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Data Evaluation Technical Memorandum on the K-1407-C Retention Basin at the Oak Ridge K-25 Site, Oak Ridge, Tennessee

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Environmental Restoration Division
K-25 Environmental Restoration Program

Data Evaluation Technical Memorandum on the K-1407-C Retention Basin at the Oak Ridge K-25 Site, Oak Ridge, Tennessee

Date Issued—October 1991

Prepared for
U.S. Department of Energy
Office of Environmental Restoration and Waste Management
under budget and reporting codes CD 10 72 and EW 20

OAK RIDGE K-25 SITE
Oak Ridge, Tennessee 37831-7101
managed by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
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ACRONYMS

BRW	bedrock well
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DETM	Data Evaluation Technical Memorandum
EPA	Environmental Protection Agency
ICP	inductively coupled plasma
IT	International Technology (Corporation)
mrad/h	millirads per hour
μR/h	microroentgens per hour
ORR	Oak Ridge Reservation
ORNL	Oak Ridge National Laboratory
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RfD	reference dose
SEG	Scientific Ecology Group
SWMU	solid waste management unit
TDHE	Tennessee Department of Health and Environment (now Tennessee Department of Environment and Conservation)
TSD	treatment, storage, or disposal
UNW	unconsolidated well

EXECUTIVE SUMMARY

The K-1407-C Retention Basin was a surface impoundment at the Oak Ridge K-25 Site. The basin was used primarily for storing potassium hydroxide scrubber sludge generated at the K-25 Site. In addition, from 1960 to 1973, metal hydroxide sludges that were removed from the K-1407-B Holding Pond were discharged to the K-1407-C Retention Basin. The sludge in the K-1407-B Pond contained discharge from the K-1420 Decontamination and Uranium Recovery, the K-1501 Steam Plant, the K-1413 Laboratory, and the K-1401 Maintenance Building. Radioactive material is also present in the K-1407-C Retention Basin, probably the result of cleaning and decontamination activities at some of the aforementioned facilities. The discharge of waste materials to K-1407-C was discontinued before November of 1988, and all sludge was removed from the retention basin. Some of the sludge was stored, and the remainder was fixed in concrete.

This Data Evaluation Technical Memorandum is specific to the K-1407-C Retention Basin and includes information pertinent to the evaluation of soil contamination. The focus of this evaluation is the effectiveness of the Phase 1 investigation of the K-1407-C Retention Basin to define site conditions adequately to support decisions regarding appropriate closure alternatives. This includes the physical characterization of the site area and the characterization of the nature and extent of contamination at the site in relation to risk characterization and statistical evaluation.

The present evaluation has concluded that the investigation of the K-1407-C Retention Basin has not characterized the site well enough to support decisions regarding closure activities. Information regarding the physical characterization and the extent of contamination at the site is deficient. The health-based screening of contaminants detected in soil at the K-1407-C Retention Basin indicates that a majority of the samples taken from a 12- to 18-in. interval contain radioactive contaminant concentrations exceeding guideline values. Because the 18-in. samples contained radionuclides, the depth of contamination is not fully characterized at this site. Therefore, additional sampling is recommended to determine the depth and lateral extent of radioactive contamination.

1. INTRODUCTION

1.1 K-25 SITE REGULATORY HISTORY

The Oak Ridge K-25 Site was built as part of the Manhattan Project during World War II to supply uranium-enriched material for nuclear weapons production. Construction of the K-25 Site started in 1943, and the K-25 Building, the first diffusion facility for large-scale separation of ^{235}U, was fully operable by August 1945. Additional buildings involved in the enrichment process, K-27, K-29, K-31, and K-33, were operable by 1956. In response to the nation's postwar nuclear emphasis, plant operations were modified to include the production of uranium compatible with reactors used to generate electric power. The K-25 Site continued to provide enriched uranium until 1985.

The separation process along with associated decontamination, maintenance, and fabrication processes resulted in the generation of various hazardous and radioactive waste by-products. Hazardous waste treatment, storage, and disposal (TSD) facilities, such as the K-1407-C Retention Basin, were created at the K-25 Site to handle such by-products. Some of these facilities continue to receive hazardous wastes, while others have been decommissioned. These TSD facilities are currently subject to the requirements of several laws:

- **Resource Conservation and Recovery Act (RCRA):** created in 1976 as a management system for hazardous wastes that mandates permitting currently operating TSD facilities.
- **Hazardous and Solid Waste Amendments:** amendments to RCRA (1984) which extended the authority of the Environmental Protection Agency (EPA) to correct releases to all media from all solid waste management units (SWMUs) at RCRA facilities.

  Under RCRA a SWMU is defined as any "discernible waste management unit at a RCRA facility from which hazardous waste or hazardous constituents might migrate, irrespective of whether the unit was intended for the management of solid or hazardous waste. Such units include any area at a facility at which hazardous wastes or hazardous constituents have been routinely and systematically released."[1]
- **Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, also referred to as Superfund):** created in 1980 to establish a program to (1) identify sites (operable units) from which environmental releases of hazardous substances have occurred or might occur, (2) ensure that they are cleaned up by responsible parties or the government, (3) evaluate damages to natural resources, and (4) create a claims procedure for parties who have cleaned up sites or spent money to restore natural resources. Sites identified by CERCLA are evaluated and then placed on the National Priorities List if appropriate.
- **Superfund Amendments and Reauthorization Act:** signed into law in 1986 as a 5-year extension of the Superfund/CERCLA program to clean up hazardous releases at uncontrolled or abandoned hazardous waste sites.

- **National Environmental Policy Act (NEPA):** directs public officials to consider the impacts of their actions (e.g., construction, remediation) on the human environment as a part of all decision-making processes.

1.2 K-1407-C RETENTION BASIN REGULATORY HISTORY

The K-1407-C Retention Basin is a surface impoundment at the K-25 Site which received waste streams from 1972 to 1988. This basin is a RCRA Interim Status unit; a closure plan for the impoundment was submitted (May 1988) to the Tennessee Department of Health and Environment (TDHE, now the Tennessee Department of Environment and Conservation).[2] This plan was approved, and removal of sludge was undertaken at that time. Verification sampling as required by the closure plan was then conducted. However, the results of this sampling indicated the presence of unsuspected radionuclide contamination. Although radionuclides are not regulated under RCRA, a revised closure plan was submitted (April 1990) which addressed the radionuclide concerns and called for additional sampling prior to the completion of closure activities.[3]

Chapter 3 of the revised closure plan states that "the results of the investigation will be compared to the guideline values contained in the *Data Analysis Approach Report for K-1407-B Holding Pond and K-1407-C Retention Basin (KER-023)* [sic.] . . . . Based on the result of the comparisons, three closure scenarios are possible: no action, excavation, or another option."[4] Therefore, the objectives of the investigation were to (1) determine if all RCRA hazardous constituents had been removed from the basin, (2) further define the nature of the radionuclide contamination, (3) determine if the radionuclide contamination was local or areal in extent, and (4) determine if concentrations were decreasing with depth. Subsequently, the sampling and analysis activities were outlined in the "Sampling Work Plan: K-1407-C Retention Basin," K/ER-21, and implemented.[5] The analytical results were analyzed, and the data evaluation is contained within this report.

1.3 PURPOSE OF THE DATA EVALUATION TECHNICAL MEMORANDUM

This Data Evaluation Technical Memorandum (DETM) is specific to the K-1407-C Retention Basin and includes the findings of a multidisciplinary team that evaluated analytical data from the soil samples. The DETM will serve to provide an appraisal of the Phase 1 data in terms of their ability to meet the proposed objectives of the sampling work plan. Additionally, the data are evaluated in relation to their validity and representativeness with respect to human-health risk assessment.

1.4 PREVIOUS DOCUMENTATION

Several documents relevant to the investigation of the K-1407-C Retention Basin have been previously prepared. These documents are listed below with a brief explanation of their content and relevance to this project.

- *Closure Plan: K-1407-C Retention Basin*, K/HS-221. The original closure plan which was submitted to TDHE (now the Tennessee Department of Environment and Conservation) for approval.[2]
- *Closure Plan: K-1407-C Retention Basin*, K/ER-27 and K/HS-221/R2. The revised closure plan which addresses the presence of radionuclide contamination in the basin.[3]
- "Sampling Work Plan: K-1407-C Retention Basin," K/ER-21 (Appendix 5 of the *Closure Plan: K-1407-C Retention Basin*). The sampling work plan contains the justification and rationale for the sampling locations and parameters. Also included within this report are the health and safety procedures implemented during the sampling activities and a description of the analytical procedures.[5]
- *Site Characterization Summary, K-1407-C Retention Basin*, K/ER-33. This document (1) summarizes all preexisting data, (2) summarizes the analytical results from the sampling outlined in K/ER-21, (3) addresses the development and initial screening of remedial alternatives, and (4) addresses potential applicable or relevant and appropriate requirements.[6]
- *Data Analysis Approach Report for K-1407-B Holding Pond and K-1407-C Retention Basin*, K/ER-23. This report contains information describing the data evaluation process conducted prior to the generation of the DETM.[7]
- *RCRA Facility Investigation Plan General Document*, K/HS-132, Revision 1. This plan, referred to as the "General Document," serves as a comprehensive reference for individual RCRA facility investigation (RFI) plans as well as for other K-25 Site RFI documentation. The General Document characterizes the K-25 Site environment, locates all known SWMUs, and provides a perspective of the scope of the K-25 operation. Sampling strategies, quality assurance (QA), and quality control (QC) associated with sampling and analysis and data management are discussed, along with procedures established to protect the health and safety of employees and the public.[8]

2. DESCRIPTION OF THE STUDY AREA

2.1 PHYSICAL CHARACTERISTICS

2.1.1 Geographic Location

The K-25 Site is located in east Tennessee ~20 miles northwest of Knoxville, Tennessee (Fig. 1), and 6 miles west of the city of Oak Ridge (Fig. 2). The K-1407-C Retention Basin is located in the northeast corner of the K-25 Site. Figure 3 is a site location map.

2.1.2 Climatology

Weather patterns in Oak Ridge are generally temperate, with warm, humid summers and cool winters. Extreme temperatures are uncommon because of the moderating influences of the adjacent mountain ranges. Annual average precipitation is 1.36 m, including ~0.25 m of snowfall.[9] Heavy precipitation occurs mostly in January, February, and July, while spring and autumn are relatively dry.

Although wind conditions in the Oak Ridge area are some of the calmest in the United States, an investigation of the wind patterns in the Oak Ridge Reservation (ORR) area confirmed good ventilation up and down the valleys. This ventilation helps circulate the air masses over Oak Ridge. Prevailing winds blow up-valley from the southwest during the day and down-valley from the northeast in the early evening and at night. This effect, which is due to the channeling of wind by the regional ridge and valley topography, is not as evident in the vicinity of the K-25 Site, which is in a relatively open area.[10] Poor air dilution typically occurs in October because of slow-moving high-pressure cells. Severe electrical storms, wind storms, and tornadoes rarely occur in the Oak Ridge area. The major contributor to this stability of air movement is the Cumberland Plateau. In addition, the area is protected by the Appalachian Mountains from the hot southeasterly winds and tropical storms which sometimes develop along the Atlantic coast.

2.1.3 General Regional Demography

The K-25 Site is part of the 63,000-acre federally owned ORR, which is located in Anderson and Roane counties. There are five counties surrounding the Reservation: Anderson, Knox, Loudon, Morgan, and Roane. The combined population of these five counties is slightly greater than 500,000.

The two major population centers within 30 miles of the site are Oak Ridge (~28,000), which lies 6 miles east of the plant, and Knoxville (~183,000), which is ~20 miles southeast of the site. Several smaller cities are located within the nearby counties: Clinton (~5200), Harriman (~8300), Kingston (~4500), Lenoir City (~5500), Loudon (~4000), Oliver Springs (~3600), and Rockwood (~5800).[11] The locations of these cities are given in Fig. 4. The largest population (~2400) within a 2-mile radius of the K-25 Site is composed of the on-site employees of the facility. In addition, a small number of visitors are present at the site at any

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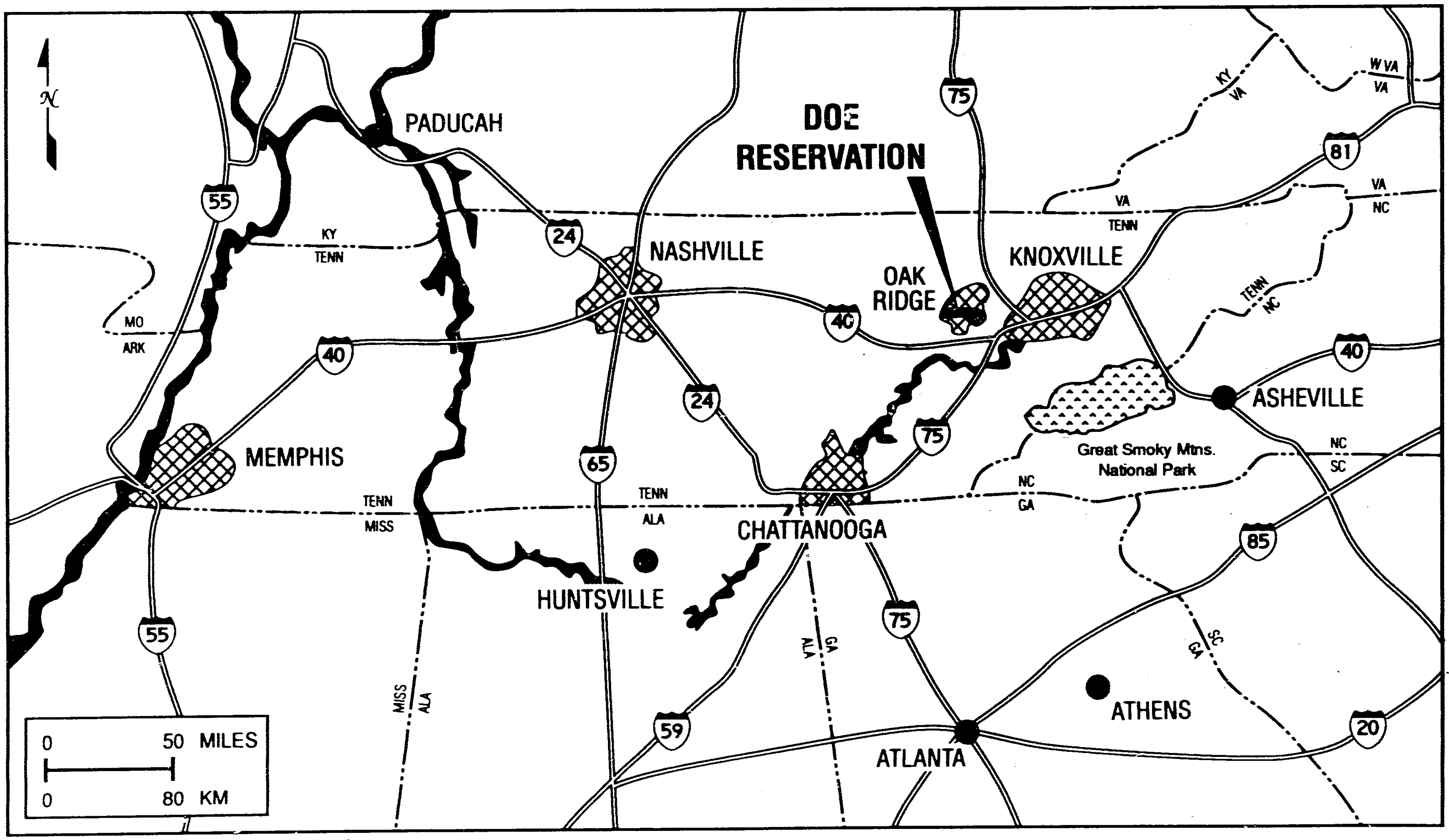

Fig. 1. Regional location of the K-25 Site.

