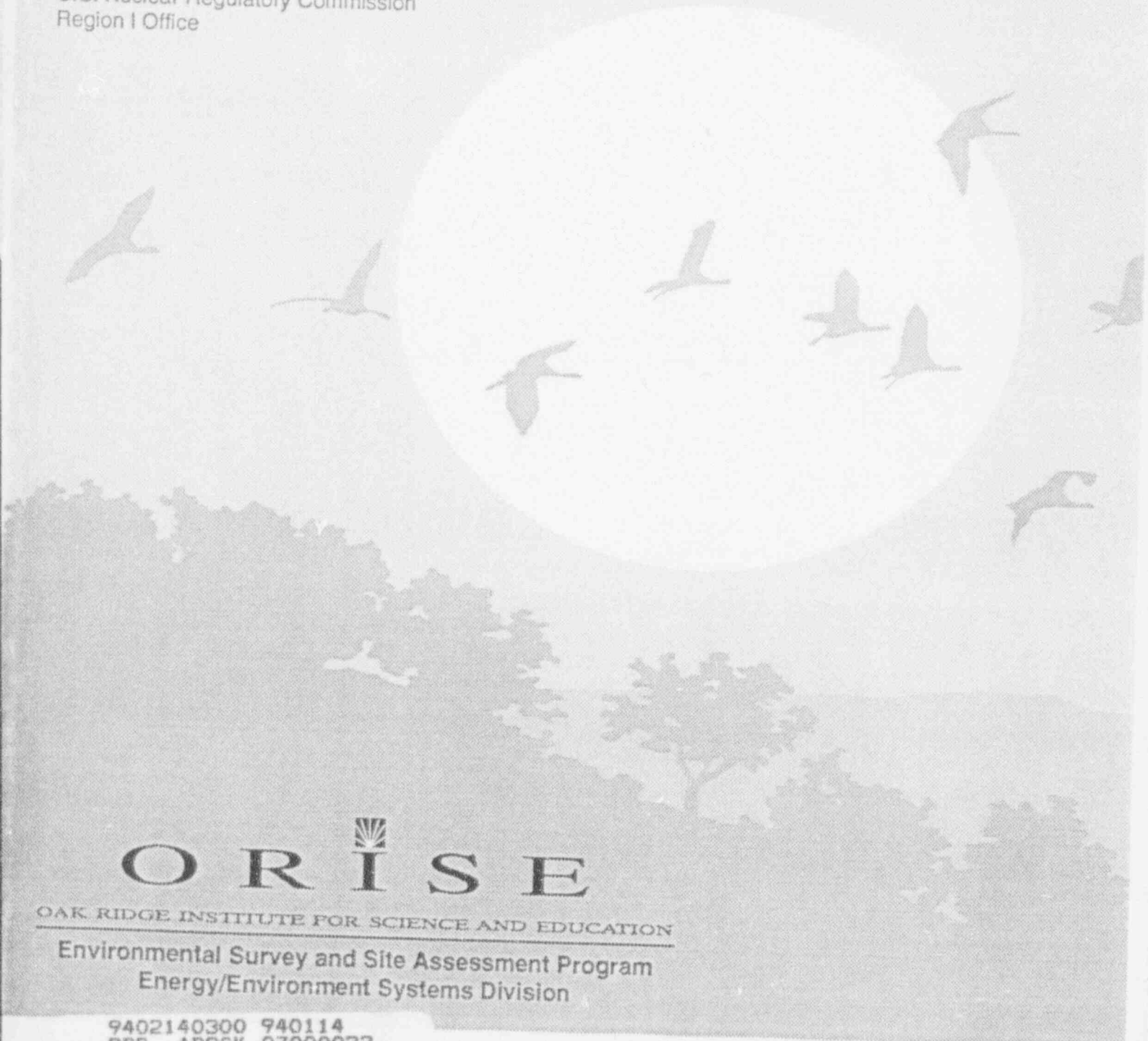
CONFIRMATORY SURVEY OF THE TEXAS INSTRUMENTS, INC. FORMER BURIAL SITE ATTLEBORO, MASSACHUSETTS

[DOCKET 070-00033]

A. J. ANSARI

Prepared for the
U.S. Nuclear Regulatory Commission
Region I Office



ORISE

OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION

Environmental Survey and Site Assessment Program
Energy/Environment Systems Division

CONFIRMATORY SURVEY OF THE TEXAS INSTRUMENTS, INC. FORMER BURIAL SITE ATTLEBORO, MASSACHUSETTS

Prepared by

A. J. Ansari

Environmental Survey and Site Assessment Program
Energy/Environment System Division
Oak Ridge Institute for Science and Education
Oak Ridge, Tennessee 37831-0117

Prepared for the

U.S. Nuclear Regulatory Commission
Region I Office

January 1994

DRAFT REPORT

This report is based on work performed under an Interagency Agreement (NRC Fin. No. A-9076) between the U.S. Nuclear Regulatory Commission and the U.S. Department of Energy. Oak Ridge Institute for Science and Education performs complementary work under contract number DE-AC05-76OR00033 with the U.S. Department of Energy.

