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888-GQA-GAM-00008
SL-1227

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June 25, 1997

W. Alexander Williams, Ph.D
U. S. Department of Energy
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Washington, D.C. 20585-0002

SUBJECT: DRAFT REPORT—VERIFICATION SURVEYS OF FROST AVENUE AND HAZELWOOD AVENUE VICINITY PROPERTIES, ST. LOUIS AIRPORT SITE VICINITY PROPERTIES, HAZELWOOD, MISSOURI

Dear Dr. Williams:

Enclosed is the draft verification survey report for the subject properties. The Environmental Survey and Site Assessment Program (ESSAP) of the Oak Ridge Institute for Science and Education completed the verification activities for these properties during Fiscal Year 1996. Comments you may have will be incorporated into the final report.

Please contact me at (423) 576-5073 or William L. (Jack) Beck at (423) 576-5031 should you have any questions.

Sincerely,

Timothy J. Vitkus
Project Manager
Environmental Survey and
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TJV:kew

Enclosure

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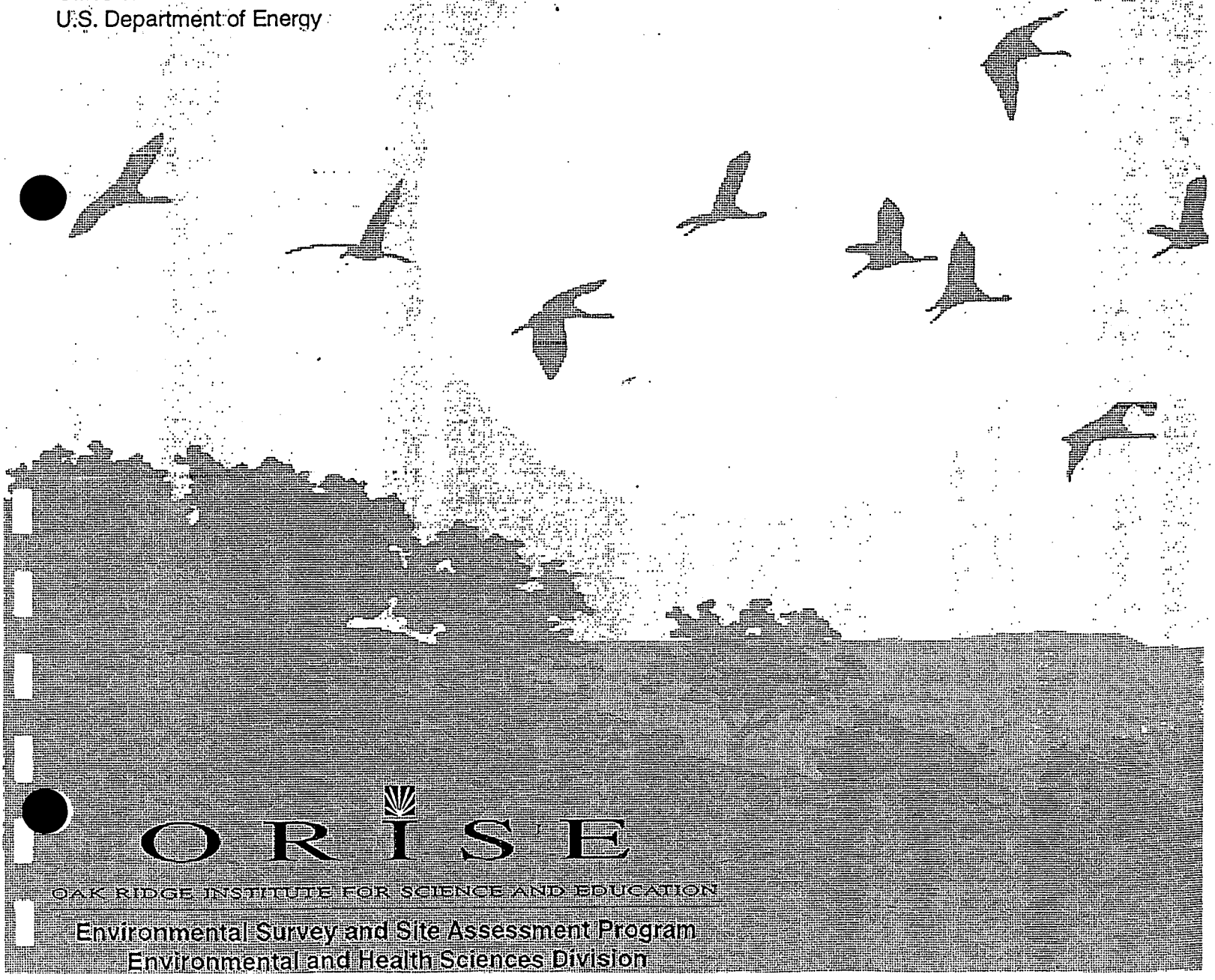
DRAFT REPORT

VERIFICATION SURVEYS OF FROST AVENUE AND HAZELWOOD AVENUE VICINITY PROPERTIES ST. LOUIS AIRPORT SITE VICINITY PROPERTIES HAZELWOOD, MISSOURI

J. L. PAYNE

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



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

VERIFICATION SURVEYS OF FROST AVENUE AND HAZELWOOD AVENUE VICINITY PROPERTIES ST. LOUIS AIRPORT SITE VICINITY PROPERTIES - HAZELWOOD, MISSOURI

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Office of Environmental Restoration
U.S. Department of Energy

DRAFT REPORT

JUNE 1997

This report is based on work performed under contract number DE-AC-05-76OR00033 with the U.S. Department of Energy.

ACKNOWLEDGMENTS

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ABBREVIATIONS AND ACRONYMS

µR/h	microroentgens per hour
µrem/h	microrem per hour
AEC	Atomic Energy Commission
ASME	American Society of Mechanical Engineers
BKG	background
BNI	Bechtel National, Inc.
cm	centimeter
CMMC	Continental Mining and Milling Company of Chicago
DOE	U.S. Department of Energy
DOE-ORO	DOE Oak Ridge Operations
EML	Environmental Measurements Laboratory
EPA	Environmental Protection Agency
ESSAP	Environmental Survey and Site Assessment Program
FSRD	Former Sites Restoration Division
FUSRAP	Formerly Utilized Sites Remedial Action Program
HISS	Hazelwood Interim Storage Site
IVC	Independent Verification Contractor
kg	kilogram
km	kilometer
m	meter
m^2	square meter
mrem/yr	millirem per year
MDC	minimum detectable concentration
MED	Manhattan Engineer District
MeV	million electron volts
NaI	sodium iodide
NIST	National Institute of Standards and Technology
ORISE	Oak Ridge Institute for Science and Education
ORNL	Oak Ridge National Laboratory
pCi/g	picocuries per gram
PMC	Project Management Contractor
RA	remedial action
SLAPS	St. Louis Airport Site
VP	Vicinity Property

VERIFICATION SURVEYS
OF
FROST AVENUE AND HAZELWOOD AVENUE
VICINITY PROPERTIES
ST. LOUIS AIRPORT SITE VICINITY PROPERTIES
HAZELWOOD, MISSOURI

INTRODUCTION AND SITE HISTORY

The St. Louis Airport Site (SLAPS) was acquired by the Manhattan Engineer District (MED) and operated from 1946 to 1966. The site was used for storage of waste materials that were generated during uranium processing from 1942 until the late 1950s at the Mallinckrodt facility, located in downtown St. Louis. These processing wastes, which included pitchblende raffinate residues, radium-bearing residues, and barium sulfate cake, were purchased by Continental Mining and Milling Company of Chicago (CMMC) in 1966 and, subsequently transported to 9200 Latty Avenue for storage under an Atomic Energy Commission (AEC) license. During transit, some of the materials spilled onto the haul roads and contiguous properties, primarily collecting in drainage ditches. The haul roads used for transport to the Latty Avenue storage site included McDonnell Boulevard, formerly Brown Avenue, Hazelwood Avenue, Pershall Road, Eva Avenue, Frost Avenue, and Latty Avenue. Redistribution of the contaminated materials probably occurred as a result of flooding, surface runoff, and road and utility line construction activities. The waste residues, stored at the Latty Avenue site, were eventually dried and shipped by rail to a mill site in Colorado.

Pursuant to specific direction in the 1984 Energy and Waste Appropriations Act, authority for remedial action at the Latty Avenue sites was assigned to the Department of Energy (DOE), and DOE initiated an investigation of the site and nearby properties. Oak Ridge National Laboratory (ORNL) performed a radiological survey of the haul roads in 1985. This survey identified areas with elevated gamma exposure rates and/or Th-230 concentrations in soil (ORNL 1986). As a result, the haul roads were designated in 1986 for remedial action under the Formerly Utilized Sites Remedial Action Program (FUSRAP). FUSRAP was created in 1974 to identify, investigate, and decontaminate or control sites where contamination above current guidelines remains from the early years of the Nation's atomic energy program. Bechtel National, Inc. (BNI), the Project Management Contractor for FUSRAP, performed site characterization activities during the period 1986 to 1989,

in order to delineate contamination boundaries, the results of which are provided in the St. Louis Sites characterization reports (BNI 1990). Several properties, located along Frost Avenue and Hazelwood Avenue, were included in this characterization survey. During Fiscal Year 1996, BNI completed remediation of ten of these properties. Remedial activities included the excavation of contaminated soil and final status surveys and sampling.

It is the policy of the DOE to perform independent verification of remedial actions conducted under FUSRAP. The Environmental Survey and Site Assessment Program (ESSAP) of the Oak Ridge Institute for Science and Education (ORISE) has been designated as the independent verification contractor (IVC) for the St. Louis sites.

SITE DESCRIPTION

SLAPS is located on the north side of the Lambert-St. Louis International Airport in St. Louis County, Missouri approximately 24 kilometers (km [15 miles]) west of downtown St. Louis. The Frost Avenue and Hazelwood Avenue vicinity properties (VPs) are located approximately 1 to 2 km northeast of SLAPS (Figures 1 and 2). The vicinity properties were assigned a numerical identifier in correspondence to a St. Louis County tax map locator number. All of the properties addressed in this report lie within the city of Hazelwood and are numbered as follows: 21, 22, 23, 24, 26, 27, and 30 on Frost Avenue, and 32, 36, and 37 on Hazelwood Avenue.

VP 21 is located on the north side of Frost Avenue. Soil contamination was confined to the right-of-way portion of the property and extended from the boundary with Frost Avenue to approximately 5 to 10 meters north of the road. Excavation depths ranged from approximately 0.5 to 1 meter (m) below the surface. The excavated portion of the property was subdivided into eight grids of approximately 100 m^2 each. A paved driveway is located between VP 21 and VP 22 (Figure 3).

VP 22 is located on the north side of Frost Avenue. Soil contamination was confined to the right-of-way portion of the property and extended from the boundary of Frost Avenue to approximately 5 to

10 meters north of the road. Excavation depths ranged from approximately 0.5 to 1 meter below the surface. The excavated portion of the property was subdivided into seven grids of approximately 100 m^2 each (Figure 4).

VP 23 is located on the north side of Frost Avenue. Soil contamination was confined to the right-of-way portion of the property and extended from the boundary with Frost Avenue to approximately 2.5 meters north of the road. Excavation depths ranged from approximately 0.5 to 1 meter below the surface. The excavated portion of the property was subdivided into four grids of approximately 100 m^2 each. A paved driveway enters the property from Frost Avenue (Figure 5).

VP 24 is located on the north side of Frost Avenue. Soil contamination was confined to the right-of-way portion of the property and extended from the boundary with Frost Avenue to approximately 5 to 10 meters north of the road. Excavation depths ranged from approximately 0.5 to 1.5 meters below the surface. The excavated portion of the property was subdivided into 18 grids of approximately 100 m^2 each. Two paved driveways enter the property from Frost Avenue (Figure 6).

VP 26 is located on the south side of Frost Avenue. Soil contamination was confined to the right-of-way portion of the property and extended from the boundary with Frost Avenue to approximately 2.5 meters south of the road. Excavation depths ranged from approximately 0.5 to 1 meter below the surface. The excavated portion of the property covered approximately 100 m^2. A paved driveway enters the property from Frost Avenue (Figure 7).

VP 27 is located on the south side of Frost Avenue. Soil contamination was confined to an 80 m^2 area approximately 10 meters south of Frost Avenue. The excavation is bounded to the south by a building, to the east by a paved parking lot, and to the west by VP 26. Excavation depths range from approximately 0.5 to 1 meter below the surface (Figure 8).

VP 30 is located on the south side of Frost Avenue. Soil contamination was confined to the right-of-way portion of the property and extended from the boundary of Frost Avenue to approximately five

meters south of the road. Excavation depths ranged from approximately 0.5 to 1 meter below the surface. The excavated portion of the property covered approximately 100 m^2 (Figure 9.)

VP 32 is located on the west side of Hazelwood Avenue. BNI had subdivided the excavated portion of the property into two units—32A and 32B. Soil contamination in unit 32B was confined to the right-of-way of the property and extended from the boundary with Hazelwood Avenue to approximately 5 to 10 meters west of the road. Unit 32A, which was previously remediated and sampled, bounded the northwest section of 32B and extended an additional 10 to 15 meters west of Hazelwood Avenue. Excavation depths in unit 32B ranged from approximately 0.5 to 1 meter below the surface. The excavated portion of unit 32B was further subdivided into nine grids of approximately 100 m^2 each (Figure 10).

VP 36 is located on the west side of Hazelwood Avenue. Soil contamination was mainly confined to the right-of-way portion of the property and extended from the boundary of Hazelwood Avenue to approximately 5 to 10 meters west of the road. At the south end of the property the excavation extends from the boundary with the road approximately 55 meters west. Excavation depths ranged from approximately 0.5 to 1 meter below the surface. The excavated portion of the property was subdivided into 17 grids of approximately 100 m^2 each (Figure 11).

VP 37 is located on the west side of Hazelwood Avenue. Soil contamination was confined to the right-of-way portion of the property and extended from the boundary of Hazelwood Avenue to approximately 5 to 15 meters west of the road. Excavation depths ranged from approximately 0.5 to 1 meter below the surface. The excavated portion of the property was subdivided into nine grids of approximately 100 m^2 each (Figure 12).

PROJECT ORGANIZATION AND RESPONSIBILITY

DOE Headquarters provides overview and coordination for all FUSRAP activities. The DOE Oak Ridge Operations (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 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 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 radiological restrictions.

OBJECTIVES

Through document reviews and independent surveys, an independent evaluation was performed. The purpose of the evaluation was to validate that procedures and methods utilized by the remedial action contractor were adequate in demonstrating the final radiological status of each vicinity property. In addition, independent verification provides assurance that the post-remediation data is sufficient, accurate, and demonstrates that remedial actions were accomplished in accordance with appropriate standards and guidelines, and that authorized limits were met.