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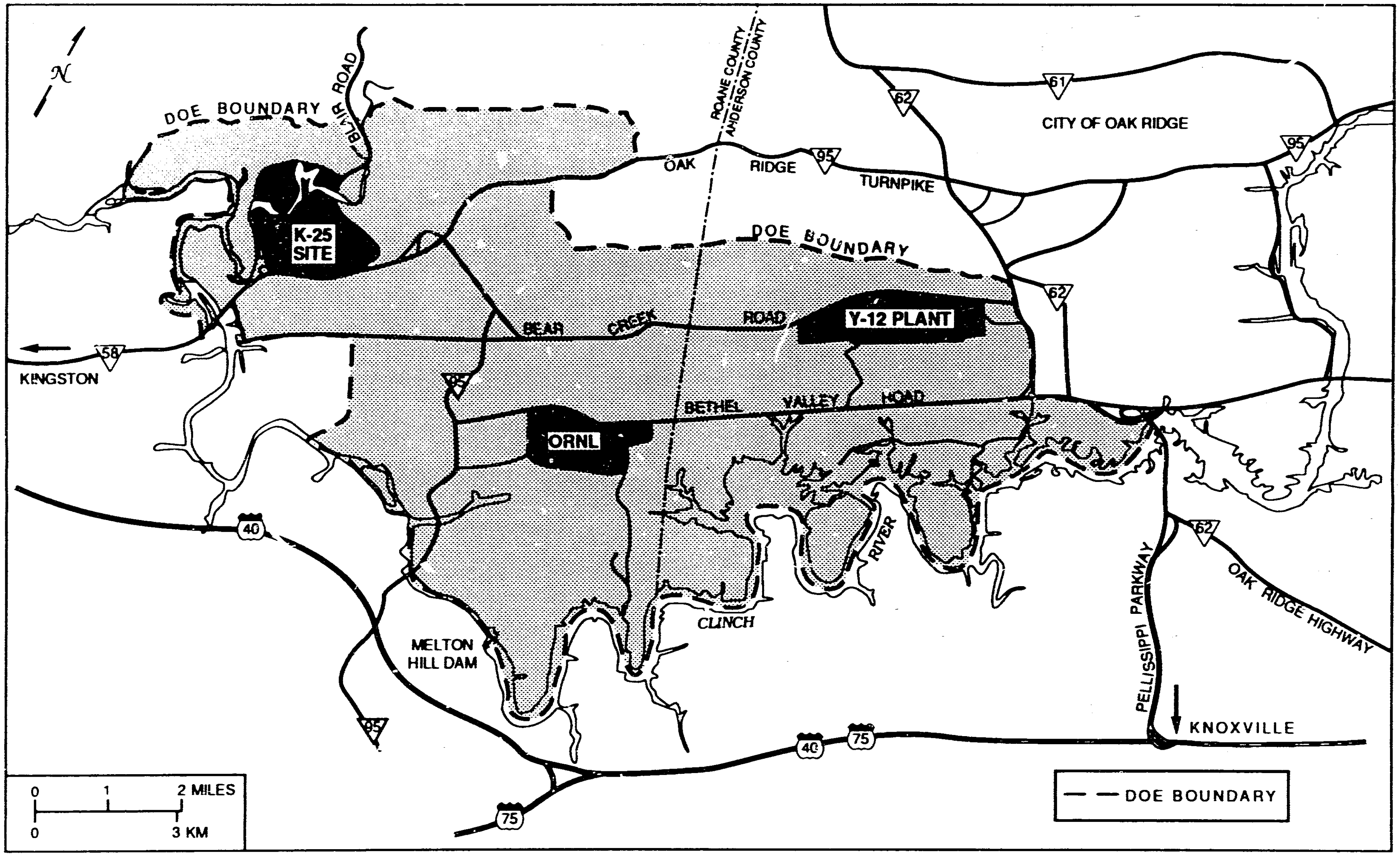


Fig. 2. Location of the K-25 Site with respect to the city of Oak Ridge.

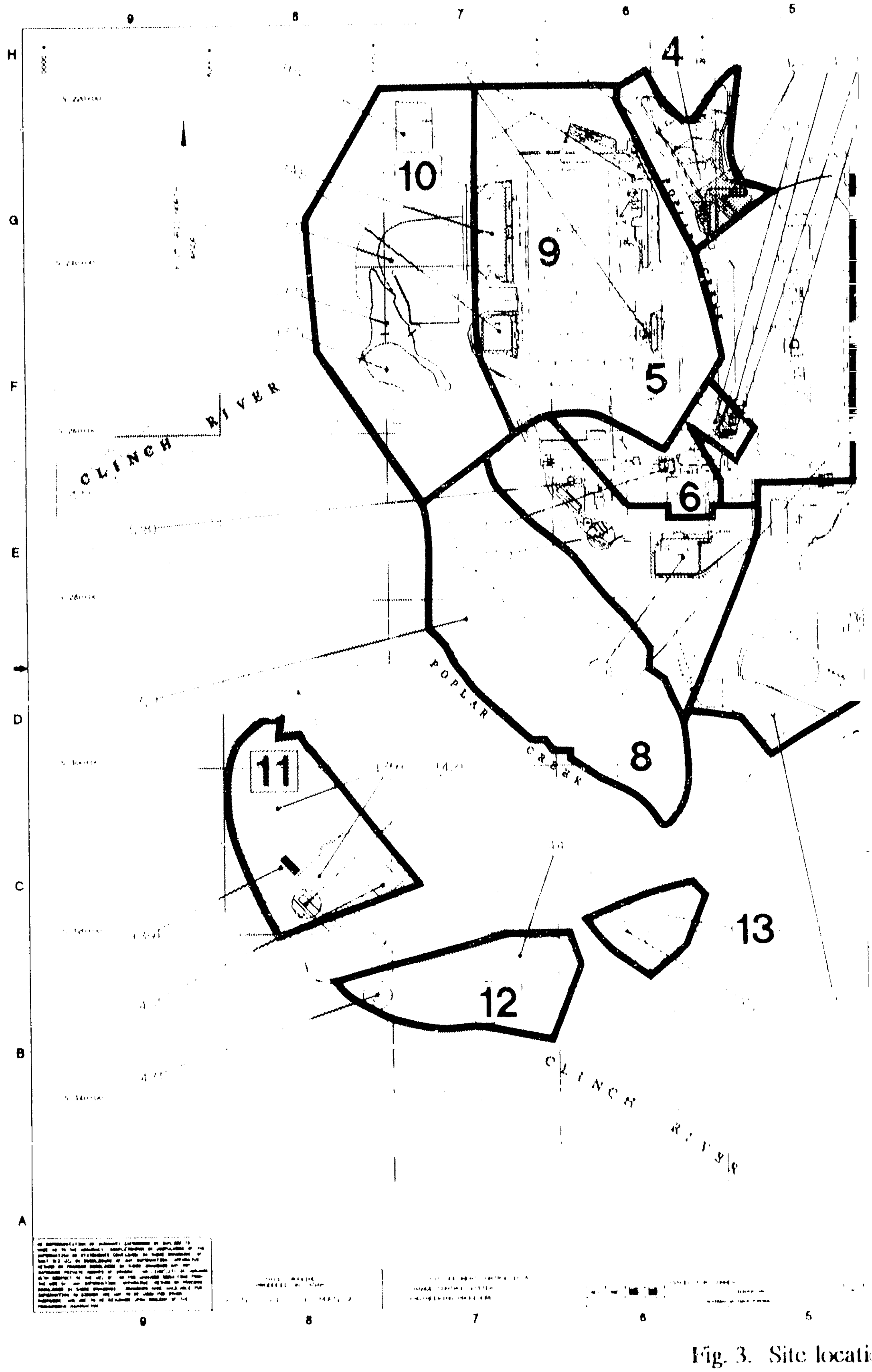
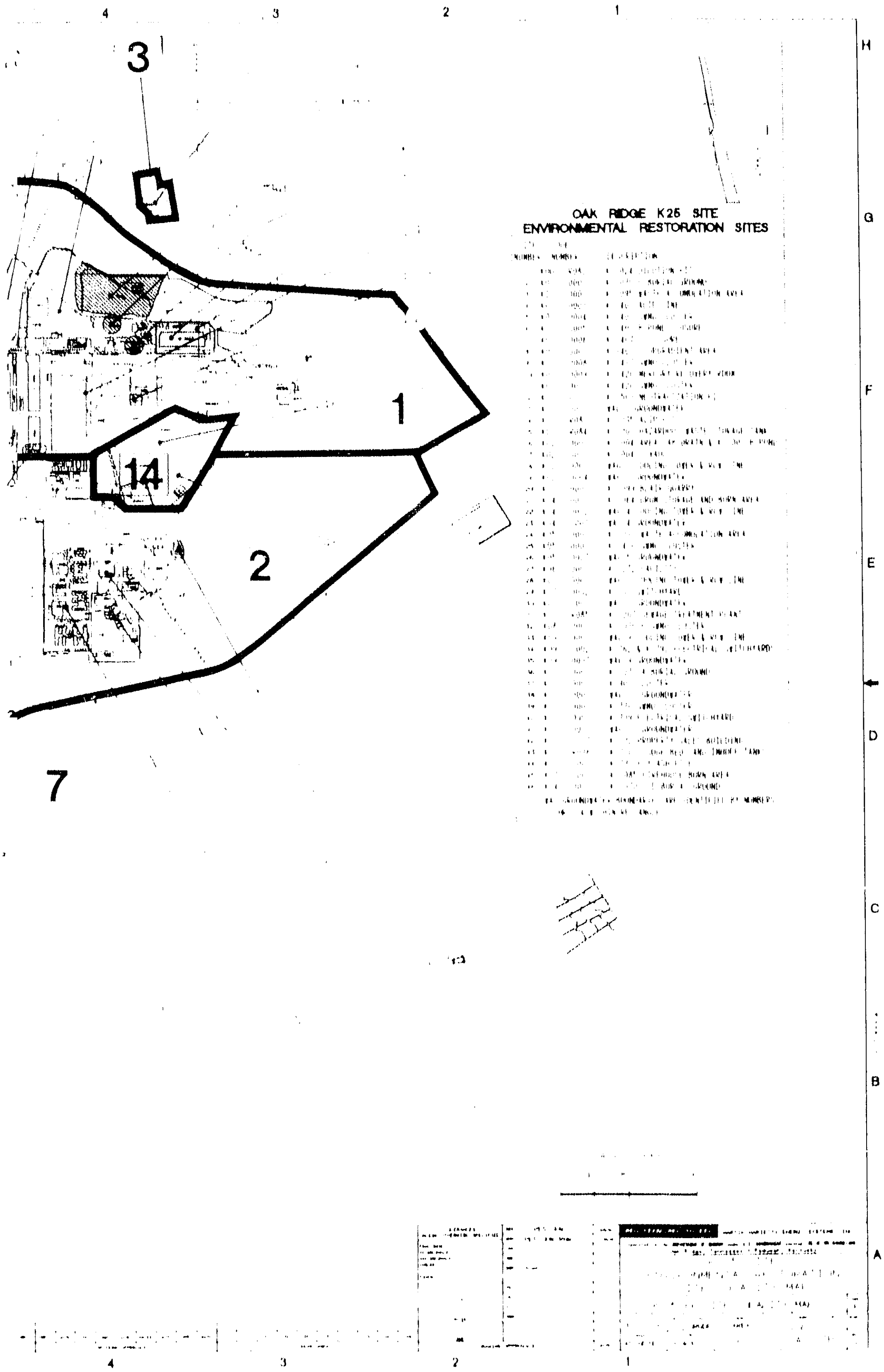


Fig. 3. Site locati



on map of K 25 Site.

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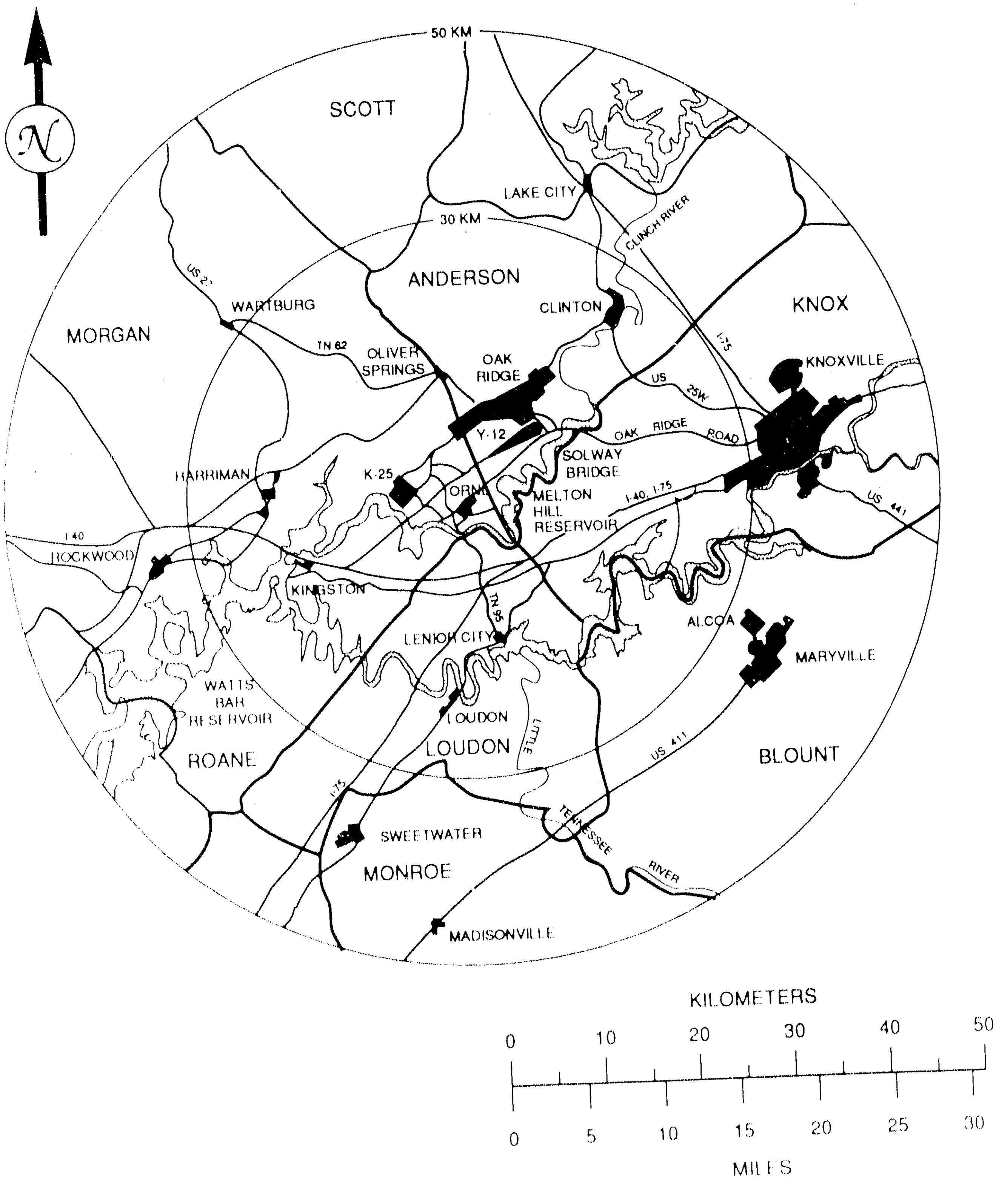


Fig. 4. Communities within a 30-mile radius of the K-25 Site.

given time. Other nearby facilities where local residents may be employed include the two industrial sites in the Clinch River Industrial Park and the Security Guard Training Facility on Bear Creek Road. One of the industrial facilities is operated by the International Technology (IT) Corporation and employs 70 workers; the other is operated by the Scientific Ecology Group (SEG) and employs 150 workers. The population present at the Security Guard Training Facility is dependent upon the ongoing activities.

