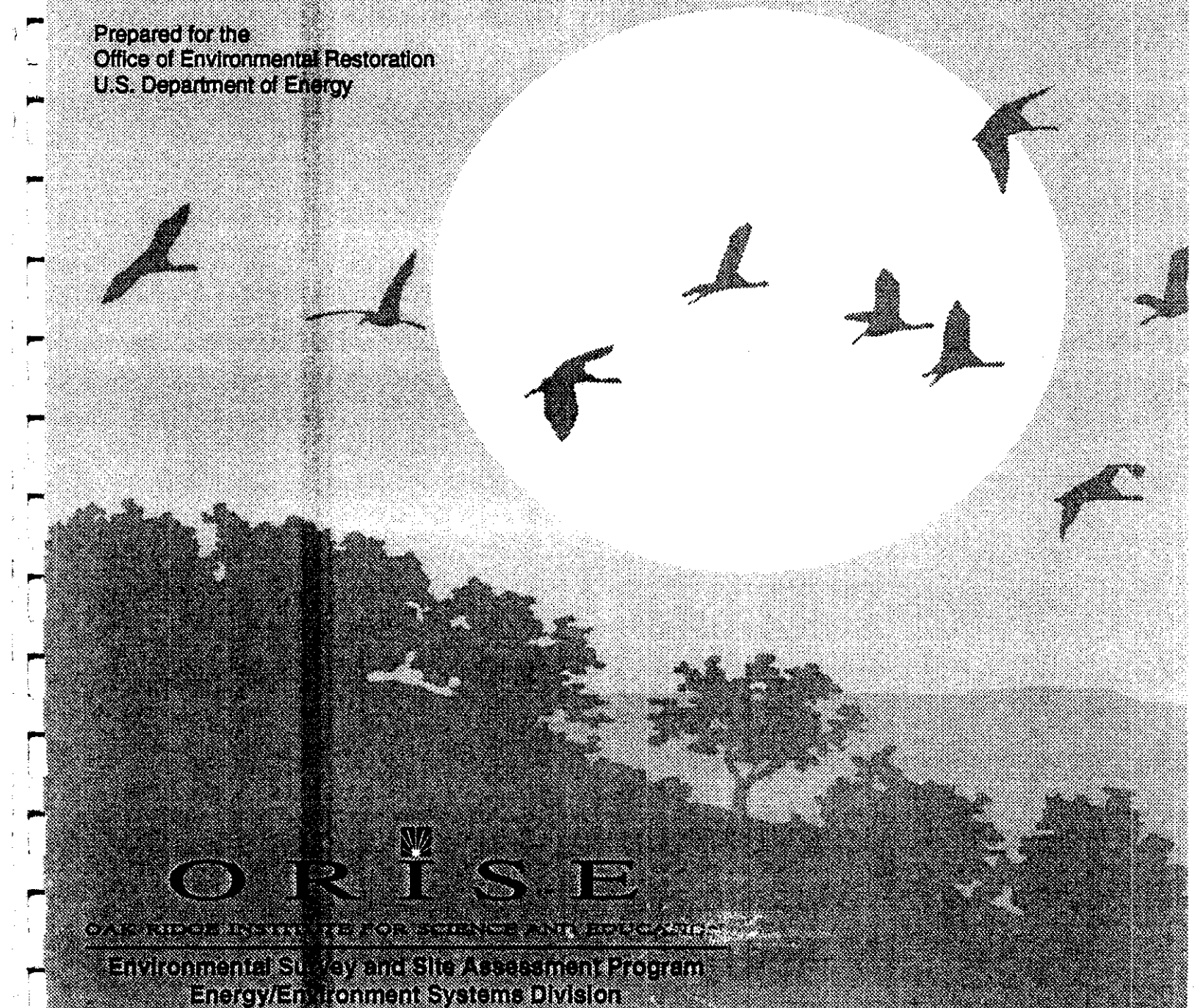
CHARACTERIZATION SURVEY OF THE BAKER AND WILLIAMS WAREHOUSES BUILDING 513-519 NEW YORK, NEW YORK

W. C. ADAMS

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



ORISE

OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION

Environmental Survey and Site Assessment Program
Energy/Environment Systems Division

CHARACTERIZATION SURVEY
OF THE
BAKER AND WILLIAMS WAREHOUSES
BUILDING 513-519
NEW YORK, NEW YORK

Prepared by

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Environmental Survey and Site Assessment Program
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FINAL REPORT

DECEMBER 1993

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ABBREVIATIONS AND ACRONYMS

AEC	Atomic Energy Commission
ASME	American Society of Mechanical Engineers
BNI	Bechtel National, Inc.
BWW	Baker and Williams Warehouses
cm	centimeter
cm^2	square centimeter
cpm	counts per minute
DOE	U.S. Department of Energy
dpm/100 cm^2	disintegrations per minute per 100 square centimeters
EML	Environmental Measurements Laboratory
ESSAP	Environmental Survey and Site Assessment Program
FSRD	Former Sites Restoration Division
ft^2	square foot
FUSRAP	Formerly Utilized Sites Remedial Action Program
GM	Geiger-Mueller
kg	kilograms
km	kilometer
lbs	pounds
m^2	square meter
MDA	minimum detectable activity
MED	Manhattan Engineer District
mi	mile
NaI	sodium iodide
NIST	National Institute of Standards and Technology
ORO	Oak Ridge Operations Office
ORISE	Oak Ridge Institute for Science and Education
ORNL	Oak Ridge National Laboratory
PMC	Project Management Contractor
QA	Quality Assurance
TMA	Thermo-Analytical Eberline

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INTRODUCTION AND SITE HISTORY

During the early 1940s, the Baker and Williams Warehouses (BWW) on West 20th Street, in New York, New York, were used by the Manhattan Engineer District (MED), predecessor to the Atomic Energy Commission (AEC) and the Department of Energy (DOE), for short term storage of uranium concentrates. According to historical information, approximately 99,430 kg (219,000 lbs) of orange and yellow sodium urinate was delivered to the Baker and Williams Warehouses in 1942 for storage and later distribution to U.S. Government Reservations. Additional documentation indicated that the warehouses also received approximately 39,000 kg of orange and yellow sodium urinate, 10,000 kg of sodium uranyl carbonate and 9,080 kg of black uranium oxide in 1943.

The Baker and Williams Company owned three adjacent warehouse buildings at 513-519, 521-527, and 529-535 West 20th Street. The warehouses have been leased by several businesses since the 1940s and are currently owned by Ralph Ferrara, Inc. Historical shipping documents indicate that MED/AEC shipments of uranium concentrates were delivered to the shipping and receiving office located in Building 529-535. However, shipments may have been received, unloaded, and stored at either of the adjacent warehouses.

