CONFIRMATORY SURVEY OF THE MAIN PROCESSING BUILDING AND ADJACENT EXTERIOR AREA CABOT CORPORATION READING, PENNSYLVANIA

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Prepared for the
Division of Waste Management
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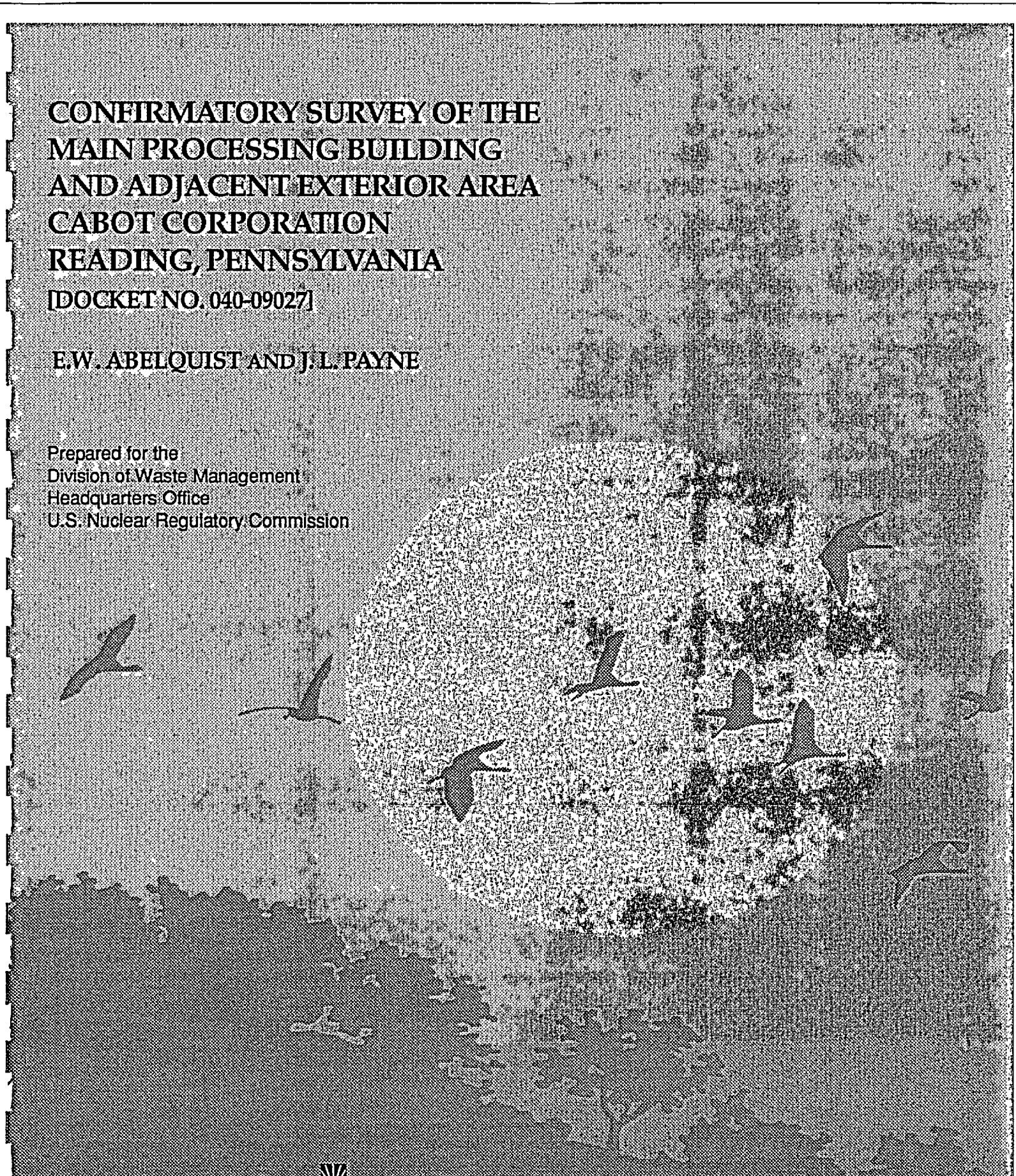

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Environmental Survey and Site Assessment Program
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ABBREVIATIONS AND ACRONYMS

ASME	American Society of Mechanical Engineers
cm	centimeter
cm^2	square centimeter
cpm	counts per minute
DOE	Department of Energy
dpm/100 cm^2	disintegrations per minute/100 square centimeters
EML	Environmental Measurement Laboratory
EPA	Environmental Protection Agency
ESSAP	Environmental Survey and Site Assessment Program
KBI	Kawecki Berylco Industries
kg	kilogram
m	meter
m^2	square meter
mm	millimeter
MeV	million electron volts
NaI	sodium iodide
NIST	National Institute of Standards and Technology
NRC	Nuclear Regulatory Commission
ORAU	Oak Ridge Associated Universities
ORISE	Oak Ridge Institute for Science and Education
pCi/g	picocuries per gram

CONFIRMATORY SURVEY
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CABOT CORPORATION
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INTRODUCTION AND SITE HISTORY

Kawecki Berylco Industries (KBI), now Cabot Corporation, operated an ore processing plant in Reading, Pennsylvania from April 1967 through May 1968 under Source Material License No. SMB-920 (Docket No. 040-09027) with the Atomic Energy Commission, predecessor to the Nuclear Regulatory Commission (NRC). KBI used an electric arc furnace to increase the percentage of tantalum in low grade tantalum ores from approximately 2% to 15% by weight.

The tantalum ore was shipped by rail to the Reading Facility and stored on-site until used. The ore consisted of glassy flakes which contained 0.11-0.29% thorium as ThO_2 and approximately 0.02% uranium as U_3O_8, which occur naturally in the ores. The ore was crushed and fed into a mix system, where it was mixed with coke and non-magnetic alloys. This mixture was transported to the furnace feed hoppers in which the metal was separated from the ore. In this process, the thorium and uranium became incorporated into the silica slag. The slag was cooled, dumped onto the floor, broken into chunks, and disposed of as waste in the nearby Slag Dump.

Between 1969 and 1983, Applied Health Physics, Inc. performed decontamination of the facility on an intermittent basis. Some building rubble, soil, and miscellaneous low level waste materials removed by the decontamination operations were disposed of in the Slag Dump.

In December 1985, at the request of the NRC, a confirmatory radiological survey was performed by the Radiological Site Assessment Program (currently the Environmental Survey and Site Assessment Program) of Oak Ridge Associated Universities (ORAU).[1] This survey identified areas of residual contamination which exceeded the guideline values for natural uranium and thorium. Within the Main Processing Building, areas exceeding the guidelines included floor and upper wall locations, beam supports, overhead cranes, the landing above the tunnel entrance,

and the hoppers. This survey did not identify any locations of elevated direct radiation or total surface activity, removable surface activity or contaminated residues and sediments in the tunnel network. Contamination on the upper walls and overhead supports of the Main Processing Building consisted of a loose dust residue; analytical results were compared to soil concentration guidelines. Numerous outdoor soil areas and isolated hot spots in excess of the guideline values were also identified.

As a result of the ORAU findings, Cabot initiated further decontamination operations which were performed by Bullinger's Mills, Inc. during the period between 1988 and 1989. Areas within the Main Processing Building were vacuumed and scrubbed, and contaminated materials which were removed were stored at Cabot's Boyertown site. Outdoor areas, that were identified as exceeding the guideline values by ORAU in 1985, were remediated and filled with stone. Final release surveys were performed by Bullinger's Mills, Inc. The final survey report indicated that removable surface contamination, exposure rate measurements, and radionuclide concentrations in soil were within the NRC guideline values.[2]

During the period of July 26 through August 2, 1991, the Environmental Survey and Site Assessment Program (ESSAP) conducted a confirmatory radiological survey of the Main Processing Building, the site of the former Raw Materials Storage Building, and the surrounding yard and parking lot of the Cabot Corporation Reading Facility.[3] This survey identified numerous areas of residual contamination which exceeded the surface contamination guidelines on the floors, walls, and overhead beams of the Main Processing Building and outdoor measurements identified several locations with soil concentrations exceeding guidelines.

As a result of the latest ESSAP findings, Cabot continued remedial actions at the Reading facility, this time performed by NES, Inc., during the period between late 1994 and early 1995. Areas within the Main Processing Building and outdoor areas, that were identified by ESSAP as exceeding the guidelines, were remediated. The radiological waste will be transferred to the Boyertown facility for temporary storage.

At the request of the NRC Headquarters' Division of Waste Management, the Environmental Survey and Site Assessment Program (ESSAP) of the Oak Ridge Institute for Science and Education (ORISE) performed an independent confirmatory radiological survey of the floor of the Main Processing Building and exterior areas adjacent to the Main Processing Building of the Cabot Corporation in Reading, Pennsylvania.

SITE DESCRIPTION

The Reading Facility site is approximately 2 hectares (5 acres) and is located in Reading, Pennsylvania (Figure 1). The site is bounded by the Reading Railroad on the west, Tulpenhocken Street on the north, and the Slag Dump on the south. The site consists of the Main Processing Building, the site of the former Raw Materials Storage Building (which has since been demolished and removed), the Slag Dump, and the surrounding yard and parking lot (Figure 2). Adjacent to the Main Processing Building are a series of warehouses operated by Hamburg Manufacturers.