CONFIRMATORY SURVEY
OF THE TEXAS INSTRUMENTS, INC.
FORMER BURIAL SITE
ATTLEBORO, MASSACHUSETTS

Prepared by: _____ Date: _____
A. J. Ansari, Project Leader
Environmental Survey and Site Assessment Program

Reviewed by: _____ Date: _____
W. L. Beck, Acting Laboratory Manager
Environmental Survey and Site Assessment Program

Reviewed by: _____ Date: _____
M. R. Landis, Project Manager
Environmental Survey and Site Assessment Program

Reviewed by: _____ Date: _____
A. T. Payne, Quality Assurance Officer
Environmental Survey and Site Assessment Program

Reviewed by: _____ Date: _____
J. D. Berger, Program Director
Environmental Survey and Site Assessment Program

ACKNOWLEDGEMENTS

The author would like to acknowledge the significant contributions of the following staff members:

FIELD STAFF

D. M. Nugent
J. L. Payne
S. E. Potter

LABORATORY STAFF

R. D. Condra
J. S. Cox
R. L. Epperson
M. J. Laudeman
S. T. Shipley

CLERICAL STAFF

T. T. Claiborne
D. A. Cox
R. D. Ellis
K. E. Waters

ILLUSTRATOR

M. A. Henke
T. D. Herrera

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS AND ACRONYMS

ASME	American Society of Mechanical Engineers
cm	centimeter
cm^2	square centimeter
cpm	counts per minute
CPS	Creative Pollution Solutions
EML	Environmental Measurement Laboratory
EPA	Environmental Protection Agency
ESSAP	Environmental Survey and Site Assessment Program
m	meter
m^2	square meter
M&C	Metals and Controls, Incorporated
MDA	minimum detectable activity
NaI	sodium iodide
NIST	National Institute for Standards Technology
NRC	Nuclear Regulatory Commission
ORAU	Oak Ridge Associated Universities
ORISE	Oak Ridge Institute for Science and Education
pCi/g	picocurie's per gram
PIC	Pressurized Ionization Chamber
RSAP	Radiological Site Assessment Program
TI	Texas Instruments, Incorporated
μR/h	microroentgen per hour

CONFIRMATORY SURVEY OF THE TEXAS INSTRUMENTS, INC. FORMER BURIAL SITE ATTLEBORO, MASSACHUSETTS

INTRODUCTION AND SITE HISTORY

The Texas Instruments Incorporated site at Attleboro, Massachusetts, was owned and operated by Metals and Controls, Inc. (M&C) until 1959, at which time M&C merged with Texas Instruments, Incorporated (TI). The General Plate Division of M&C began processing nuclear materials in 1952, and between 1952 and 1959 fabricated uranium foils for reactor experiments and fuel components and complete reactor fuel cores for the U.S. Navy. Source material license D-549 was issued permitting acquisition and title to not more than 22.7 kg (50 pounds) of refined source material for use in the production of uranium foils; additional source material was acquired and used under contract with the U.S. Government. Special nuclear materials license No. SNM-23 was issued, permitting acquisition and title to 110 kg of enriched uranium for fabrication of the fuel components and cores. After the merger in 1959, Texas Instruments continued fabricating reactor fuel cores, primarily for research and production reactors. Also, source materials, i.e., natural uranium and thorium, were still being fabricated for sale to various corporations.

A 1964 Texas Instruments health and safety manual states that uranium- and thorium-contaminated noncombustible scrap material and machinery were collected in 55-gallon steel drums and were disposed of through authorized agencies, or were buried on-site in compliance with 10CFR20.304. Burials were made from 1958 to 1961, and the burial site was closed in 1967. Records indicate two known burials, one in 1958 of contaminated ductwork, and one in 1961 of 28.4 mCi of enriched uranium noncombustible scrap. Work with nuclear materials was gradually reduced beginning in 1968 and was terminated in 1974. The interior of the facility was decontaminated and released for unrestricted use by the Nuclear Regulatory Commission (NRC) in 1983.

The Radiological Site Assessment Program (RSAP) of the Oak Ridge Associated Universities (ORAU) conducted a radiological survey of portions of the facility's outdoor areas during April and May, 1984. The results of that survey indicated several areas with surface and/or subsurface uranium concentrations in excess of guidelines.[1] In the summer of 1992, Creative Pollution Solutions, Inc. was contracted by Texas Instruments Inc. to initiate remediation activities. The licensee submitted a post-excavation radiological survey report to the NRC in November of 1992.[2]

The Environmental Survey and Site Assessment Program (ESSAP) of the Oak Ridge Institute for Science and Education (ORISE) performed a confirmatory survey of the excavated area in December of 1992. The results of that survey indicated that the full extent of the burial site, particularly on the west side, adjacent to Building 11 parking lot, had not been determined.[3] Subsequently, further remediation of the former burial site was performed by Creative Pollution Solutions, Inc. Following those remediations, the licensee completed final survey activities and backfilling operations.[4]

The U.S. Nuclear Regulatory Commission, Region I Office, requested that the Environmental Survey and Site Assessment Program (ESSAP) of the Oak Ridge Institute for Science and Education (ORISE) perform an independent confirmatory survey of the former burial site. This report summarizes the procedures and results of that survey.