The DOE reviewed available historical documentation that described the previous MED/AEC activities conducted at this facility and based on this information, the DOE determined that the potential for radioactive material to be present as a result of the past activities was low. However, the information was insufficient to verify the radiological condition of the site after MED/AEC activities were terminated. DOE decided that a radiological survey should be

performed to determine if additional investigations were warranted under the Formerly Utilized Sites Remedial Action Program (FUSRAP), or if the site could be eliminated from the program.[1]

In August 1989, the Environmental Survey and Site Assessment Program (ESSAP) of Oak Ridge Associated Universities (now known as Oak Ridge Institute for Science and Education [ORISE]) conducted a designation survey of the interior surfaces of Buildings 521-527 and 529-535. Activity in excess of the DOE guidelines for residual uranium activity on surfaces was detected on the floor of the West Bay of Building 521-527 and in several small areas on the floor and lower west wall located in the East Bay, in the basement of Building 521-527.[2] As a result of the findings by ESSAP, the BWW site was designated for inclusion into FUSRAP and was determined to qualify as a candidate for the DOE expedited protocol for remedial actions at small FUSRAP sites. In March/April 1991, characterization of the contaminated areas in Buildings 521-527 and 529-535 was performed by ESSAP; this was followed by remediation and post-remedial action surveys by Bechtel National, Inc. (BNI) and independent verification by ESSAP.[3-4] Remedial actions were successful in removing contamination to levels which would allow future use of these buildings without radiological control restrictions.

During the March/April 1991 operations, ESSAP also conducted surveys of accessible surfaces in Building 513-519. Results of these surveys identified small areas of fixed residual uranium contamination in excess of the DOE guidelines on the floors of the basement, 1st, and 5th floors; the entire 3rd floor area on the east side of the building also appeared to be contaminated.[6] No areas of contamination were identified at that time on the 2nd, 4th, 6th, and 7th floors. No removable contamination was identified. Because materials were stored in the Warehouse at the time of this survey, access to floor surfaces was limited to less than 50% of the floor area. These findings were described in a December 1991 ORAU report, "Radiological Survey of the Baker and Williams Warehouse, Building 513-519, New York, New York." [5] Based on these findings, Building 513-519 will be remediated under the FUSRAP expedited protocol.

PROJECT ORGANIZATION AND RESPONSIBILITY

DOE Headquarters provides overview and coordination for all FUSRAP activities. The DOE Oak Ridge Operations Office (DOE-ORO) is responsible for implementation of FUSRAP and the Former Sites Restoration Division (FSRD) of DOE-ORO, manages the daily activities.

Under the standard FUSRAP protocol, an initial investigation survey of a potential site is performed by ORISE or Oak Ridge National Laboratory (ORNL), under contract to DOE Headquarters. If appropriate, DOE Headquarters designates the site into FUSRAP based upon the results provided by the initial investigation. DOE's Project Management Contractor (PMC) for FUSRAP is Bechtel National, Inc. (BNI). BNI is responsible for the planning and the implementation of FUSRAP activities and managing the site characterization and remedial actions. The final phase for a FUSRAP site is independent verification which is provided by ORISE or ORNL after remedial action is complete. This verification process provides independent (third party) data to assist DOE in evaluating the accuracy of the post-remedial action status of the site, as presented by the PMC, and in assuring that the documentation accurately and adequately describes the condition of the site. DOE Headquarters uses the information developed by the remediation and verification activities to certify that a site can be released for use, without restrictions.

The Baker and Williams Warehouses were selected for remediation under an expedited protocol being used within FUSRAP. In contrast to the standard protocol, under the expedited protocol, the designation contractor functions as the organization responsible for the characterization and verification activities, while BNI is responsible for conducting the remedial action and post-remedial action survey. Because the Baker and Williams Warehouses have previously been designated, ESSAP will function as the organization responsible for characterization and verification only.

SITE DESCRIPTION

The BWW site is located on the west side of New York City in the borough of Manhattan (Figure 1). Building 513-519, consisting of eight levels, has approximately 855 m^2 (9200 ft^2) of floor space per level. The building is constructed of steel, concrete, terra-cotta, and brick. Floors have been coated with a 5 cm (2 in) thick asphalt sealant. In preparation for the characterization and remedial action activities all stored materials had been removed from the building to enable access to all floor and wall surfaces.

Because results of a previous ESSAP survey indicated that residual contamination, in excess of the DOE guidelines, existed on the entire Third Floor-East Bay area, BNI was tasked to remediate this floor prior to further characterization by ESSAP. BNI performed preliminary remedial actions on the floor by removing approximately 0.2 cm (1/16 inch) layers of the asphalt sealant using a scabbling machine (Blastrac). The results were successful at removing the surface contamination from the majority of the asphalt surface. Cursory floor and lower wall scans by ESSAP indicated that surface contamination remained on the lower (1 m) portions of the west and south walls, at the wall and floor interfaces, and at various locations throughout the floor. Remedial actions uncovered contamination on the concrete floor beneath the asphalt at the wall and floor interfaces. Therefore, small patches of asphalt from selected locations on the floor were removed in order to expose the underlying concrete floor and survey the concrete underneath. The results indicated that widespread residual contamination was present under the asphalt sealant. A decision was made to remove the entire asphalt sealant floor covering so that subsequent identification of contaminated areas and their remediation could be conducted by BNI. Subsequently, ESSAP would review BNI's data for this area and then perform characterization survey activities.

OBJECTIVES

The objectives of the characterization survey were to define the extent of contamination in excess of guidelines and delineate the areas requiring remediation.

PROCEDURES

ESSAP personnel conducted a characterization survey of the Basement, First Floor-East Bay, Third Floor and the Elevator Pit-East Bay of Building 513-519 between May 3 and July 8, 1993. Survey activities were conducted in accordance with a site-specific survey plan, submitted to and approved by the DOE.[6] The instruments and procedures used in this survey are described in the ESSAP Survey Procedures Manual and summarized in Appendices A and B.

REFERENCE GRID

A 1 m × 1 m alphanumeric reference grid was established by ESSAP on floors and lower walls (up to 2 m) of each floor. Measurement and sampling locations and areas that were delineated as exceeding guidelines were referenced to this grid.

SURFACE SCANS

Floor and lower wall (up to 2 m) surfaces were scanned for beta and gamma activity using gas proportional, GM, and NaI scintillation detectors coupled to instruments with audible indicators. Particular attention was given to cracks and joints in the floors and walls, ledges, overhead and horizontal surfaces, and other locations where material may have accumulated. Locations of elevated direct radiation identified by surface scans were marked for further investigation.

Areas of elevated direct radiation identified by initial surface scans, were further delineated with GM detectors coupled to instruments with audible indicators. Action levels, in counts per minute (cpm) that were equivalent to the 5,000 and 15,000 dpm/100 cm^2 guideline levels, for each GM detector, were determined (See Appendix B).