The Main Processing Building is a steel/concrete structure, having one main open floor and three small interior rooms. This building contains approximately 10,000 square meters (m^2) of floor space, of which approximately 6,000 m^2 was used for smelting, crushing, chemical extractions, and storage of raw materials. Figure 3 indicates the portion of the facility in which thorium processing was performed by KBI. Mixing, crushing, and smelting were performed in Bay D-E of the building and chemical separations were performed in Bay A-B. Tunnels, used for material storage and transport, run beneath the Processing Building. The ceiling of the Main Processing Building varies in height from 15 to 20 meters (m) above the floor and is in extremely poor condition. A major portion of the ceiling and roof is inaccessible due to its deteriorated condition.

The former Raw Materials Storage Building was demolished by the property owner, due to safety concerns over its deteriorated condition. A portion of the yard, west of the Main Processing Building, was backfilled by the owner with part of the debris from the Raw Materials Storage Building. A portion of the structure was also placed in the Slag Dump. The yard and

parking lot areas adjacent to the Main Processing Building are approximately 10,000 m^2; of which, approximately 7,200 m^2 was involved in the handling of the raw materials and ore.

OBJECTIVES

The objectives of the confirmatory survey were to provide independent document reviews and radiological data for use by the NRC in evaluating the adequacy and accuracy of the licensee's procedures and termination survey results.

DOCUMENT REVIEW

ESSAP has reviewed the licensee's decommissioning plan and radiological survey data.[4] 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 January 30 and 31, 1995, ESSAP performed a confirmatory survey at the Cabot Corporation Reading Facility. The survey was conducted in accordance with a survey plan dated January 24, 1995, submitted to and approved by the NRC's Division of Waste Management, Headquarters Office.[5] This report summarizes the procedures and results of the survey.

SURVEY PROCEDURES: INTERIOR

Reference Grid

The Main Processing Building was divided into 8 survey units designated as numbers 28-35 (Figure 4). Affected areas within these survey units were subdivided into 1 m $\times$ 1 m reference grids. The reference grids established by the decommissioning contractor in the affected areas

were used by ESSAP to reference measurement locations. Measurements performed in ungridded areas (unaffected areas) were recorded on a site drawing.

Surface Scans

Surface scans for alpha, beta, and gamma activity were performed on the floor using large area gas proportional detectors and NaI scintillation detectors coupled to ratemeters or ratemeter-scalers with audible indicators. Scan coverage was approximately 50 to 60% in unaffected areas and 100% in affected areas. Locations of elevated activity were marked for further investigation.

Surface Activity Measurements

Natural uranium and natural thorium emit both alpha and beta radiation at comparable levels; thus, either alpha or beta activity may be measured for determining the residual activity of these radionuclides. Because rough or dirty surfaces may selectively attenuate alpha radiation, beta measurements were performed on the surfaces.

Measurements for total beta surface activity were performed at 127 locations, including locations of elevated activity identified by surface scans. A smear sample for determining removable activity was obtained from each direct measurement location on concrete, asphalt or other solid surface (smears were not performed on gravel or soil surfaces). Measurement locations are indicated on Figures 5 through 12.

SURVEY PROCEDURES: EXTERIOR

Reference Grid

The reference grid established by the decommissioning contractor was used by ESSAP for referencing measurement and sampling locations (Figure 2).

Surface Scans

Gamma surface scans were performed over approximately 75% of the unaffected areas and over 100% of the affected areas. Locations of elevated surface activity were marked for further investigation.

Surface Activity Measurements

Measurements for total beta activity were performed at 20 locations on the paved surfaces (Figure 13).

Soil Sampling

The analysis results of background soil samples, collected during a previous ORAU survey at this facility (reference 1), were used for comparison. These background levels are assumed to have not changed significantly between 1985 and 1995. A total of 10 surface (0-15 cm) soil samples was collected from the areas adjacent to the Main Processing Building (Figure 13).

SAMPLE ANALYSIS AND DATA INTERPRETATION

Samples and data were returned to ORISE's ESSAP laboratory in Oak Ridge, Tennessee for analysis and interpretation. Soil samples were analyzed by gamma spectrometry. Spectra were reviewed for U-238, U-235, Th-232, and Th-228, and any other identifiable photopeaks. Soil sample results were reported in units of picocuries per gram (pCi/g). Smears were analyzed for gross alpha and gross beta activity. Direct measurement data and smear data were converted to units of disintegrations per minute/100 square centimeters (dpm/100 cm^2). Additional information concerning major instrumentation, sampling equipment, and analytical procedures is provided in Appendices A and B. Results were compared to the NRC guidelines which are provided in Appendix C.

FINDINGS AND RESULTS

DOCUMENT REVIEW

ESSAP reviewed the licensee's decommissioning plan and radiological survey data.[6] In ESSAP's opinion, the decommissioning plan outlined an appropriate approach for decontamination. ESSAP expressed its concern that certain aspects of the final status survey plan were not sufficiently detailed, e.g., specific measurement and sampling frequencies in affected areas, and information on how the measurements were compared to the guidelines, were not stated. The survey data adequately represented the radiological status of the surveyed areas on the floor of the Main Processing Building and the exterior areas. ESSAP expressed its concern to the NRC on using the results of a previous confirmatory survey (reference 3) performed by ESSAP, as a characterization survey.

SURVEY RESULTS

Surface Scans

Surface scans identified several locations of elevated activity on the floor of the Main Processing Building and on the exterior paved area.

Surface Activity Measurements

Surface activity measurements for total and removable beta activity are summarized in Table 1. Direct measurements were performed at all locations of elevated surface activity identified by scans. Total beta activity for all measurement locations, prior to remediation, ranged from <200 to 9,500 dpm/100 cm^2. Total beta activity for all locations, after the locations exceeding the maximum guideline value were remediated by the decommissioning contractor, ranged from <200 to 2,500 dpm/100 cm^2.

All removable activity was less than the minimum detectable activity of the procedure, which is 12 dpm/100 cm^2 for alpha and 16 dpm/100 cm^2 for beta.

Radionuclide Concentrations in Soil Samples

Total uranium and total thorium concentrations for samples were calculated, based on the secular equilibrium state of the two decay series. Total uranium was determined by multiplying the measured U-238 concentration, based on the Th-234 daughter, by 2 (to account for the U-234) and adding to that value, the measured U-235 concentration; total thorium was determined by adding the measured Th-232 concentration, based on the Ac-228 daughter, and the Th-228 concentration, based on the Pb-212 daughter.

Total uranium and total thorium concentrations in background samples ranged from 1.3 to 4.8 pCi/g (2.7 pCi/g, average) and 1.4 to 3.8 pCi/g (2.5 pCi/g, average), respectively. Concentrations of total uranium and total thorium in soil samples collected from the exterior of the site range from <1.7 to <5.8 pCi/g and from 0.8 to 9.2 pCi/g, respectively. Results are summarized in Table 2.

COMPARISON OF RESULTS WITH GUIDELINES

The NRC guidelines for surface contamination and residual levels of radionuclides in soil, established for license termination or release of a facility for unrestricted use are presented in Appendix C. The primary contaminants of concern for this site are natural thorium and natural uranium. The applicable NRC guidelines for residual thorium and uranium surface activity levels are:[7]

Natural thorium

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

3,000 dpm/100 cm^2, total, maximum in a 100 cm^2 area

200 dpm/100 cm^2, removable activity

Natural uranium

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

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

1,000 α dpm/100 cm^2, removable activity

Because the contamination present at the Reading Facility was a mixture of natural uranium and thorium in varying proportions, the more conservative guidelines for natural thorium were used for comparison with surface activity measurements. Beta activity measurements were used for guideline comparison.

As previously discussed surface scans identified numerous locations of elevated activity at the site that were marked for further investigation. Direct measurements were performed at each of these locations which resulted in 12 of the locations exceeding the maximum guideline value. An additional 19 locations were between the average and the maximum guideline values.

The decommissioning contractor performed remedial activities on the 12 locations which exceeded the maximum guideline. ESSAP performed post-remediation measurements at these locations and the resulting surface activity levels at all locations were below 3,000 dpm/100 cm^2. The areal extent of the locations of direct radiation that exceeded 1,000 dpm/100 cm^2 averaged less than 100 cm^2 and surface scans indicated no significant activity on the surrounding surface. Although measurements to determine 1 m^2 averages were not performed, the average guideline was considered satisfied.

Soil concentrations for residual uranium and thorium wastes in soil are presented in the NRC's Branch Technical Position on "Disposal or Onsite Storage of Thorium and Uranium Wastes from Past Operations." The following guidelines were used for comparison with the results:[8]

Natural Uranium (U-238 + U-234 + U-235): 10 pCi/g*

Natural Thorium (Th-232 + Th-228): 10 pCi/g*

*With all daughters present and in equilibrium

In addition, because a mixture of radionuclides is present at the site, the sum of the ratios of the soil concentration of each radionuclide to the guideline for that radionuclide must not exceed unity. That is,

$$Sum\ of\ the\ Ratios = \frac{Conc\ U}{10} + \frac{Conc\ Th}{10} \leq 1$$

Concentrations of thorium and uranium in all soil samples meet the established guideline of 10 pCi/g above background, as demonstrated by the "sum of the ratios" rule (Table 2).

SUMMARY

On January 30 and 31, 1995, at the request of the NRC Headquarters' Division of Waste Management, the Environmental Survey and Site Assessment Program of ORISE performed a confirmatory survey at the Cabot Corporation Reading Facility in Reading, Pennsylvania. Survey activities included document reviews, surface scans, direct measurements and soil sampling.

The confirmatory survey identified numerous locations of elevated activity on the floor of the Main Processing Building that required further remediation. The potential for remaining hot spots was minimized to a degree by the extensive floor scan coverage performed by ESSAP. The confirmatory survey results are consistent with those of the decommissioning contractor and support the licensee's conclusion that residual activity levels on the floor of the Main Processing Building and adjacent exterior areas satisfy the guidelines for release to unrestricted use.