DOCUMENT REVIEW

ESSAP reviewed BNI's field data results and supporting documentation concerning site remediation activities. Information was evaluated to assure that areas identified as exceeding site guidelines had undergone decontamination and that residual radioactive material and exposure rate levels satisfied the established guidelines.

SURVEY PROCEDURES

During the 1996 Fiscal Year, ESSAP personnel visited 10 SLAPS vicinity properties located on Frost Avenue and Hazelwood Avenue and performed visual inspections and independent measurements and sampling of remediated areas in accordance with the SLAPS vicinity property survey plan previously submitted to and approved by the DOE (ORISE 1994). Procedures were in accordance with the ORISE/ESSAP Survey Procedures and Quality Assurance Manuals (ORISE 1995a and b). Verification activities included gamma surface scans, exposure rate measurements, and surface and subsurface soil sampling.

REFERENCE SYSTEM

Measurement and sampling locations were referenced to BNI designated sampling grid blocks, each having an area of approximately 100 m^2. Measurement and sampling locations outside the designated grid blocks were referenced to the grid or to prominent site features.

SURFACE SCANS

Surface scans for gamma activity were conducted over 100 percent of the remediated areas using NaI scintillation detectors coupled to ratemeters with audible indicators. Locations of elevated direct radiation, indicating the presence of surface or subsurface contamination, were marked for further investigation. Gamma scans were also performed over unremediated soil surfaces adjacent to the excavations.

EXPOSURE RATE MEASUREMENTS

Exposure rate measurements were performed at each surface soil sampling location at 1 m above the surface using a microrem meter (Figures 3 through 12). Background exposure rate measurements, performed during previous SLAPs vicinity property surveys, were used for comparison (Figure 13).

SOIL SAMPLING

ESSAP collected 137 surface soil samples from systematically selected locations and/or locations of elevated direct gamma radiation identified from surface scans (Figures 3 through 12).

ESSAP also collected 52 samples from boreholes. Borehole locations included locations of elevated surface activity where additional subsurface sampling was required due to increases in gamma count rates following surface sampling, and beneath paved driveways. Figures 3, 5, 6, and 7 show borehole locations.

Background soil samples, collected during previous SLAPS vicinity property surveys, were used for comparison of results (Figure 13).

Additionally, ESSAP requested and received 11 samples collected by BNI for confirmatory analysis. Six samples were collected following additional remediation of locations identified by ESSAP during verification activities of VP 24. The remaining five samples were final survey samples collected from VP 32, section A.

SAMPLE ANALYSIS AND DATA INTERPRETATION

Samples and survey data were returned to ORISE's ESSAP Laboratory in Oak Ridge, Tennessee for analysis and interpretation. Sample analysis was in accordance with the ORISE/ESSAP Laboratory Procedures Manual (ORISE 1995c). Soil samples were initially analyzed by solid state gamma spectrometry. The primary radionuclide of interest was Th-230, however, spectra were also reviewed for uranium and Ra-226, and any other identifiable photopeaks. Selected samples were also analyzed for isotopic thorium by alpha spectrometry. Analytical results for soil were reported in units of picocuries per gram (pCi/g). Exposure rates were reported in units of microroentgens per hour (μR/h).

Additional information concerning major instrumentation, sampling equipment, and analytical procedures is provided in Appendices A and B. Results were compared to generic and site-specific guidelines which are provided in Appendix C.

FINDINGS AND RESULTS

DOCUMENT REVIEW

Overall, most deficiencies in survey procedures and documentation that ESSAP identified were addressed by BNI and the field data results and supporting documentation provided reasonable documentation of the radiological status of the properties relative to exposure rates and the 100 m^2 average residual radionuclide concentrations in soils. However, BNI did not address ESSAP's recommendation that they modify their standard post-remedial action (RA) soil sampling methods to ensure that any locations of elevated radionuclide concentrations were identified and documented. The basis for this recommendation was that gamma surface scans alone cannot detect Th-230, the principal site contaminant, at guideline levels. Current and proposed radiological survey guidance documents recommend a statistically-based sampling approach to demonstrate compliance with guidelines when the scanning sensitivity is not adequate to detect contaminants at the guideline level. It is ESSAP's opinion that BNI's post-remedial action survey and sampling approach may have resulted in areas of residual activity not being detected.

INDEPENDENT VERIFICATION SURVEY FINDINGS AND RESULTS

Surface scans and analysis of the initial verification soil samples identified residual contamination within 6 of the 10 vicinity properties. BNI performed additional remediation and ESSAP resampled these identified areas during subsequent surveys at the SLAPS VPs. Exposure rates and radionuclide concentrations in soil samples were compared to background values collected during previous SLAPS VP surveys which are provided in Table 1. Background exposure rates ranged from 9 to 10

μR/h. Average radionuclide concentrations in background soil samples were 0.9 pCi/g for Ra-226, 1.31 pCi/g for Th-230, and 1.1 pCi/g for U-238 (ORISE 1996). The following is a summary of findings and results for the individual vicinity properties included in this report.

Vicinity Property 21

Surface scans identified locations of elevated direct gamma radiation within VP 21 in an unremediated area between grids 1 and 2. Elevated direct gamma radiation was also noted in grid 6 along the south wall of the excavation which borders Frost Avenue. ESSAP initially collected six soil samples—three surface (0 to 15 cm) and three subsurface (15 to 30 cm)—from three locations within the area between grids 1 and 2. One sample was collected from the south wall of grid 6 at the location of elevated surface activity. Five systematic surface samples, one each from the center and four points equidistant from the grid center and the grid corners (5-point configuration), were collected in grid 3. Additionally, six samples were collected from two borehole locations in the driveway area near the east end of VP 21 at depths of 0-15 cm, 15-30 cm, and 30-45 cm. Figure 3 shows soil sampling locations.

Exposure rates and radionuclide concentrations in initial soil samples including background, are summarized in Table 2. Exposure rates ranged from 5 to 11 μR/h. Radionuclide concentration ranges were as follows: 0.8 to 16.3 pCi/g for Ra-226, less than 4.0 to 650 pCi/g for Th-230, and less than 2.6 to 5.4 pCi/g for U-238.

Two sampling locations, one in the area between grids 1 and 2 and one in grid 6 along the south excavation wall, exceeded the guidelines for Th-230. The sample from the area between grids 1 and 2 also exceeded the guideline for Ra-226. As a result, BNI excavated the area between grids 1 and 2. ESSAP performed additional verification activities of this area during a subsequent survey visit that included gamma surface scans, exposure rate measurements, and the collection of five additional systematic soil samples (Figure 3). Exposure rates and radionuclide concentrations in samples

following the additional remediation are also presented in Table 2 and ranged from 0.8 to 1.4 pCi/g for Ra-226 and for Th-230 were less than 4.5 pCi/g. Exposure rates ranged from 5 to 6 μR/h in the area.

Vicinity Property 22

Surface scans identified one location of elevated direct gamma radiation within VP 22 in grid 1, which BNI remediated while ESSAP was on-site. ESSAP collected five systematic surface soil samples in a 5-point configuration, from grids 1 and 6. Exposure rate and sampling locations are shown on Figure 4.

Exposure rates and radionuclide concentrations in soil samples, including background, are summarized in Table 3. Exposure rates ranged from 6 to 7 μR/h. Concentration ranges were as follows: 1.0 to 1.8 pCi/g for Ra-226, 1.53 to 12.90 pCi/g for Th-230. And less than 1.8 to 3.0 pCi/g for U-238.

Vicinity Property 23

Surface scans identified two locations of elevated direct gamma radiation, one each in grids 1 and 3. ESSAP collected a total of 15 systematic surface samples from grids 1, 2, and 4. Samples were collected along the east to west center line of the excavation. The two locations of elevated direct gamma radiation were also sampled. Additionally, six samples were collected from two boreholes that were hand-augured beneath the paved driveway adjacent to the excavation. Samples were collected from 0-15 cm, 15-30 cm, and 30-45 cm depths from each borehole. Exposure rate and soil sampling locations are shown on Figure 5.

Exposure rates and radionuclide concentrations in soil samples, including background, are summarized in Table 4. Exposure rates ranged from 4 to 13 μR/h. Concentration ranges were as follows: 0.8 to 2.0 pCi/g for Ra-226, less than 4.9 to 28.6 pCi/g for Th-230, and less than 2.1 to 2.6 pCi/g for U-238.

Vicinity Property 24

Surface scans identified locations of elevated direct gamma radiation within VP 24 in grids 2, 4, 8, 9, and 12. Systematic soil samples were collected in a 5-point configuration from seven grids. Surface and subsurface samples (15-30 cm) were also collected at locations of elevated direct radiation detected by surface scans. Additionally, 12 samples were collected from four borehole locations in the adjacent paved driveways. Exposure rate and soil sampling locations are shown on Figure 6.

Exposure rates and radionuclide concentrations in initial soil samples, including background, are summarized in Table 5. Exposure rates ranged from 4 to 15 μR/h. Radionuclide concentration ranges were as follows: 0.7 to 16.6 pCi/g for Ra-226, less than 4.7 to 773.4 pCi/g for Th-230, and 0.7 to 12.3 pCi/g for U-238.

Numerous sampling locations in grids 2, 8, 9, and 12 exceeded the guidelines for Th-230 and one location in grid 9 exceeded the Ra-226 guideline. As a result, BNI performed additional remedial activities in these grids. Upon completion of the additional remediation, ESSAP, performed additional verification activities of each grid that included either gamma surface scans, exposure rate measurements, and independent soil sampling during subsequent survey visits (grids 2 and 9) or performed confirmatory analysis of the post-remedial action (post-RA) samples that BNI collected (grids 8 and 12). Final verification exposure rate and sampling locations are also shown on Figure 6.

Final verification exposure rates (grids 2 and 9) and radionuclide concentrations in soil samples are also presented in Table 5. Final exposure rates ranged from 5 to 7 μR/h. Final radionuclide concentrations ranges were as follows: 0.7 to 1.7 pCi/g for Ra-226, less than 15 to 25.5 pCi/g for Th-230, and 0.8 to 1.8 pCi/g for U-238.

Vicinity Property 26

Surface scans did not identify any locations of elevated direct gamma radiation. ESSAP collected five systematic surface soil samples along the east to west center line of the excavation. Additionally, six samples were collected from two boreholes which were hand-augered beneath the paved driveway adjacent to the excavation. Samples were collected from 0-15 cm, 15-30 cm, and 30-45 cm depths at each borehole. Exposure rate and soil sampling locations are shown on Figure 7.

Exposure rates and radionuclide concentrations, in soil samples, including background, are summarized in Table 6. Exposure rates ranged from 9 to 11 μR/h. Concentration ranges were as follows: 0.7 to 1.4 pCi/g for Ra-226, less than 4.1 pCi/g for Th-230, and 0.6 to 1.4 pCi/g for U-238.

Vicinity Property 27

Surface scans did not identify any locations of elevated direct gamma radiation. ESSAP collected six random surface soil samples from the excavation. Exposure rate and soil sampling locations are shown on Figure 8.

Exposure rates and radionuclide concentrations in soil samples, including background, are summarized in Table 7. Exposure rates ranged from 11 to 15 μR/h. Concentration ranges were as follows: 1.1 to 1.2 pCi/g for Ra-226, less than 4.7 to 5.9 pCi/g for Th-230, and 1.0 to 1.2 pCi/g for U-238.

Vicinity Property 30

Surface scans did not identify any locations of elevated direct gamma radiation. ESSAP collected five systematic surface soil samples, in a 5-point configuration, from the excavation. Additionally, two surface samples were collected outside the excavation. Exposure rate and soil sampling locations are shown on Figure 9.

Exposure rates and radionuclide concentrations in soil samples, including background, are summarized in Table 8. Exposure rates ranged from 8 to 10 μR/h. Concentration ranges were as follows: 1.0 to 1.3 pCi/g for Ra-226, less than 4.8 pCi/g for Th-230, and 1.0 to 1.2 pCi/g for U-238.

Vicinity Property 32

Surface scans did not identify any locations of elevated direct gamma radiation within Unit 32B. ESSAP collected five systematic surface soil samples, in a 5-point configuration, from grids 2 and 8. Exposure rate and soil sampling locations for Unit 32B are shown on Figure 10. Additionally, ESSAP received BNI's post-RA data and performed confirmatory analysis of BNI's post-RA samples from Unit 32A.

Exposure rates and radionuclide concentrations in soil samples, collected by ESSAP and post-RA samples received from BNI, including background, are summarized in Table 9. Exposure rates ranged from 9 to 11 μR/h. Concentration ranges were as follows: 1.1 to 1.5 pCi/g for Ra-226, 1.58 to 8.36 pCi/g for Th-230, and less than 1.5 to 2.5 pCi/g for U-238 for Unit 32B. For Unit 32A concentration ranges were 0.8 to 1.2 pCi/g for Ra-226, less than 14.8 pCi/g for Th-230, and 0.8 to 2.0 pCi/g for U-238.

Vicinity Property 36

Surface scans identified one location of elevated direct gamma radiation within grid 4. ESSAP collected five systematic surface soil samples, in 5-point configurations, from grids 4, 9, and 16. Exposure rate and soil sampling locations are shown on Figure 11.

Exposure rates and radionuclide concentrations in soil samples, including background, are summarized in Table 10. Exposure rates ranged from 10 to 15 μR/h. Concentration ranges were as follows: 0.9 to 6.5 pCi/g for Ra-226, 1.58 to 290 pCi/g for Th-230, and 0.5 to 7.4 pCi/g for U-238. BNI performed additional remedial activities at sample location 207 in grid 4 and ESSAP collected

a post-RA verification sample during a subsequent survey visit. The radionuclide concentrations in this sample are also presented in Table 10 and were as follows: 1.8 pCi/g for Ra-226, 19.6 pCi/g for Th-230, and 2.3 pCi/g for U-238.

Vicinity Property 37

Surface scans identified one location of elevated direct gamma radiation within grid 2. ESSAP collected five systematic surface soil samples, in 5-point configurations, from grids 2 and 9. Exposure rate and soil sampling locations are shown on Figure 12.

Exposure rates and radionuclide concentrations in soil, including background, are summarized in Table 12. Exposure rates ranged from 10 to 14 μR/h. Concentration ranges were as follows: 1.2 to 7.2 pCi/g for Ra-226, 1.45 to 261 pCi/g for Th-230, and 0.6 to 3.5 pCi/g for U-238. BNI performed additional remedial activities at sample location 179 in grid 2 and ESSAP collected a post-RA verification sample on a subsequent survey visit. The radionuclide concentrations in this sample are also presented in Table 11 and were as follows: 0.9 pCi/g for Ra-226, less than 4.3 pCi/g for Th-230, and 0.9 pCi/g for U-238.