The nearest privately owned residential properties are in the Sugar Grove Valley, Dyllis, and Poplar Springs communities. The three communities are comprised of ~50 homes. The majority of these are located ~1.5 miles north of the K-25 Site in the Sugar Grove Valley and Dyllis communities. A smaller number of homes are located 2 miles west-southwest of the plant area and west of the Clinch River, as part of the Poplar Springs community. If an average of four occupants per dwelling is assumed, the residential population represented within a 2-mile radius is less than 200. Other residential areas near the K-25 Site are Bradbury, which is located ~5 miles to the south, across the Clinch River, and Edgewood and Lawnville, which are located immediately west-northwest of the Poplar Springs community.

2.1.4 Land Use

According to Chap. 5 of the General Document, the region around the K-25 Site contains areas of agricultural, residential, industrial, and recreational uses. Because the land immediately surrounding the plant is a federal reservation, it is primarily undeveloped.[12]

Agricultural uses of nearby land include: limited-scale private gardening; raising of tobacco, corn, wheat, and soybeans as cash crops; raising of beef cattle; and dairy farming. Some areas are also used for commercial logging.[12]

Nearby industrial use of the land includes the Oak Ridge National Laboratory (ORNL), the Oak Ridge Y-12 Plant, Phyton Technologies, Inc., SEG, and IT Corporation's Bear Creek Radiological Laboratory. Only the SEG and IT Corporation laboratories are within 2 miles of the K-25 Site. Tennessee Valley Authority facilities near the plant are the Melton Hill Dam, the Bull Run Steam Plant, and the Kingston Steam Plant. None of these is within 6 miles of the plant.[13]

The nearby Watts Bar Lake Embayment/Clinch River waterway is used as a recreational area by both pleasure boaters and fishermen. There are a number of small camping areas and boat launching ramps in the vicinity; one of the ramps is located slightly more than a mile upstream of the K-25 Site. There are no other recreational facilities within 2 miles of the K-25 Site. A small dirt-surface racetrack is located ~4 miles south of the plant and attracts several thousand spectators during the racing season. There is a public swimming area at Melton Hill Dam, 7 miles southeast and upstream of the plant. Sport hunting of game birds and game animals occurs seasonally in the region surrounding the plant. Also, deer hunting is authorized on some parts of the ORR as a population control measure; some of these seasonal hunting areas are within 2 miles of the K-25 Site.[13] All harvested animals are screened for beta and gamma radiation contamination, and those animals with high radiation readings are confiscated.

2.1.5 Hydrogeology

The K-1407-C Retention Basin lies in a small valley located between McKinney Ridge and Pine Ridge. Both groundwater and surface runoff in the area flow toward the south-southwest to the K-1700 Stream (also known as Mitchell Branch), which flows ~1500 ft before discharging into Poplar Creek. Groundwater flow in this area occurs mainly in the limestone bedrock within a system of interconnecting, solution-enlarged fractures and bedding planes. The geologic feature that may have the greatest influence on the migration of site contamination is a branch fault of the Whiteoak Mountain Fault. The extensive fractures and brecciation associated with faulting could serve a preferable pathway if contamination is transported via groundwater. The exact location of the fault relative to the K-1407-C Retention Basin has not been determined.

2.1.5.1 Geology

The unconsolidated material in the area of the K-1407-C Retention Basin ranges in thickness from 11 to 40 ft. The thickness of the unconsolidated zone decreases along the axis of the valley and increases along the hillsides to the north and south. The unconsolidated material is comprised of clay and lithic fragments. The K-1407-C area is underlain by rocks of the upper part of the Conasauga Group, which typically consists of massive limestone or limestone interbedded with calcareous shale. The limestones are generally gray to blue-gray, fine-grained, and oolitic, and the shale is gray to blue to green-gray with minor amounts of chert. The upper Conasauga, which may contain some dolomite or dolomitic limestone, grades stratigraphically downward (to the south) into predominantly calcareous shale.

The structural attitude of bedrock strata in the K-1407-C area is inferred from field measurements in nearby areas by R. H. Ketelle of ORNL (unpublished geologic map). The areal geology of the K-25 Site is shown in Fig. 5. The strike of the bedding in the area of the K-1407-C Retention Basin is roughly east-west. The bedding is very steeply inclined, probably dipping mainly to the south, although some bedding may dip to the north. The steep and variable dips are the result of structural deformation associated with the Whiteoak Mountain Fault. The predominant geologic feature in the area is a splay fault associated with the Whiteoak Mountain Fault. This north-south trending fault transverses the area of the site. This fault is the result of tectonic activities which have thrust the Conasauga Group over the Chickamauga limestone to the west. The faulting has caused extensive fracturing and jointing within the affected bedrock strata, in particular the more competent limestones and dolostones. The fault may influence the migration of contaminants from the site via groundwater. The exact location of the fault has not been determined.

2.1.5.2 Hydrology

The K-1407-C Retention Basin is located in the K-1700 watershed, which drains the northeastern corner of the plant first in a westerly direction and then northward to Poplar Creek. Downgradient from the site, surface runoff is collected into subsurface drains along with storm drains from other parts of the plant and considerable groundwater effluent. This water then flows through the K-1700 National Pollutant Discharge Elimination System station. There are no perennial streams [other than K-1700 (Mitchell Branch)] or springs on this site. According to data generated by the Tennessee Valley Authority, the K-1407-C area is above the 100-year flood level.

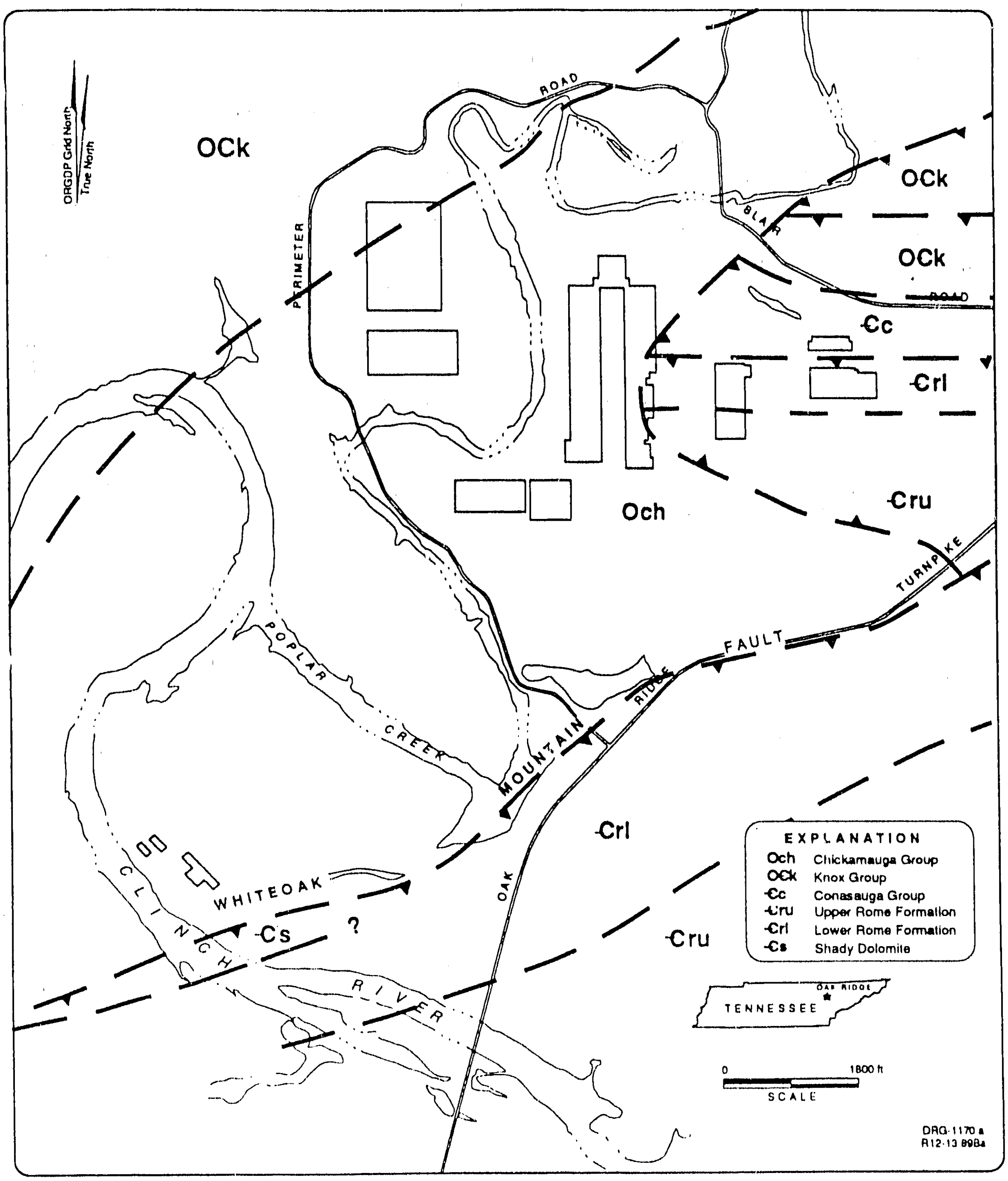


Fig. 5. Geology in the vicinity of the K-25 Site. *Source:* Geraghty and Miller, Inc., *Hydrogeology of the Oak Ridge Gaseous Diffusion Plant*, K/Sub/85-22224/12, Martin Marietta Energy Systems, Inc., Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tennessee, December 1989.

Groundwater flow in the unconsolidated and bedrock zones is toward the valley where it discharges to the K-1700 Stream, as illustrated in Figs. 6 and 7. Bedrock wells (BRWs) BRW-13 and BRW-14 are paired with unconsolidated wells (UNWs) UNW-11 and UNW-10, respectively. (See Figs. 6 and 7.) Water elevations from these paired wells indicate a downward vertical groundwater flow gradient in the area of the retention basin. Hydraulic head measurements from unconsolidated wells in the vicinity indicate that the water table is relatively close to the bottom of the retention basin. The bottom of the retention basin has an elevation of ~758 to 760 ft, and the elevation of the water table in September 1990 was ~750 to 755 ft in the area of the retention basin. The relationship of the groundwater is likely to have a significant influence on the migration potential of contamination from the soil in the retention basin.

Groundwater storage and flow in the K-1407-C area occurs mainly in the limestone bedrock within a system of interconnecting, solution-enlarged fractures and bedding planes. The shales are more subject to plastic deformation, and their fractures tend to be relatively tight and restrictive to groundwater flow. Hydraulic conductivity of the unconsolidated material ranges from 10^{-7} to 10^{-3} cm/s. Most of the tests produced values in the 10^{-5}- to 10^{-4}-cm/s range. Hydraulic conductivity measured in BRW-7 and BRW-8 was 10^{-4} and 10^{-5} cm/s, respectively. The hydraulic conductivity determined for wells in the vicinity is listed in Table 21.

2.1.6 Data Limitations Related to Physical Characterization

Additional characterization of the hydrogeology of the area is needed to determine the potential for contaminant transport via groundwater. The relationship of groundwater to the retention basin and the exact location of the fault in the area of the K-1407-C Retention Basin are not known. These factors could have a significant influence on the groundwater regime and transport pathways from the retention basin. Additionally, to quantify the migration potential of contaminants via the groundwater or surface water, soil parameters influencing transport, such as particle-size distribution, porosity, soil pH and oxidation-reduction potential, cation-exchange capacity, mineralogy, and organic carbon fraction must be determined.

2.2 OPERATIONAL AND HISTORICAL INFORMATION

Until September 1985, the K-25 Site was involved in the enrichment of ^{235}U using uranium hexaflouride. This material was then processed and used as fuel in nuclear power reactors for electrical power generation. The K-1407-C Retention Basin is a surface impoundment at the K-25 Site. The basin has a storage volume of ~4 million gal and was used primarily for storing potassium hydroxide scrubber sludge generated at the K-25 Site. In addition, from 1960 to 1973 metal hydroxide sludges that were removed from the K-1407-B Holding Pond were discharged to the K-1407-C Retention Basin. The sludge in the K-1407-B Pond contained discharge from the K-1420 Decontamination and Uranium Recovery Unit, the K-1501 Steam Plant, the K-1413 Laboratory, and the K-1401 Maintenance Building. In addition, radioactive material in the K-1407-C Retention Basin may be the result of cleaning and decontamination activities at the aforementioned facilities.

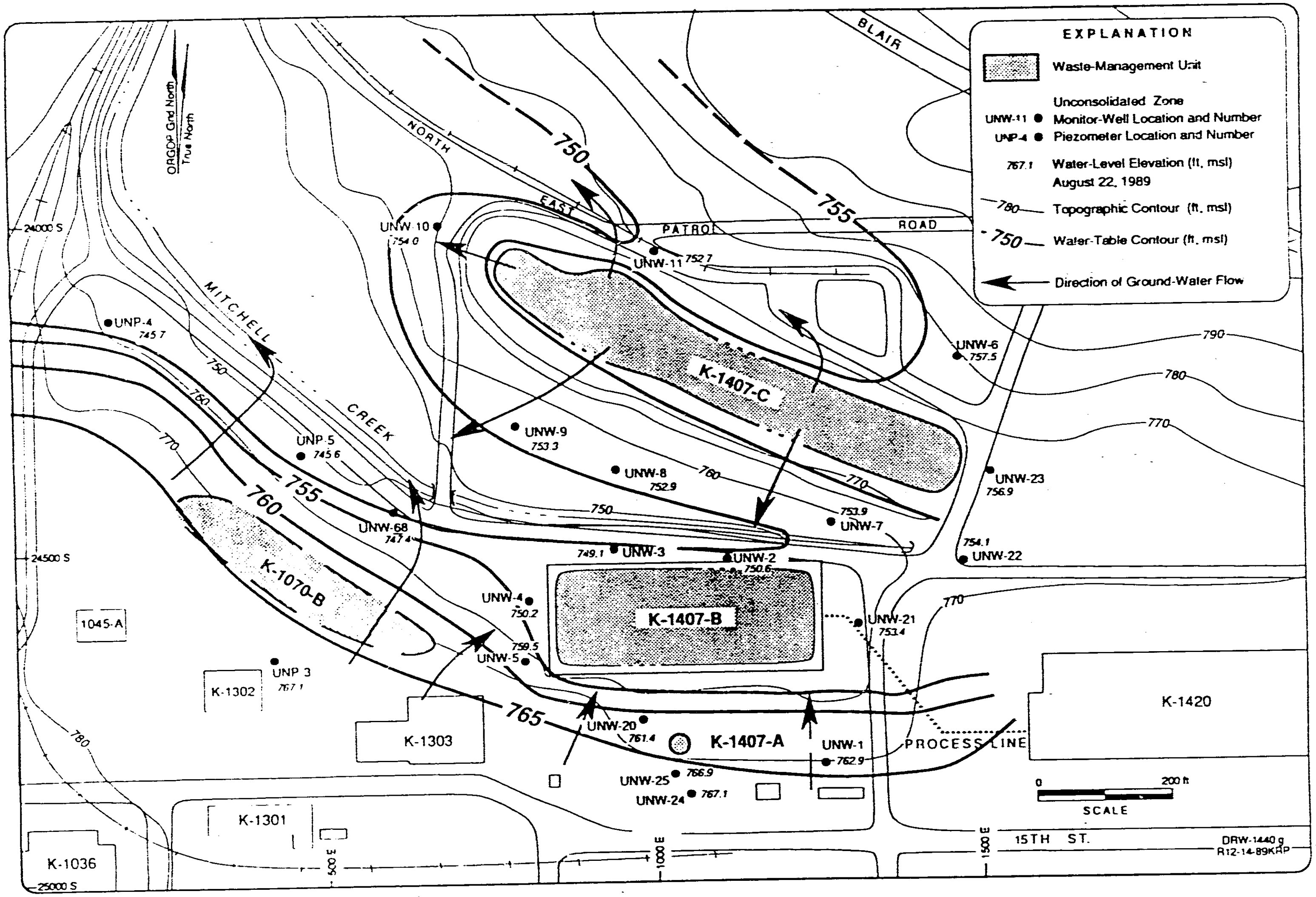


Fig. 6. K-1407-C Retention Basin areal water table contour map and unconsolidated zone monitoring wells. *Source:* Geraghty and Miller, Inc., *Hydrogeology of the Oak Ridge Gaseous Diffusion Plant*, K/Sub/85-22224/12, Martin Marietta Energy Systems, Inc., Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tennessee, December 1989.