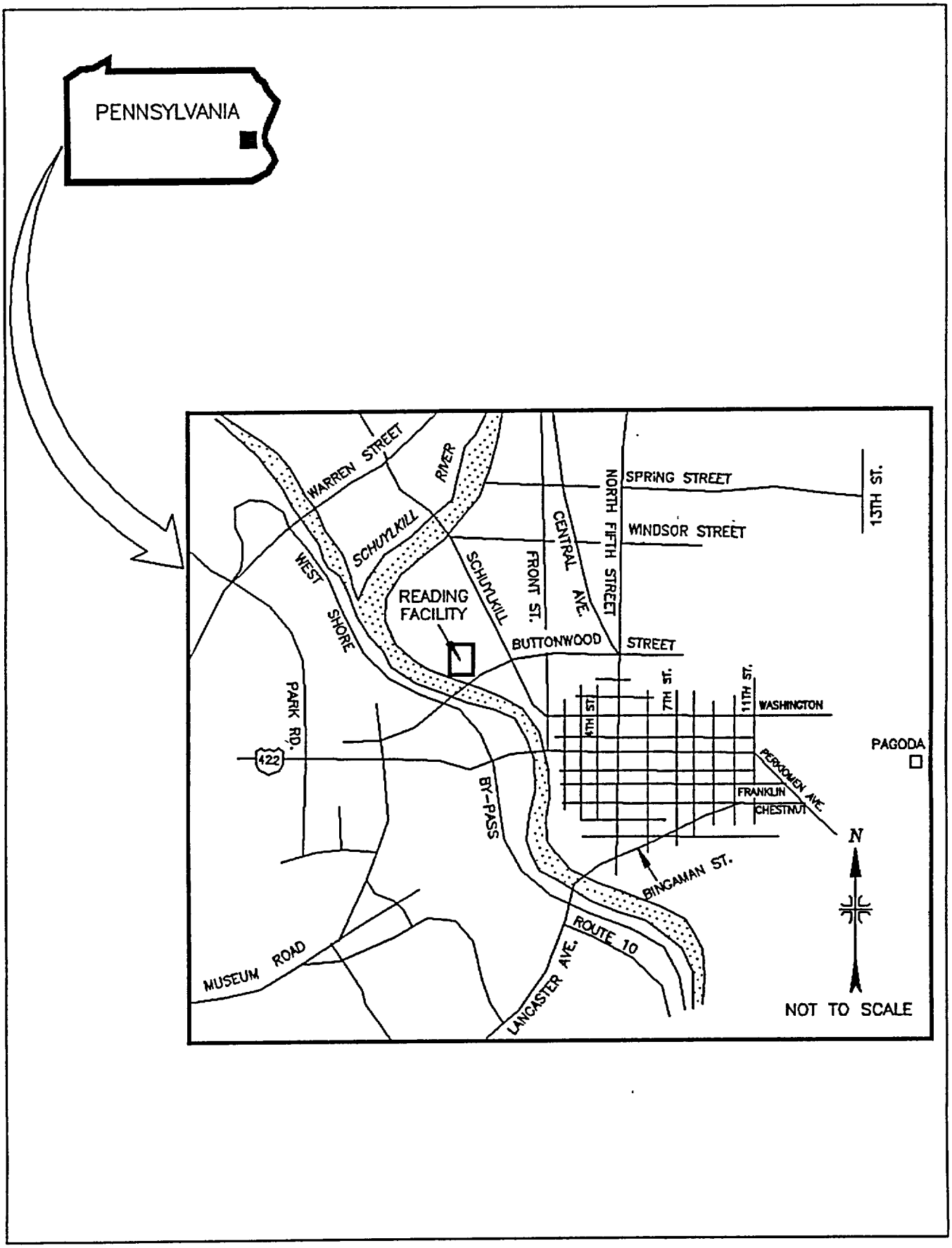


FIGURE 1: Location of the Cabot Corporation, Reading Facility, Reading, Pennsylvania