COMPARISON OF RESULTS WITH GUIDELINES

Soil sample results were compared to the generic and site-specific soil concentration guidelines (DOE 1990a and 1990b). These guidelines are as follows:

Radionuclide	Soil Concentration Above Background
Ra-226, Th-230	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 greater than 15 cm below the surface.
U-238	50 pCi/g

Radionuclide concentrations in soil samples from Vicinity Properties 26, 27, and 30 were all below the surface guideline limits. Concentrations in soil samples from Vicinity Properties 21 and 37 were below surface guideline values following additional remedial action by BNI.

Four soil samples from Vicinity Properties 22, 32, and 36 had concentrations of Th-230 which exceeded the surface guideline values but were less than the subsurface guideline. Because the surface these samples were collected from was originally, and will be again following backfill, at a depth greater than 15 cm, the subsurface guideline is applicable and has been satisfied.

Three soil samples collected from Vicinity Properties 23 and 36 had concentrations of Th-230 exceeding the subsurface guideline. However, the guidelines permit averaging the radionuclide concentration over an area of 100 m^2 and application of the hot spot criteria. For both grids 1 and 2 in VP 23, and grid 4 in VP 36, the 100 m^2 averages for Th-230 concentration, which were 7.48 pCi/g, 9.54 pCi/g, and 8.7 pCi/g, respectively, satisfied the guideline.

The elevated activity noted in the VP 21 excavation wall of grid 6—a condition also noted for most of the other VPs surveyed—was not associated with the property to be released, but rather the contamination that remains beneath the road base. BNI intends to prepare a hazard assessment for this material at a later date.

The basic dose limit for exterior land areas is 100 mrem/yr, which includes external exposure plus the sum of all other pathways. In implementing this limit, the DOE also applies as low as reasonably achievable principles (DOE 1990a). Exposure rates were comparable to background levels.

SUMMARY

During the 1996 Fiscal Year, ESSAP performed verification surveys of 10 St. Louis Airport Site Vicinity Properties located on Frost Avenue and Hazelwood Avenue in Hazelwood, Missouri. Survey activities included contractor data and document reviews, surface scans, exposure rate measurements, and surface and subsurface soil sampling.

Verification surveys of the properties identified the presence of undocumented locations with elevated Th-230 concentration levels. ESSAP performed additional investigations of these locations and determined that additional remediation was necessary. ESSAP's resurveys of these areas—after the additional remediation—as well as the survey results for the remainder of the remediated portions of the properties, support BNI's conclusion that exposure rates are comparable to background levels and radionuclide concentration levels satisfy the 100 m^2 average guidelines. However, it should be noted that the verification surveys did identify numerous areas of residual contamination most likely due to the post-remedial action sampling methods and insensitivity of field instrumentation to detect Th-230 at guideline levels. As a result, it is ESSAP's opinion that other small areas of residual Th-230 in excess of 15 pCi/g may remain on the properties.

FIGURES

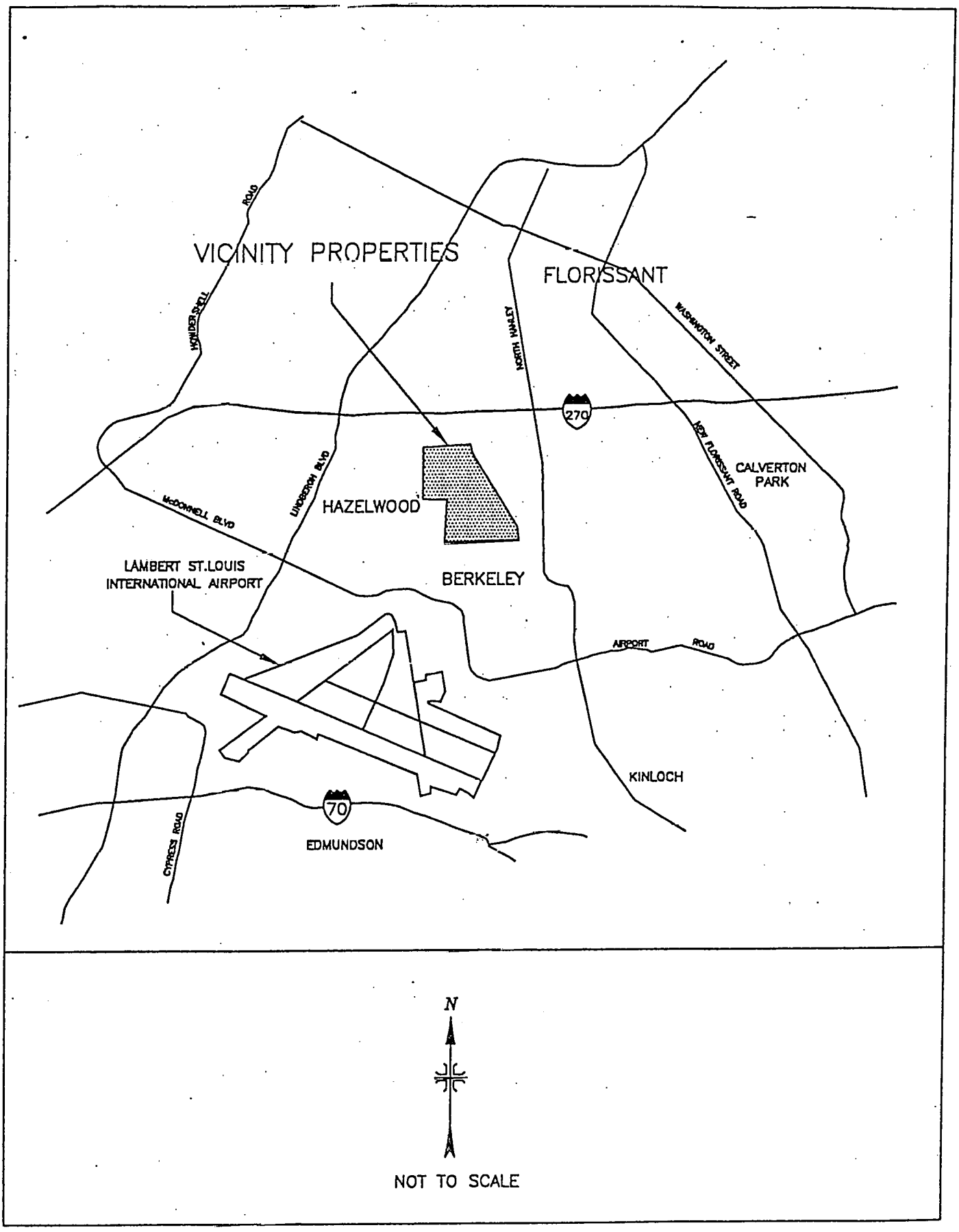

FIGURE 1: Hazelwood, Missouri Area Showing Location of SLAPS Vicinity Properties

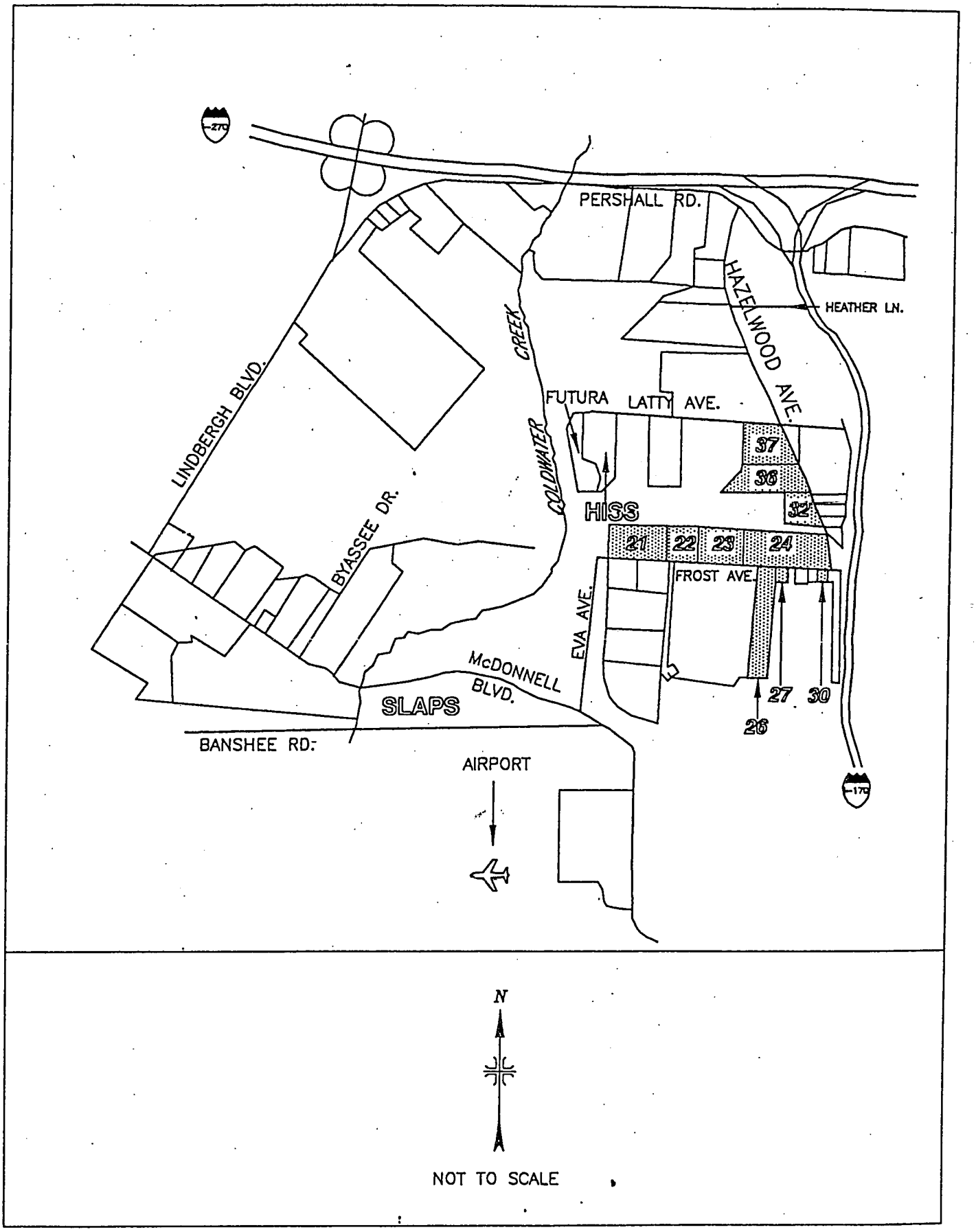

FIGURE 2: Location of Frost Avenue and Hazelwood Avenue SLAPS Vicinity Properties

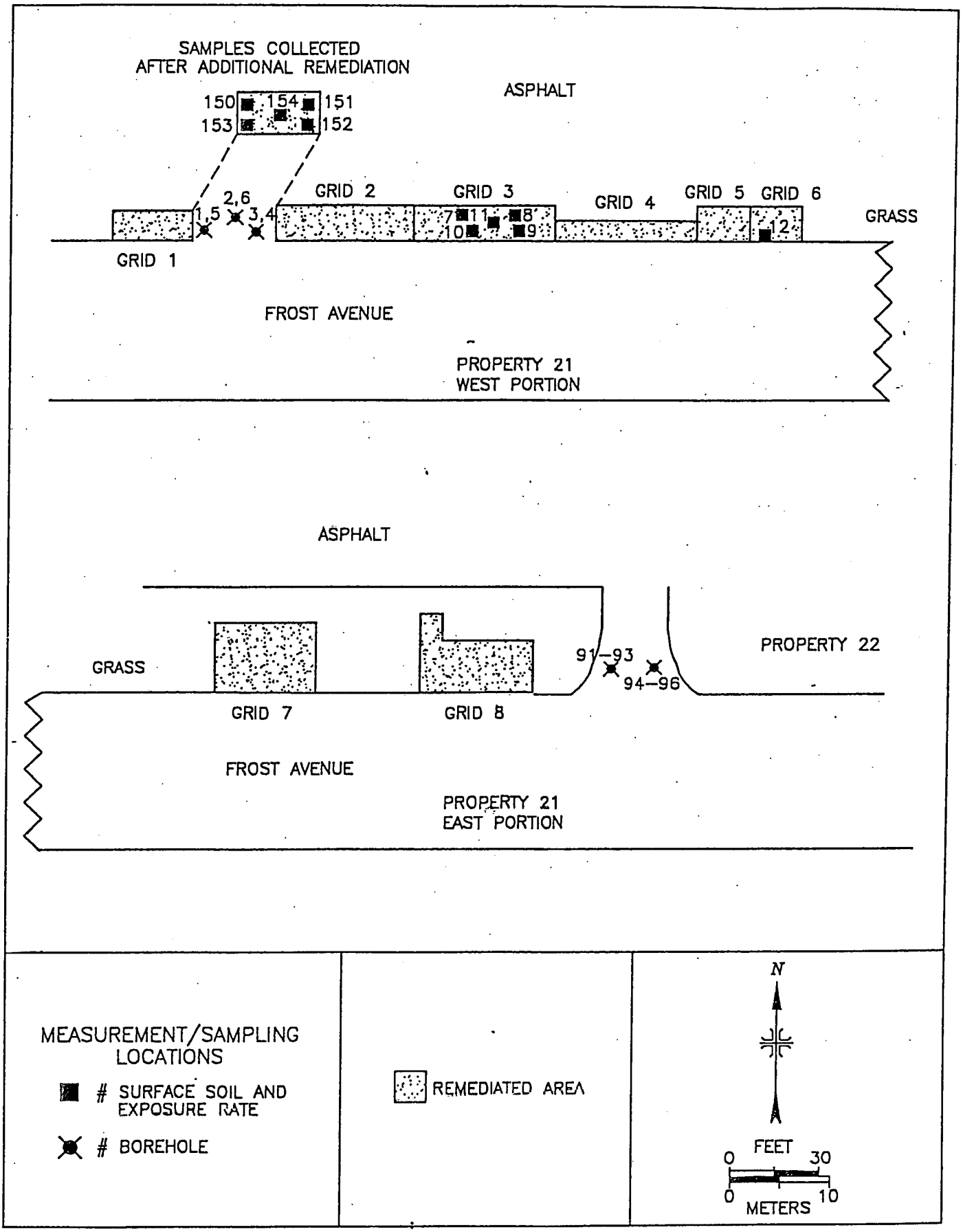

FIGURE 3: SLAPS Vicinity Properties, Property 21 – Measurement and Sampling Locations