SITE DESCRIPTION

The Texas Instruments Inc. Facility, Attleboro, MA is located in North Attleboro, approximately 48 kilometers south of Boston on Route 123 (Figure 1). The former burial site is located between Buildings 11 and 12 (Figure 2). The area of concern for remediation activities was approximately 10,000 m^2. The excavated area at the burial site was approximately 2,500 m^2 and the average depth of the excavated area was approximately 1.5 meters. The west end of the excavation extended into the parking lot, adjacent to Building 11. The excavated area has been backfilled and landscaped. The area which extended into the parking lot has been repaved.

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 survey data, relative to established guidelines.

DOCUMENT REVIEW

The final radiological status report, provided by the Texas Instruments Incorporated, were reviewed by ESSAP as part of the confirmatory activities.[4] Analytical procedures and methods utilized by the licensee were reviewed for adequacy and appropriateness. The data were reviewed for accuracy, completeness, and compliance with applicable NRC guidelines.

PROCEDURES

On December 14 and 15, 1993, ESSAP performed a confirmatory survey of the former burial site. The survey was conducted in accordance with a survey plan which was submitted to and approved by the NRC, Region I Office.[5]

REFERENCE GRID

A 10 m x 10 m grid was established during ESSAP's radiological survey of this site in 1984 which was subsequently used by the licensee.[2,4] The same reference grid was used in this survey.

SURFACE SCANS

Surface scans of the former burial site (approximately 10,000 m^2) were performed using NaI detectors coupled to countrate meters with audible indicators. Surface scans for gamma radiation were performed on 100% of the former excavation and the two meter perimeter immediately surrounding that area. Approximately 50% of the remaining surface area was also scanned.

EXPOSURE RATE MEASUREMENTS

Background exposure rates, determined during a previous ESSAP survey of this facility, were used for comparison.[1]

Exposure rate measurements were performed at 1 m above the surface at 12 locations, using a pressurized ionization chamber (PIC). Measurement locations are illustrated in Figure 3.

SOIL SAMPLING

The analysis results of background soil samples, collected during a previous ESSAP survey of this facility, were used for comparison.[1]

Five surface soil samples were obtained at the center of randomly selected grid blocks. In addition, two surface soil samples were collected from the area between grid coordinates 185N, 170E and 195N, 180E where the licensee had reported slightly elevated gamma radiation.[4] Sampling locations are illustrated in Figure 4.

Thirty-seven soil samples were collected from 14 boreholes. The boreholes were drilled on and around the former excavated area to a depth of approximately 2 meters, except for a number of locations where relatively large pieces of rock were encountered at a depth of approximately 1-1.5 meters. On the west side of the excavation, boreholes were drilled 3 meters from the edge of the former excavation at approximately 20 meter intervals. For the remaining perimeter area, boreholes were drilled at approximately 40 meter intervals. The location of a number of boreholes had to be moved because of their proximity to water, gas, and compressed air lines.

The boreholes were scanned for gamma activity, using a collimated NaI detector coupled to a countrate meter with an audible indicator. Systematic soil samples were collected from the surface (0-15 cm), the middle (85-100 cm), and the bottom (185-200 cm) of each borehole. In the parking lot area, the "surface" soil sample was approximately 30 cm below the surface of the pavement. Furthermore, when the depth of a borehole was 1.5 m, the bottom soil sample

was collected at 135-150 cm. When the depth of a borehole was 1 m, only two samples were collected from that borehole (0-15, and 85-100 cm).

SAMPLE ANALYSIS AND DATA INTERPRETATION

Samples and data were returned to ORISE's ESSAP laboratory in Oak Ridge, TN for analysis and interpretation. Exposure rates were reported in μR/h. Soil samples were analyzed by gamma spectrometry. Spectra were reviewed for U-235, U-238, Th-232, Th-228, and any other identifiable photopeaks. Soil 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.[6] In ESSAP's opinion, the licensee documents provide an adequate description of the radiological condition of the facility relative to the NRC guidelines for release to unrestricted use.

SURFACE SCANS

Surface scans for gamma activity did not identify any locations of elevated direct radiation.

EXPOSURE RATE MEASUREMENTS

The background exposure rates, previously measured at this site, ranged from 10 to 11 μR/h and averaged 10 μR/h.[1]

Exposure rates, measured at 12 locations on the former burial site ranged from 9 to 11 μR/h. (Table 1).