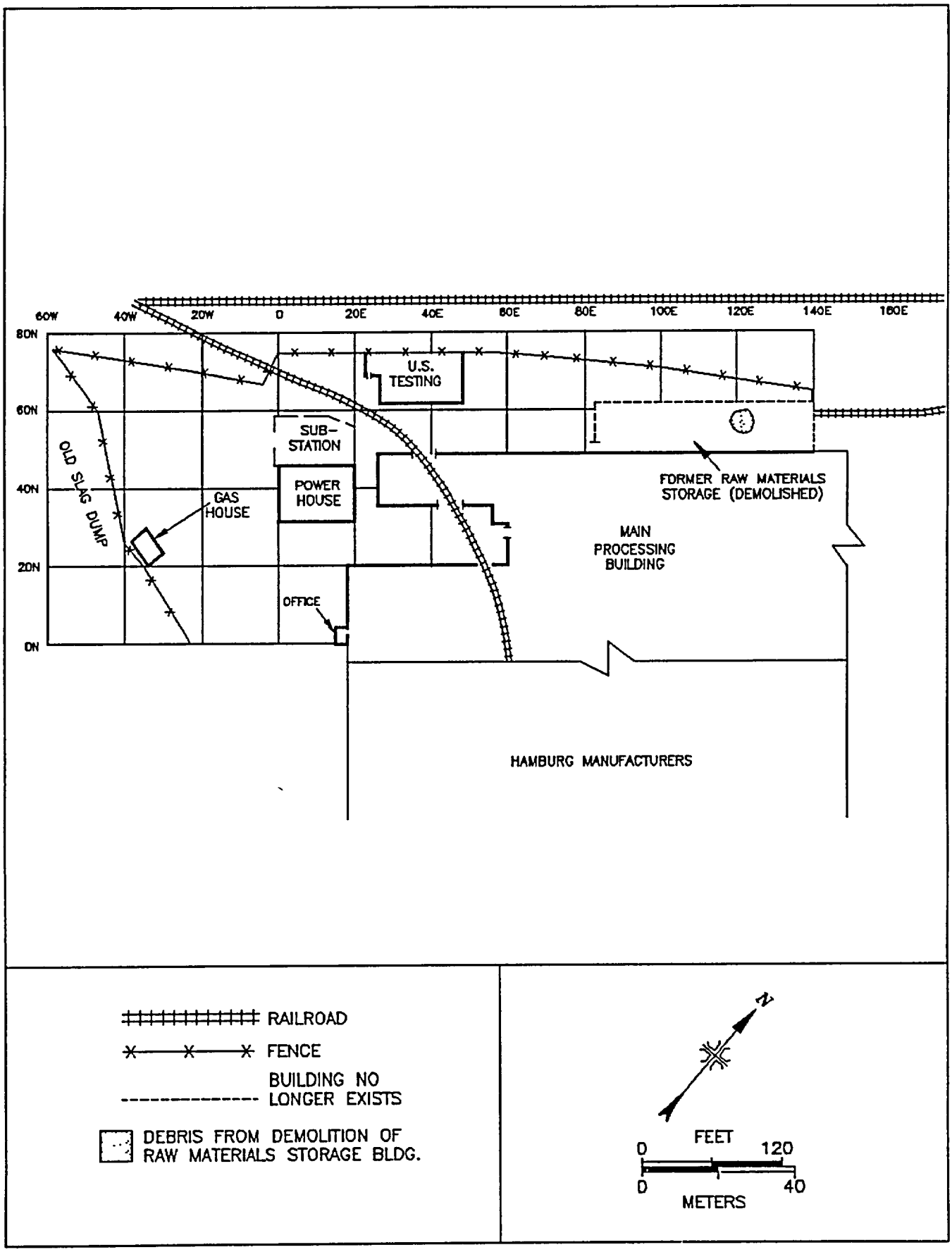


FIGURE 2: Plot Plan of the Reading Facility with External Survey Reference Grid

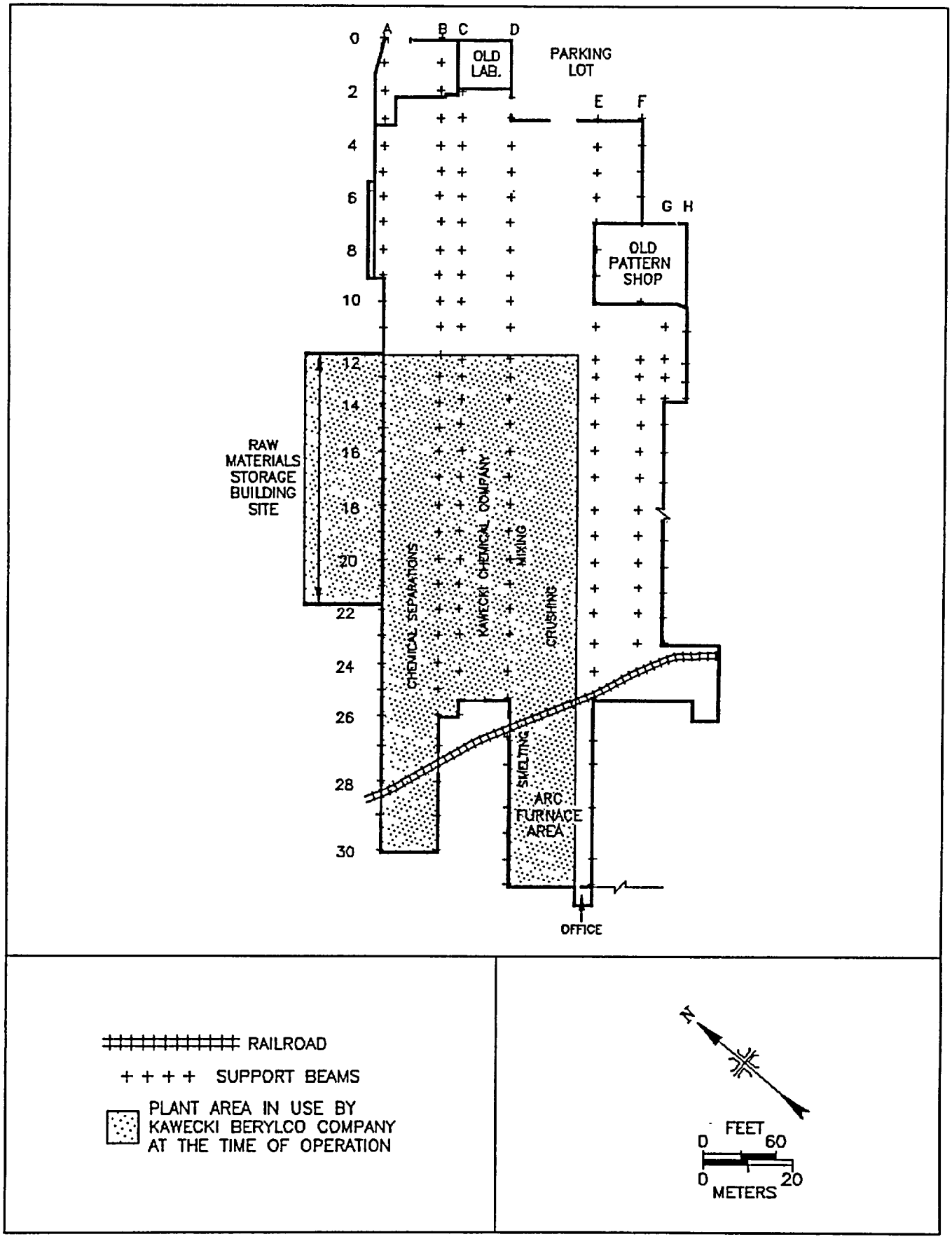


FIGURE 3: Reading Facility – Main Processing Building, Portions Used During Operation

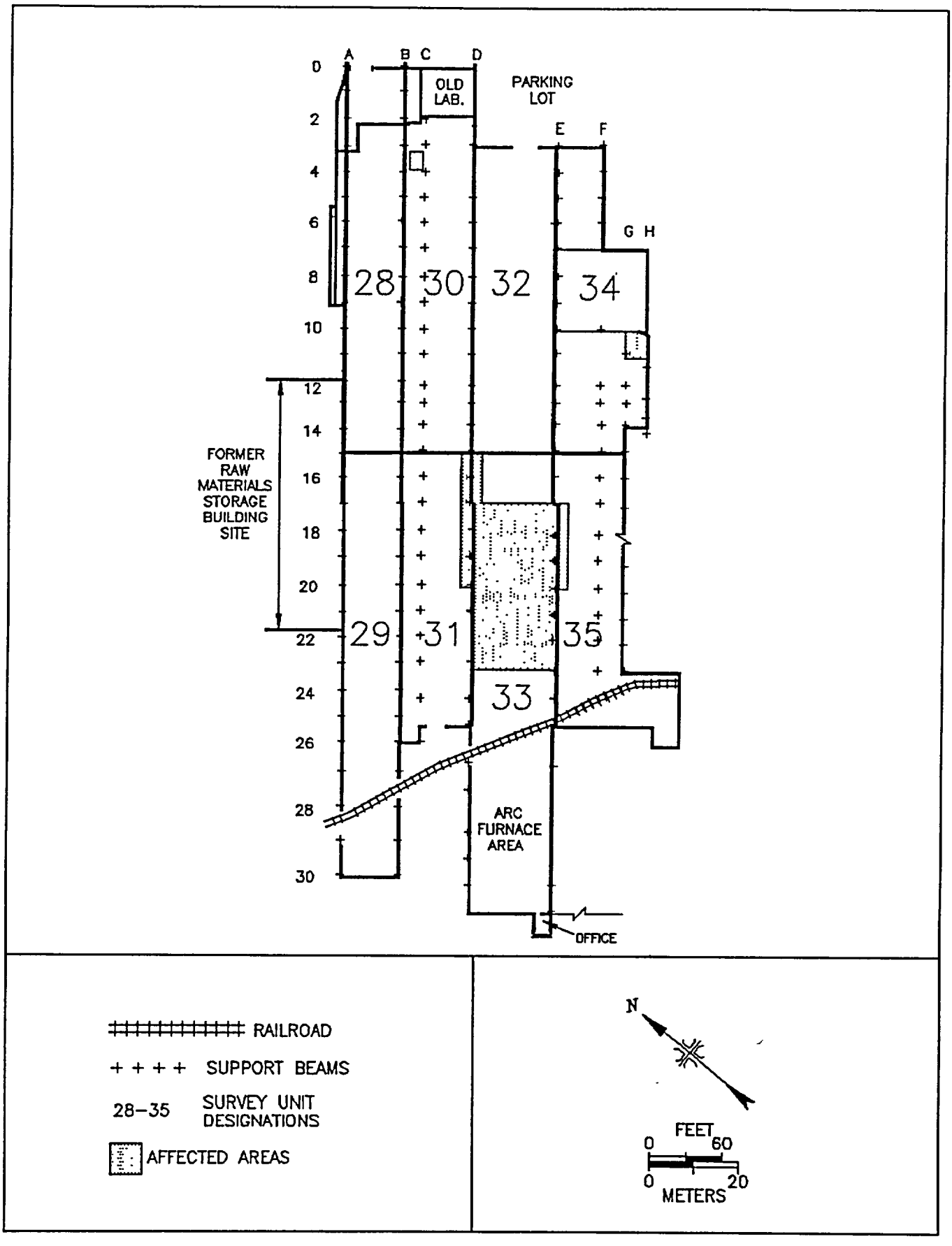


FIGURE 4: Reading Facility – Main Processing Building Survey Unit Designations

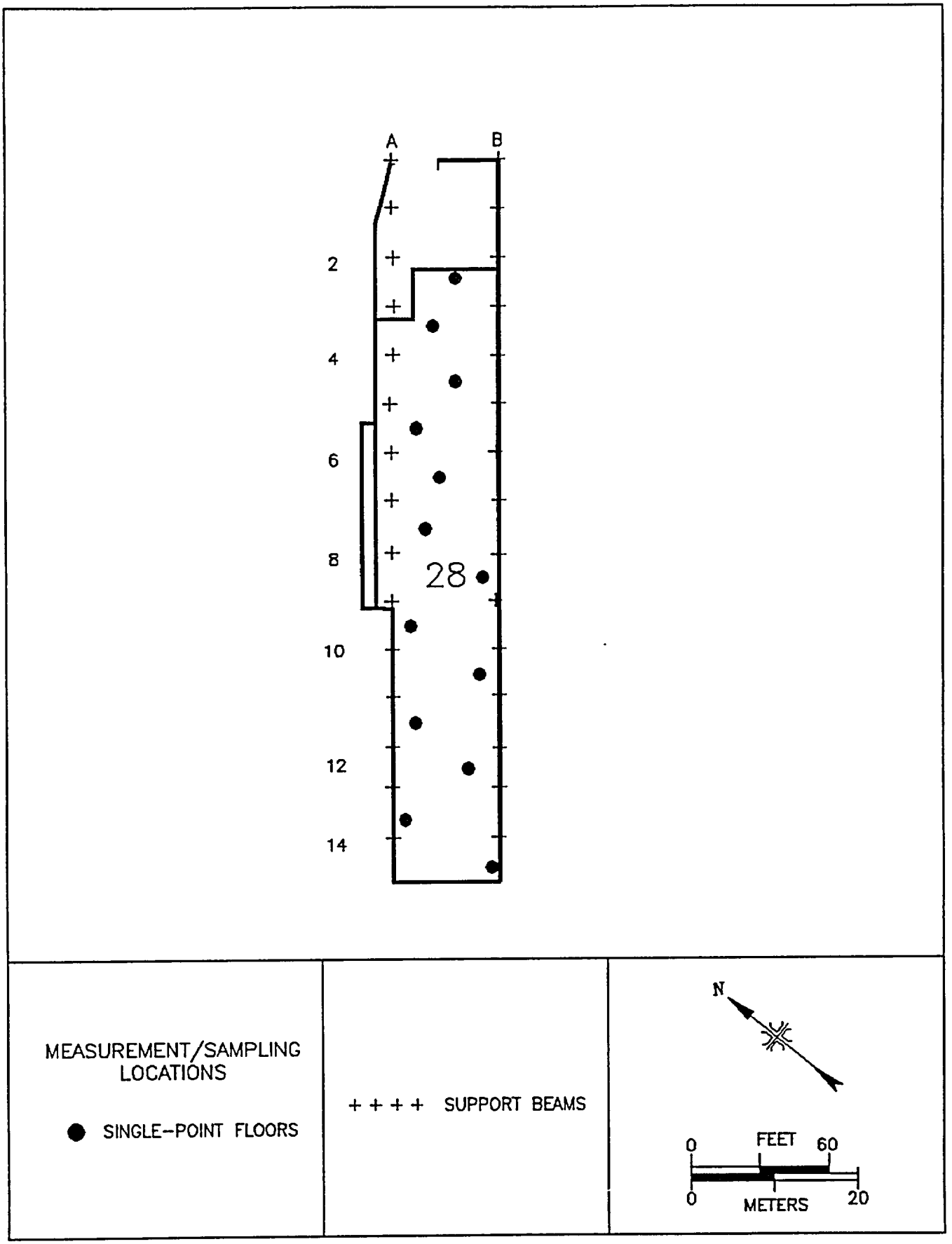


FIGURE 5: Main Processing Building, Survey Unit Number 28 – Measurement and Sampling Locations

