepted unrestricted activity levels (Table 1) should be removed from the site. The facility owner may then have unrestricted use of the site with no requirement for a license. If the facility owner so desires, the remainder of the reactor facility may be dismantled and all vestiges removed and disposed of.

d. Conversion to a New Nuclear System or a Fossil Fuel System. This alternative, which applies only to nuclear power plants, utilizes the existing turbine system with a new steam supply system. The original nuclear steam supply system should be separated from the electric generating system and disposed of in accordance with one of the previous three retirement alternatives.

3. SURVEILLANCE AND SECURITY FOR THE RETIREMENT ALTERNATIVES WHOSE FINAL STATUS REQUIRES A POSSESSION-ONLY LICENSE

A facility which has been licensed under a possession-only license may contain a significant amount of radioactivity in the form of activated and

contaminated hardware and structural materials. Surveillance and commensurate security should be provided to assure that the public health and safety are not endangered.

a. Physical security to prevent inadvertent exposure of personnel should be provided by multiple locked barriers. The presence of these barriers should make it extremely difficult for an unauthorized person to gain access to areas where radiation or contamination levels exceed those specified in Regulatory Position C.4. To prevent inadvertent exposure, radiation areas above 5 mR/hr, such as near the activated primary system of a power plant, should be appropriately marked and should not be accessible except by cutting of welded closures or the disassembly and removal of substantial structures and/or shielding material. Means such as a remote-readout intrusion alarm system should be provided to indicate to designated personnel when a physical barrier is penetrated. Security personnel that provide access control to the facility may be used instead of the physical barriers and the intrusion alarm systems.

b. The physical barriers to unauthorized entrance into the facility, e.g., fences, buildings, welded doors, and access openings, should be inspected at least quarterly to assure that these barriers have not deteriorated and that locks and locking apparatus are intact.

c. A facility radiation survey should be performed at least quarterly to verify that no radioactive material is escaping or being transported through the containment barriers in the facility. Sampling should be done along the most probable path by which radioactive material such as that stored in the inner containment regions could be transported to the outer regions of the facility and ultimately to the environs.

d. An environmental radiation survey should be performed at least semiannually to verify that no significant amounts of radiation have been released to the environment from the facility. Samples such as soil, vegetation, and water should be taken at locations for which statistical data has been established during reactor operations.

e. A site representative should be designated to be responsible for controlling authorized access into and movement within the facility.

f. Administrative procedures should be established for the notification and reporting of abnormal occurrences such as (1) the entrance of an unauthorized person or persons into the facility and (2) a significant change in the radiation or contamination levels in the facility or the offsite environment.

g. The following reports should be made:

(1) An annual report to the Director of Licensing, U.S. Atomic Energy Commission, Washington, D.C. 20545, describing the results of the environmental and facility radiation surveys, the status of the facility, and an evaluation of the performance of security and surveillance measures.

(2) An abnormal occurrence report to the Regulatory Operations Regional Office by telephone within 24 hours of discovery of an abnormal occurrence. The abnormal occurrence will also be reported in the annual report described in the preceding item.

h. Records or logs relative to the following items should be kept and retained until the license is terminated, after which they must be stored with other plant records:

(1) Environmental surveys,

(2) Facility radiation surveys,

(3) Inspections of the physical barriers, and

(4) Abnormal occurrences.

4. DECONTAMINATION FOR RELEASE FOR UNRESTRICTED USE

If it is desired to terminate a license and to eliminate any further surveillance requirements, the facility should be sufficiently decontaminated to prevent risk to the public health and safety. After the decontamination is satisfactorily accomplished and the site inspected by the Commission, the Commission may authorize the license to be terminated and the facility abandoned or released for unrestricted use. The licensee should perform the decontamination using the following guidelines:

a. The licensee should make a reasonable effort to eliminate residual contamination.

b. No covering should be applied to radioactive surfaces of equipment of structures by paint, plating, or other covering material until it is known that contamination levels (determined by a survey and documented) are below the limits specified in Table 1. In addition, a reasonable effort should be made (and documented) to further minimize contamination prior to any such covering.

c. The radioactivity of the interior surfaces of pipes, drain lines, or ductwork should be determined

by making measurements at all traps and other appropriate access points, provided contamination at these locations is likely to be representative of 2contamination on the interior of the pipes, drain lines, or ductwork. Surfaces of premises, equipment, or scrap which are likely to be contaminated but are of such size, construction, or location as to make the surface inaccessible for purposes of measurement should be assumed to be contaminated in excess of the permissible radiation limits.

d. Upon request, the Commission may authorize a licensee to relinquish possession or control of premises, equipment, or scrap having surfaces contaminated in excess of the limits specified. This may include, but is not limited to, special circumstances such as the transfer of premises to another licensed organization that will continue to work with radioactive materials. Requests for such authorization should provide:

(1) Detailed, specific information describing the premises, equipment, scrap, and radioactive contaminants and the nature, extent, and degree of residual surface contamination.