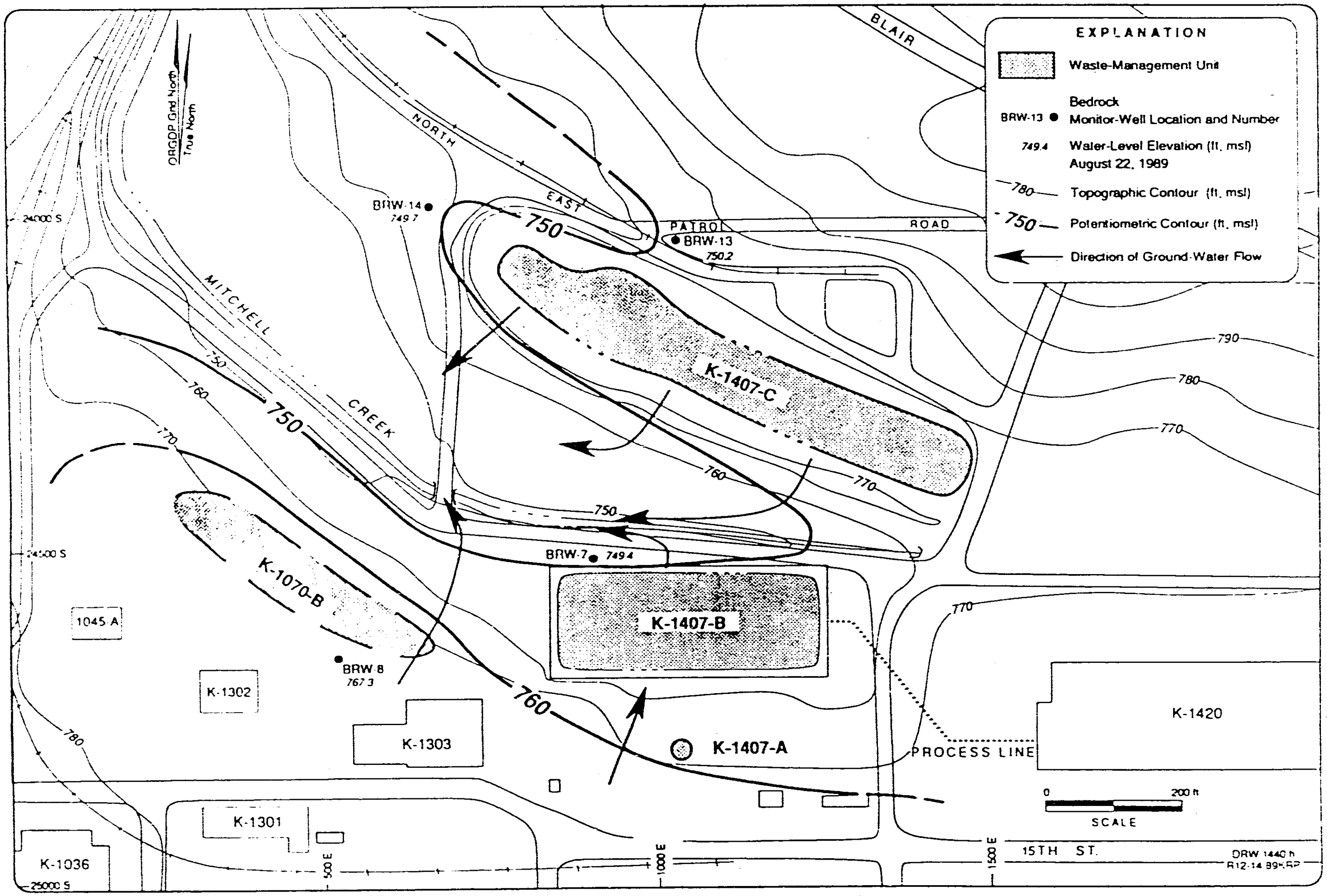


Fig. 7. Bedrock groundwater flow in K-1407-C Retention Basin area and bedrock monitoring wells. *Source:* Gerahty and Miller, Inc., *Hydrogeology of the Oak Ridge Gaseous Diffusion Plant*, K/Sub/85-22224/12, Martin Marietta Energy Systems, Inc., Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tennessee, December 1989.

Table 1. Hydraulic conductivities in the K-1407-C area

Well designation	Method of analysis	
	Bouwer (cm/s)	Hvorslov (cm/s)
UNP-3	5.40×10^{-6}	1.66×10^{-5}
UNP-4	2.79×10^{-6}	8.19×10^{-6}
UNP-5	3.23×10^{-6}	4.28×10^{-6}
UNW-1	3.56×10^{-4}	4.21×10^{-4}
UNW-2	1.44×10^{-4}	6.11×10^{-4}
UNW-3	2.33×10^{-4}	4.83×10^{-4}
UNW-4	1.08×10^{-4}	4.01×10^{-4}
UNW-5	2.38×10^{-5}	2.16×10^{-4}
UNW-6	3.72×10^{-3}	3.47×10^{-5}
UNW-7	1.08×10^{-4}	6.51×10^{-3}
UNW-8	1.01×10^{-4}	3.60×10^{-4}
UNW-9	2.56×10^{-3}	8.23×10^{-3}
UNW-10	1.06×10^{-7}	3.08×10^{-7}
UNW-11	5.43×10^{-7}	2.51×10^{-7}
BRW-1	1.34×10^{-3}	
BRW-7	3.58×10^{-5}	
BRW-8	6.71×10^{-5}	

The discharge of waste materials to K-1407-C was discontinued before November of 1988, and all sludge was removed and stored or fixed in concrete. Liquid waste and the sludge layer in the retention basin were removed using a portable hydraulic dredge that was mounted on a pontoon. To facilitate the sludge removal, berms were constructed to subdivide the retention basin by mounding the soil and sludge from the retention basin bottom. If possible, liquid and sludge were pumped through a discharge line to the K-1419 Sludge Fixation Plant. In the event the material would not pass through the discharge line, it was hauled with a clam shell from the northeast end of the retention basin and transported to the K-1419 facility.

Removal of material was continued until indigenous soil was encountered and the retention basin was visibly clean.

2.3 PREVIOUS INVESTIGATIONS

A waste-sampling program to characterize the sludge in the K-1407-C Retention Basin was conducted in May 1985. In addition to sludge sampling, the investigation included sampling the soil beneath the sludge in 6-in. intervals to a depth of 18 in. The sampling method and analytical results are included in the *Closure Plan: K-1407-C Retention Basin* (K/ER-27).[3] Evaluation of the data resulting from this sampling program indicated that the concentrations of hazardous waste constituents in the soil below the sludge layer did not exceed the proposed toxicity characteristic leaching procedure limits. Additionally, the organic constituents present in the sludge layer were not detected in the soil layers, and the extraction procedure toxicity constituents which were detected in the sludge and soil were not in the groundwater. Based on these results, a clean closure of K-1407-C Retention Basin was proposed.

After the removal of sludge from the K-1407-C Retention Basin, preliminary soil sampling was performed to ascertain if contamination had migrated into the soil beneath the sludge. This sampling effort consisted of five samples taken along the long axis of the retention basin. The results indicated that no organics or other RCRA hazardous constituents were present, but radionuclides were detected in all samples. The analytical results of the preliminary soil samples are included in the *Closure Plan: K-1407-C Retention Basin* (K/ER-27).[3] Based on the radionuclide contamination detected in the five exploratory samples, a large-scale soil sampling operation was conducted, the results of which are the subject of the current evaluation.

3. FIELD INVESTIGATION

3.1 SAMPLING

The most recent attempt to determine the extent of soil contamination in the K-1407-C Retention Basin was initiated in 1989. Fifty-seven sample locations were based on a 75- by 29-ft grid overlay of the retention basin, shown in Fig. 8. In addition, 23 samples were collected at locations of anomalously high radiation indicated during a walking radiation survey of the retention basin (Fig. 8). The samples taken as a result of the radiation survey are designated as biased samples. The biased samples were taken in an attempt to account for radioactive contamination at locations which are not included in the sampling grid. The use of biased and grid sampling should ensure the thorough characterization of the horizontal extent of radionuclide contamination in the retention basin. Samples at these locations were taken in 6-in. intervals to a depth of 18 in. Samples were analyzed for gross alpha, beta, and gamma radioactivity; for the radioactive isotopes americium, cesium, cobalt, curium, europium, neptunium, plutonium, potassium, strontium, technetium, and uranium; and for metals.

3.2 RESULTS OF GAMMA AND BETA-GAMMA SURFACE SCANS

Surface gamma scan ranges in accessible areas of individual grid blocks at the K-1407-C Retention Basin are shown in Fig. 9. Typical exposure rates generally ranged from 11 to 15 μR/h outside the rope boundary and from 11 to 29 μR/h inside the rope boundary. Highest scan ranges reached 120 μR/h in grid block 10C and 79 μR/h in grid blocks 6E, 8E, and 18E. Gamma exposure rates exceeded 40 μR/h in more than half of the grid blocks and exceeded typical levels of the immediate vicinity (11 to 15 μR/h) in all grid blocks.

The beta-gamma scan was conducted primarily to identify areas contaminated with radionuclides that are not strong gamma emitters (such as ^{99}Tc and strontium). Surface beta-gamma scan ranges in accessible areas of individual grid blocks are shown in Fig. 10. Typical beta-gamma dose rates in uncontaminated areas inside the rope boundary generally ranged from 0.036 to 0.072 mrad/h; highest dose rates reached 1.9 mrad/h in grid block 10C, 1.6 mrad/h in 8E, and 1.4 mrad/h in 2G and 16G. Beta-gamma radiation levels exceeded typical background levels in 17 grid blocks. Details of the gamma and beta-gamma surface scans are summarized in Table 2.

Figure 11 shows the approximate locations of specific contaminated spots and areas identified during the surface scan. Gamma exposure rates ranged from 17 to 120 μR/h, and beta-gamma dose rates ranged from 0.036 to 1.9 mrad/h. Radiation levels were generally higher on the north side of the basin at the base of the bank and extending up the bank and on the earthen dike that projects from the north bank to near the south bank at the center of the basin along grid line 7. Typical gamma levels on the road north of the basin (not shown on Fig. 11) ranged from 12 to 15 μR/h. Typical gamma levels along the top of the south bank generally ranged from 11 to 15 μR/h and increased to 17 to 23 μR/h as the surveyor descended the bank toward the bottom of the pond. Nine contaminated spots with gamma exposure rates ranging from 36 to 85 μR/h were identified outside the rope boundary. In addition, a spot ~1 m^2 measuring 17 to 36 μR/h and 0.18 mrad/h (not shown on Fig. 11) was identified on the road in the area north of grid line 5.

3.3 GAMMA EXPOSURE RATES AND BETA-GAMMA DOSE RATES AT SAMPLING POINTS

Gamma exposure rates and beta-gamma dose rates measured at the surface and at depths of 6, 12, and 18 in. are given in Appendix A, along with sample numbers, stake numbers, locations, dates, times, analyses, and comments. Gamma radiation levels fluctuated with increasing depth in 38% of the sampling holes, decreased with depth in 30%, remained constant in 18%, and showed slight increases in 14%. Beta-gamma radiation levels decreased with increasing depth in 60% of the sampling holes and fluctuated with increasing depth in 38%. Gamma exposure rates of samples ranged from 11 to 130 μR/h; beta-gamma dose rates ranged from 0.014 to 1.7 mrad/h. Figure 12 shows surface gamma exposure rates at sampling points ranging from 11 to 110 μR/h, and Fig. 13 shows surface beta-gamma dose rates at the same points ranging from 0.030 to 1.7 mrad/h. Sampling points that appear to be covered with water were sampled during dry periods when the water pools were smaller.

3.4 ALPHA RADIATION

On September 19, 1989, alpha contamination measuring <100 dpm/100 cm^2 was detected on a pair of field work gloves. The gloves were discarded. On September 20, 1989, alpha contamination measuring ~100 dpm/100 cm^2 was detected on the soles of a pair of knee-length rubber boots. The boots were decontaminated by scrubbing with soap and water. On October 3, 1989, alpha contamination measuring 400 dpm/100 cm^2 was detected on a pair of plastic safety glasses. In this case, the contamination could not be removed by scrubbing with soap and water; the glasses were disposed of according to the rules and regulations governing radioactive wastes.

3.5 AMBIENT AIR

No radiological contamination was detected when the filters from personal air samplers worn by site personnel during dry, dusty conditions were analyzed for alpha- and beta-emitting radionuclides.

HNU™ and OVM™ readings in the breathing zone were consistently less than 1.0 ppm. On November 9, 1989, a fluctuating OVM reading of 0.0 to 1.4 ppm was measured at the top of the sample hole during the collection of sample BH056ASO12A; the OVM reached 6.0 ppm very briefly during this sample interval. A fluctuating OVM reading of 0.0 to 1.6 ppm was measured when another sample (BH056ASO18A) was collected from the same hole. OVM readings in the breathing zone ranged from 0.0 to 0.3 ppm during the collection of these two samples.