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES

Total uranium concentrations in background soil samples, previously determined for this site, ranged from 1.0 to 2.4 pCi/g.[1]

Concentrations of U-235, U-238, and total uranium in surface soil samples ranged from <0.1 to 0.4 pCi/g, 0.7 to 10 pCi/g, and 3.0 to 20 pCi/g, respectively. Concentrations of U-235, U-238, and total uranium in subsurface soil samples ranged from <0.1 to 0.6 pCi/g, 0.6 to 13 pCi/g, and 2.9 to 27 pCi/g, respectively (Table 2).

COMPARISON OF RESULTS WITH GUIDELINES

The NRC guidelines for residual concentrations of radionuclides in soil, established for license termination or release of a facility for unrestricted use are presented in Appendix C. The primary contaminant of concern at this site is enriched uranium.

The soil concentration guideline for enriched uranium is 30 pCi/g.[7] The total uranium concentrations in all surface and subsurface soil samples were within this limit.

At this site, the applicable NRC guideline for exposure rate at 1 m above the surface is 10 μR/h above background, consistent with the Branch Technical Position.[7] All exposure rates were within this limit.

SUMMARY

During the period December 14 and 15, 1993, at the request of the NRC Region I Office, the Environmental Survey and Site Assessment Program of ORISE performed a confirmatory survey of the former burial site at Texas Instruments Incorporated. The survey activities consisted of surface scans for gamma activity, exposure rate measurements, and soil sampling.

Exposure rates were all within the 10 μR/h above background criterion. The radionuclide concentrations in surface and subsurface soil samples were less than the applicable guidelines for release for unrestricted use. In ESSAP's opinion, the licensee documents provide an adequate description of the radiological condition of the facility.

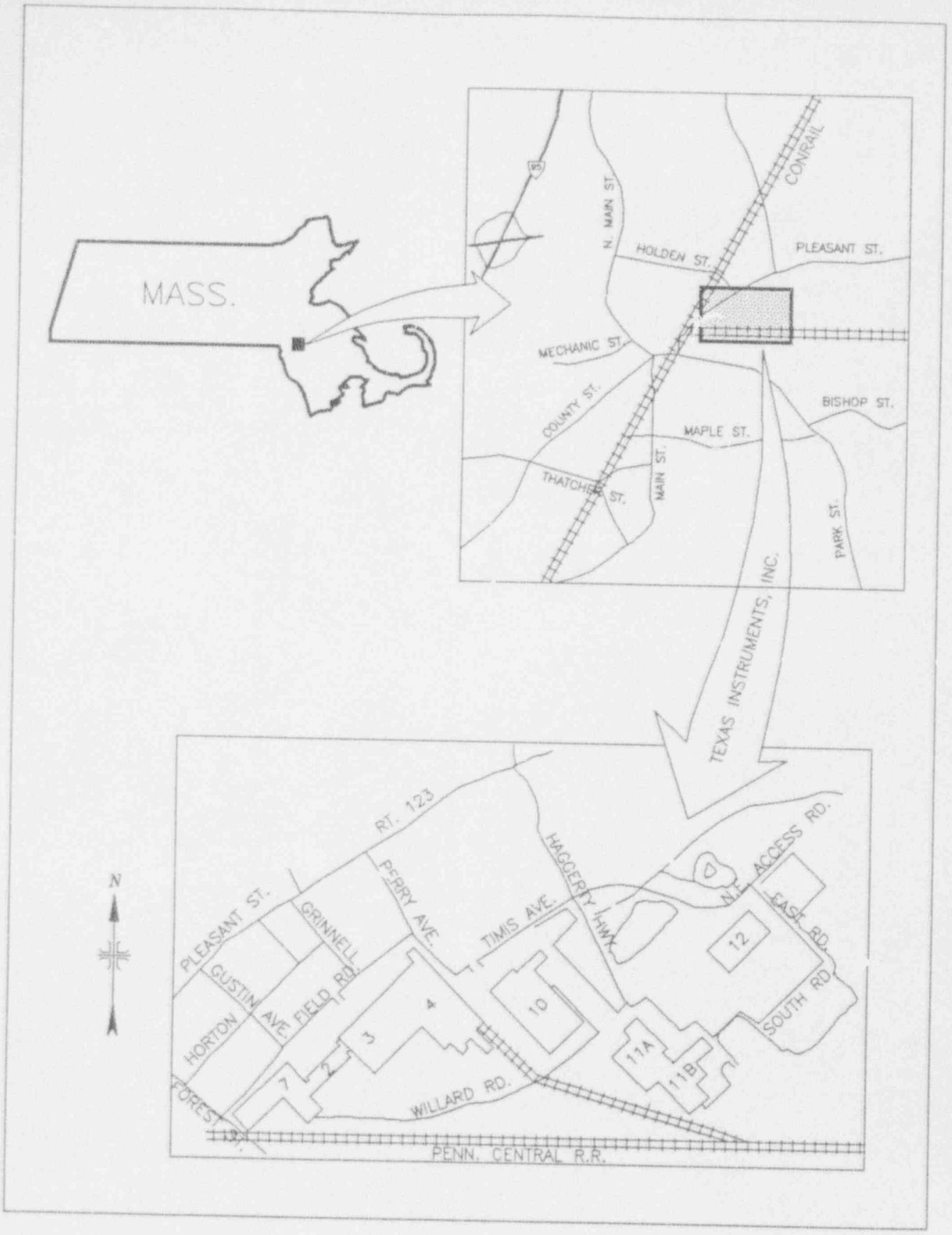


FIGURE 1: Map of Attleboro, Massachusetts – Location and Plan View of the Texas Instruments Site