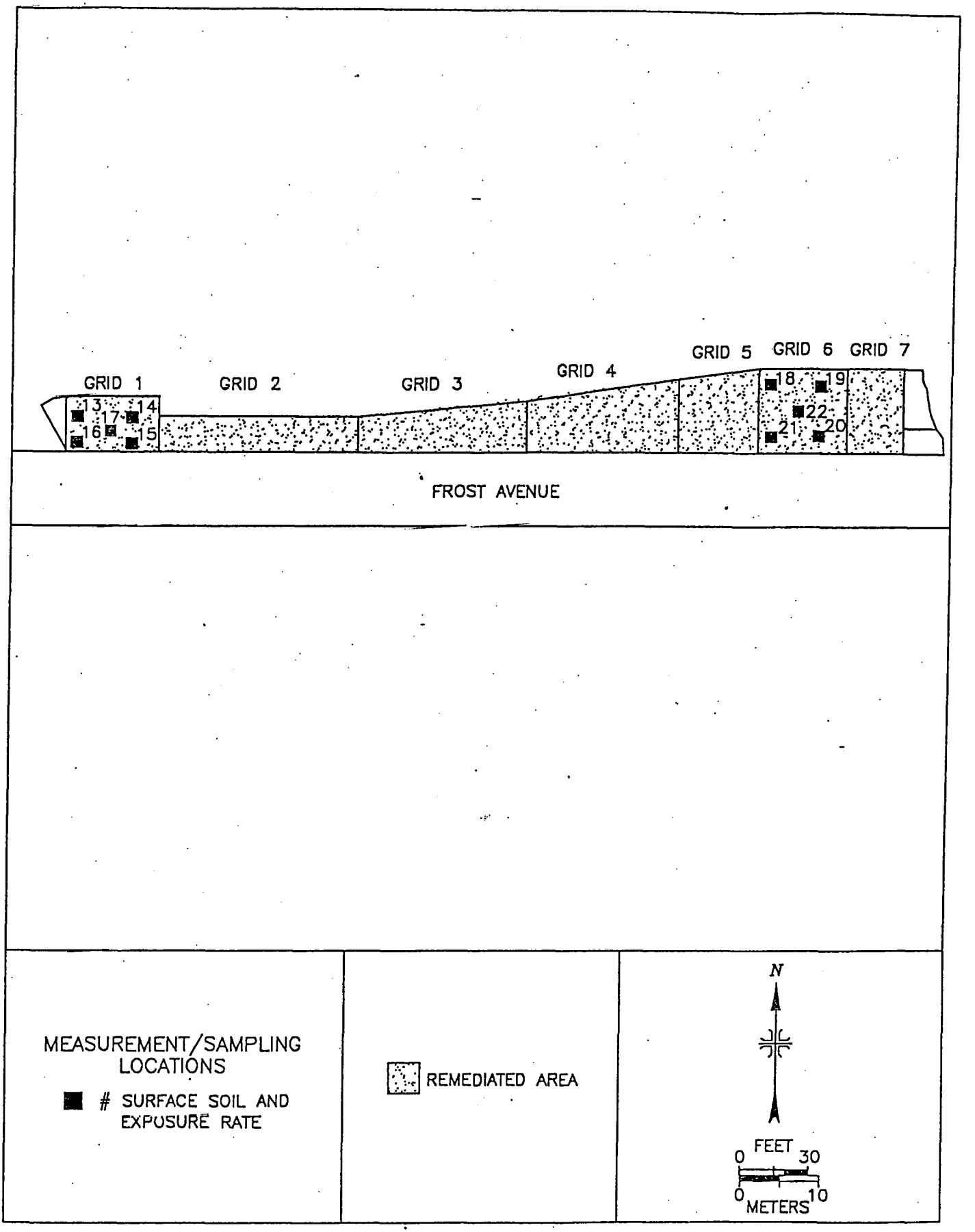

FIGURE 4: SLAPS Vicinity Properties, Property 22 – Measurement and Sampling Locations

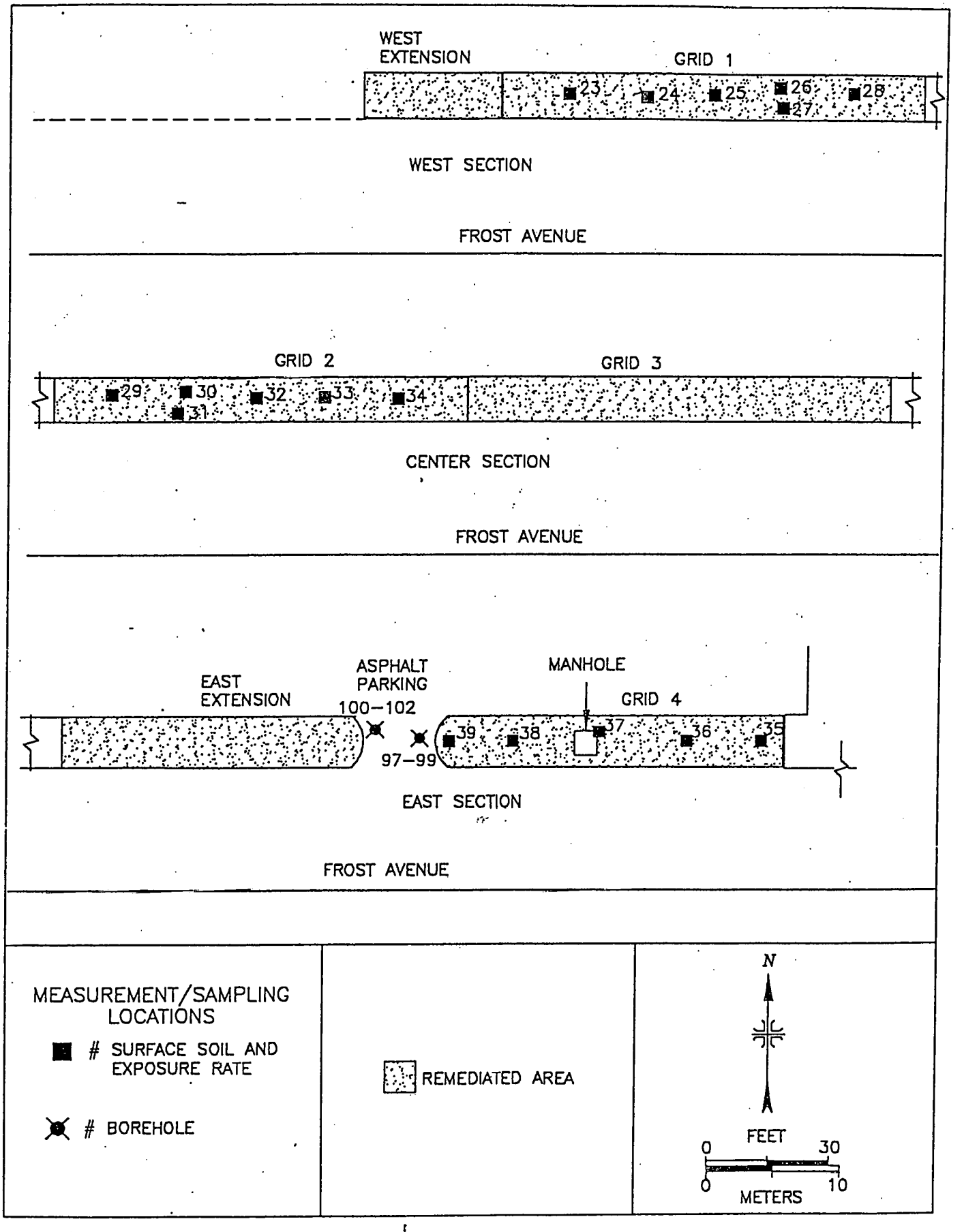

FIGURE 5: SLAPS Vicinity Properties, Property 23 – Measurement and Sampling Locations

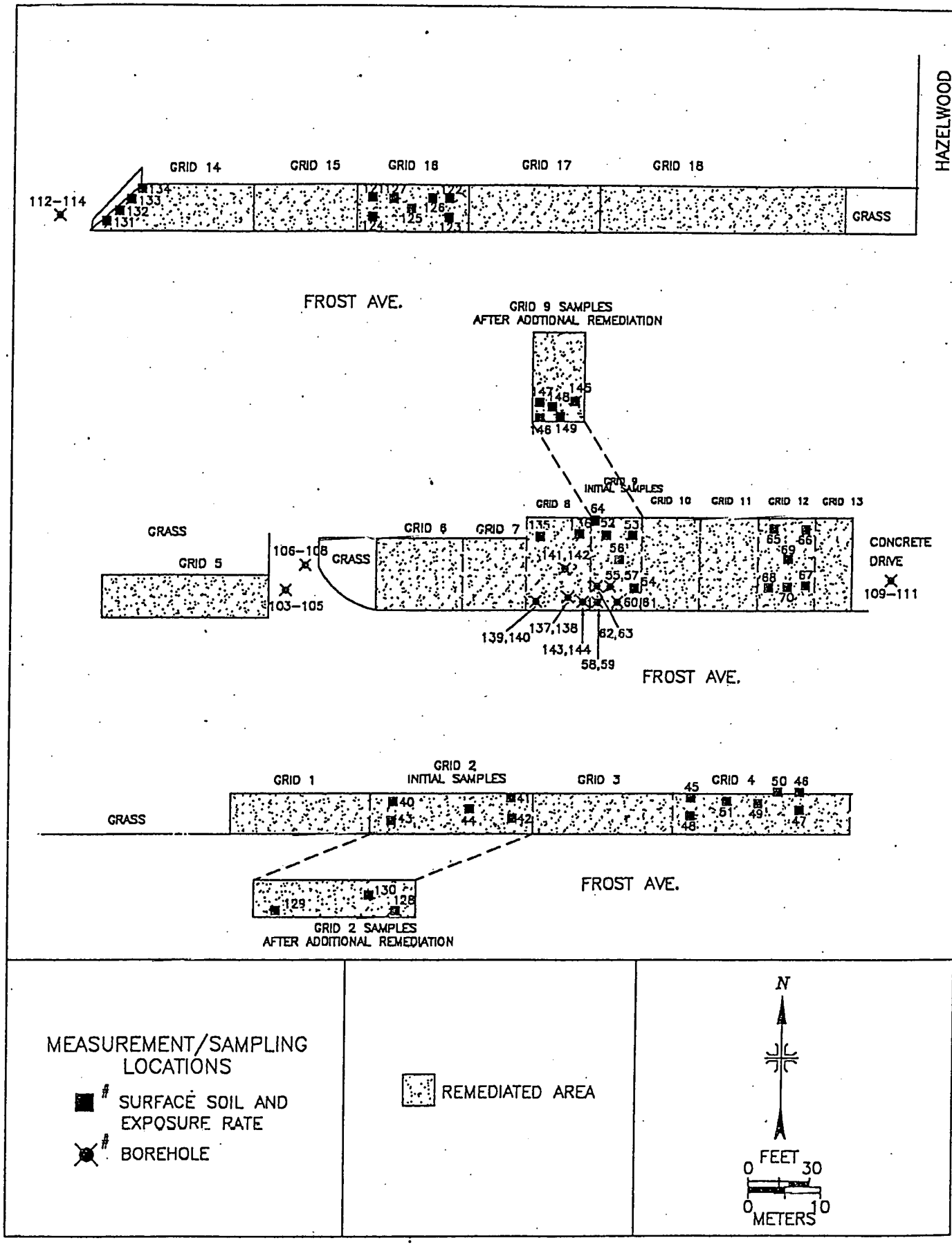

FIGURE 6: SLAPS Vicinity Properties, Property 24 – Measurement and Sampling Locations

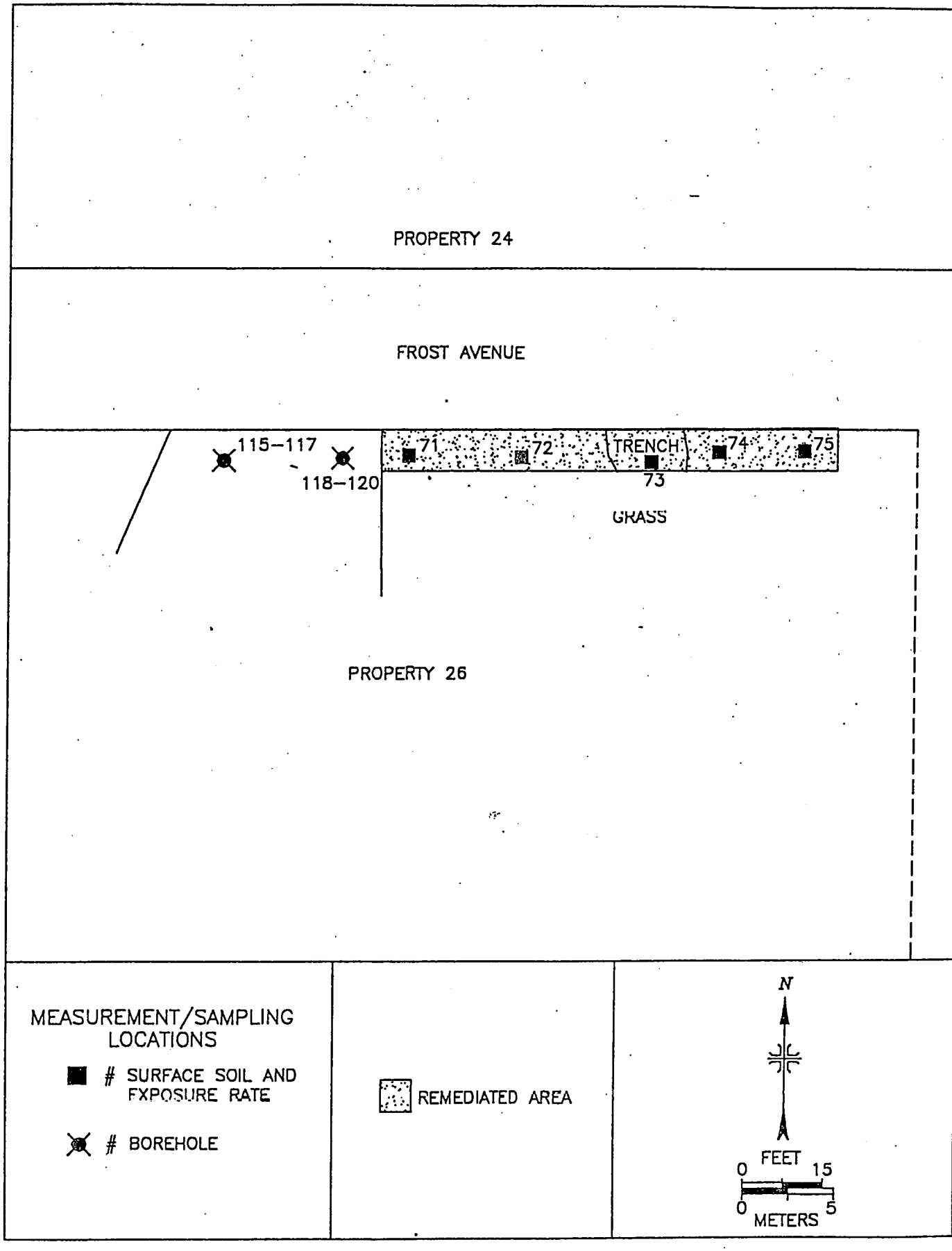

FIGURE 7: SLAPS Vicinity Properties, Property 26 – Measurement and Sampling Locations