These action levels were then used to define the boundaries of the areas that exceeded guidelines by placing the detector on the surface and allowing the instrument to stabilize in the ratemeter mode. If the countrate was above the action level determined for the 15,000 dpm/100 cm^2 guideline level, the area was marked with environmentally safe paint and would be remediated.

If the countrate was above the action level for 5,000 dpm/100 cm^2 guideline and below the 15,000 dpm/100 cm^2, additional static measurements were taken in the adjacent areas to determine the extent of the contamination that exceeded the action level for 5,000 dpm/100 cm^2. These areas were also marked.

Surface scans were then performed in areas immediately adjacent to the marked areas to determine if any contiguous areas of elevated direct radiation had not been identified. If the countrate was below the action level for 5000 dpm/100 cm^2, then the area was not included in the areas to be remediated. The areas delineated as exceeding guidelines are illustrated on Figures 2 through 7. Due to the nature of the remedial actions performed on the Third Floor-East Bay, the areas depicted on Figure 5 as exceeding guidelines were those determined by BNI after the removal of the asphalt sealant floor covering.

SURFACE ACTIVITY MEASUREMENTS

The contaminant of concern is processed natural uranium, i.e. uranium separated from its long lived daughter products, but in its naturally occurring isotopic abundances. Processed natural uranium emits both alpha and beta radiation in approximately equal proportions; either beta activity levels or alpha activity levels may, therefore, be measured determining uranium surface activity levels.

Measurements of beta activity levels, rather than alpha activity, provide a more accurate representation of uranium surface activity due to conditions of the building surfaces (e.g. dusty, porous, or rough), which may selectively attenuate the alpha activity. Therefore, beta activity levels were used for comparison with the guideline values.

Measurements of beta activity were performed within and adjacent to the areas identified as exceeding guidelines. These measurements demonstrate that those areas identified as having elevated direct radiation during surface scans exceeded guideline levels and that the adjacent areas are below guidelines. Smears for determining removable contamination were obtained from representative direct measurement locations.

SAMPLE ANALYSIS AND DATA INTERPRETATION

Samples and survey data were returned to the ESSAP laboratory in Oak Ridge, TN for analyses and interpretation. 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 cm^2. Additional information concerning major instrumentation, sampling equipment, and analytical procedures is provided in Appendices A and B. Results were compared to the DOE guidelines which are provided in Appendix C.

GUIDELINES

Measurement and sampling data were compared to the DOE radiological protection requirements and guidelines for cleanup of residual radioactive material and release of property. These guidelines are summarized in Appendix C.

The controlling contaminant at Baker and Williams Warehouses is uranium. The uranium residual surface contamination guidelines are:

Total Activity

5000 α dpm/100 cm^2, averaged over 1 m^2

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

Removable Activity

1000 α dpm/100 cm^2

FINDINGS AND RESULTS

SURFACE SCANS

The results of the surface scans and subsequent delineation of areas that exceeded guidelines are presented on Figures 2 through 7. Surface scans identified areas that exceeded guidelines on the following floor levels: Basement-East Bay; Basement-West Bay; First Floor-East Bay; Third Floor-East Bay; Third Floor-West Bay; and, in the Elevator Pit-East Bay. Surface scans of the remaining floors and bays did not identify areas of contamination exceeding guidelines and those survey results will be presented in a separate report.

SURFACE ACTIVITY LEVELS

Residual uranium activity, exceeding DOE surface contamination guideline levels, was identified at four locations in the Basement-East Bay; six locations in the Basement-West Bay; twenty-one locations on the First Floor-East Bay; on the lower portion of the west and south wall on the Third Floor-East Bay; one location on the Third Floor-West Bay; and, two locations in the Elevator Pit-East Bay. Results of surface activity measurements at locations inside the areas that exceed guidelines are summarized in Table 1; direct measurements ranged from 5000 to 580,000 dpm/100 cm^2 for beta activity, and removable activity levels ranged from <12 to 340 dpm/100 cm^2 for alpha and <20 to 320 dpm/100 cm^2 for beta.

Results of surface activity measurements at locations outside the areas that exceed guidelines are summarized in Table 2; direct measurements ranged from <1500 to 4600 dpm/100 cm^2 for beta activity, and removable activity levels were less than the minimum detectable activity of the procedure, which were 12 dpm/100 cm^2 for alpha and 20 dpm/100 cm^2 for beta.

Two areas on the Fifth Floor-East Bay, previously identified as areas of elevated activity, were determined to be below guideline levels.

SUMMARY

At the request of the U.S. Department of Energy, the Oak Ridge Institute for Science and Education's Environmental Survey and Site Assessment Program conducted a characterization survey of Building 513-519 at the Baker and Williams Warehouses on West 20th Street in New York City, New York. Characterization activities included surface scans and surface activity measurements.

Residual uranium contamination, in excess of DOE surface contamination guidelines, was identified in 5 of 16 bays and in the elevator pit of the East Bay of the Baker and Williams Warehouses. The boundaries of the surface contamination, in excess of the guidelines, were marked and this information was provided to Bechtel National, Inc. for use in performing appropriate remedial actions. Following remedial action and post-remedial action monitoring, a verification survey was performed by ESSAP; the results will be presented in a separate report.