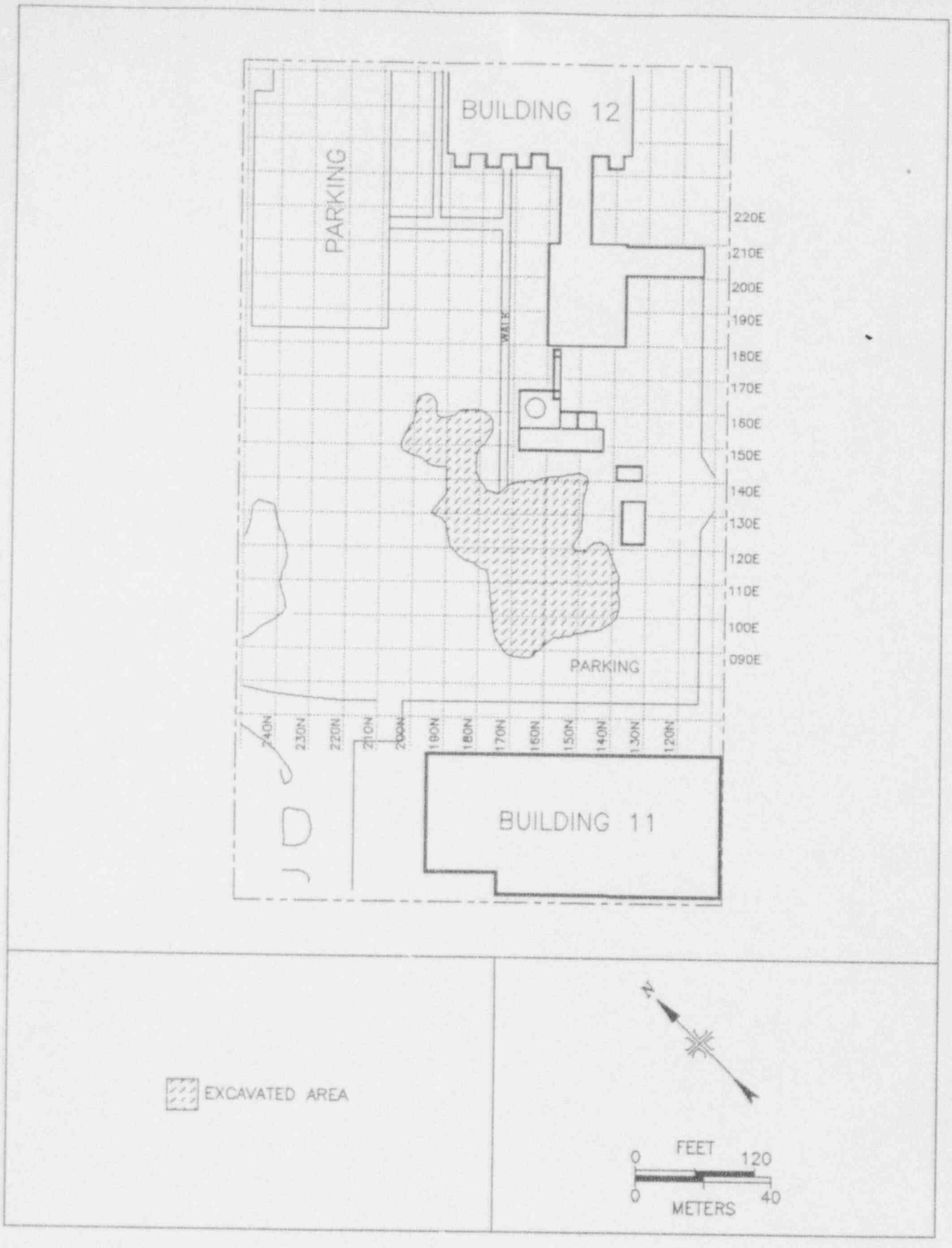


FIGURE 2: The Former Burial Site – Extent of Excavation

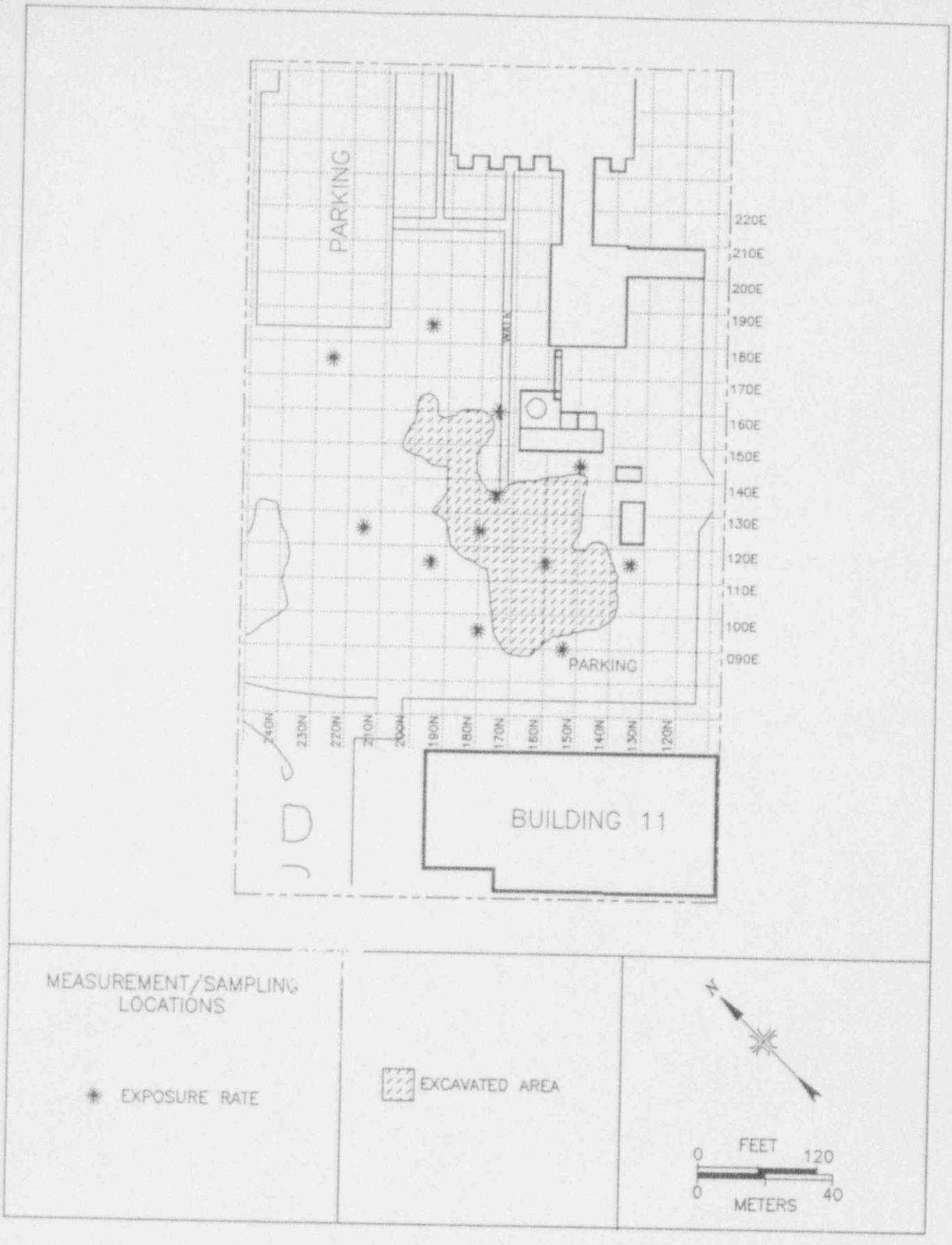


FIGURE 3: The Former Burial Site – Exposure Rate Measurement Locations

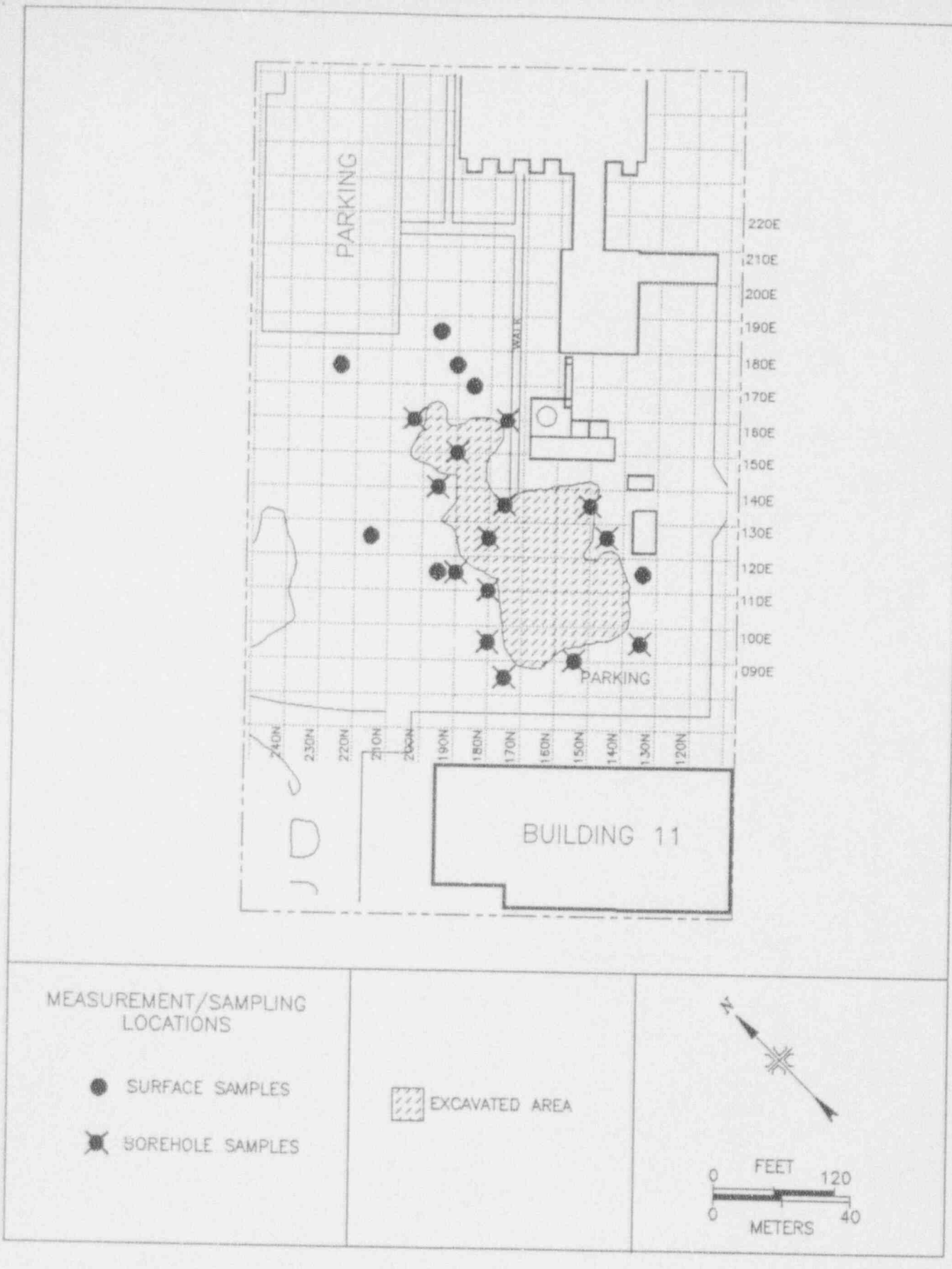


FIGURE 4: The Former Burial Site – Soil Sampling Locations

TABLE 1

EXPOSURE RATE MEASUREMENTS
TEXAS INSTRUMENTS, INC.
FORMER BURIAL SITE
ATTLEBORO, MASSACHUSETTS

Location[a]	Exposure Rate at 1 m above the surface (μR/h)
135N, 115E	9
150N, 145E	9
155N, 90E	11
160N, 115E	9
175N, 135E	9
175N, 160E	10