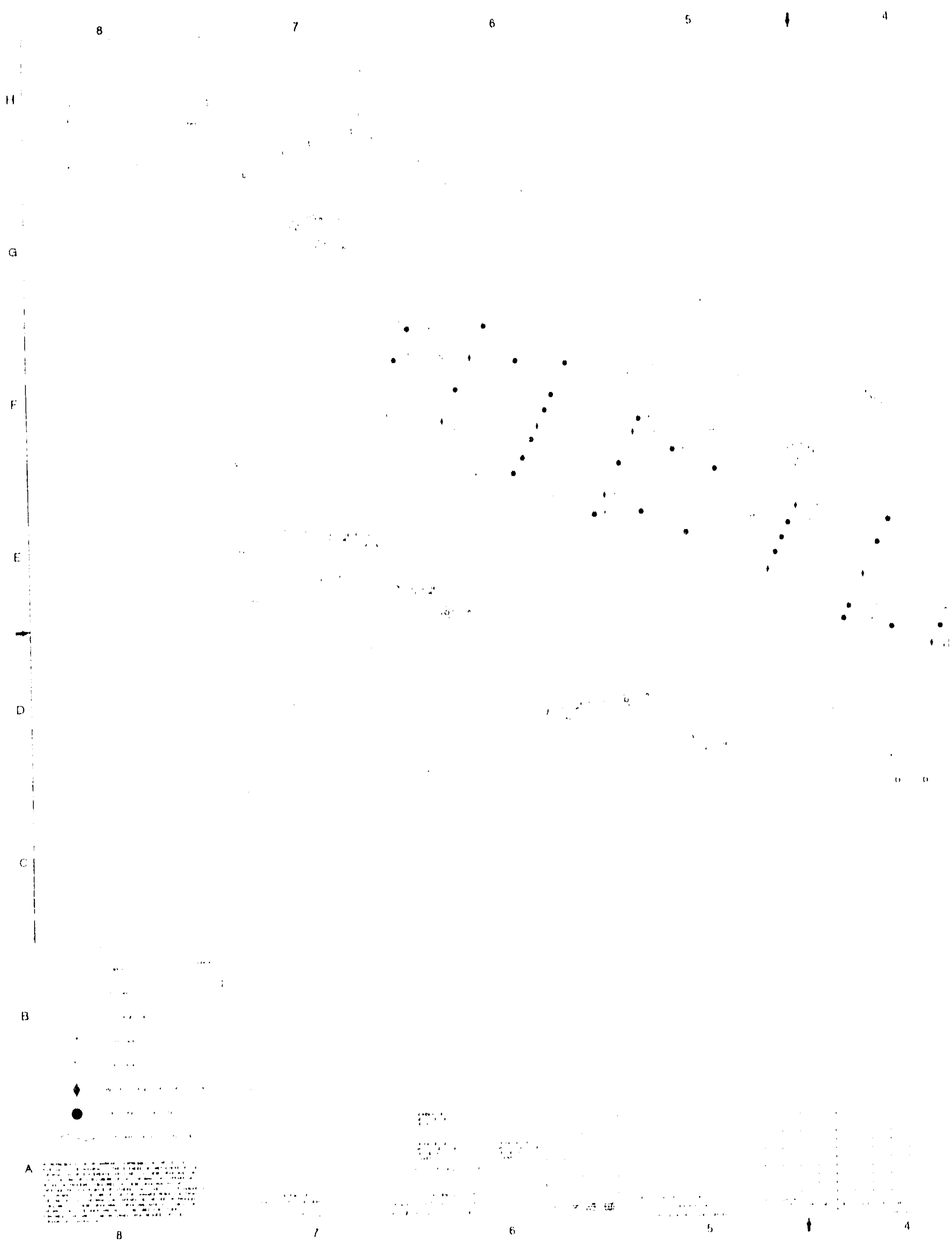
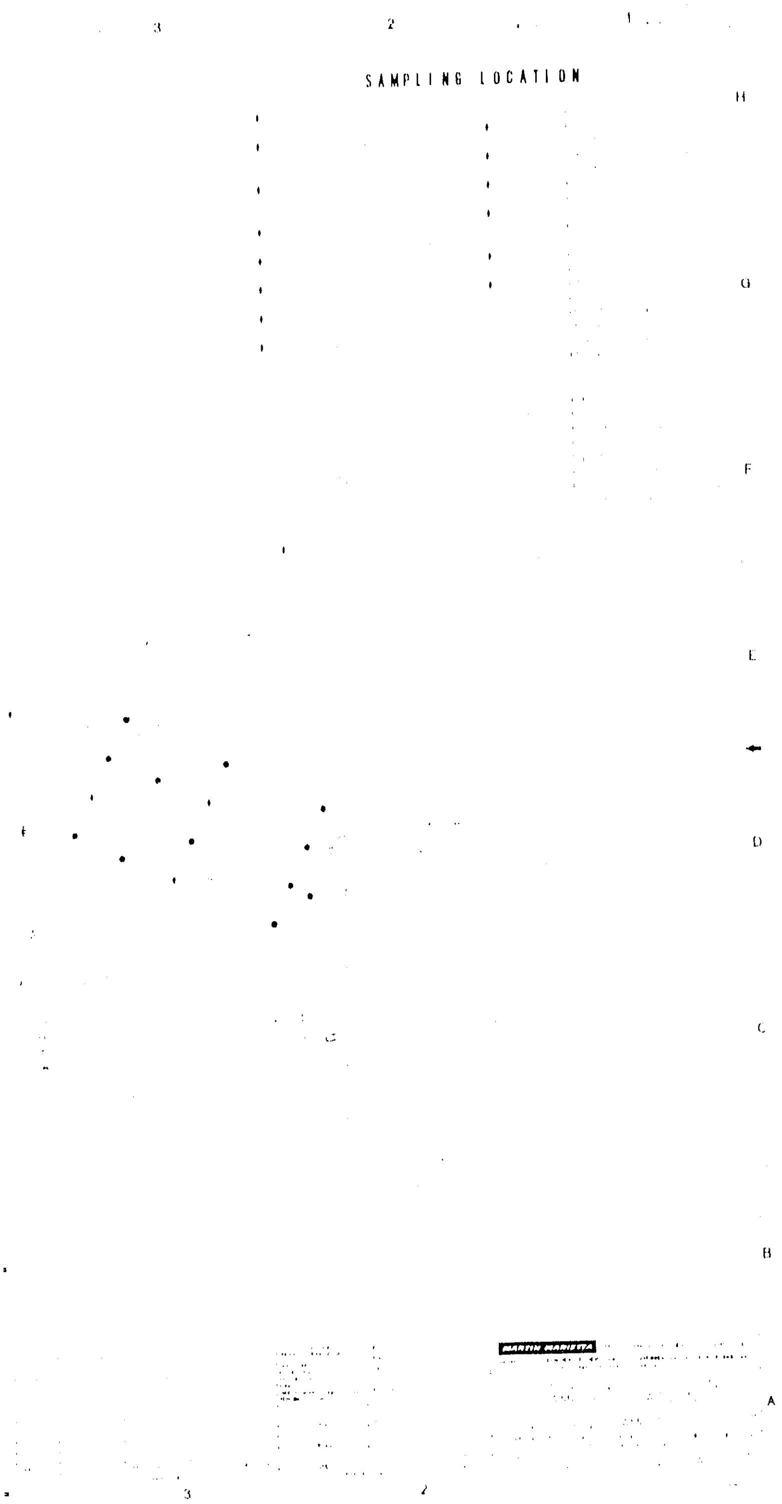


Fig. 8. Sample location grid for the K-1407-C



Retention Basin.

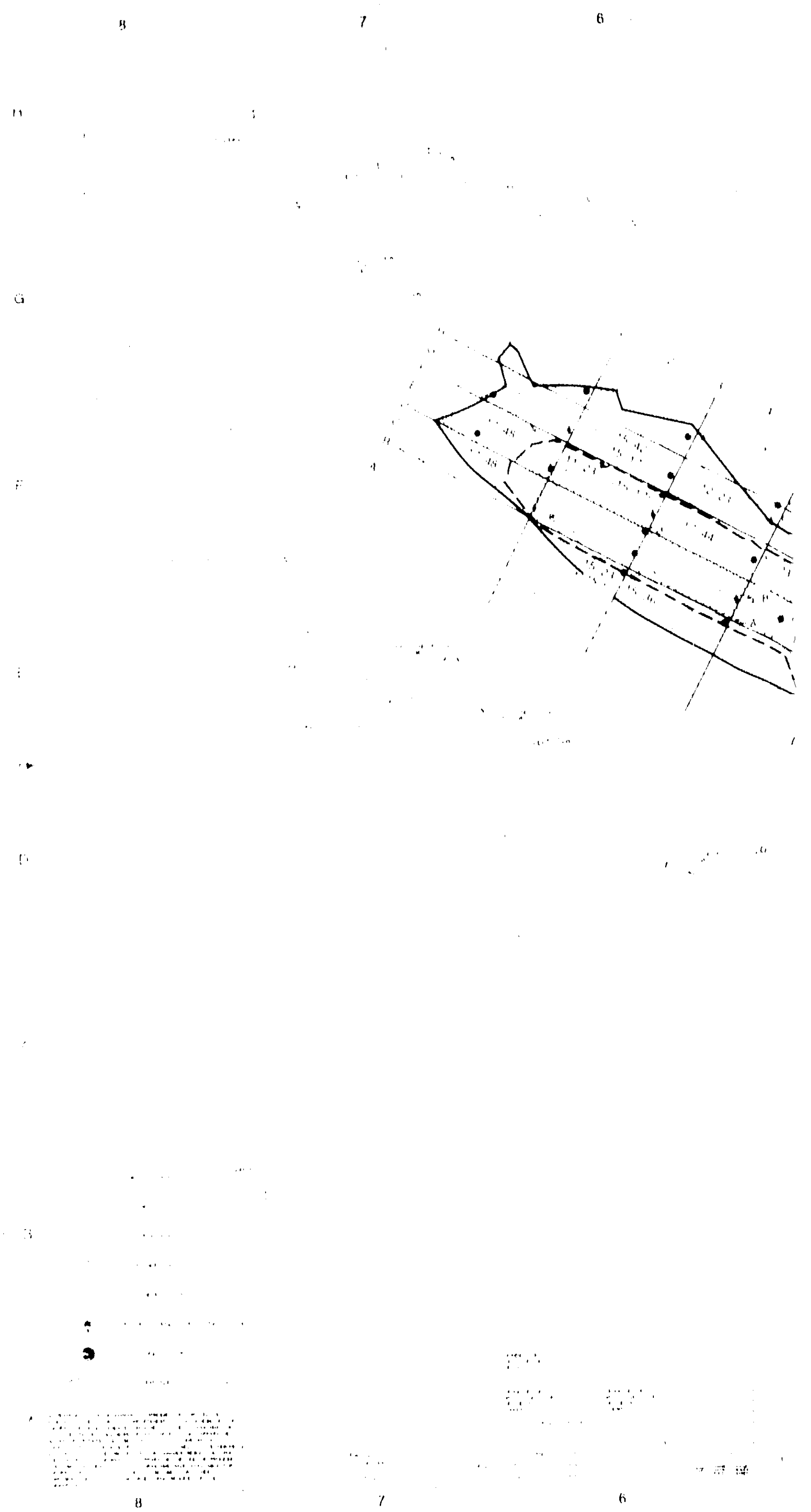
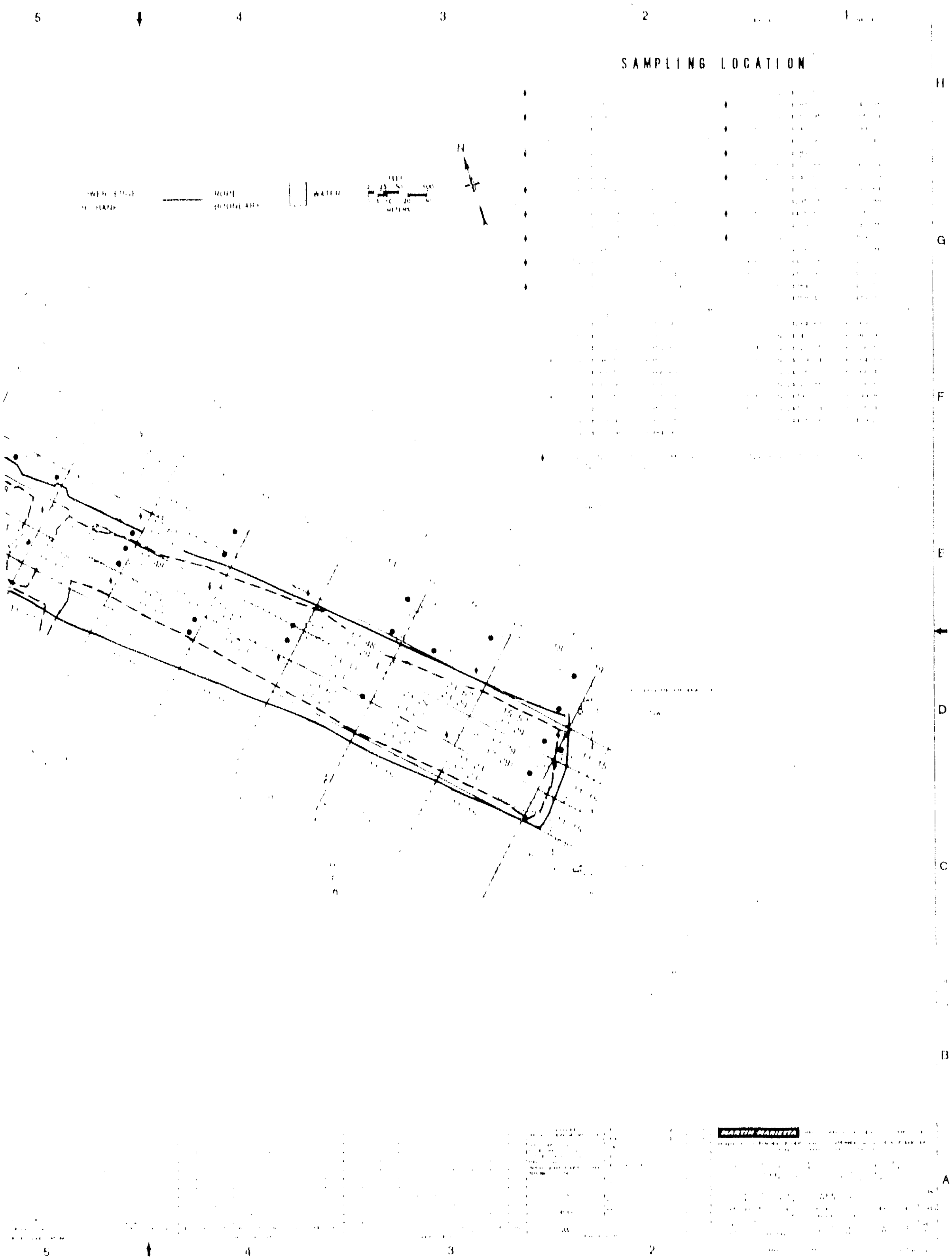


Fig. 9. Ranges of surface
Retention Basin (September 19



gamma exposure rates (μR/h) measured at the K-1407-C
9 to January 1990).