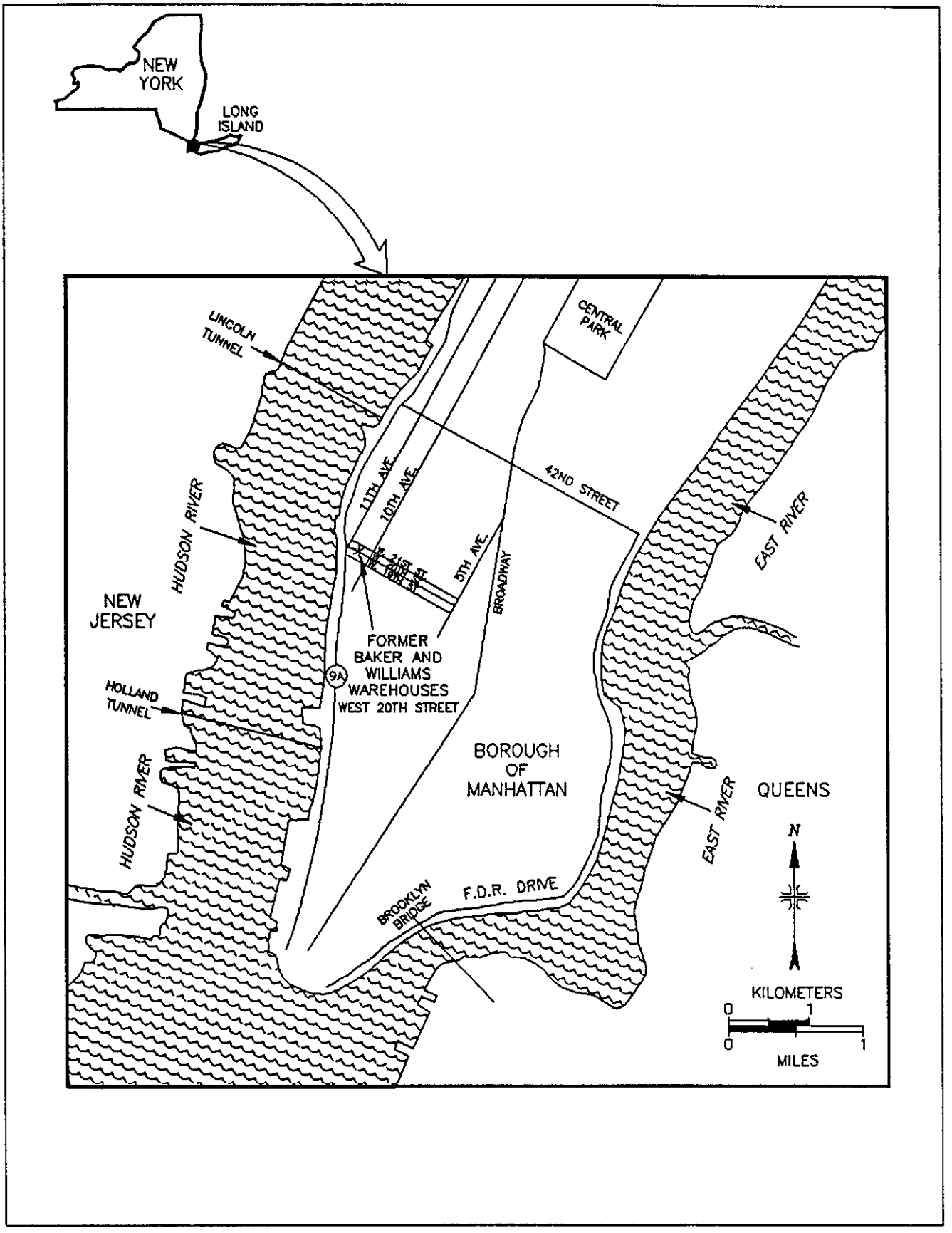

FIGURE 1: Location of the Baker and Williams Warehouses, New York, New York

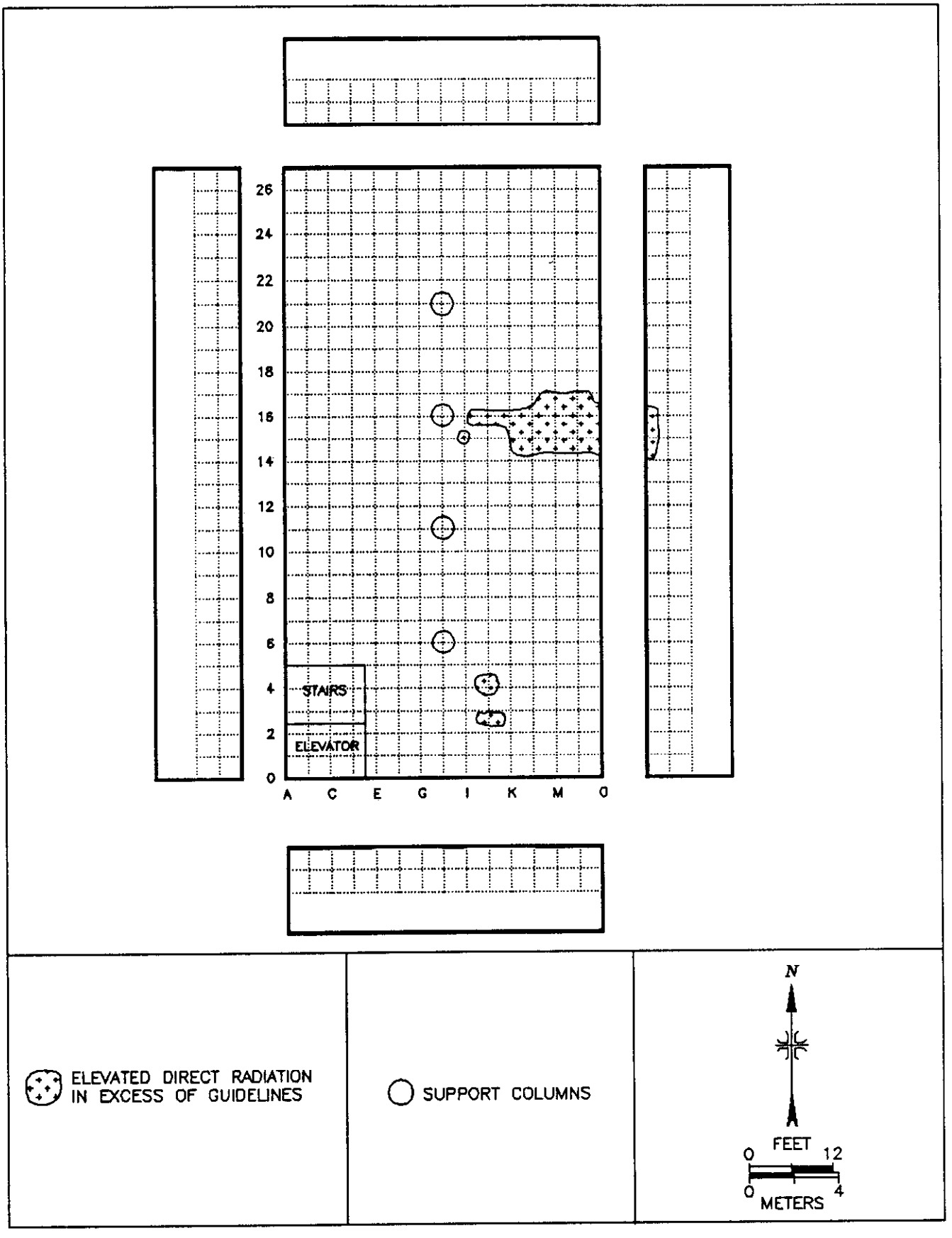

FIGURE 2: Basement, East Bay — Areas of Elevated Direct Radiation that Exceed Guidelines