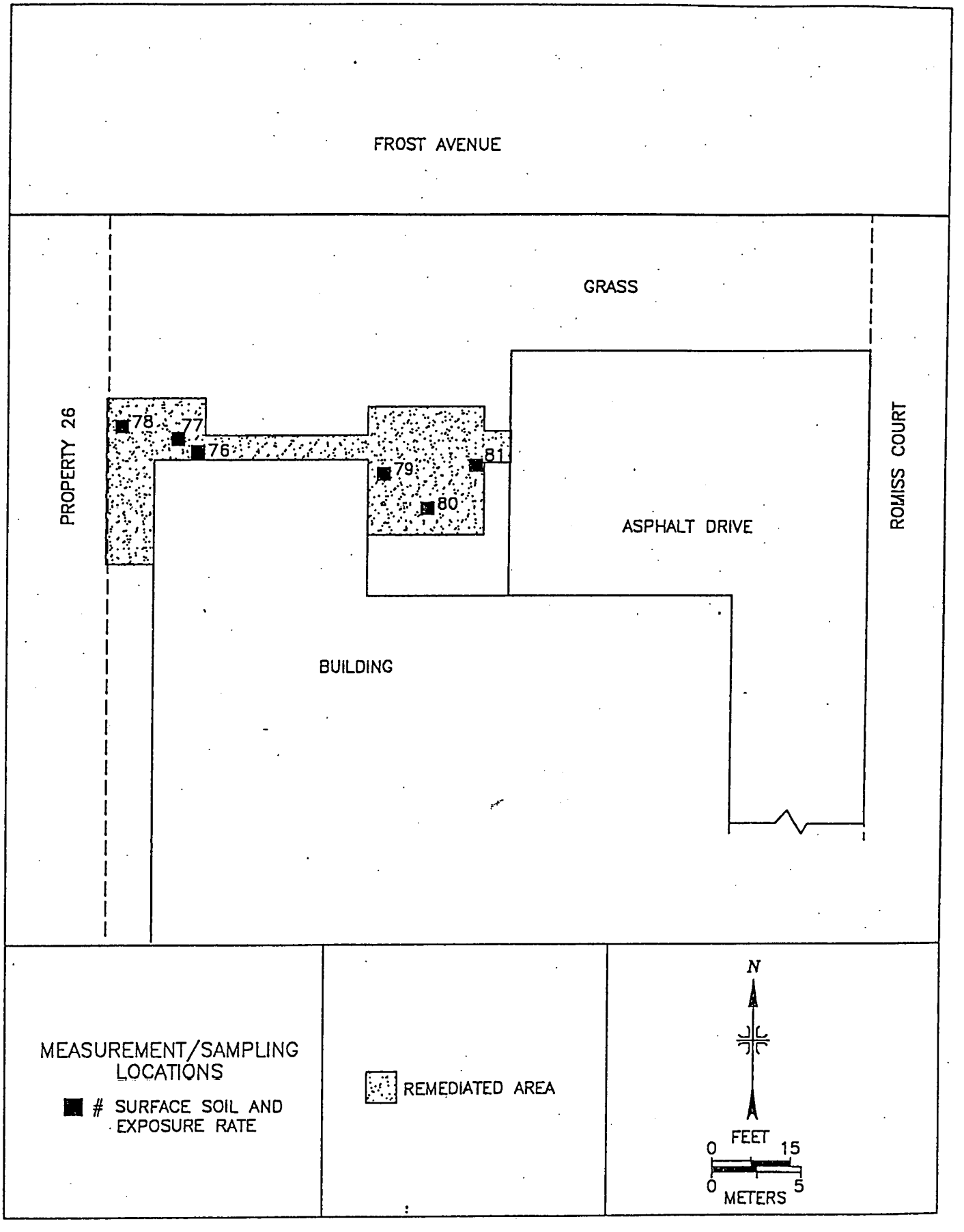

FIGURE 8: SLAPS Vicinity Properties, Property 27 – Measurement and Sampling Locations

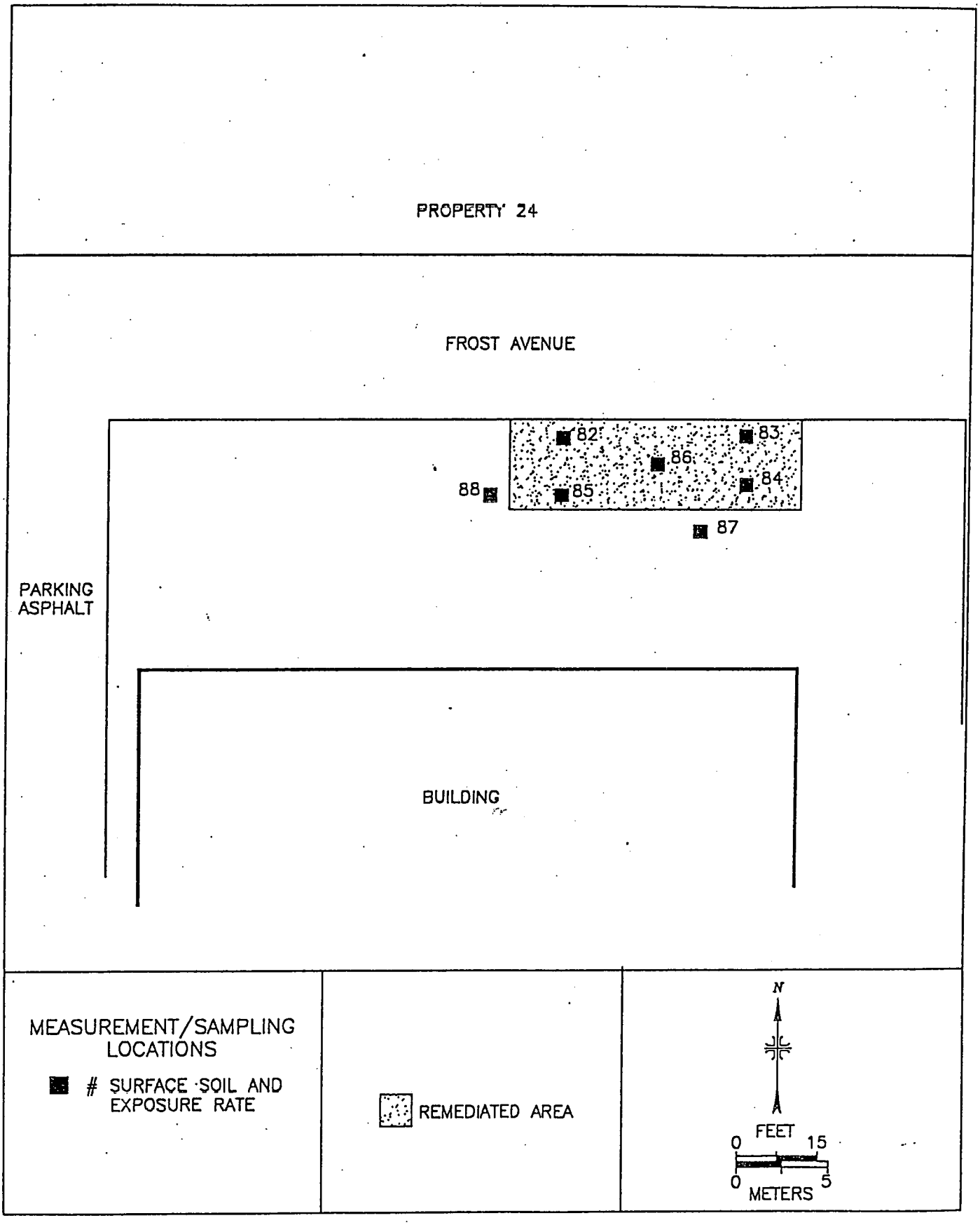

FIGURE 9: SLAPS Vicinity Properties, Property 30 – Measurement and Sampling Locations

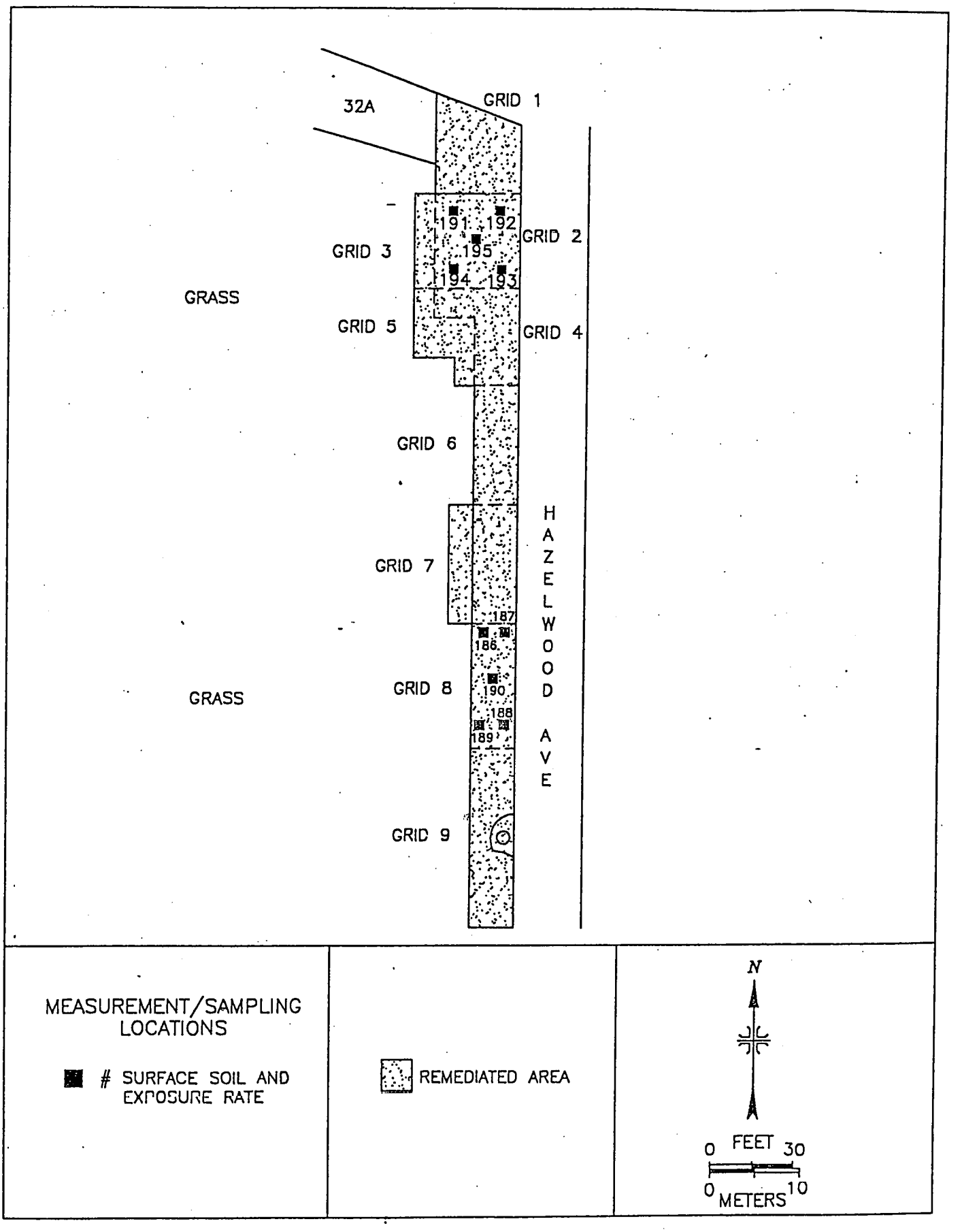

FIGURE 10: SLAPS Vicinity Properties, Property 32B – Measurement and Sampling Locations

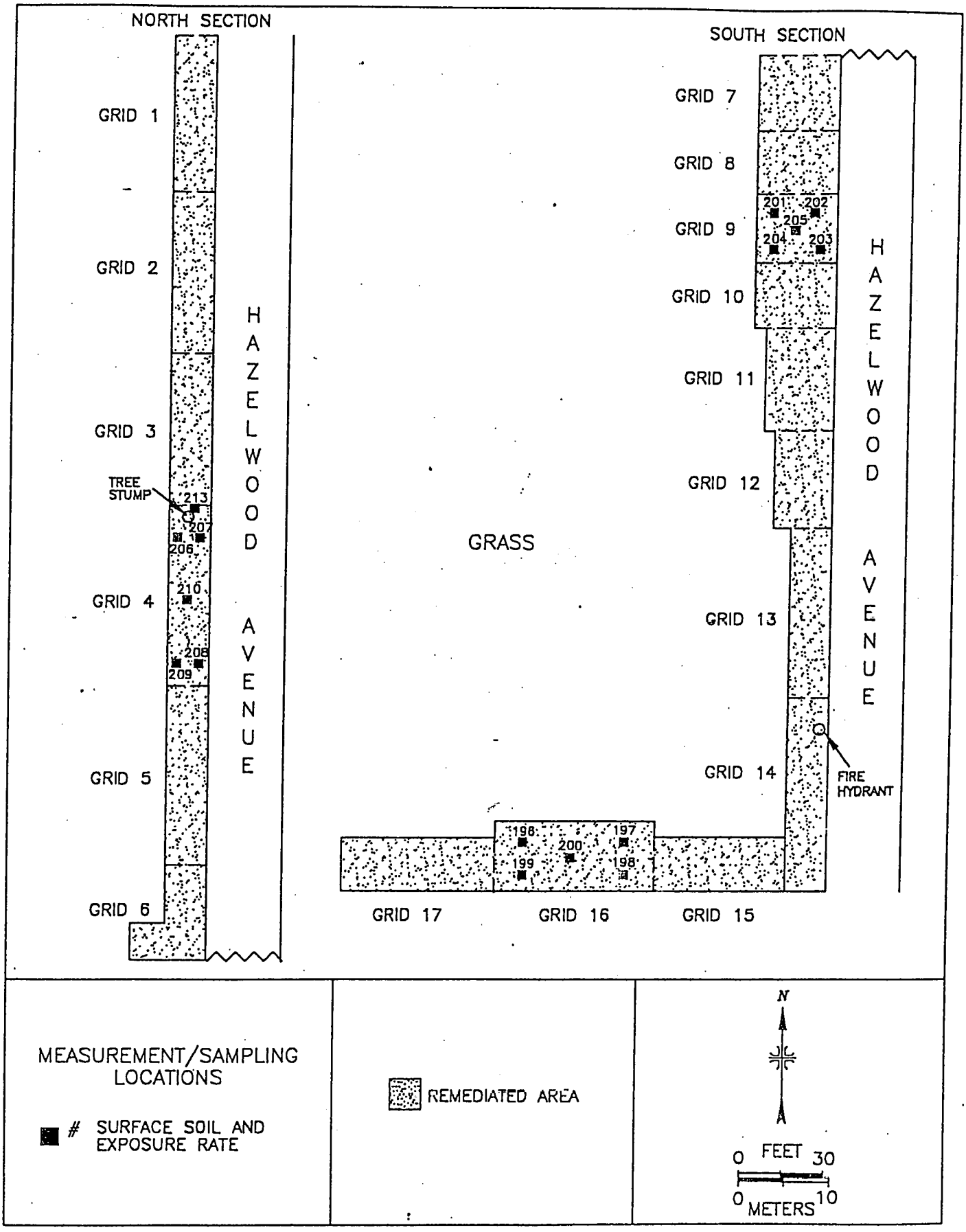

FIGURE 11: SLAPS Vicinity Properties, Property 36 – Measurement and Sampling Locations