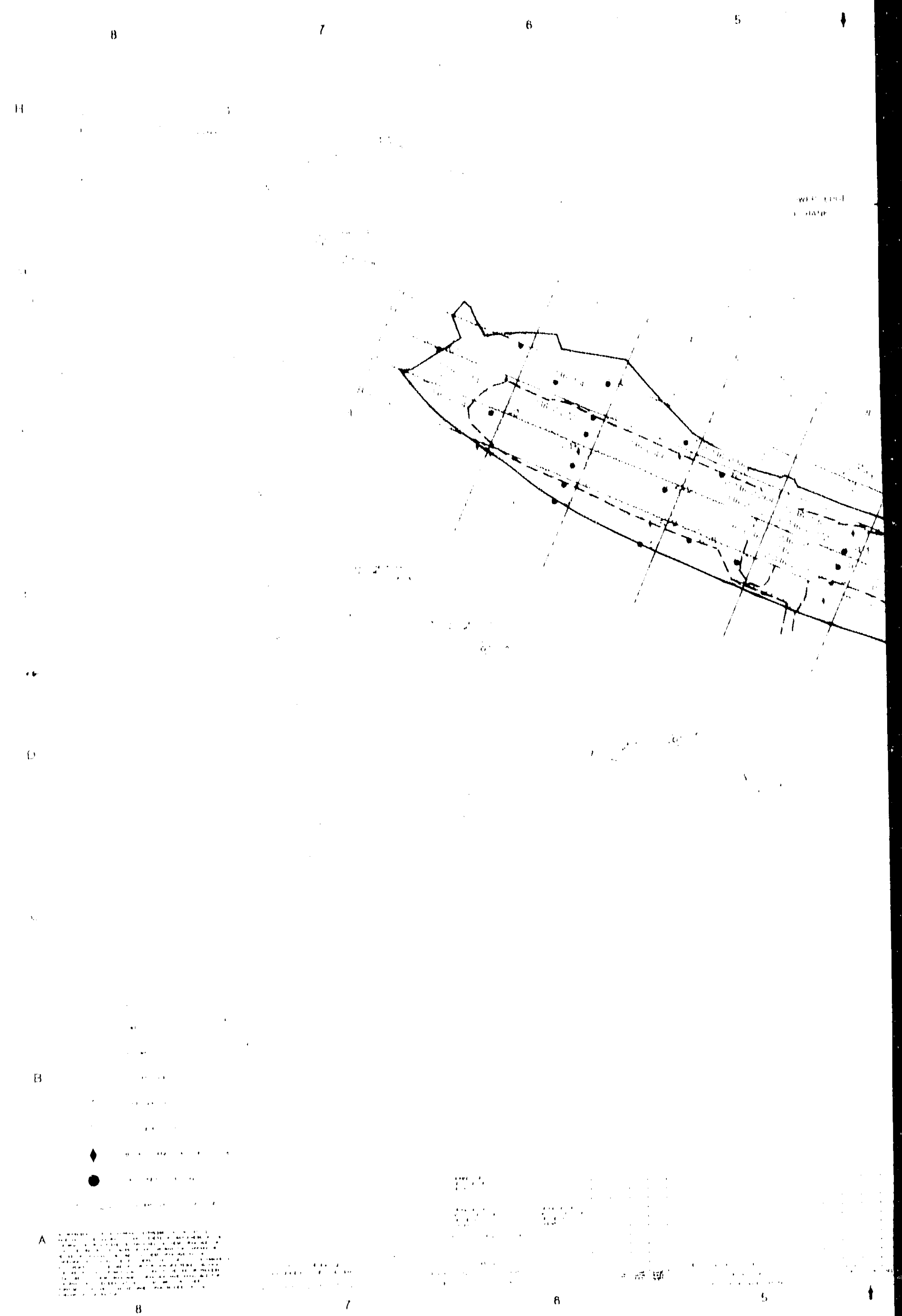
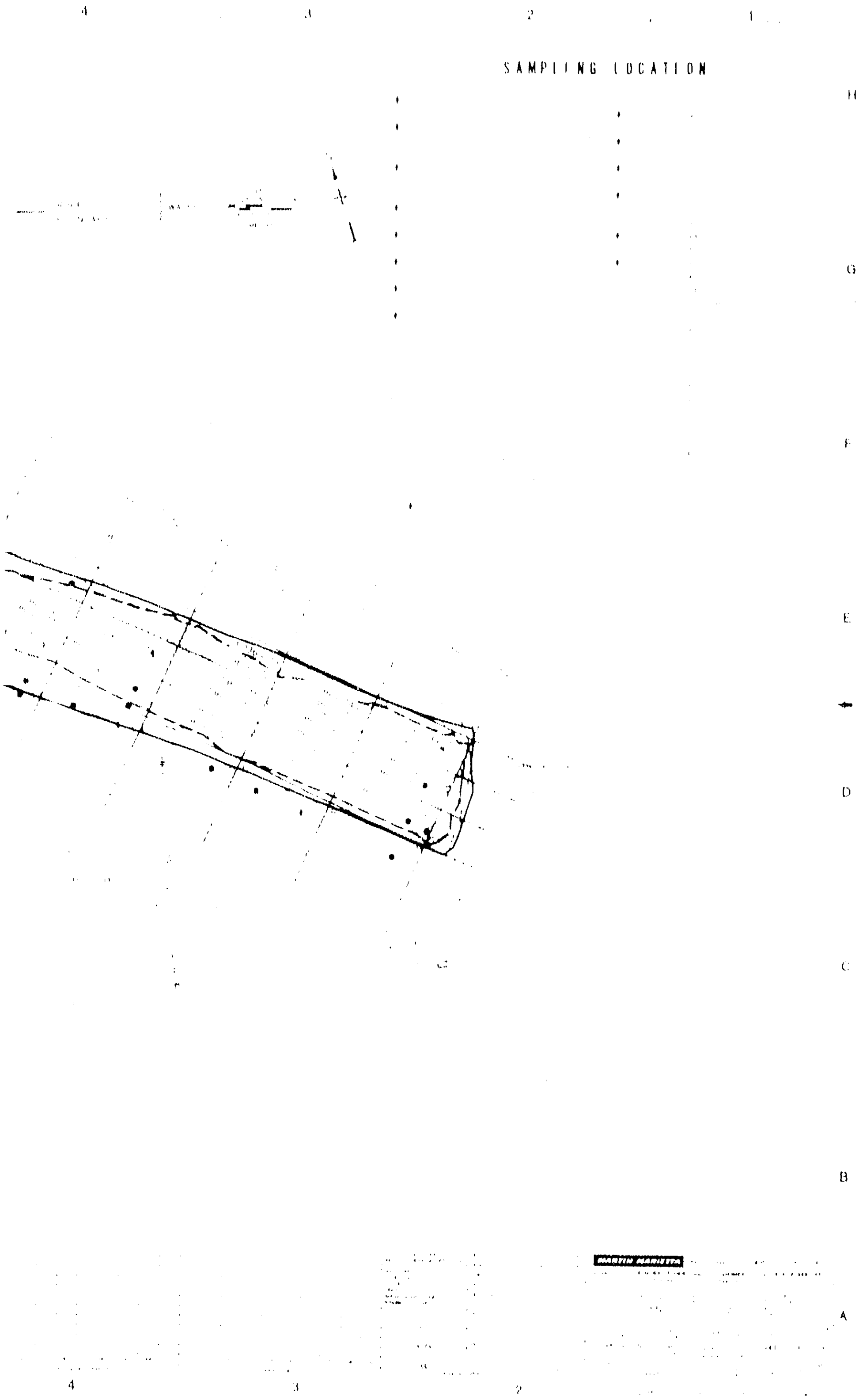


Fig. 10. Ranges of beta-gamma dose rates (m
Basin (September 1989 to January 1990).



rad/h) measured at the K-1407-C Retention

Table 2. Summary of findings from surface gamma and beta-gamma scans at the K-1407-C Retention Basin

	Gamma exposure rates		Beta-gamma dose rates	
Grid block[a]	Surface scan range (μR/h)	Comments on gamma scan	Surface scan range (mrad/h)	Comments on beta-gamma scan
18G	15-57	Generally 17-29 μR/h; spots up to 54 μR/h along line between 17H and 19H; highest measurement (54 μR/h at surface, 23 μR/h at 1 m) found ~15 ft W of 19H at center of 10- × 10-ft area measuring 29-54 μR/h	0.018-0.89	Generally 0.036-0.072 mrad/h; spots along bottom of bank 0.11-0.68 mrad/h; area 15 ft W of 19H measured 0.89 mrad/h at surface and 0.058 mrad/h at 1 m
18E	17-79	Generally 17-29 μR/h with one small area (<1 m^2) ranging from 29-79 μR/h at 19F; highest measurements: 79 μR/h at surface, 32 μR/h at 1 m	0.036-0.32	Generally 0.036-0.072 mrad/h; highest measurements at 19F: 0.32 mrad/h at surface, 0.072 mrad/h at 1 m
18C	11-23	Generally 17-23 μR/h, 11-17 μR/h along bank	0.036-0.072	Generally 0.036-0.072 mrad/h
16G	23-67	Generally 23-29 μR/h; elevated region (~35 × 5 ft) with spots (29-67 μR/h) extending from line ~5 ft S of 15H-17H N up steep bank; second elevated region (29 μR/h) extending ~15 ft W and 10 ft N of 17F	0.036-1.4	Generally 0.036-0.072 mrad/h; spotty contamination in N part of grid block ranging from 0.11-1.4 mrad/h; region W and N of 17F measured 0.11-0.29 mrad/h
16E	23-29	Generally 23-27 μR/h; elevated region at NE corner described in Block 16G; spots along 15F-D measuring 29 μR/h	0.036-0.13	Generally 0.036-0.072 mrad/h; spots along 15F-D measuring 0.13 mrad/h
16C	11-27	Generally 23-27 μR/h	0.018-0.072	Generally 0.018-0.072 mrad/h
14G	17-48	Generally 17-29 μR/h; 17-48 μR/h on bank; water standing at W end	0.036-0.43	Generally 0.036-0.072 mrad/h; 0.072-0.43 mrad/h on bank; water standing W end
14E	13-33	Generally ~23 μR/h; ranging to 29 μR/h in elevated region near center of block	0.036-0.16	Generally 0.036-0.072 mrad/h, ranging to 0.16 mrad/h in elevated region near center of block

Table 2 (continued)

	Gamma exposure rates		Beta-gamma dose rates	
Grid block[a]	Surface scan range (μR/h)	Comments on gamma scan	Surface scan range (mrad/h)	Comments on beta-gamma scan
14C	23-67	Generally 23-27 μR/h; spot 67 μR/h	0.036-0.27	Generally 0.036-0.072 mrad/h; spot 0.27 mrad/h
12G		Almost entirely covered by water; spots 32 and 36 μR/h.		
12E	13-29	Generally 17 μR/h; water covering most of N side	0.029-0.12	Generally 0.036-0.072 mrad/h; water covering most of N side
12C	11-23	Generally 11-23 μR/h	0.018-0.072	Generally 0.018-0.072 mrad/h
10G	17-61	Generally 17-23 μR/h		Beta-gamma scan impossible because of overgrown vegetation
10E	17-48	Generally 17-29 μR/h; 48 μR/h in erosion runnels N of washout channel	0.036-0.30	Generally 0.036-0.072 mrad/h; 0.072-0.29 mrad/h south of drainage channel with highest levels in erosion runs
10C	11-120	Generally 11-17 μR/h; spot 120 μR/h near 9B; elevated levels along south edge of block at base of bank	0.036-1.9	Generally 0.036-0.072 mrad/h; spot near 9B measured 1.9 mrad/h
8E	17-79	Generally 17-23 μR/h on flat area S of slope, 29-79 μR/h on N side of block in erosion runs; water in SE corner	0.036-1.6	0.036-0.072 mrad/h on S side of block; 1.6 mrad/h at 54-μR/h spot on berm; water in SE corner
8C	11-58	Generally 11-17 μR/h; high 58 μR/h	0.036-0.35	Generally 0.036-0.072 mrad/h; elevated levels along berm at W end of block; 0.35 mrad/h at 58-μR/h spot
6G	12-85	Generally 12-23 μR/h	0.036-0.56	
6E	23-92	Generally 23-29 μR/h S of slope on flat area; elevated levels on berm at E end of block and on slope at N end of block	0.036-0.68	Generally 0.036-0.072 mrad/h; 0.072-0.68 mrad/h in elevated area

Table 2 (continued)

Grid block[a]	Gamma exposure rates: Surface scan range (μR/h)	Gamma exposure rates: Comments on gamma scan	Beta-gamma dose rates: Surface scan range (mrad/h)	Beta-gamma dose rates: Comments on beta-gamma scan
6C	11-73	Generally 11-23 μR/h, with several elevated spots on berm at E end; highest spot, 73 μR/h; water and mud covered W end of block	0.036-0.36	0.11-0.36 mrad/h on berm; 0.11-0.25 mrad/h in 15-ft strip beside berm; water and mud covered W end of block
4G	12-23	Generally 12-13 μR/h in flat area, 13-17 μR/h on slope, 23 μR/h in erosion runs		0.040 mrad/h at 23-μR/h spot in erosion run
4E	17-44	Generally 17-23 μR/h; elevated region, 23-44 μR/h, along bottom of slope; water and mud covering S part of block prevented thorough survey	0.036-0.49	
4C	15-36	Block almost entirely covered with water and mud; surveyed area generally 15-17 μR/h, with elevated spots 21-36 μR/h		No beta-gamma survey because of water and mud
2G	15-42	Generally 15-17 μR/h, with elevated spots up to 42 μR/h; vegetation prevented thorough survey	0.036-1.4	
2E	11-23	Generally 15-17 μR/h; heavy vegetation prevented thorough survey	0.036-0.072	Very limited beta-gamma survey because of vegetation
2C	15-23	Mostly covered by water and mud. Generally 15-17 μR/h, with one spot 23 μR/h		No beta-gamma survey because of mud and water
West end		Slope at west end generally 29-42 μR/h, with some spots 48 μR/h		

[a]Grid blocks are shown in Figs. 9 and 10.