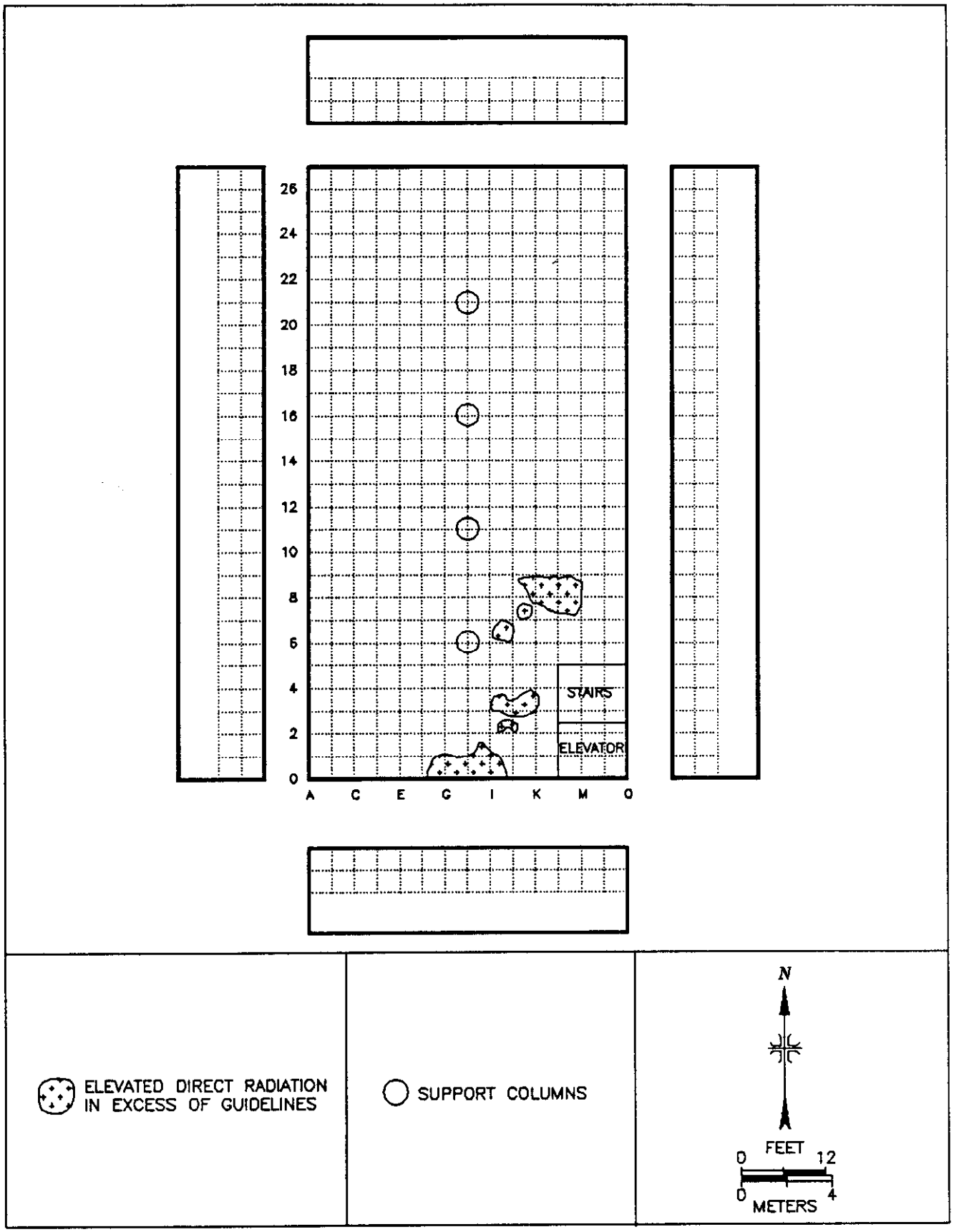

FIGURE 3: Basement, West Bay — Areas of Elevated Direct Radiation that Exceed Guidelines

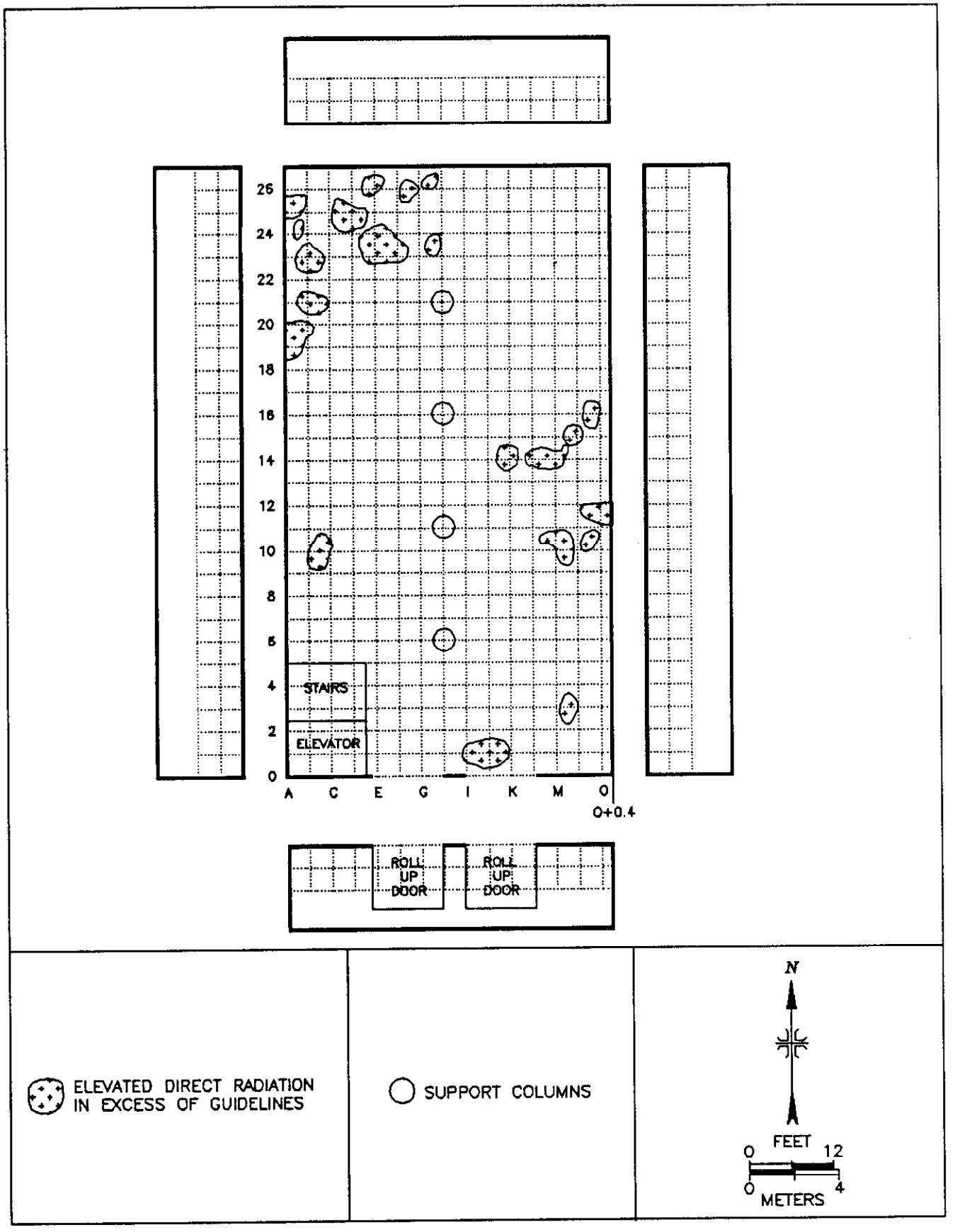

FIGURE 4: First Floor, East Bay – Areas of Elevated Direct Radiation that Exceed Guidelines