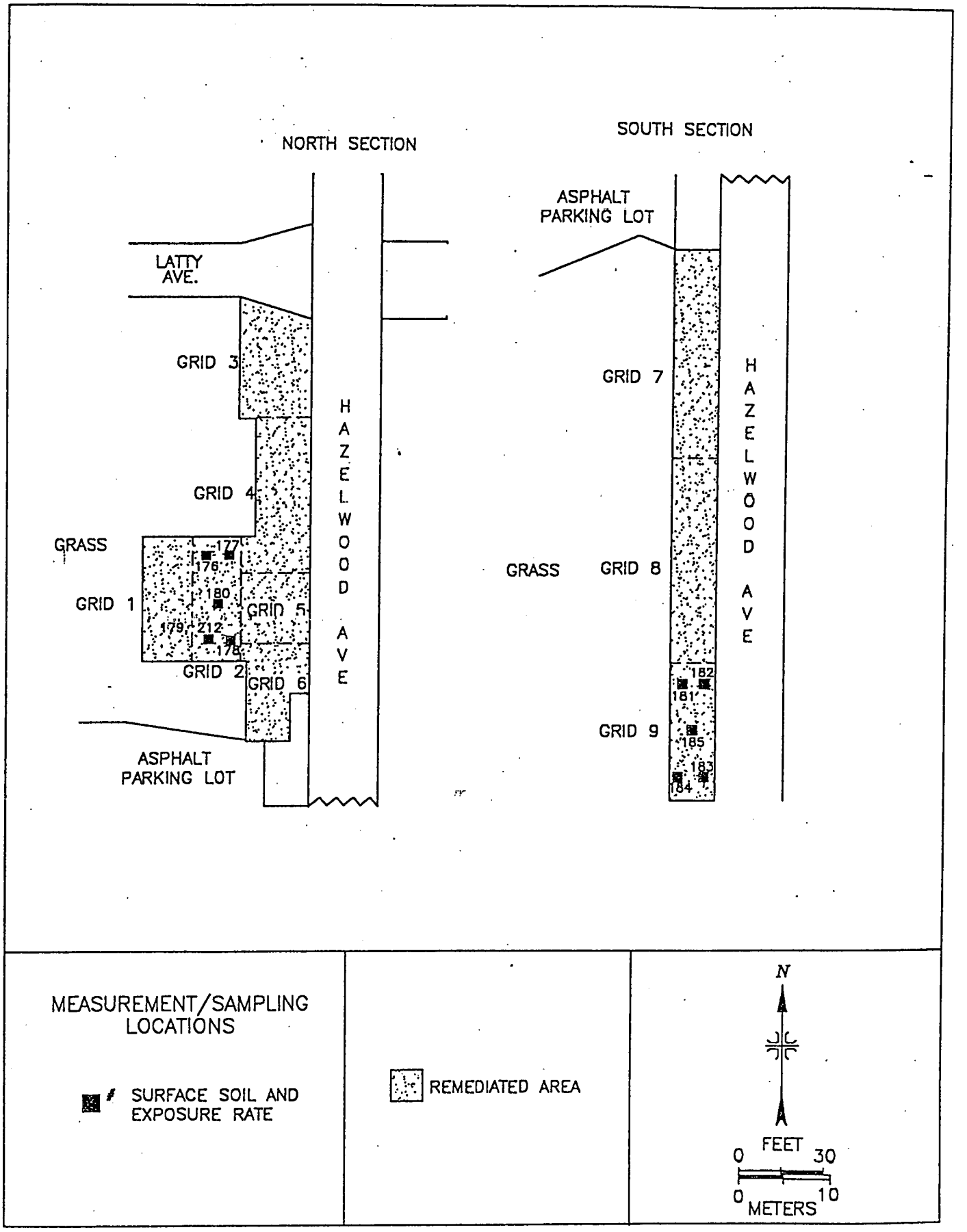

FIGURE 12: SLAPS Vicinity Properties, Property 37 = Measurement and Sampling Locations

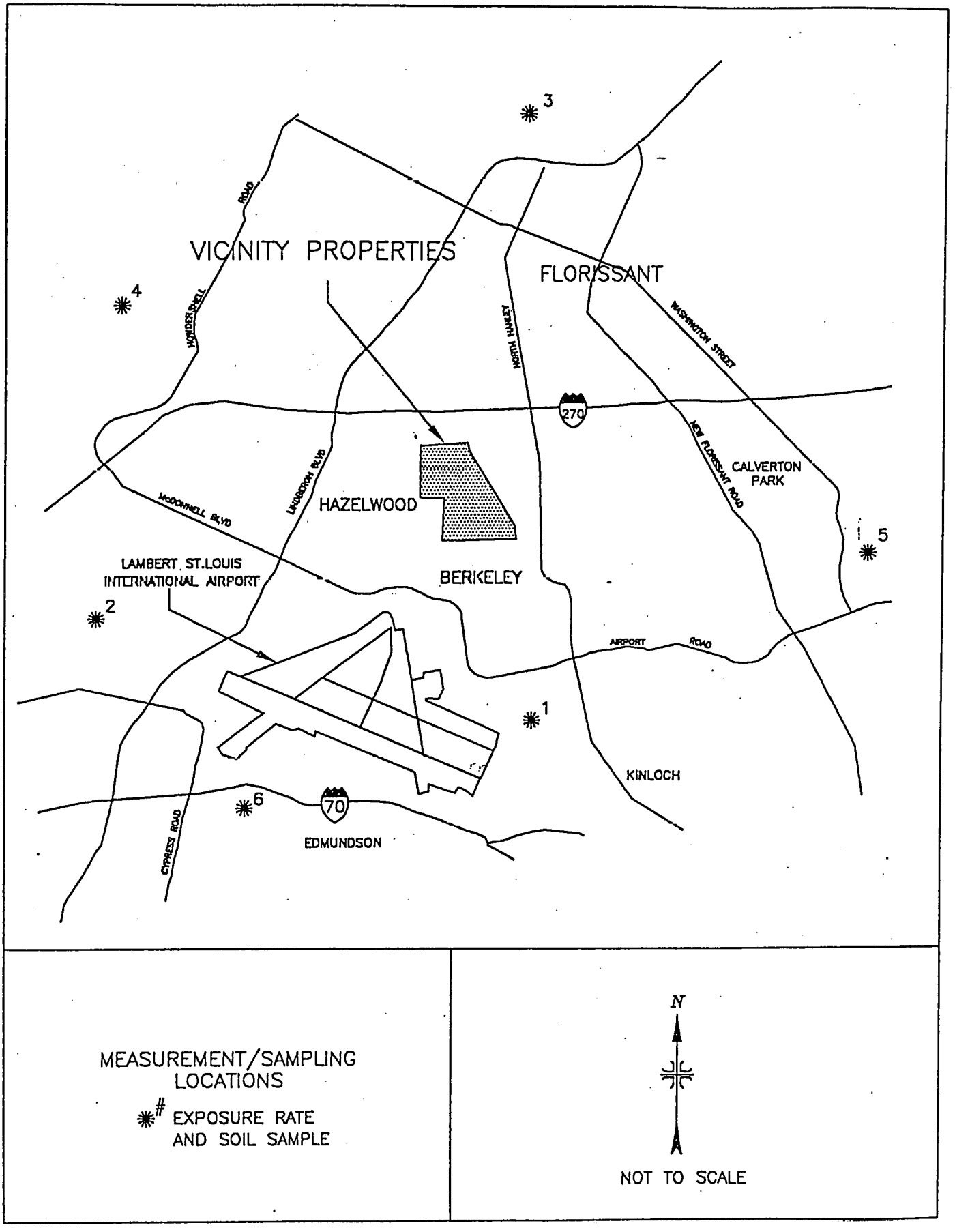

FIGURE 13: Hazelwood, Missouri Area – Background Measurement and Sampling Locations

TABLES

TABLE 1

BACKGROUND EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES ST. LOUIS AIRPORT SITE VICINITY PROPERTIES HAZELWOOD, MISSOURI

Location No.	Location[a]	Exposure Rate at 1 m (μR/h)	Radionuclide Concentrations (pCi/g)		
			Ra-226	Th-230	U-238
1	School Access Road and Harmond Rd.	10	1.0 ± 0.1[b]	1.31 ± 0.2[c]	1.1 ± 0.5
2	Fee Fee Road and Duncombe Drive	10	0.7 ± 0.1		0.9 ± 0.5
3	St. Ferdinand Park at St. Pierre Street	9	0.9 ± 0.1		1.3 ± 0.4
4	White Birch Park	9	0.8 ± 0.1		1.1 ± 0.4
5	Robert Superior Park	9	0.9 ± 0.1		1.2 ± 0.4
6	St. Ann Park at St. Ambrose Lane	9	0.8 ± 0.1		0.9 ± 0.3

[a]efer to Figure 13.
[b]Uncertainties represent the 95% confidence level, based only on counting statistics.
[c]Composite of samples 1 through 6. Alpha spectrometry results.

TABLE 2

EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES ST. LOUIS AIRPORT SITE VICINITY PROPERTY NUMBER 21 HAZELWOOD, MISSOURI

Sample Location[a]	Exposure Rates at 1 m (μR/h)[b]	Radionuclide Concentrations (pCi/g)[b]		
		Ra-226	Th-230	U-238
AREA BETWEEN GRIDS 1 AND 2				
1 (0-15 cm)	7	1.1 ± 0.3[c]	5.19 ± 0.57[d]	1.0 ± 1.4
5 (15-30 cm)	---[e]	1.3 ± 0.2	10.56 ± 1.06[d]	1.1 ± 1.1
2 (0-15 cm)	5	1.5 ± 0.2	7.22 ± 0.89[d]	2.7 ± 1.4
6 (15-30 cm)	---	1.3 ± 0.2	6.04 ± 0.70[d]	1.8 ± 1.6
3 (0-15 cm)	5	3.3 ± 0.3	110 ± 20	<2.5
4 (15-30 cm)	---	16.3 ± 0.6	650 ± 49	5.4 ± 3.0
AREA BETWEEN GRIDS 1 AND 2 AFTER ADDITIONAL REMEDIATION				
150	5	1.3 ± 0.1	<3.4	1.0 ± 0.3
151	5	0.8 ± 0.1	2.8 ± 2.3	0.8 ± 0.3
152	5	1.2 ± 0.1	<3.4	1.1 ± 0.3
153	5	1.2 ± 0.1	<4.5	1.1 ± 0.4
154	6	1.4 ± 0.1	<3.5	1.3 ± 0.4
GRID 3				
7	7	1.2 ± 0.2	1.7 ± 0.3	2.4 ± 1.6
8	7	1.2 ± 0.2	2.22 ± 0.33[d]	1.2 ± 0.9
9	6	1.3 ± 0.2	4.35 ± 0.49[d]	2.1 ± 1.5
10	8	1.3 ± 0.2	2.01 ± 0.32[d]	2.1 ± 1.6
11	7	0.9 ± 0.2	3.02 ± 0.47[d]	0.7 ± 1.2
GRID 6[f]				
12	11	4.0 ± 0.3	77.79 ± 6.96[d]	<2.6

TABLE 2 (Continued)

EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
ST. LOUIS AIRPORT SITE VICINITY PROPERTY NUMBER 21
HAZELWOOD, MISSOURI

Sample Location[a]	Exposure Rates at 1 m (μR/h)[b]	Radionuclide Concentrations (pCi/g)[b]		
		Ra-226	Th-230	U-238
ASPHALT DRIVE BETWEEN PROPERTIES 21 AND 22				
91 (0-15 cm)	---	0.9 ± 0.1	<4.0	0.8 ± 0.3
92 (15-30 cm)	---	1.0 ± 0.1	<3.1	0.9 ± 0.3
93 (30-45 cm)	---	0.8 ± 0.1	<4.0	1.0 ± 0.3
94 (0-15 cm)	---	0.9 ± 0.1	3.8 ± 2.4	1.2 ± 0.3
95 (15 - 30 cm)	---	0.9 ± 0.1	<3.0	1.2 ± 0.3
96 (30-45 cm)	---	0.9 ± 0.1	<4.0	1.3 ± 0.4

[a]Refer to Figure 3.
[b]Results include background.
[c]Uncertainties represent the 95% confidence level, based only on counting statistics.
[d]Alpha spectrometry value.
[e]Measurement not performed.
[f]Represents soil from the excavation wall adjoining road base that will be hazard assessed.

TABLE 3

EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES ST. LOUIS AIRPORT SITE VICINITY PROPERTY NUMBER 22 HAZELWOOD, MISSOURI

Sample Location[a]	Exposure Rates at 1 m (μR/h)[b]	Radionuclide Concentrations (pCi/g)[b]		
		Ra-226	Th-230	U-238
GRID 1				
13	---	1.1 ± 0.2[c]	2.72 ± 0.37[d]	1.2 ± 1.1
14	7	1.1 ± 0.2	1.85 ± 0.29[d]	3.0 ± 1.5
15	6	1.4 ± 0.2	2.01 ± 0.30[d]	<1.8
16	6	1.0 ± 0.2	1.53 ± 0.25[d]	1.7 ± 1.2
17	6	1.3 ± 0.2	1.54 ± 0.25[d]	1.8 ± 1.2
GRID 6				
18	6	1.7 ± 0.2	1.97 ± 0.29[d]	<1.6
19	7	1.3 ± 0.2	1.56 ± 0.27[d]	2.2 ± 1.3
20	7	1.8 ± 0.2	12.90 ± 1.29[d]	2.5 ± 1.4
21	6	1.2 ± 0.2	5.55 ± 0.59[d]	2.2 ± 1.2
22	6	1.4 ± 0.2	2.05 ± 0.29[d]	<1.5

[a]Refer to Figure 4.
[b]Results include background.
[c]Uncertainties represent the 95% confidence level, based only on counting statistics.
[d]Alpha spectrometry results.