180N, 95E	11
180N, 125E	9
195N, 115E	10
195N, 185E	9
215N, 125E	9
225N, 175E	9

[a]Refer to Figure 3.

TABLE 2

URANIUM CONCENTRATIONS IN SOIL SAMPLES
TEXAS INSTRUMENTS, INC.
FORMER BURIAL SITE
ATTLEBORO, MASSACHUSETTS

Location[a]	Depth (cm)	Uranium Concentrations (pCi/g)[b]		
		U-235	U-238	Total U[c]
135N, 95E	0-15	0.3 ± 0.1	3.2 ± 1.2	10
	85-100	<0.1	0.6 ± 1.4	2.9
	185-200	0.2 ± 0.1	2.3 ± 1.2	6.9
135N, 115E	0-15	0.2 ± 0.1	0.9 ± 1.0	5.5
145N, 125E	0-15	<0.1	6.0 ± 1.7	8.3
	85-100	0.2 ± 0.1	4.4 ± 1.3	9.0
150N, 135E	0-15	<0.1	2.6 ± 1.1	4.9
	85-100	0.3 ± 0.1	4.1 ± 0.9	11
155N, 90E	0-15	<0.1	1.1 ± 1.0	3.4
	85-100	<0.1	2.2 ± 0.8	4.5
	185-200	0.2 ± 0.1	3.2 ± 1.4	7.8
175N, 85E	0-15	0.1 ± 0.1	1.5 ± 1.0	3.8
	85-100	<0.1	1.8 ± 1.4	4.1
	135-105	<0.1	1.6 ± 1.3	3.9
175N, 135E	0-15	<0.1	2.0 ± 1.5	4.3
	85-100	0.3 ± 0.1	7.2 ± 1.5	14
175N, 160E	0-15	0.2 ± 0.1	1.6 ± 1.1	5.6
	85-100	0.2 ± 0.1	1.6 ± 1.4	6.2
	185-200	0.2 ± 0.1	1.8 ± 0.9	6.4
180N, 95E	0-15	<0.2	3.7 ± 1.3	8.3
	85-100	<0.1	1.7 ± 1.2	4.0
	185-200	0.1 ± 0.1	3.4 ± 1.2	5.7
180N, 110E	0-15	0.4 ± 0.1	10.4 ± 2.1	20
	85-100	0.4 ± 0.1	12.7 ± 1.7	22
	135-150	<0.1	2.4 ± 1.8	4.7