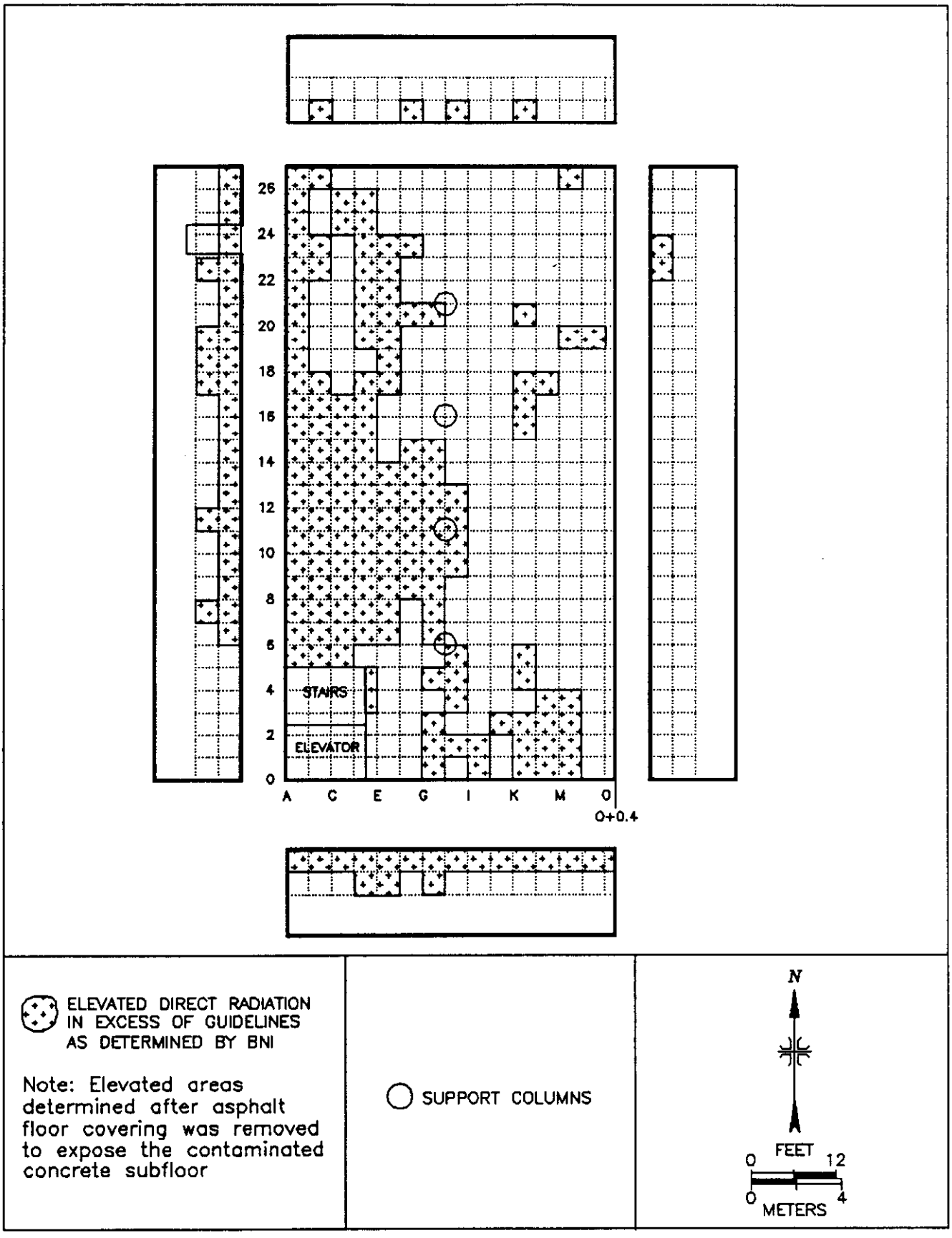

FIGURE 5: Third Floor, East Bay — Areas of Elevated Direct Radiation that Exceed Guidelines