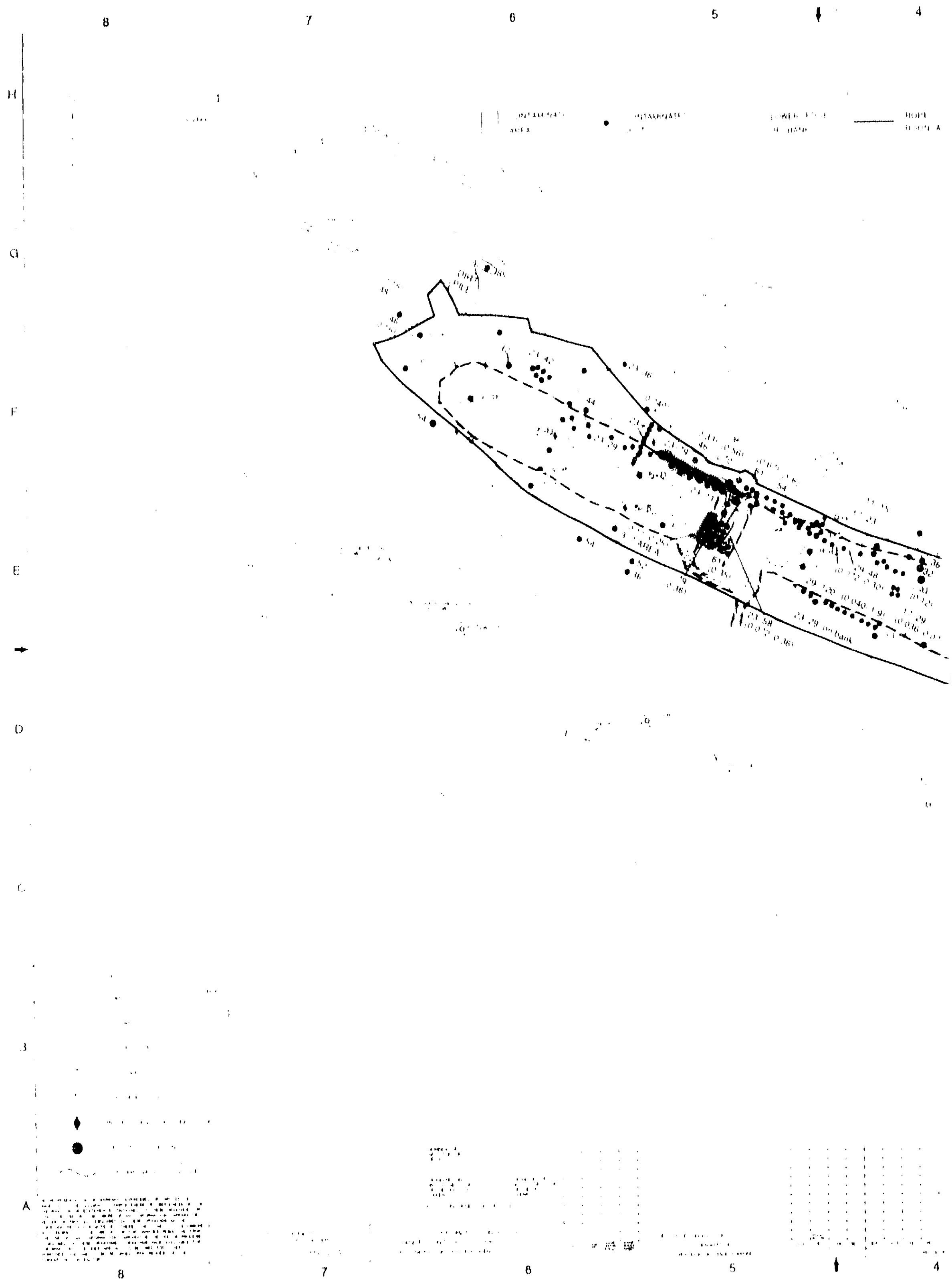
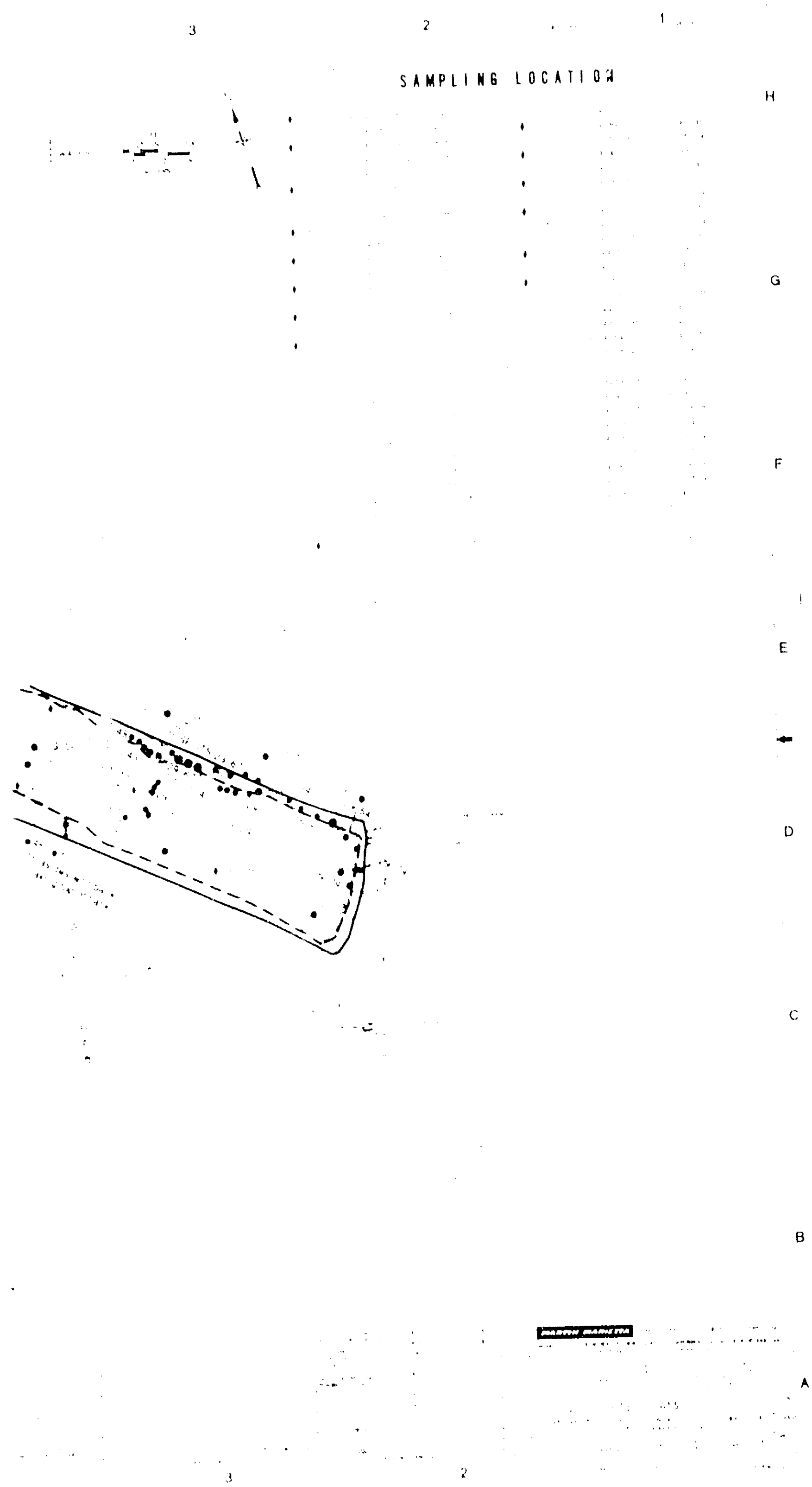


Fig. 11. Elevated surface gamma exposure rates (
(mrad/h in parentheses) at the K-1407-C Retention Basin



R/h) and beta-gamma dose rates
(September 1989 to January 1990).

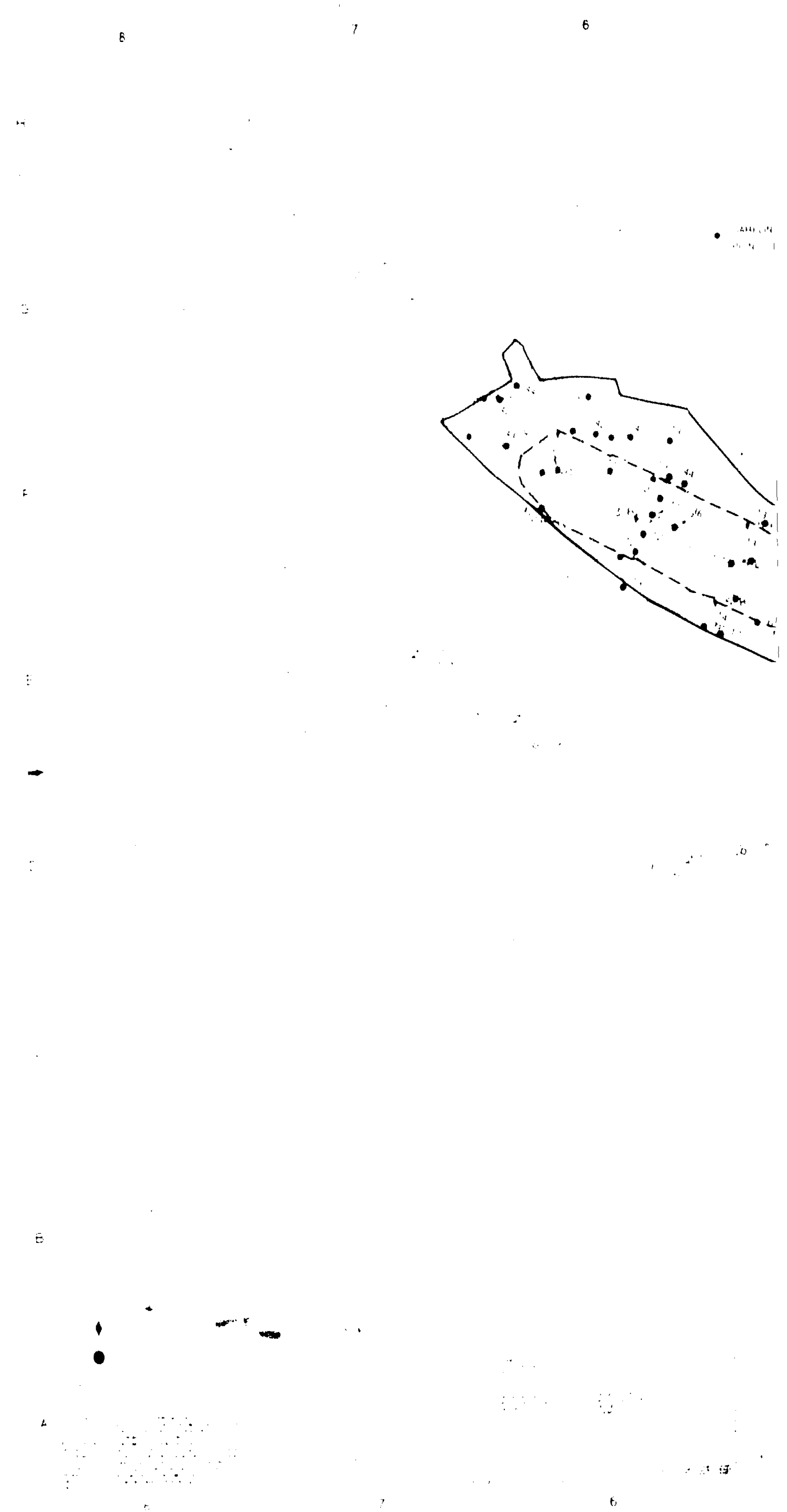
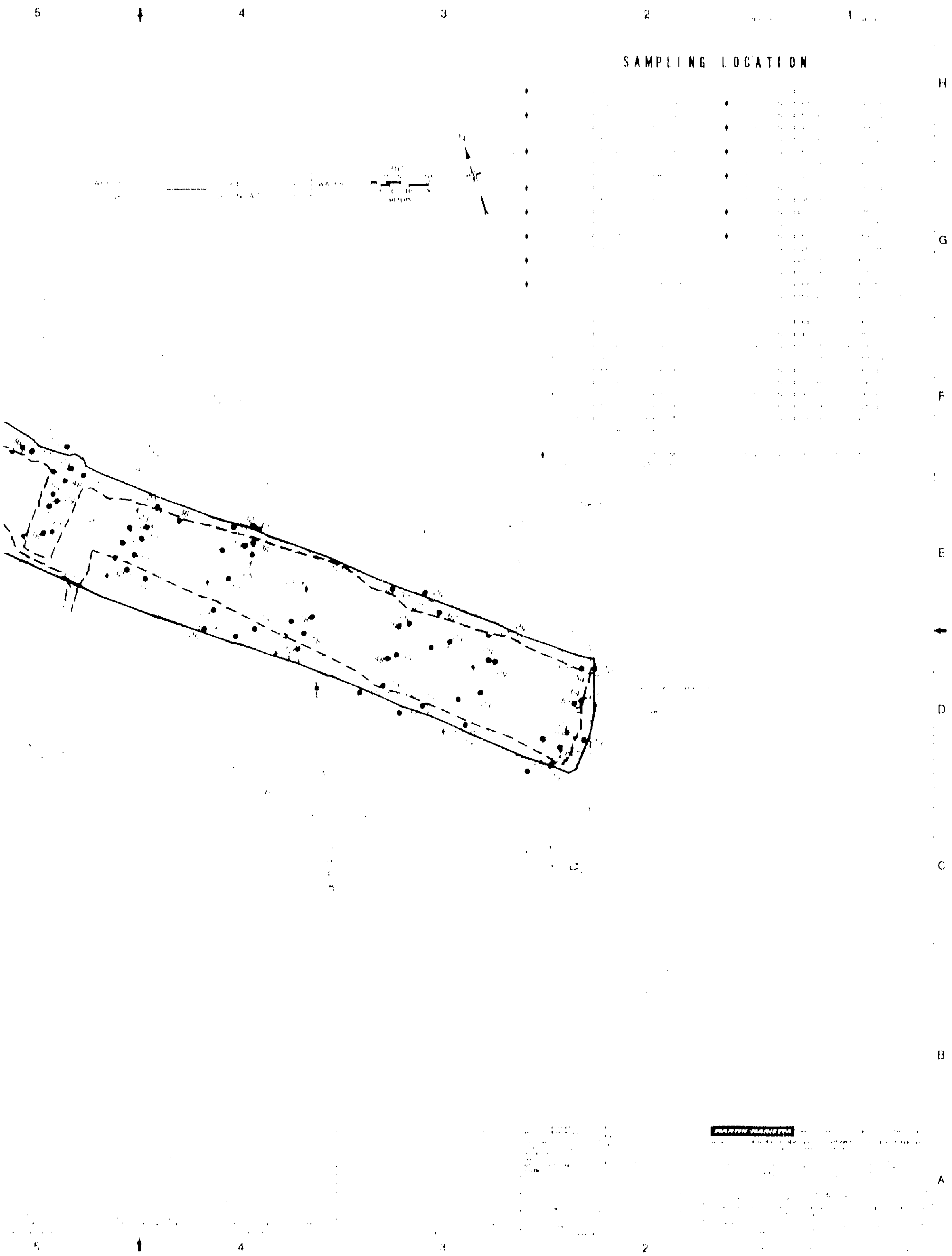


Fig. 12. Surface gamma (
Retention Basin (September 19



xposure rates (μR/h) at sampling points at the K-1407-C
89 to January 1990).