TABLE 2 (Continued)

URANIUM CONCENTRATIONS IN SOIL SAMPLES
TEXAS INSTRUMENTS, INC.
FORMER BURIAL SITE
ATTLEBORO, MASSACHUSETTS

Location[a]	Depth (cm)	Uranium Concentrations (pCi/g)[b]		
		U-235	U-238	Total U[c]
185N, 125E	0-15	<0.1	1.7 ± 1.2	4.0
	85-100	0.3 ± 0.1	4.5 ± 1.3	11
185N, 170E	0-15	<0.1	0.7 ± 0.9	3.0
190N, 115E	0-15	<0.1	2.4 ± 1.5	4.7
	85-100	0.5 ± 0.1	2.1 ± 1.5	14
190N, 150E	0-15	<0.1	0.8 ± 1.0	3.1
	85-100	0.4 ± 0.1	6.5 ± 1.6	16
	185-200	0.6 ± 0.1	10.3 ± 1.8	24
190N, 175E	0-15	0.1 ± 0.1	1.5 ± 1.0	3.8
195N, 115E	0-15	0.4 ± 0.1	3.4 ± 1.6	13
195N, 140E	0-15	<0.1	1.2 ± 0.9	3.5
	85-100	0.3 ± 0.1	2.1 ± 1.1	9.0
	185-200	<0.1	..7 ± 1.1	4.0
195N, 185E	0-15	<0.1	1.1 ± 0.8	3.4
200N, 160E	0-15	<0.1	1.2 ± 1.2	3.5
	85-100	0.6 ± 0.1	13 ± 2.0	27
	185-200	0.5 ± 0.1	2.8 ± 1.0	14
215N, 125E	0-15	<0.1	1.4 ± 0.9	3.7
225N, 175E	0-15	<0.1	1.6 ± i.2	3.9

[a]Refer to Figure 4.
[b]Uncertainties represent the 95% confidence level based only on counting statistics.
[c]Total uranium concentrations are calculated based on a U-234 to U-235 activity ratio of 22:1.

REFERENCES

1. "Radiological Survey of the Texas Instruments Site, Attleboro, Massachusetts," Oak Ridge Associated Universities, January, 1985.

2. "Post Excavation Radiological Survey Report, Texas Instruments Incorporated Burial Site, Attleboro, Massachusetts," Creative Pollution Solutions, Inc., November 28, 1992.

3. Letter from A. Jaberaboansari (ORISE) to J. Roth (NRC), reference: "Interim Radiological Survey Report for the Texas Instruments Incorporated Burial Site", January 25, 1993.

4. "Remediation of the Former Radioactive Waste Burial Site", Final Report, Creative Pollution Solutions, Inc., September 1993.

5. "Confirmatory Survey Plan for the Texas Instruments Incorporated Burial Site, Attleboro, Massachusetts", Oak Ridge Institute for Science and Education, December 6, 1993.

6. Letter from A. J. Ansari (ORISE) to M. C. Roberts (NRC), reference: "Comments on the Final Report: Remediation of the Former Radioactive Waste Burial Site at Texas Instruments Incorporated", December 1, 1993.

7. 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.

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)

Ludlum Ratemeter-Scaler
Model 2200
(Ludlum Measurements, Inc.,
Sweetwater, TX)

Detectors

Reuter-Stokes Pressurized Ion 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)

APPENDIX B

SURVEY AND ANALYTICAL PROCEDURES

APPENDIX B

SURVEY AND ANALYTICAL PROCEDURES

SURVEY PROCEDURES

Surface Scans

Surface scans for gamma activity were performed by passing the probes slowly over the surface; the distance between the probe and the surface was maintained at a minimum. The scans were performed using NaI detectors coupled to countrate meters with audible indicators. Identification of elevated levels was based on increases in the audible signal from the recording and/or indicating instrument.

Exposure Rate Measurements

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

Soil Sampling

Approximately 1 kg of soil was collected at each sample location. Surface soil samples were collected at 0-15 cm depth. Samples from boreholes were collected from the surface (0-15 cm), the center (85-100 cm), and the bottom (185-200 cm) of each borehole. Collected samples were placed in a plastic bag, sealed, and labeled in accordance with ESSAP survey procedures.

ANALYTICAL PROCEDURES

Gamma Spectrometry

Samples of 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:

U - 235	0.186 MeV
U - 238	0.063 MeV from Th-234*
Th-228	0.583 MeV from Tl-208
Th-232	0.911 MeV from Ac-228*

*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 based only on counting statistics. 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 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. Calibration of pressurized ionization chambers was performed by the manufacturer.

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

- Survey Procedures Manual, Revision 7
- Laboratory Procedures Manual, Revision 7
- Quality Assurance Manual, Revision 6

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

GUIDELINES FOR RESIDUAL CONCENTRATIONS OF THORIUM AND URANIUM WASTES IN SOIL

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 fro
m 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.