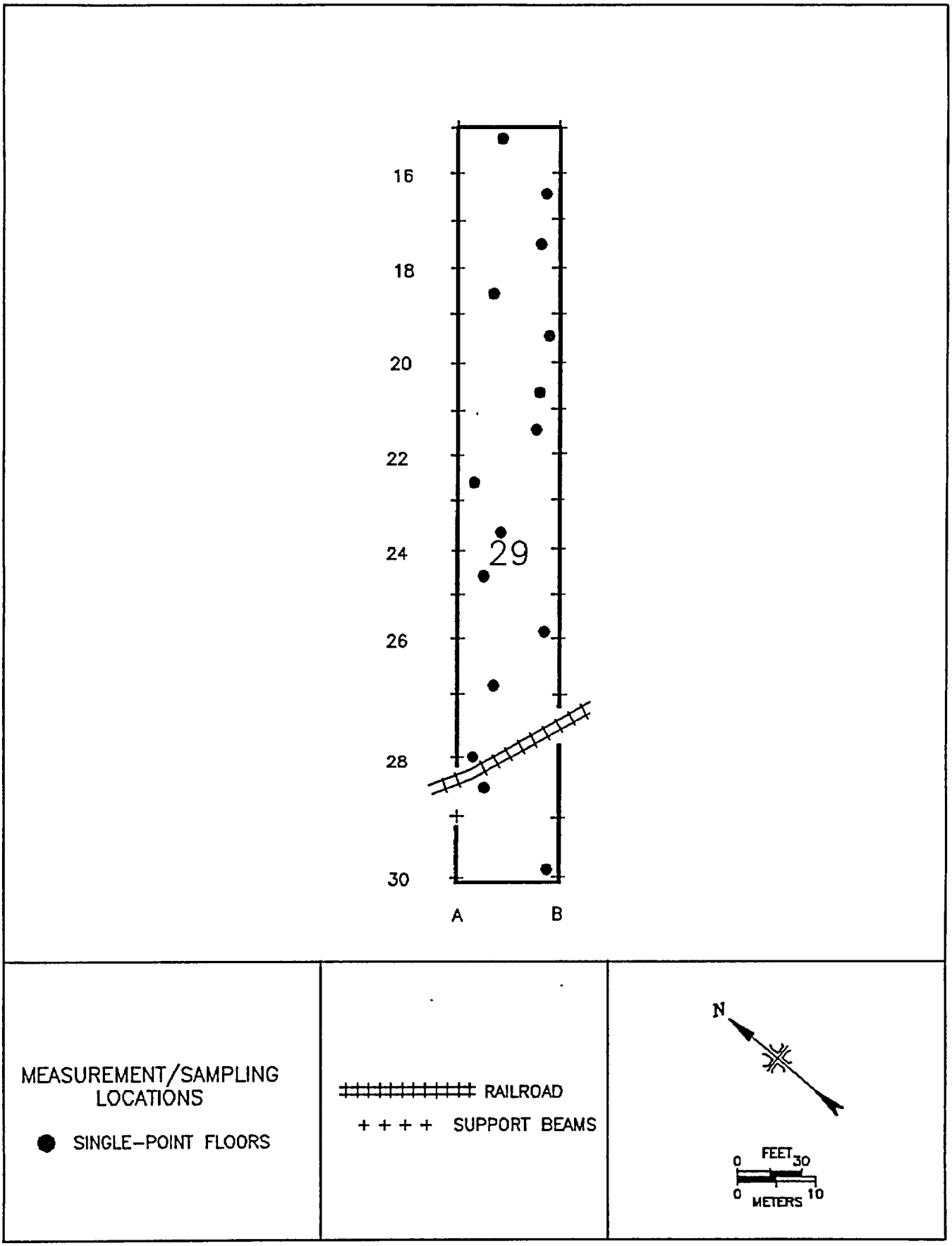


FIGURE 6: Main Processing Building, Survey Unit Number 29 – Measurement and Sampling Locations

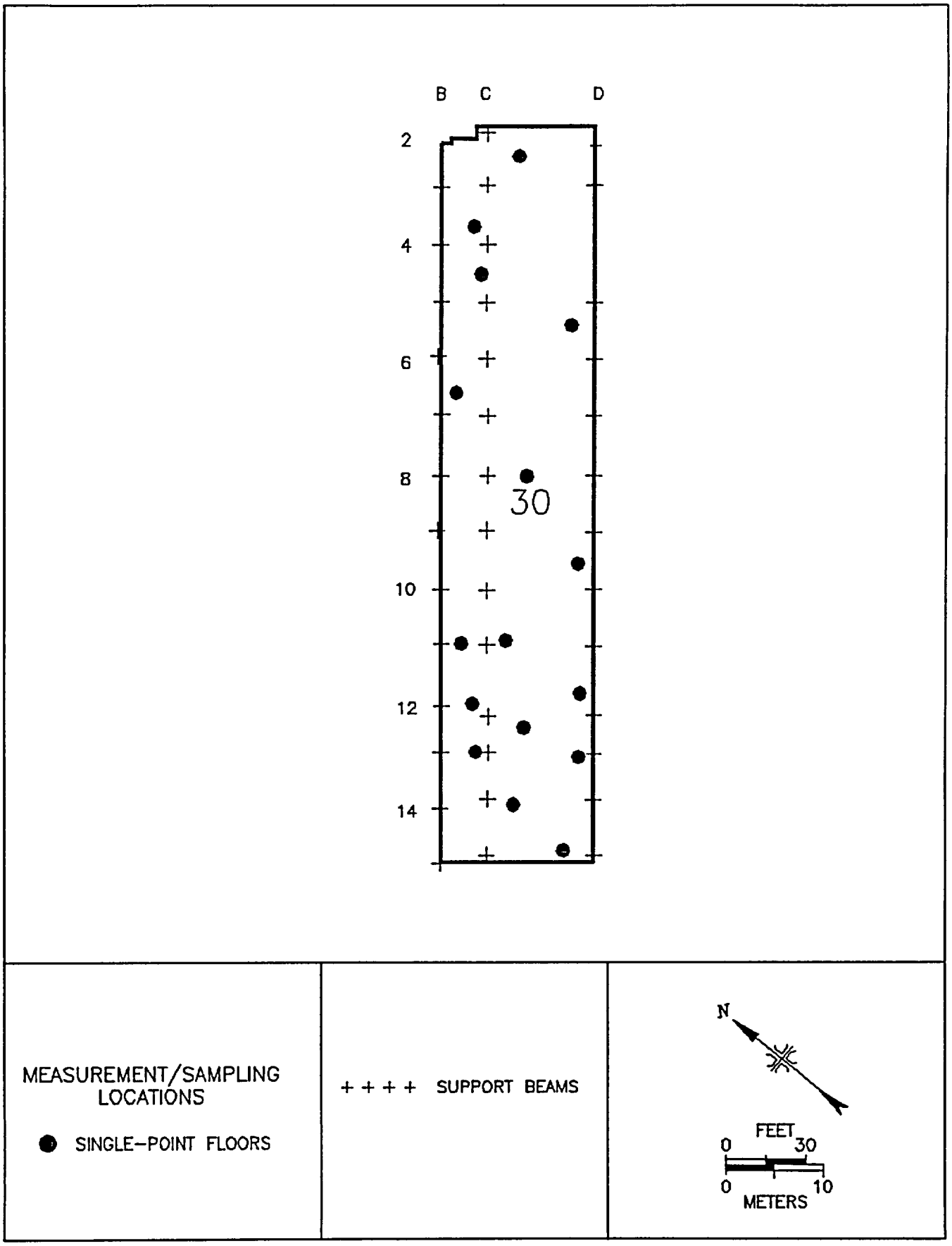
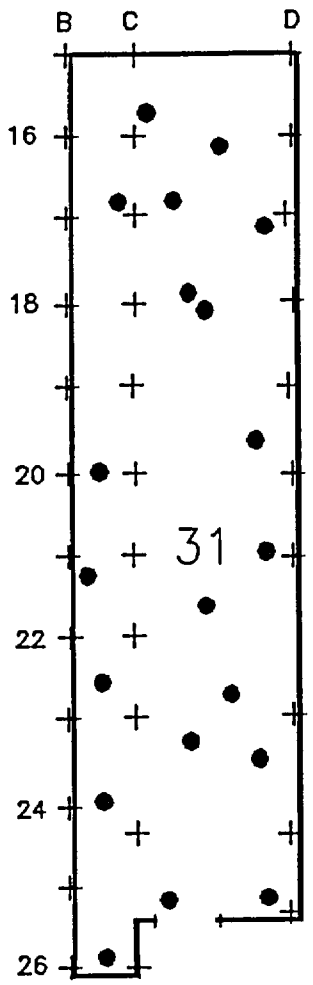


FIGURE 7: Main Processing Building, Survey Unit Number 30 – Measurement and Sampling Locations



MEASUREMENT/SAMPLING LOCATIONS

● SINGLE-POINT FLOORS

+ + + + SUPPORT BEAMS

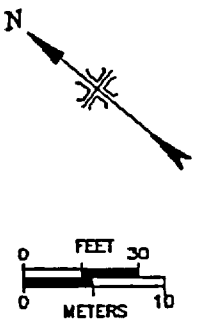


FIGURE 8: Main Processing Building, Survey Unit 31 – Measurement and Sampling Locations