(2) A detailed health and safety analysis indicating that the residual amounts of materials on surface areas, together with other considerations such as the prospective use of the premises, equipment, or scrap, are unlikely to result in an unreasonable risk to the health and safety of the public.

e. Prior to release of the premises for unrestricted use, the licensee should make a comprehensive radiation survey establishing that contamination is within the limits specified in Table 1. A survey report should be filed with the Director of Licensing, U.S. Atomic Energy Commission, Washington, D.C. 20545, with a copy to the Director of the Regulatory Operations regional Office having jurisdiction. The report should be filed at least 30 days prior to the planned date of abandonment. The survey report should:

(1) Identify the premises;

(2) Show that reasonable effort has been made to reduce residual contamination to as low as practicable levels;

(3) Describe the scope of the survey and the general procedures followed; and

(4) State the finding of the survey in units specified in Table 1.

After review of the report, the Commission may inspect the facilities to confirm the survey prior to granting approval for abandonment.

5. REACTOR RETIREMENT PROCEDURES

As indicated in Regulatory Position C.2, several alternatives are acceptable for reactor facility retirement. If minor disassembly or "mothballing" is planned, this could be done by the existing operating and maintenance procedures under the license in effect. Any planned actions involving an unreviewed safety question or a change in the technical specifications should be reviewed and approved in accordance with the requirements of 10 CFR § 50.59.

If major structural changes to radioactive components of the facility are planned, such as removal of the pressure vessel or major components of the primary system, a dismantlement plan including the information required by § 50.82 should be submitted to the Commission. A dismantlement plan should be submitted for all the alternatives of Regulatory Position C.2 except mothballing. However, minor disassembly activities may still be performed in the absence of such a plan, provided they are permitted by existing operating and maintenance procedures. A dismantlement plan should include the following:

a. A description of the ultimate status of the facility

b. A description of the dismantling activities and the precautions to be taken.

c. A safety analysis of the dismantling activities including any effluents which may be released.

d. A safety analysis of the facility in its ultimate status.

Upon satisfactory review and approval of the dismantling plan, a dismantling order is issued by the Commission in accordance with § 50.82. When dismantling is completed and the Commission has been notified by letter, the appropriate Regulatory Operations Regional Office inspects the facility and verifies completion in accordance with the dismantlement plan. If residual radiation levels do not exceed the values in Table 1, the Commission may terminate the license. If possession-only license under which the dismantling activities have been conducted or, as an alternative, may make application to the State (if an Agreement State) for a byproduct materials license.

TABLE 1
ACCEPTABLE SURFACE CONTAMINATION LEVELS

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

[a]Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta- gamma-emitting nuclides 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 observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.
[c]Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each such object.
[d]The maximum contamination level applies to an area of not more than 100 cm^2.
[e]The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.

Guidelines for Residual Concentrations of Thorium and Uranium Wastes in Soil

On October 23, 1981, the Nuclear Regulatory Commission published in the Federal register a notice of Branch Technical Position on "Disposal or Onsite Storage of Thorium and Uranium Wastes from Past Operations." This document established guidelines for concentrations of uranium and thorium in soil, that will limit maximum radiation received by the public under various conditions of future land usage. These concentrations are as follows:

Material	Maximum Concentrations (pCi/g) for various options			
	1[a]	2[b]	3[c]	4[d]
Natural Thorium (Th-232 + Th-228) with daughters present and in equilibrium	10	50	--	500
Natural Uranium (U-238 + U-234) with daughters present and in equilibrium	10	--	40	200
Depleted Uranium:				
Soluble	35	100	--	1,000
Insoluble	35	300	--	3,000
Enriched Uranium:				
Soluble	30	100	--	1,000
Insoluble	30	250	--	2,500

[a]Based on EPA cleanup standards which limit radiation to 1 mrad/yr to lung and 3 mrad/yr to bone from ingestion and inhalation and 10 μR/h above background from direct external exposure.
[b]Based on limiting individual dose to 170 mrem/yr.
[c]Based on limiting equivalent exposure to 0.02 working level or less.
[d]Based on limiting individual dose to 500 mrem/yr and in case of natural uranium, limiting exposure to 0.02 working level or less.