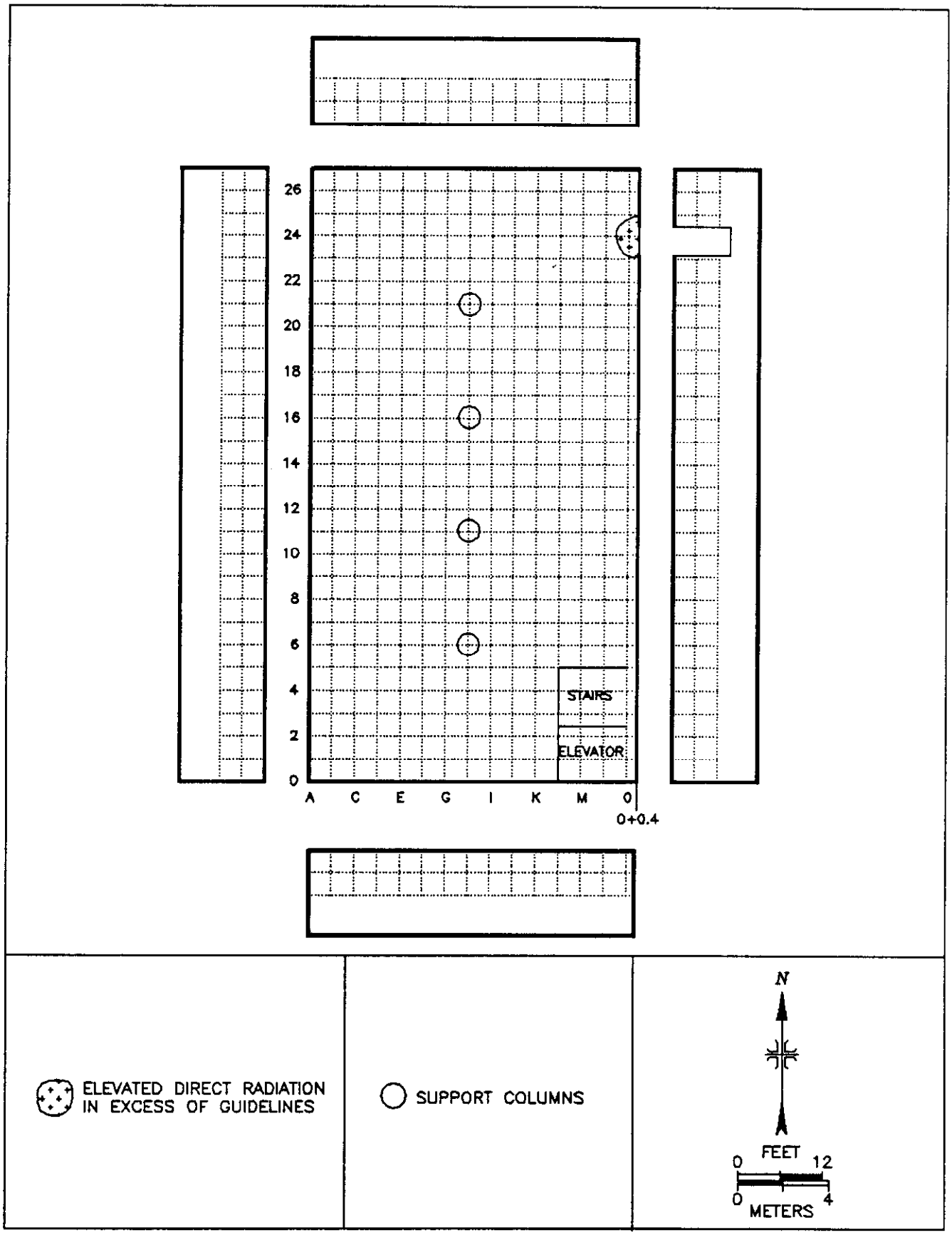

FIGURE 6: Third Floor, West Bay – Areas of Elevated Direct Radiation that Exceed Guidelines

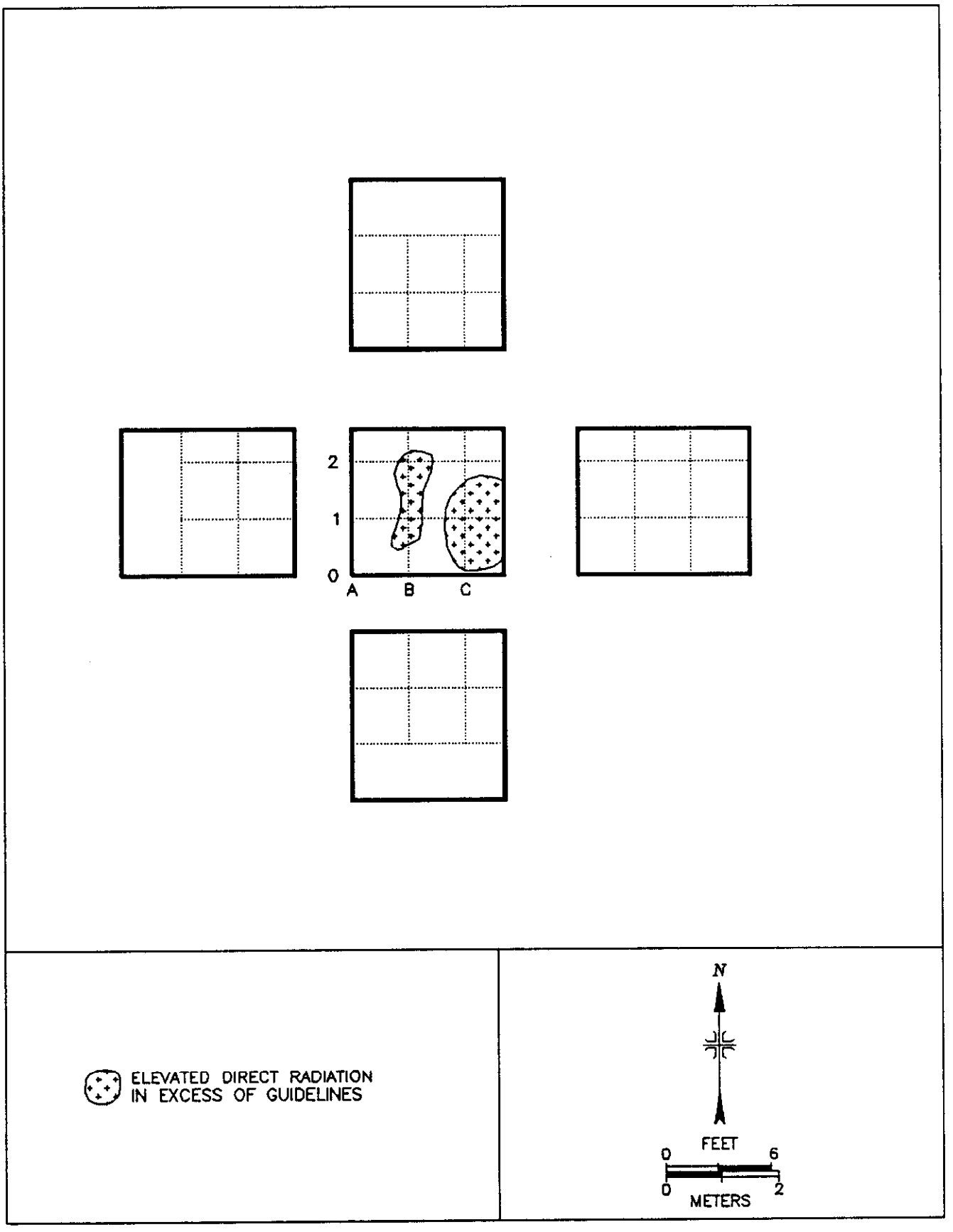

FIGURE 7: Elevator Pit, East Bay – Areas of Elevated Direct Radiation that Exceed Guidelines

TABLE 1

SUMMARY OF SURFACE ACTIVITY MEASUREMENTS INSIDE THE AREAS THAT EXCEED GUIDELINES BAKER AND WILLIAMS WAREHOUSE BUILDING 513-519 NEW YORK, NEW YORK

Location	Figure Number	Beta Surface Activity Range (dpm/100 cm^2)	Removable Activity Range (dpm/100 cm^2)	
			Alpha	Beta
Basement-East Bay	2	6,500 to 140,000	< 12 to 72	< 20 to 84
Basement-West Bay	3	19,000 to 51,000	< 12	< 20
First Floor-East Bay	4	5,000 to 24,000	< 12	< 20
Third Floor-East Bay	5	6,500 to 580,000	< 12 to 340	< 20 to 320
Third Floor-West Bay	6	5,100	< 12	< 20
Elevator Pit-East Bay	7	5,800 to 13,000	< 12	< 20

TABLE 2

SUMMARY OF SURFACE ACTIVITY MEASUREMENTS OUTSIDE THE AREAS THAT EXCEED GUIDELINES BAKER AND WILLIAMS WAREHOUSE BUILDING 513-519 NEW YORK, NEW YORK

Location	Figure Number	Beta Surface Activity Range (dpm/100 cm^2)	Removable Activity Range (dpm/100 cm^2)	
			Alpha	Beta
Basement-East Bay	2	<1,500 to 2,200	<12	<20
Basement-West Bay	3	<1,700	<12	<20
First Floor-East Bay	4	<2,200 to 4,600	<12	<20
Third Floor-East Bay	5	<2,200	<12	<20
Third Floor-West Bay	6	<2,100	<12	<20
Elevator Pit-East Bay	7	<1,900 to 4,300	<12	<20

REFERENCES

1. "Implementation Plan for Radiological Survey Protocols," Bechtel National, Inc.; Formerly Utilized Sites Remedial Action Program, July 1988.