TABLE 4

EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES ST. LOUIS AIRPORT SITE VICINITY PROPERTY NUMBER 23 HAZELWOOD, MISSOURI

Sample Location[a]	Exposure Rates at 1 m (μR/h)[b]	Radionuclide Concentrations (pCi/g)[b]		
		Ra-226	Th-230	U-238
GRID 1				
23	5	1.2 ± 0.2[c]	4.02 ± 0.48[d]	<2.1
24	5	1.4 ± 0.2	5.84 ± 0.78[d]	1.3 ± 1.4
25	6	1.4 ± 0.2	4.57 ± 0.69[d]	<2.1
26	5	1.7 ± 0.2	4.43 ± 0.57[d]	2.3 ± 1.5
27	8	1.8 ± 0.2	19.75 ± 2.25[d]	2.5 ± 1.8
28	5	1.1 ± 0.2	6.26 ± 0.65[d]	2.0 ± 1.4
100 m^2 Average:			7.48	
GRID 2				
29	7	1.3 ± 0.2	4.38 ± 0.60[d]	<1.6
30	4	2.0 ± 0.3	28.61 ± 3.64[d]	2.6 ± 1.5
31	6	1.5 ± 0.2	3.37 ± 0.44[d]	2.6 ± 1.6
32	6	1.5 ± 0.2	2.15 ± 0.32[d]	0.9 ± 1.0
33	7	1.3 ± 0.2	4.60 ± 0.59[d]	1.8 ± 1.4
34	5	1.5 ± 0.2	14.12 ± 1.47[d]	1.8 ± 1.4
100 m^2 Average:			9.54	
GRID 4				
35	10	0.9 ± 0.1	<4.9	1.1 ± 0.4
36	13	1.0 ± 0.1	5.4 ± 2.8	1.2 ± 0.4
37	12	0.9 ± 0.1	4.6 ± 2.8	1.4 ± 0.4
38	12	0.8 ± 0.1	3.6 ± 1.7	0.9 ± 0.2
39	8	0.9 ± 0.1	6.4 ± 2.4	0.9 ± 0.3

TABLE 4 (Continued)

EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
ST. LOUIS AIRPORT SITE VICINITY PROPERTY NUMBER 23
HAZELWOOD, MISSOURI

Sample Location[a]	Exposure Rates at 1 m (μR/h)[b]	Radionuclide Concentrations (pCi/g)[b]		
		Ra-226	Th-230	U-238
ASPHALT DRIVE BETWEEN GRIDS 3 AND 4, BOREHOLES				
97 (0-15 cm)	---[c]	1.1 ± 0.1	5.0 ± 2.4	1.2 ± 0.3
98 (15-30 cm)	---	1.1 ± 0.1	<3.2	1.1 ± 0.3
99 (30-45 cm)	---	1.2 ± 0.1	<3.1	1.4 ± 0.3
100 (0-15 cm)	---	1.1 ± 0.1	<3.2	1.5 ± 0.3
101 (15-30 cm)	---	1.3 ± 0.1	<3.2	1.5 ± 0.3
102 (30-45 cm)	---	1.3 ± 0.1	<3.2	1.0 ± 0.3

[a]Refer to Figure 5.
[b]Results include background.
[c]Uncertainties represent the 95% confidence level, based only on counting statistics.
[d]Alpha spectrometry results.
[e]Measurements not performed.

TABLE 5

EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES ST. LOUIS AIRPORT SITE VICINITY PROPERTY 24 HAZELWOOD, MISSOURI

Sample Location[a]	Exposure Rate (μR/h)[b]	Radionuclide Concentrations (pCi/g)[b]		
		Ra-226	Th-230	U-238
GRID 2				
40	12	0.7 ± 0.1[c]	<4.3	1.4 ± 0.4
41	11	0.9 ± 0.1	<3.6	1.1 ± 0.3
42	12	1.3 ± 0.1	26.4 ± 3.7	1.5 ± 0.4
128 (After additional remediation of Location 42)	7	1.0 ± 0.1	5.7 ± 2.4	1.1 ± 0.3
43	13	1.3 ± 0.1	28.7 ± 3.9	2.3 ± 0.4
129 (After additional remediation of Location 43)	5	1.1 ± 0.1	5.7 ± 2.8	1.5 ± 0.3
44	12	0.9 ± 0.1	<4.6	1.3 ± 0.3
130 (After additional remediation of Location 44)	6	1.0 ± 0.1	<3.2	1.0 ± 0.3
GRID 4				
45	13	1.1 ± 0.1	<3.5	1.3 ± 0.4
46	11	0.8 ± 0.1	<4.5	0.9 ± 0.3
47	11	1.2 ± 0.1	12.7 ± 3.3	1.7 ± 0.4
48	11	1.0 ± 0.1	8.3 ± 2.7	1.4 ± 0.4
49	9	1.1 ± 0.1	<3.6	1.3 ± 0.3
50	10	1.0 ± 0.1	<4.7	1.0 ± 0.3
51	13	1.1 ± 0.1	<3.6	1.1 ± 0.3

TABLE 5 (Continued)

EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
ST. LOUIS AIRPORT SITE VICINITY PROPERTY 24
- HAZELWOOD, MISSOURI

Sample Location[a]	Exposure Rate (μR/h)[b]	Radionuclide Concentrations (pCi/g)[b]		
		Ra-226	Th-230	U-238
GRID 8				
135	5	1.1 ± 0.1	<4.4	0.8 ± 0.3
136	4	1.1 ± 0.1	<3.2	0.9 ± 0.3
137	5	3.8 ± 0.1	111.6 ± 4.3	3.2 ± .4
138 (15-30 cm)	---[d]	1.9 ± 0.1	34.5 ± 4.1	1.7 ± 0.4
155[e] (After additional remediation of Locations 137/138)	---	0.8 ± 0.1	<10	0.7 ± 0.7
156[e] (After additional remediation of Location 137/138)	---	0.8 ± 0.1	<10	1.4 ± 0.7
157[e] (After additional remediation of Locations 137/138)	---	0.9 ± 0.2	25.5 ± 11.7	1.4 ± 0.9
139	5	1.1 ± 0.1	4.9 ± 2.6	1.5 ± 0.3
140 (15-30 cm)	---	1.1 ± 0.1	2.8 ± 2.1	1.2 ± 0.3
141	6	1.1 ± 0.1	<4.1	1.2 ± 0.4
142 (15-30 cm)	---	1.6 ± 0.1	<3.6	1.0 ± 0.3
143	5	1.4 ± 0.1	13.3 ± 2.9	1.5 ± 0.4
144 (15-30 cm)	---	1.0 ± 0.1	4.5 ± 2.2	0.9 ± 0.2
100 m^2 average			10.3	

TABLE 5 (Continued)

EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
ST. LOUIS AIRPORT SITE VICINITY PROPERTY 24
HAZELWOOD, MISSOURI

Sample Location[a]	Exposure Rate (μR/h)[b]	Radionuclide Concentrations (pCi/g)[b]		
		Ra-226	Th-230	U-238
GRID 9				
52	8	0.9 ± 0.1	2.7 ± 2.5	0.9 ± 0.3
53	10	1.0 ± 0.1	<3.1	0.9 ± 0.3
54	14	1.5 ± 0.1	25.9 ± 3.1	1.5 ± 0.4
145 (After additional remediation of Location 54)	6	1.3 ± 0.1	8.2 ± 3.0	0.9 ± 0.3
55	12	16.6 ± 0.2	773.4 ± 9.7	12.3 ± 0.8
57 (15-30 cm)	---	6.7 ± 0.1	291.1 ± 6.4	7.3 ± 0.6
146 (After additional remediation of Location 55/57)	5	1.3 ± 0.1	10.2 ± 3.0	1.4 ± 0.3
56	10	1.0 ± 0.1	6.9 ± 3.2	1.2 ± 0.4
58	15	4.7 ± 0.1	173.4 ± 5.2	3.4 ± 0.5
59 (15-30 cm)	---	6.8 ± 0.1	249.2 ± 8.0	8.7 ± 0.7
147 (After additional remediation of Location 58/59)	5	1.3 ± 0.1	6.6 ± 3.3	1.1 ± 0.4
60	11	2.2 ± 0.1	60.1 ± 3.3	1.9 ± 0.3
61 (15-30 cm)	---	2.3 ± 0.1	47.9 ± 4.3	1.8 ± 0.4
148 (After additional remediation of Location 60/61)	6	1.3 ± 0.1	7.6 ± 3.2	1.8 ± 0.3
62	12	1.6 ± 0.1	26.0 ± 3.2	1.4 ± 0.4
63 (15-30 cm)	---	1.5 ± 0.1	21.2 ± 3.3	1.5 ± 0.4

TABLE 5 (Continued)

EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
ST. LOUIS AIRPORT SITE VICINITY PROPERTY 24
HAZELWOOD, MISSOURI

Sample Location[a]	Exposure Rate (μR/h)[b]	Radionuclide Concentrations (pCi/g)[b]		
		Ra-226	Th-230	U-238
GRID 9 (Continued)				
149 (After additional remediation of Location 62)	5	1.7 ± 0.1	20.0 ± 3.6	1.3 ± 0.4
64	14	1.1 ± 0.1	3.1 ± 2.5	0.8 ± 0.3
100 m^2 average			8.2	
GRID 12				
65	12	1.1 ± 0.1	<3.3	0.9 ± 0.3
66	13	1.0 ± 0.1	3.5 ± 2.5	1.4 ± 0.3
67	11	1.5 ± 0.1	19.1 ± 3.7	1.0 ± 0.3
164[e] (After additional remediation of Location 67)	---	1.3 ± 0.1	<15	1.7 ± 1.1
68	15	1.9 ± 0.1	38.0 ± 4.0	2.0 ± 0.4
165[e] (After additional remediation of Location 68)	---	1.0 ± 0.2	<12	1.4 ± 1.2
69	14	1.2 ± 0.1	<3.5	1.2 ± 0.3
70	13	1.7 ± 0.1	26.8 ± 4.0	1.5 ± 0.4
166[e] (After additional remediation of Location 70)	---	0.9 ± 0.2	<14	1.8 ± 1.0

TABLE 5 (Continued)

EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
ST. LOUIS AIRPORT SITE VICINITY PROPERTY 24
HAZELWOOD, MISSOURI

Sample Location[a]	Exposure Rate (μR/h)[b]	Radionuclide Concentrations (pCi/g)[b]		
		Ra-226	Th-230	U-238
GRID 14				
131	5	1.2 ± 0.1	<4.4	0.9 ± 0.3
132	5	1.2 ± 0.1	<4.6	0.8 ± 0.3
133	6	1.4 ± 0.1	<3.4	0.8 ± 0.3
134	5	1.3 ± 0.1	<3.4	1.1 ± 0.3
GRID 16				
121	5	0.8 ± 0.1	<4.1	1.0 ± 0.3
122	5	0.9 ± 0.1	<3.2	1.0 ± 0.3
123	5	0.9 ± 0.1	<3.2	0.8 ± 0.3
124	6	1.0 ± 0.1	<4.2	1.0 ± 0.3
125	7	1.0 ± 0.1	<3.4	1.0 ± 0.3
126	5	0.9 ± 0.1	<3.2	0.9 ± 0.3
127	5	1.1 ± 0.1	<4.2	0.9 ± 0.3
BOREHOLES				
103 (0-15 cm)	6	1.1 ± 0.1	6.5 ± 2.5	1.2 ± 0.3
104 (15-30 cm)	---	1.0 ± 0.1	<4.2	1.1 ± 0.3
105 (30-45 cm)	---	1.1 ± 0.1	<3.1	1.2 ± 0.3
106 (0-15 cm)	6	1.1 ± 0.1	2.1 ± 1.9	1.2 ± 0.2
107 (15-30 cm)	---	1.0 ± 0.1	<4.0	0.9 ± 0.3
108 (30-45 cm)	---	1.1 ± 0.1	4.4 ± 2.3	1.1 ± 0.3
109 (0-15 cm)	6	1.0 ± 0.1	6.0 ± 2.7	1.3 ± 0.4

TABLE 5 (Continued)

EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
ST. LOUIS AIRPORT SITE VICINITY PROPERTY 24
HAZELWOOD, MISSOURI

Sample Location[a]	Exposure Rate (μR/h)[b]	Radionuclide Concentrations (pCi/g)[b]		
		Ra-226	Th-230	U-238
BOREHOLES (Continued)				
110 (15-30 cm)	---	1.1 ± 0.1	<3.1	0.8 ± 0.3
111 (30-45 cm)	---	1.1 ± 0.1	<3.1	0.9 ± 0.3
112 (0-15 cm)	. 6	1.0 ± 0.1	<4.1	1.0 ± 0.3
113 (15-30 cm)	---	1.2 ± 0.1	<3.0	1.0 ± 0.3
114 (30-45 cm)	---	1.2 ± 0.1	<4.1	1.1 ± 0.4

[a]Refer to Figure 6.
[b]Results include background.
[c]Uncertainties represent the 95% confidence level, based only on counting statistics.
[d]Measurement not performed.
[e]Samples collected by BNI. Not Shown on Figure 6.

TABLE 6

EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES ST. LOUIS AIRPORT SITE VICINITY PROPERTY NUMBER 26 HAZELWOOD, MISSOURI

Sample Location[a]	Exposure Rates at 1 m (μR/h)[b]	Radionuclide Concentrations (pCi/g)[b]		
		Ra-226	Th-230	U-238
GRID 1				
71	9	0.8 ± 0.1[c]	<2.5	0.6 ± 0.2
72	9	0.7 ± 0.1	2.0 ± 1.6	0.7 ± 0.2
73	11	1.0 ± 0.1	<3.1	0.8 ± 0.3
74	9	0.9 ± 0.1	<3.8	0.8 ± 0.3
75	10	1.2 ± 0.1	<3.7	0.9 ± 0.3
ASPHALT DRIVE				
115 (0-15 cm)	---[d]	1.1 ± 0.1	<3.0	1.0 ± 0.3
116 (15-30 cm)	---	1.2 ± 0.1	<4.1	1.4 ± 0.4
117 (30-45 cm)	---	1.4 ± 0.1	<3.3	1.2 ± 0.4
118 (0-15 cm)	---	1.1 ± 0.1	<4.0	0.9 ± 0.3
119 (15-30 cm)	---	1.2 ± 0.1	<3.2	1.0 ± 0.3
120 (30-45 cm)	---	1.1 ± 0.1	<3.2	1.3 ± 0.3

[a]Refer to Figure 7.
[b]Results include background.
[c]Uncertainties represent the 95% confidence level, based only on counting statistics.
[d]Measurement not performed.