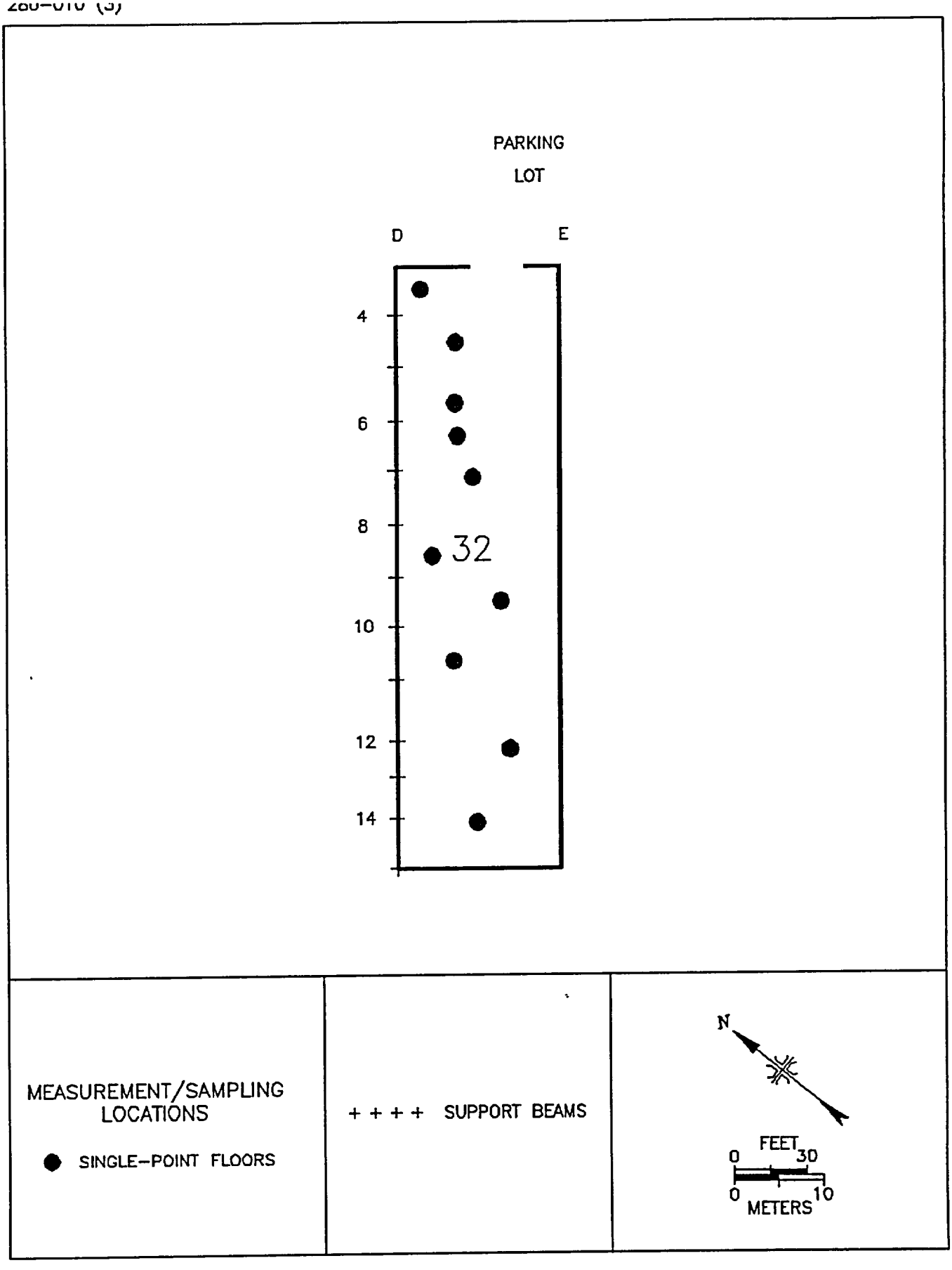


FIGURE 9: Main Processing Building, Survey Unit Number 32 – Measurement and Sampling Locations

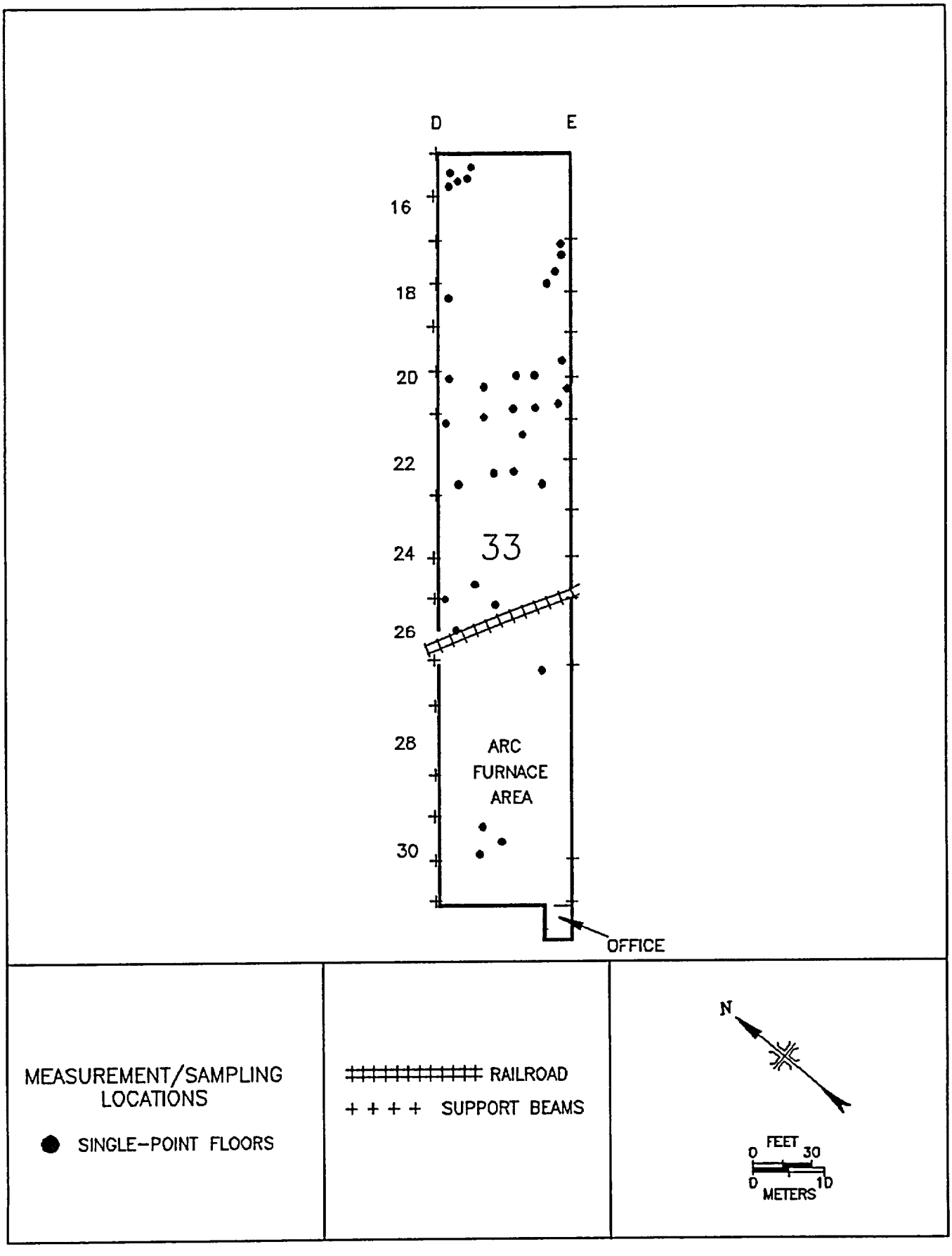


FIGURE 10: Main Processing Building, Survey Unit Number 33 – Measurement and Sampling Locations