2. "Radiological Survey of the Baker and Williams Warehouses, New York, New York," Oak Ridge Associated Universities, June 1990.

3. "Characterization Survey of the Baker and Williams Warehouses, Building 521-527, New York, New York, " Oak Ridge Associated Universities, November 1991.

4. "Verification Survey of the Baker and Williams Warehouses, Building 521-527, New York, New York," Oak Ridge Institute for Science and Education, May 1992.

5. "Radiological Survey of the Baker and Williams Warehouses, Building 513-519, New York, New York," Oak Ridge Associated Universities, December 1991.

6. "Radiological Survey Plan for Building 513-519 of the Baker and Williams Warehouse New York, New York," Oak Ridge Institute for Science and Education, April 27, 1993.

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 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 cm^2
(Eberline, Santa Fe, NM)

Ludlum Gas Proportional Detector
Model 43-37
Effective Area, 550 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

Low Background Gas Proportional Counter
Model LB-5110
(Tennelec, Oak Ridge, TN)

APPENDIX B

SURVEY AND ANALYTICAL PROCEDURES

APPENDIX B

SURVEY AND ANALYTICAL PROCEDURES

SURVEY PROCEDURES

Surface Scans

A large surface area, gas proportional floor monitor was used to scan the floors and walls of the surveyed areas. Other surfaces were scanned using small area (15.5 cm^2 or 100 cm^2) hand-held detectors. Combinations of detectors and instruments used for the scans were:

Beta	—	gas proportional detector with ratemeter-scaler
Beta	—	pancake GM detector with ratemeter-scaler
Gamma	—	NaI scintillation detector with ratemeter

Elevated direct radiation areas identified by surface scans were compared to action levels, which ESSAP developed based on the DOE guidelines. These action levels were used to delineate areas of contamination. The action levels were calculated as follows:

$$\text{Action Level (cpm)} = [\text{site criteria (dpm/100 cm}^2) \times E \times G \times T] + B$$

T = count time (minutes)

E = operating efficiency (counts per disintegration)

G = geometry (detector area cm^2/100)

B = background (cpm)

where: T = 1 minute

E = ranged from 0.15 to 0.17 cpm/dpm

G = 15.5 cm^2 for pancake GM detector

B = 58 cpm

The action levels for the detector/ratemeter-scaler combinations used in this survey ranged from 180 to 198 cpm and from 412 to 462 cpm for the 5,000 and 15,000 dpm/100 cm^2 guidelines, respectively.

To delineate contaminated areas, the detector/ratemeter-scaler combination was operated in the ratemeter mode. Surface scans were performed over the suspect areas by passing the probe slowly over the surface; the distance between the probe and the surface was maintained—nominally about 1 cm. Identification of elevated levels was based on increases in the audible signal from the recording and/or indicating instrument at which time the detector was placed on the surface and the approximate countrate was determined. All countrates above the action levels for the 15,000 dpm/100 cm^2 guideline were marked as exceeding guidelines. Any areas that had multiple countrates in excess of the action levels for the 5000 dpm/100 cm^2 guideline were also marked.

Surface Activity Measurements

Measurements of total beta activity levels were performed using GM detectors with portable ratemeter-scalers. Beta activity measurements were performed at locations of elevated direct radiation, using GM detectors with ratemeter-scalers.

Direct measurements (cpm), which were integrated over 1 minute in a static position, were converted to activity levels (dpm/100 cm^2) by dividing the net count rate by the 4 π efficiency and correcting for the active area of the detector. The beta activity background count rates for GM detectors averaged 58 cpm. Beta efficiency factors ranged from 0.15 to 0.17 for the GM detectors. The effective window for the GM detectors was 15.5 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 with two or three fingers, and approximately 100 cm^2 of the surface was wiped. Smears were placed in labeled envelopes with the location and other pertinent information recorded.

UNCERTAINTIES AND DETECTION LIMITS

Detection limits, referred to as minimum detectable activity (MDA), were based on 2.71 + 4.66 times the statistical deviation of the background count. When the activity was determined to be less than the MDA of the measurement procedures, the result was reported as less than the 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. Additional uncertainties, associated with sampling and measurement procedures, have not been propagated into the data presented in this report.

CALIBRATION AND QUALITY ASSURANCE

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

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

SUMMARY OF DEPARTMENT OF ENERGY RESIDUAL RADIOACTIVE MATERIAL GUIDELINES

APPENDIX C

SUMMARY OF DEPARTMENT OF ENERGY RESIDUAL RADIOACTIVE MATERIAL GUIDELINES[1]

BASIC DOSE LIMITS

The basic dose limit for the annual radiation dose (excluding radon) received by an individual member of the general public is 100 mrem/yr.[2] In implementing this limit, DOE applies as low as reasonably achievable principles to set site-specific guidelines.

EXTERNAL GAMMA RADIATION

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

SURFACE CONTAMINATION GUIDELINES

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

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

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

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

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

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

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

SOIL GUIDELINES

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

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

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

[c] If the average concentration in any surface or below-surface area, less than or equal to 25 m^2, exceeds the authorized limit of guideline by a factor of $(100/A)^{½}$, where A is the area or the elevated region in square meters, limits for "hot spots" shall also be applicable. Procedures for calculating these hot spot limits, which depend on the extent of the elevated local concentrations, are given in the DOE Manual for Implementing Residual Radioactive Materials Guidelines.[3] In addition, every reasonable effort shall be made to remove any source of radionuclide that exceeds 30 times the appropriate limit for soil, irrespective of the average concentration in the soil.

REFERENCES

1. "Guidelines for Residual Radioactive Material at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites," U.S. Department of Energy, Revision 2, March 1987.

2. "Radiation Protection of the Public and the Environment," DOE Order 5400.5, U.S. Department of Energy, February 8, 1990.

3. Argonne National Laboratory "A Manual for Implementing Residual Radioactive Material Guidelines," DOE/CH8901, June 1989.