TABLE 7

EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES ST. LOUIS AIRPORT SITE VICINITY PROPERTY NUMBER 27 HAZELWOOD, MISSOURI

Location[a]	Exposure Rates at 1 m (μR/h)[b]	Radionuclide Concentrations (pCi/g)		
		Ra-226	Th-230	U-238
GRID 1				
76	11	1.1 ± 0.1[b]	5.9 ± 2.7	1.2 ± 0.4
77	12	1.2 ± 0.1	<3.6	1.1 ± 0.4
78	12	1.1 ± 0.1	<4.7	1.1 ± 0.4
79	12	1.2 ± 0.1	<3.5	1.0 ± 0.3
80	15	1.1 ± 0.1	<4.5	1.1 ± 0.3
81	13	1.1 ± 0.1	<4.6	1.2 ± 0.3

[a]Refer to Figure 8.
[b]Results include background.
[c]Uncertainties represent the 95% confidence level, based only on counting statistics.

TABLE 8

EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES ST. LOUIS AIRPORT SITE VICINITY PROPERTY NUMBER 30 HAZELWOOD, MISSOURI

Sample Location[a]	Exposure Rates at 1 m (μR/h)[b]	Radionuclide Concentrations (pCi/g)[b]		
		Ra-226	Th-230	U-238
82	9	1.1 ± 0.1[c]	<3.3	1.2 ± 0.3
83	9	1.1 ± 0.1	<4.8	1.1 ± 0.3
84	9	1.1 ± 0.1	<3.5	1.0 ± 0.3
85	8	1.1 ± 0.1	<3.4	1.1 ± 0.4
86	10	1.1 ± 0.1	<3.6	1.0 ± 0.3
87	10	1.0 ± 0.1	<4.6	1.0 ± 0.3
88	10	1.3 ± 0.1	3.4 ± 3.2	1.2 ± 0.3

[a]Refer to Figure 9.
[b]Results include background.
[c]Uncertainties represent the 95% confidence level, based only on counting statistics.

TABLE 9

EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES ST. LOUIS AIRPORT SITE VICINITY PROPERTY NUMBER 32 HAZELWOOD, MISSOURI

Sample Location[a]	Exposure Rates at 1 m (μR/h)[b]	Radionuclide Concentrations (pCi/g)[b]		
		Ra-226	Th-230	U-238
32B - GRID 2				
191	9	1.4 ± 0.2[c]	5.32 ± 0.54[d]	<1.5
192	10	1.4 ± 0.2	7.70 ± 0.74[d]	1.0 ± 0.8
193	10	1.2 ± 0.1	8.36 ± 0.81[d]	1.6 ± 0.7
194	9	1.1 ± 0.2	4.95 ± 0.53[d]	0.9 ± 0.8
195	9	1.3 ± 0.2	3.97 ± 0.45[d]	2.2 ± 1.0
32B - GRID 8				
186	11	1.3 ± 0.2	1.72 ± 0.27[d]	2.5 ± 1.1
187	10	1.3 ± 0.2	1.58 ± 0.26[d]	1.6 ± 1.1
188	10	1.5 ± 0.2	1.72 ± 0.27[d]	1.7 ± 1.0
189	11	1.4 ± 0.2	2.08 ± 0.33[d]	2.0 ± 1.1
190	10	1.2 ± 0.1	2.50 ± 0.36[d]	1.6 ± 0.9
32A				
171[e]	---[f]	0.9 ± 0.2	<13.1	0.8 ± 0.9
172[e]	---	0.9 ± 0.1	<13.8	0.9 ± 0.8
173[e]	---	0.8 ± 0.1	<12.6	1.7 ± 0.9
174[e]	---	1.0 ± 0.2	<12.8	1.4 ± 0.9
175[e]	---	1.2 ± 0.2	<14.8	2.0 ± 1.1

[a]Refer to Figure 10.
[b]Results include background.
[c]Uncertainties represent the 95% confidence level, based only on counting statistics.
[d]Alpha spectrometry results.
[e]Samples collected by BNI. Sample locations are not shown on Figure 10.
[f]Measurement not performed.

TABLE 10

EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES ST. LOUIS AIRPORT SITE VICINITY PROPERTY NUMBER 36 HAZELWOOD, MISSOURI

Sample Location[a]	Exposure Rates at 1 m (μR/h)[b]	Radionuclide Concentrations (pCi/g)[b]		
		Ra-226	Th-230	U-238
GRID 4				
206	12	0.9 ± 0.1[c]	1.70 ± 0.26[d]	0.8 ± 0.7
207	11	6.5 ± 0.3	290 ± 20	7.4 ± 2.1
213 (After additional remediation of Location 207)	---[e]	1.8 ± 0.1	19.6 ± 4.6	2.3 ± 0.4
208	10	1.2 ± 0.1	11.83 ± 1.13[d]	2.1 ± 0.9
209	12	1.2 ± 0.1	5.95 ± 0.64[d]	1.6 ± 0.9
210	11	1.2 ± 0.1	4.27 ± 0.47[d]	1.4 ± 0.8
100 m^2 Average Concentration:			8.7	
GRID 9				
201	11	1.0 ± 0.1	1.91 ± 0.31[d]	1.1 ± 1.0
202	13	1.0 ± 0.1	2.01 ± 0.26[d]	1.3 ± 0.9
203	14	1.0 ± 0.2	1.96 ± 0.28[d]	0.5 ± 0.8
204	14	1.1 ± 0.1	1.95 ± 0.26[d]	0.9 ± 0.8
205	13	1.1 ± 0.1	4.05 ± 0.46[d]	1.0 ± 0.7
GRID 16				
196	13	0.9 ± 0.1	1.72 ± 0.27[d]	1.7 ± 1.0
197	15	0.9 ± 0.1	1.58 ± 0.26[d]	1.7 ± 1.0
198	15	0.9 ± 0.1	1.72 ± 0.27[d]	0.8 ± 0.8
199	13	1.2 ± 0.1	2.08 ± 0.33[d]	1.0 ± 0.6
200	13	1.1 ± 0.2	2.50 ± 0.36[d]	1.0 ± 0.9

[a]Refer to Figure 11.
[b]Results include background.
[c]Uncertainties represent the 95% confidence level, based only on counting statistics.
[d]Alpha spectrometry analysis values.
[e]Measurement not performed.

TABLE 11

EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES ST. LOUIS AIRPORT SITE VICINITY PROPERTY NUMBER 37 HAZELWOOD, MISSOURI

Sample Location[a]	Exposure Rates at 1 m (μR/h)[b]	Radionuclide Concentrations (pCi/g)[b]		
		Ra-226	Th-230	U-238
GRID 2				
176	11	1.5 ± 0.2[c]	2.28 ± 0.33[d]	1.0 ± 0.9
177	13	1.3 ± 0.2	1.57 ± 0.24[d]	1.4 ± 1.0
178	12	1.5 ± 0.2	1.45 ± 0.27[d]	3.5 ± 1.9
179	12	7.2 ± 0.3	261 ± 23	2.4 ± 1.1
212 (After additional remediation of Location 179)	---[e]	0.9 ± 0.1	<4.3	0.9 ± 0.3
180	14	1.7 ± 0.2	2.64 ± 0.35[d]	1.3 ± 1.0
GRID 9				
181	11	1.7 ± 0.2	1.86 ± 0.27[d]	0.6 ± 1.0
182	11	1.5 ± 0.2	4.60 ± 0.54[d]	0.7 ± 0.7
183	11	1.3 ± 0.2	3.34 ± 0.41[d]	1.4 ± 0.9
184	10	1.2 ± 0.2	2.50 ± 0.33[d]	1.2 ± 0.8
185	12	1.4 ± 0.2	4.29 ± 0.51[d]	0.9 ± 1.0

[a]Refer to Figure 12.
[b]Results include background.
[c]Uncertainties represent the 95% confidence level, based only on counting statistics.
[d]Alpha spectrometry results.
[e]Measurement not performed.

REFERENCES

Bechtel National, Inc. (BNI). Radiological Characterization Report for FUSRAP Properties in the St. Louis, Missouri Area, Volumes I-III. Oak Ridge, TN; March 1990.

Oak Ridge National Laboratory (ORNL). Results of the Radiation Measurements Taken at Transportation Routes (1M004) in Hazelwood, Missouri. Oak Ridge, TN; December 1986.

Oak Ridge Institute for Science and Education (ORISE). Proposed Verification Survey Plan for the St. Louis Airport Site Vicinity Properties , St. Louis, Missouri. Oak Ridge, Tennessee; October 19, 1994.

Oak Ridge Institute for Science and Education. Survey Procedures Manual for the Energy/Environment Systems Division, Environmental Survey and Site Assessment Program, Revision 9. Oak Ridge, Tennessee; April 30, 1995a.

Oak Ridge Institute for Science and Education. Quality Assurance Manual for the Energy/Environment Systems Division, Environmental Survey and Site Assessment Program, Revision 7. Oak Ridge, Tennessee; January 31, 1995b.

Oak Ridge Institute for Science and Education. Laboratory Procedures Manual for the Energy/Environment Systems Division, Environmental Survey and Site Assessment Program, Revision 9. Oak Ridge, Tennessee; January 31, 1995c.

Oak Ridge Institute for Science and Education. Draft Reports—Verification Surveys of Properties 19, 20, 41, 43, 44, and 45, St. Louis Airport Site Vicinity Properties, Hazelwood and Berkeley, Missouri. Oak Ridge, Tennessee; February 23, 1996.

U.S. Department of Energy (DOE). Radiation Protection of the Public and Environment. Washington, DC: DOE Order 5400.5; June 1990a.

U.S. Department of Energy. Memorandum from J. Fiore to L. Price, "Uranium Cleanup Guidelines for St. Louis, MO, FUSRAP Sites," November 6, 1990b.

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 employer.

DIRECT RADIATION MEASUREMENT

Instruments

Bicron Micro Rem Meter
(Bicron Corporation, Newberg, OH)

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

Detectors

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

LABORATORY ANALYTICAL INSTRUMENTATION

Alpha Spectrometry System
Tennelec Model 256
(Oxford, Oak Ridge, TN)
Used in conjunction with:
Surface Barrier and Ion Implanted Detectors
(EG&G ORTEC, Oak Ridge, TN and Canberra, Meriden, CT) and
Multichannel Analyzer
3100 Vax Workstation
(Canberra, Meriden,CT)

Alpha Spectrometry System
Canberra Model 7401VR
(Canberra, Meriden, CT)
Used in conjunction with:
Ion Implanted Detectors and
Multichannel Analyzer
3100 Vax Workstations
(Canberra, Meriden, CT)

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 were performed by passing the detectors slowly over the surface; the distance between the detector and the surface was maintained at a minimum—nominally about 1 cm. 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:

Gamma - NaI scintillation detector with ratemeter

Exposure Rate Measurements

Measurements of dose equivalent rates (μrem/h) were performed at 1 m above the surface using a Bicron microrem meter. Although the instrument displays data in μrem/h, the μrem/h to μR/h conversion is essentially unity.

Soil Sampling

Approximately 1 kg of soil was collected at each sample location. Collected samples were placed in a plastic bag, sealed, and labeled in accordance with ESSAP survey procedures.

GAMMA SPECTROMETRY

Soil samples 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 concerns were:

Ra-226	0.352 MeV from Pb-214*
Th-230	0.067 MeV
U-238	0.063 MeV from Th-234*

*Secular equilibrium assumed.
Spectra were also reviewed for other identifiable photopeaks.

ALPHA SPECTROMETRY

Soil samples were crushed, homogenized and analyzed for isotopic thorium. Samples were dissolved by potassium fluoride and pyrosulfate fusion and the elements of interest were precipitated with barium sulfate. Barium sulfate precipitate was redissolved and the specific elements of interest were individually separated by liquid-liquid extraction and re-precipitated with a cerium fluoride carrier. The precipitate was then counted using surface barrier and ion implanted detectors (ORTEC), alpha spectrometers (Tennelec and Canberra), and a multichannel analyzer (Nuclear Data).

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 concentration (MDC), were based on 2.71 plus 4.65 times the standard deviation of the background count [$2.71 + (4.65\sqrt{BKG})$]. When the activity was determined to be less than the MDC of the measurement procedure, the result was reported as less than MDC. 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.

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

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

The procedures contained in these manuals were developed to meet the requirements of DOE Order 5700.6C and ASME NQA-1 for Quality Assurance and contain measures to assess processes during their performance.

Quality control procedures include:

- Daily instrument background and check-source measurements to confirm that equipment operation is within acceptable statistical fluctuations.
- Participation in EPA and EML laboratory Quality Assurance Programs.
- Training and certification of all individuals performing procedures.
- Periodic internal and external audits.

APPENDIX C

RESIDUAL RADIOACTIVE MATERIAL GUIDELINES SUMMARIZED FROM DOE ORDER 5400.5

APPENDIX C

RESIDUAL RADIOACTIVE MATERIAL GUIDELINES SUMMARIZED FROM DOE ORDER 5400.5

BASIC DOSE LIMITS

The basic limit for the annual radiation dose (excluding radon) received by an individual member of the general public is 100 mrem/y. In implementing this limit, DOE applies as low as reasonable 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.

SOIL GUIDELINES

Radionuclides	Soil Concentration (pCi/g) Above Background[a,b,c]
Radium-226 Radium-228 Thorium-230 Thorium-232	5 pCi/g when averaged over the first 15 cm of soil below the surface; 15 pCi/g when averaged over any 15-cm-thick soil layer below the surface layer.
Uranium-238	50 pCi/g

[a] These guidelines take into account in growth 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 $(100/A)^{1/2}$, where A is the area or the elevated region in square meters, limits for "hot spots" shall also be applicable. Procedures for calculating these hot spot limits, which depend on the extent of the elevated local concentrations, are given in the DOE Manual for Implementing Residual Radioactive Materials Guidelines, DOE/Ch/8901. In addition, every reasonable effort shall be made to remove any source of radionuclide that exceeds 30 times the appropriate limit for soil, irrespective of the average concentration in the soil.

REFERENCES

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

2. "DOE Order 5400.5, Radiation Protection of the Public and the Environment," February 1990.

SL-1227

00-2311

Formerly Utilized Sites Remedial Action Program (FUSRAP)

ADMINISTRATIVE RECORD

for the St. Louis Site, Missouri

U.S. Department of Energy

4.14-1070.2