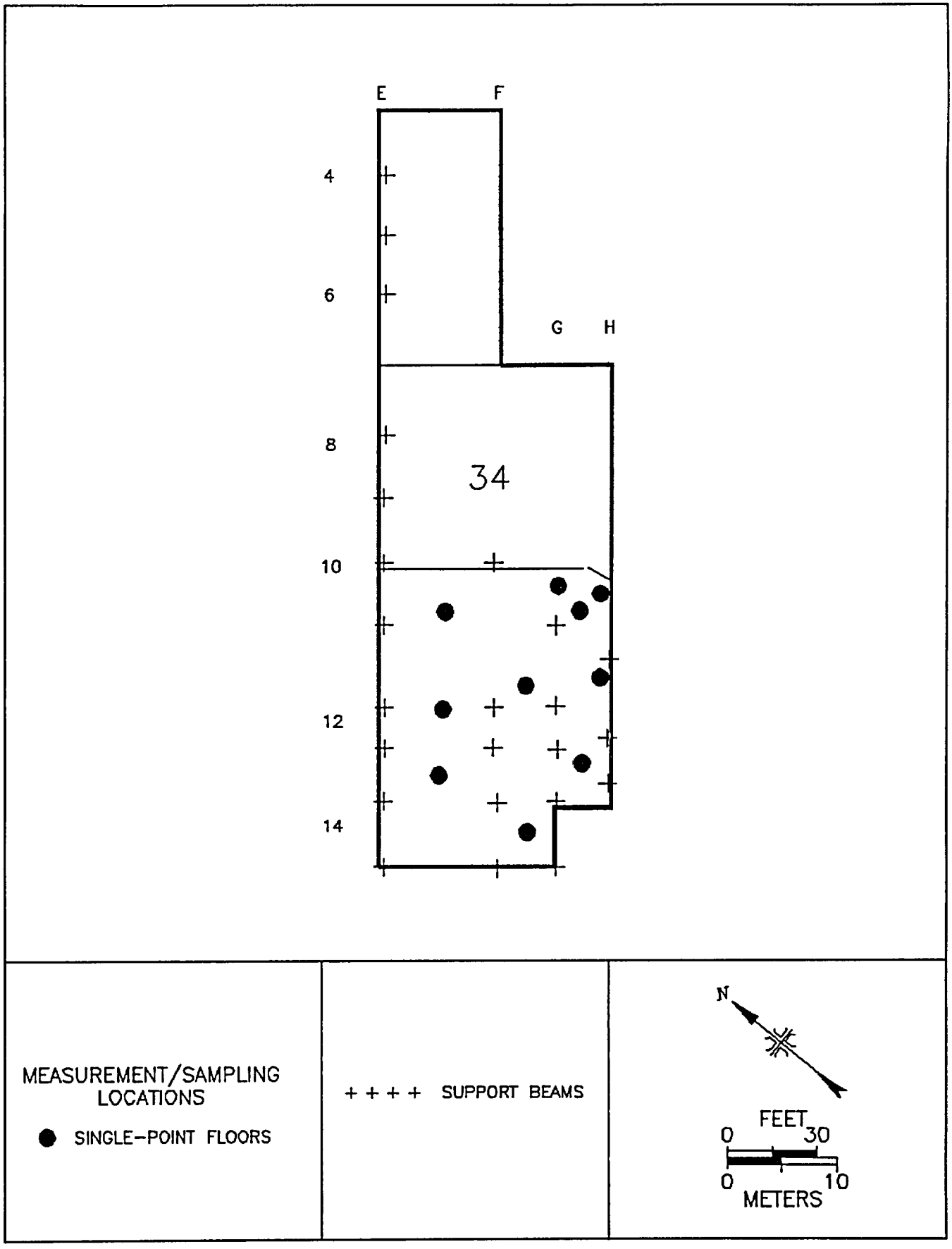


FIGURE 11: Main Processing Building, Survey Unit Number 34 – Measurement and Sampling Locations

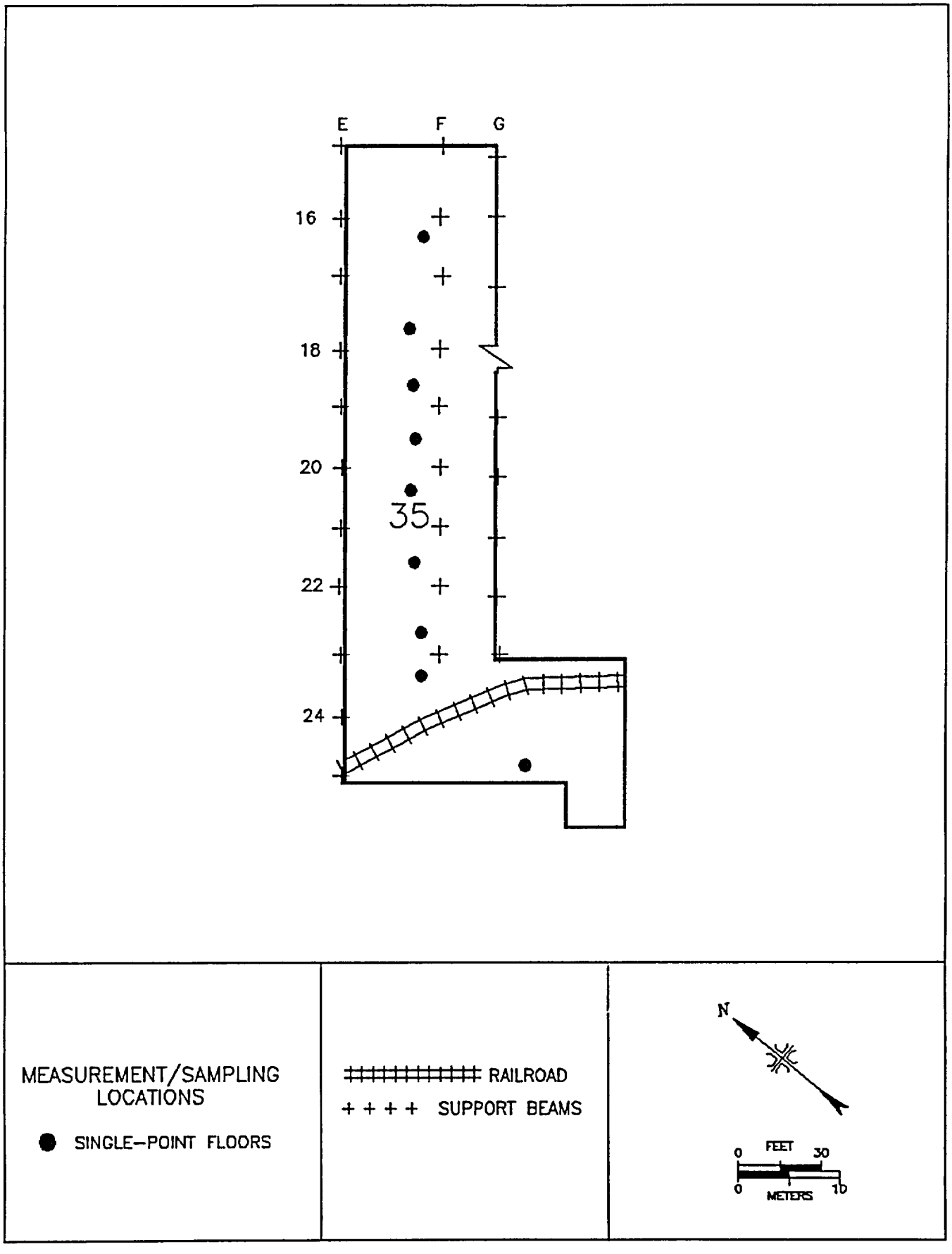


FIGURE 12: Main Processing Building, Survey Unit Number 35 – Measurement and Sampling Locations

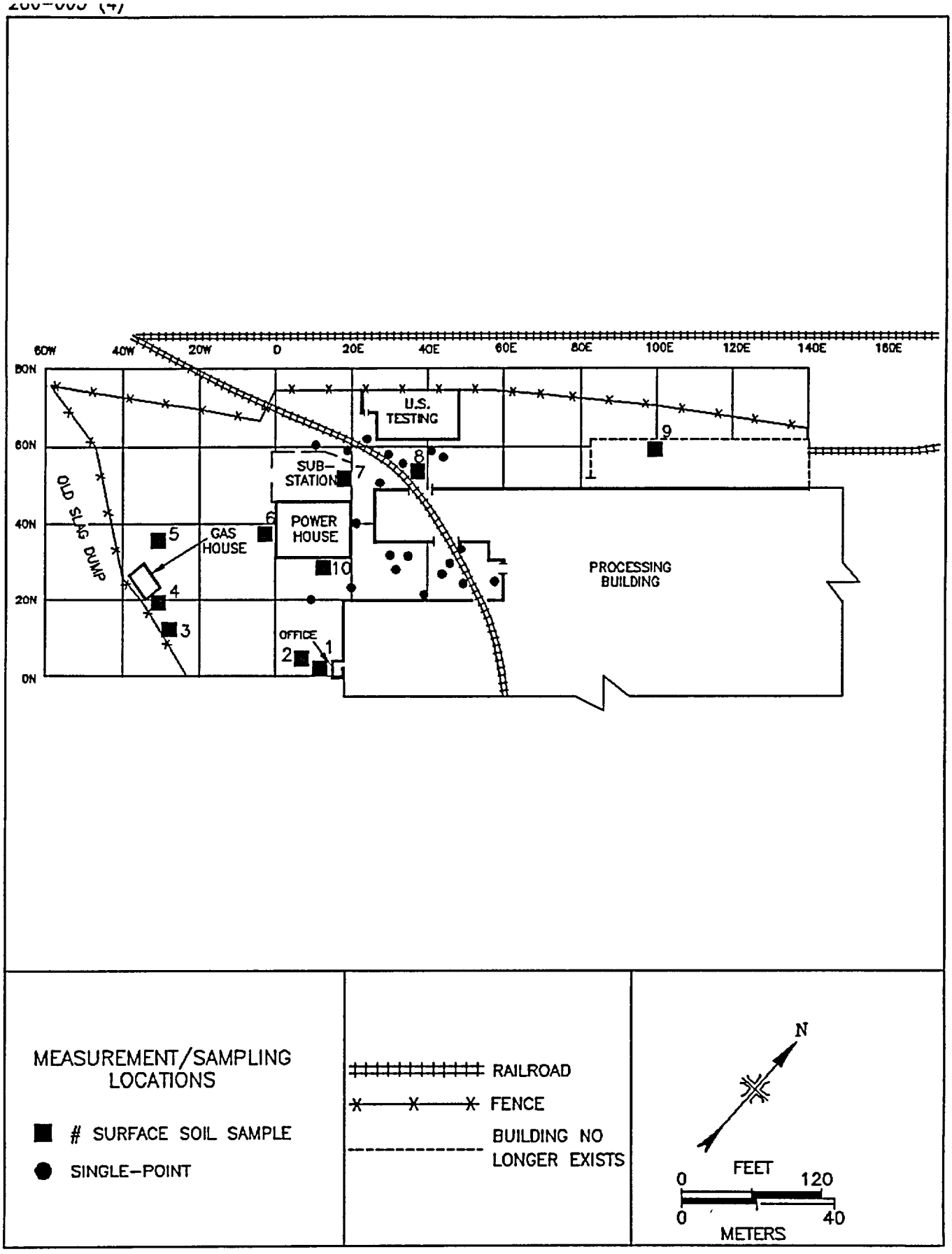


FIGURE 13: Reading Facility – Exterior Measurement and Sampling Locations

TABLE 1

SUMMARY OF SURFACE ACTIVITY LEVELS
FOR THE MAIN PROCESSING BUILDING AND EXTERIOR AREA
CABOT CORPORATION
READING, PENNSYLVANIA

Floor Survey Unit #[a]	Number of Direct Measurement Locations		Range of Total Beta Activity (dpm/100 cm^2) Pre-remediation	Range of Total Beta Activity (dpm/100 cm^2) Post-remediation	Range of Removable Activity (dpm/100 cm^2)	
	Total	Exceeding Maximum Criteria[b]			Alpha	Beta
28	13	0	<240-570	N/A[c]	<12	<16
29	15	0	<240-990	N/A	<12	<16
30	16	0	<200-610	N/A	<12	<16
31	20	3	<200-4,900	<200-1,100[d]	<12	<16
32	10	0	400-740	N/A	<12	<16
33	34	8	270-9,500	270-2,500[d]	<12	<16
34	10	1	370-3,300	370-800	<12	<16
35	9	0	390-1,100	N/A	<12	<16
Exterior Paved Area	20	0	270-1,600	N/A	<12	<16

[a]Based on the decommissioning contractor's area designations (Figure 4).
[b]The maximum criteria for thorium is 3,000 dpm/100 cm^2.
[c]N/A - Post-remediation measurements were not necessary.
[d]1 m^2 average guideline was satisfied.

TABLE 2

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
FROM THE EXTERIOR AREA OF THE MAIN PROCESSING BUILDING
CABOT CORPORATION
READING, PENNSYLVANIA

Location[a]		Radionuclide Concentrations (pCi/g)		
		Total U	Total Th	Sum of the Ratios[b]
#1	2N, 17E	<5.6	4.8	0.52
#2	4N, 14E	<4.5	8.0	0.73
#3	10N, 30W	<2.3	2.4	-0.05
#4	20N, 35W	<1.9	1.2	-0.21
#5	38N, 30W	<2.9	0.8	-0.15
#6	39N, 0E	<2.1	2.4	-0.07
#7	50N, 20E	<5.8	4.6	0.52
#8	50N, 38E	<4.1	9.2	0.81
#9	60N, 100E	<2.6	1.8	-0.08
#10	28N, 16E	<1.7	1.0	-0.25

[a]Refer to Figure 13.

[b]The sum of the ratios were calculated by subtracting the background total uranium concentration (2.7 pCi/g) and total thorium concentration (2.5 pCi/g) from each sample total uranium and thorium concentration, respectively, and applying the following equation:

$$Sum\ of\ the\ Ratios = \frac{Conc\ U}{10} + \frac{Conc\ Th}{10}$$

REFERENCES

1. "Preliminary Survey Results, Confirmatory Radiological Survey of the KBI Division of Cabot Corporation, Reading, Pennsylvania," Oak Ridge Associated Universities, March 1986.

2. "Final Decontamination and Decommissioning Survey, dated 1988-1989," Cabot Corporation, August 1990.

3. "Confirmatory Radiological Survey for Portions of the Cabot Corporation Reading Facility, Reading, Pennsylvania," Environmental Survey and Site Assessment Program, Oak Ridge Institute for Science and Education, June 1993.

4. "Decommissioning Plan for the Main Processing Building and Surrounding Area at the Reading, Pennsylvania Site," NES, Inc., December 1994.

5. Oak Ridge Institute for Science and Education "Proposed Confirmatory Survey Plan for the Main Processing Building and Adjacent Exterior Area, Cabot Corporation, Reading, Pennsylvania (Docket No. 040-09027)," January 24, 1995.

6. Oak Ridge Institute for Science and Education, letter from E. W. Abelquist to R. Hogg, NRC/NMSS, "Document Review - Decommissioning Plan for the Main Processing Building and Surrounding Area at the Reading, Pennsylvania Site," January 23, 1995.

7. U.S. Nuclear Regulatory Commission, Division of Fuel Cycle and Material Safety, Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source or Special Nuclear Material, Washington, D.C., August 1987.

8. U.S. Nuclear Regulatory Commission, Disposal or Onsite Storage of Thorium and Uranium Wastes from Past Operations, Washington, D.C., October 23, 1991.

APPENDIX A

MAJOR INSTRUMENTATION

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

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

Detectors

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

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

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

LABORATORY ANALYTICAL INSTRUMENTATION

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

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. Large surface area, gas proportional detectors were used to scan the floors of the surveyed areas. 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 detector with ratemeter-scaler
Gamma	—	NaI scintillation detector with ratemeter

Surface Activity Measurements

Measurements of total beta activity levels were performed using gas proportional detectors with portable ratemeter-scalers. Alpha activity contributions to beta measurements were eliminated by using suitable absorber thickness to attenuate alpha radiation.

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 4 π efficiency (no correction for the active area of the detector was necessary for the Ludlum Model 43-68 detectors). The beta activity background count rates for the proportional detectors averaged approximately 180 cpm. Beta efficiency factors ranged from 0.29-0.30 for the gas proportional detectors calibrated to Tl-204. The effective window for the gas proportional detector is 100 cm^2.

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.

Miscellaneous Samples

Soil Samples

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

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

Miscellaneous Samples

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.

All photopeaks associated with the radionuclides of concern were reviewed for consistency of activity. Energy peaks used for determining the activities of radionuclides of concern were:

Th-228	0.238 MeV from Pb-212*
Th-232	0.911 MeV from Ac-228*
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 [$2.71 + (4.66\sqrt{BKG})$]. 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 radionuclide in samples, the detection limits differ from sample to sample and instrument to instrument.

CALIBRATION AND QUALITY ASSURANCE

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

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

- Survey Procedures Manual, Revision 8 (December 1993)
- 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

GUIDELINES FOR DECONTAMINATION OF FACILITIES AND EQUIPMENT PRIOR TO RELEASE FOR UNRESTRICTED USE OR TERMINATION OF LICENSES FOR BYPRODUCT, SOURCE OR SPECIAL NUCLEAR MATERIAL

AND

GUIDELINES FOR RESIDUAL CONCENTRATIONS OF THORIUM AND URANIUM WASTES IN SOIL

GUIDELINES FOR DECONTAMINATION OF FACILITIES AND EQUIPMENT PRIOR TO RELEASE FOR UNRESTRICTED USE OR TERMINATION OF LICENSES FOR BYPRODUCT, SOURCE, OR SPECIAL NUCLEAR MATERIAL

U. S. Nuclear Regulatory Commission
Division of Fuel Cycle & Material Safety
Washington, D.C. 20555

August 1987

The instructions in this guide, in conjunction with Table 1, specify the radionuclides and radiation exposure rate limits which should be used in decontamination and survey of surfaces or premises and equipment prior to abandonment or release for unrestricted use. The limits in Table 1 do not apply to premises, equipment, or scrap containing induced radioactivity for which the radiological considerations pertinent to their use may be different. The release of such facilities or items from regulatory control is considered on a case-by-case basis.

1. The licensee shall make a reasonable effort to eliminate residual contamination.

2. Radioactivity on equipment or surfaces shall not be covered by paint, plating, or other covering material unless contamination levels, as determined by a survey and documented, are below the limits specified in Table 1 prior to the application of the covering. A reasonable effort must be made to minimize the contamination prior to use of any covering.

3. The radioactivity on the interior surfaces of pipes, drain lines, or ductwork shall be determined by making measurements at all traps, and other appropriate access points, provided that contamination at these locations is likely to be representative of contamination on the interior of the pipes, drain lines, or ductwork. Surfaces or 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, shall be presumed to be contaminated in excess of the limits.

4. Upon request, the Commission may authorize a licensee to relinquish possession or control of premises, equipment, or scrap having surfaces contaminated with materials in excess of the limits specified. This may include, but would not be limited to special circumstances such as razing of buildings, transfer from premises to another organization continuing work with radioactive materials, or conversion of facilities to a long-term storage or standby status. Such requests must:

    a. Provide detailed, specific information describing the premises, equipment or scrap, radioactive contaminants, and the nature, extent, and degree of residual surface contamination.

    b. Provide a detailed health and safety analysis which reflects that the residual amounts of materials on surface areas, together with other considerations such as prospective use of the premises, equipment, or scrap, are unlikely to result in an unreasonable risk to the health and safety of the public.

5. Prior to release of premises for unrestricted use, the licensee shall make a comprehensive radiation survey which establishes that contamination is within the limits specified in Table 1. A copy of the survey report shall be filed with the Division of Fuel Cycle, Medical, Academic, and Commercial Use Safety, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, and also the Administrator of the NRC Regional Office having jurisdiction. The report should be filed at least 30 days prior to the planned date of abandonment. The survey report shall:

   a. Identify the premises.

   b. Show that reasonable effort has been made to eliminate residual contamination.

   c. Describe the scope of the survey and general procedures followed.

   d. State the findings of the survey in units specified in the instruction.

   Following review of the report, the NRC will consider visiting the facilities to confirm the survey.

TABLE 1
ACCEPTABLE SURFACE CONTAMINATION LEVELS

Nuclides[a]	Average[b,c,f]	Maximum[b,d,f]	Removable[b,e,f]
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.

[f] The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h at 1 cm and 1.0 mrad/h at 1 cm, respectively, measured through not more than 7 milligrams per square centimeter of total absorber.

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 establishes 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.