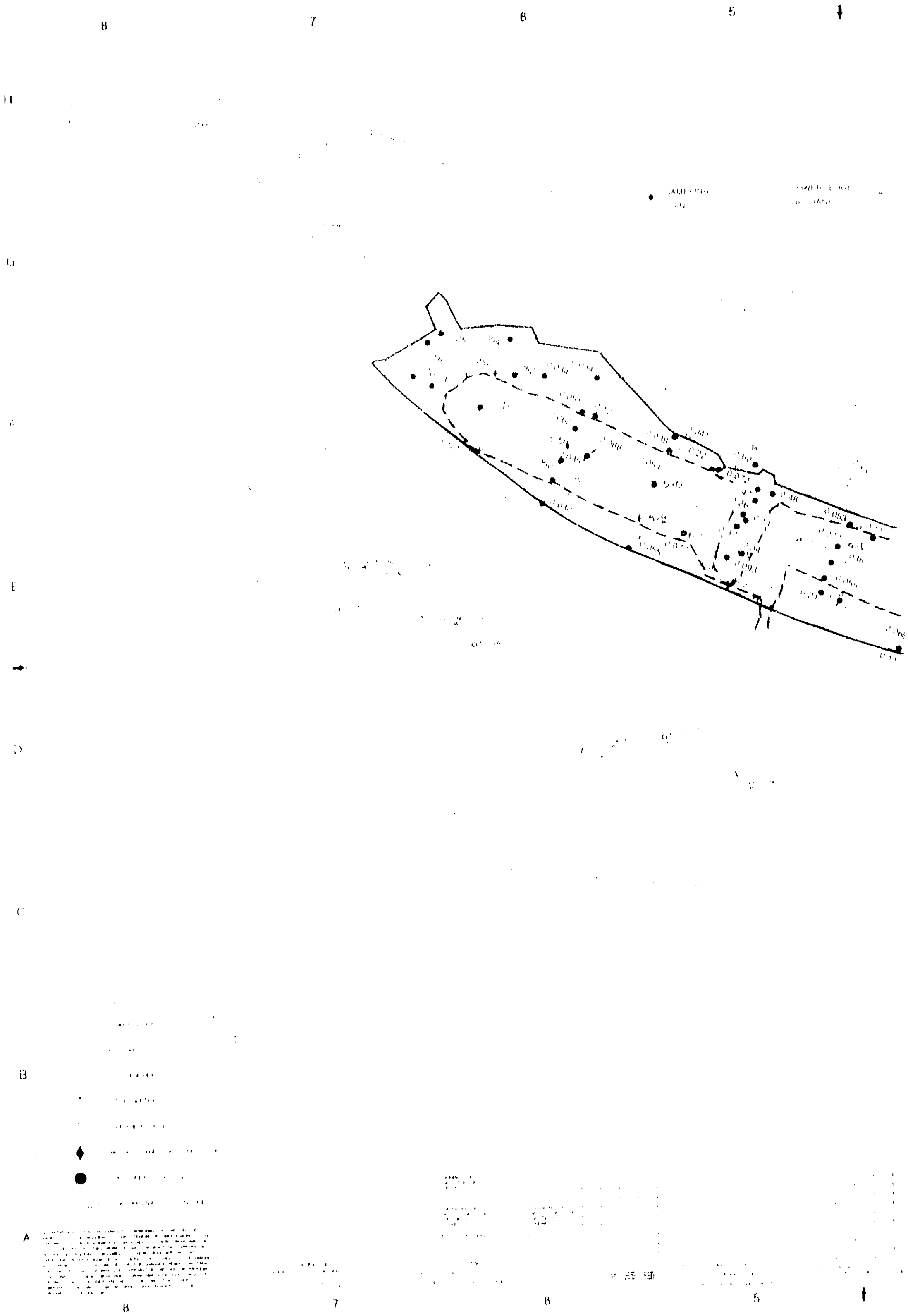
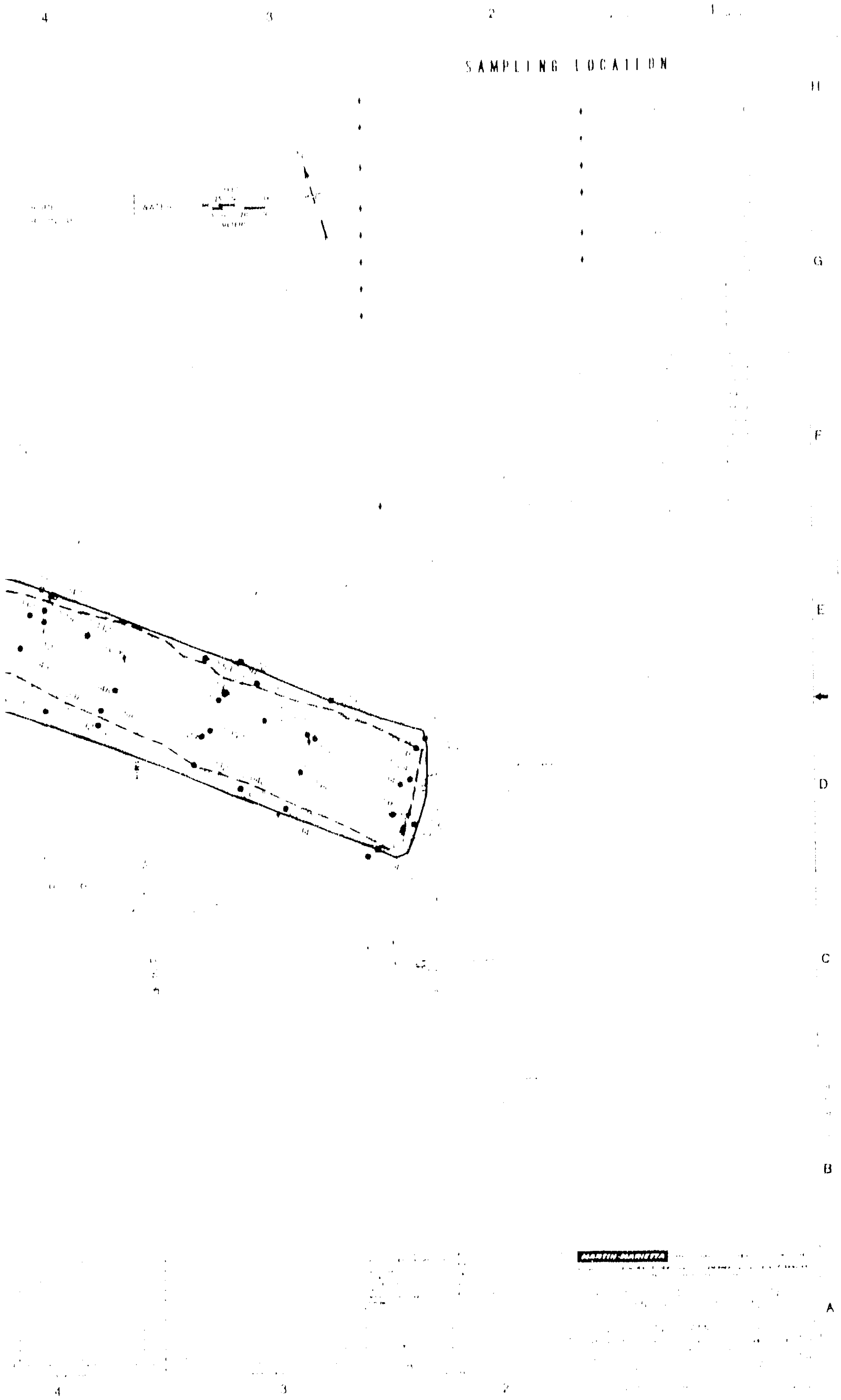


Fig. 13. Surface beta-gamma dose rates (m
Retention Basin (September 1989 to January 19



1/h) at sampling points at the K 1407-C
).

3.6 SIGNIFICANCE OF FIELD MEASUREMENTS

Survey results show widespread residual radioactivity at the K-1407-C Retention Basin site. Typical surface gamma exposure rates in the vicinity of the basin ranged from 11 to 15 μR/h, while accessible areas in the basin ranged from 11 to 120 μR/h, with all grid blocks exceeding typical background levels. Numerous spots of surface contamination ranging from 23 to 79 μR/h were primarily concentrated on the north side of the basin at the base of the bank, extending up the bank, and along the top of the earthen dike that bisects the basin. Contaminants consisted of alpha, beta, and gamma emitters; at least a part of the alpha contamination was transferable to boots and equipment.

Typical surface beta-gamma dose rates ranged from 0.036 to 0.072 mrad/h, with highest measured levels reaching 1.9 mrad/h (25 to 50 times typical levels). Surface beta-gamma scan ranges exceeded typical background levels in 80% of the grid blocks surveyed.

Contamination in the area is not entirely confined to the basin. Nine contaminated spots ranging from 36 to 85 μR/h were identified outside the rope boundary. Another spot measuring 17 to 36 μR/h (0.18 mrad/h) was identified on the road north of the basin.

Approximately 25% of the basin was inaccessible during the period of this survey because of standing water, heavy vegetation, or steep terrain. It is highly probable that additional contamination is located in the inaccessible areas.

3.7 DATA LIMITATIONS

Limitations associated with the sampling of the K-1407-C Retention Basin are related to the ability of the investigation to represent adequately the distribution of contaminants in the soil. One of the berms constructed during the sludge removal remains across the west end of the retention basin. This berm was produced by mounding soil from the floor of the retention basin; therefore, it is not reasonable to assume a correlation between samples taken from the berm and other locations. In addition, it should be noted that sample depth does not correlate to the soil's original depth beneath the bottom of the sludge. During removal of the sludge, the amount of material excavated relative to the original retention basin bottom varied; therefore, samples of the same depth cannot be strictly correlated in relation to their proximity to the source of contamination. Because samples were not taken below 18 in., the depth to which contamination extends is unknown. Finally, because no background samples are available, it is difficult to differentiate between naturally occurring regional background metal concentrations and metal concentrations related to site operations.

4. QUALITY ASSURANCE/QUALITY CONTROL

4.1 DATA QUALITY OBJECTIVES

The data quality objectives for the K-1407-C Retention Basin are to obtain samples representative of the soil beneath the site. A review of the operations conducted at the site revealed that the site was used for storing sludge containing metallic or radioactive compounds. Although the sludge was removed, there was insufficient information on the site to determine the completeness of the sludge removal process or the effects of leaching from the sludge prior to removal. There is no evidence of organic contamination at the site; thus no organic analyses were necessary. Because of the nature of the site, soil was the only medium sampled. In addition to the soil samples, various QA samples were analyzed. These samples included equipment rinsates used to determine the adequacy of field cleaning procedures and field blanks to assure that water used in the field was not contaminated. Matrix spike samples were analyzed to determine the effectiveness of analytical preparation methodology. The samples were collected, prepared, and shipped following accepted EPA methodology. The metal analyses were performed according to accepted EPA protocol. There is no established EPA protocol for radiological samples. The analytical data for K-1407-C Retention Basin soil is presented in Appendix B.

4.2 ANALYTICAL METHODOLOGY

Samples were analyzed for metals (including mercury) by the Analytical Chemistry Department of the Oak Ridge K-25 Site and for radiological components by the ORNL Analytical Chemistry Division. Table 3 is a summary of the number and the types of analyses performed on samples as part of the K-1407 Retention Basin investigation.

Table 3. Summary of K-1407-C analyses

Analysis	Soil samples		Water samples	
	Samples	Matrix samples	Equipment rinsates	Field blanks
ICP metals	44	7	0	0
Mercury	47	4	0	0
Radiochemical	222	0	16	14

4.2.1 Inorganic

As stated in Sect. 4.1, the site was used for the storage of metal-contaminated sludge; consequently, the presence of metallic contamination was a concern in the site investigation. The analytical method EPA-6010 (SW-846) was used for the determination of all metals of concern except mercury. Mercury was determined by the analytical method EPA-7471 (also SW-846).

4.2.2 Radiochemical

Radiochemical contamination was determined to be the major concern for the K-1407-C site because of the storage of major quantities of potassium hydroxide scrubber sludge that contained radiochemical contamination; therefore, all samples collected were analyzed for radiochemical contamination. The aqueous QA samples (equipment rinsates and field blanks) were preserved by lowering the pH of the samples to <2.0 using HNO_3. The procedures for specific radiochemical analytes are given in Table 4. Since there are no EPA-approved procedures for most of the specific radiochemical analytes, the samples were analyzed using ORNL radiochemical methods.

Table 4. Radiochemical analysis methodologies

Analyte	Analytical method
^{241}Am	ORNL 231034
^{137}Cs	EPA 905.0
^{60}Co	EPA 905.0
^{244}Cm	ORNL 231034
^{237}Np	ORNL 231535
^{238}Pu	ORNL 231625
^{239}Pu	ORNL 231625
^{90}Sr	EPA 905.0
^{99}Tc	ORNL 221833
^{234}U	ORNL 231933
^{238}U	ORNL 231933
Alpha	EPA 900
Beta	EPA 900
Gamma	EPA 901.1

4.3 HOLDING TIMES

Samples analyzed for metals by inductively coupled plasma (ICP) have holding times of 6 months. None of the samples for ICP metals exceeded holding time limitations. Because mercury is a volatile metal, the holding time for samples scheduled for mercury analyses is 28 days. Of the 47 samples analyzed for mercury, 6 were analyzed beyond the 28-day holding time. These samples are identified in Table 5.

Table 5. Mercury analyses exceeding holding times

Sample location	Holding time (days)
09F, 0–6 in.	29
09F, 6–12 in.	29
09F, 12–18 in.	29
07D, 0–6 in.	30
07D, 6–12 in.	30
07D, 12–18 in.	30

4.4 EQUIPMENT RINSATES

Equipment rinsates are QA samples designed to demonstrate the cleanliness of equipment used for sampling. They are used to determine the potential for cross-contamination of samples. These samples are water samples obtained by washing equipment with clean water immediately after the completion of the cleaning process. These samples are preserved according to EPA guidelines for aqueous samples and are then analyzed for all parameters of interest. For samples taken from the K-1407-C Retention Basin, equipment rinsates were collected for radiochemical analyses. No equipment rinsates were collected for samples submitted for metals analyses.

4.4.1 Radiochemical

Only five of the radiochemical analytes showed sample activity at levels which could indicate potential problems from contamination between samples (cross-contamination). They are gross alpha, gross beta, ^{99}Tc, ^{238}U, and ^{234}U. Equipment rinsate results and the corresponding sample results for those radiochemical analytes are presented in Figs. 14 to 18. The data are plotted chronologically in order of sampling. The figures show that equipment rinsate data are only available for a limited number of samples analyzed for ^{99}Tc, ^{238}U, and ^{234}U. Data are available for alpha and beta throughout the sampling process. The figures show that radiochemical activity in the equipment rinsates is insignificant relative to radiochemical levels in the samples, so no sample-to-sample contamination is indicated.

4.4.2 Inorganic

As stated previously, no equipment rinsates were collected for samples analyzed for metals. For five metals (nickel, chromium, lead, uranium, and mercury) there were some samples at elevated levels following samples at higher levels. The possibility of cross-contamination due to the previous high sample cannot be ruled out without the presence of rinsate data. The sample data for these five metals are shown in Figs. 19 to 23. The data are plotted chronologically in order of sampling. The correlation between sample order number and sample identification is given in Table 6 for nickel, chromium, lead, and uranium and in Table 7 for mercury.

DWG. NO. K/G-91-1443
(U)

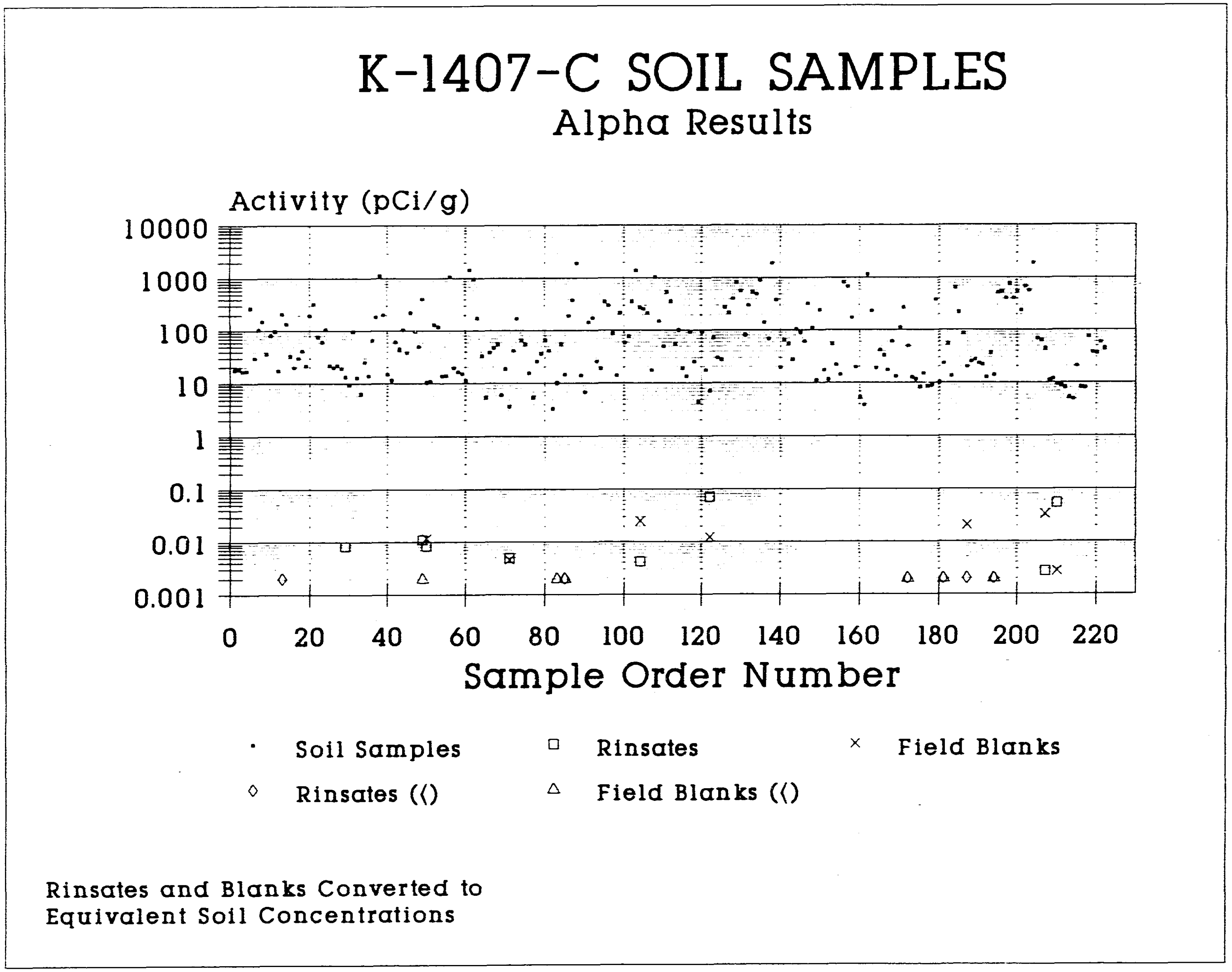


Fig. 14. Comparison of alpha results for rinsates, blanks, and samples.

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(U)

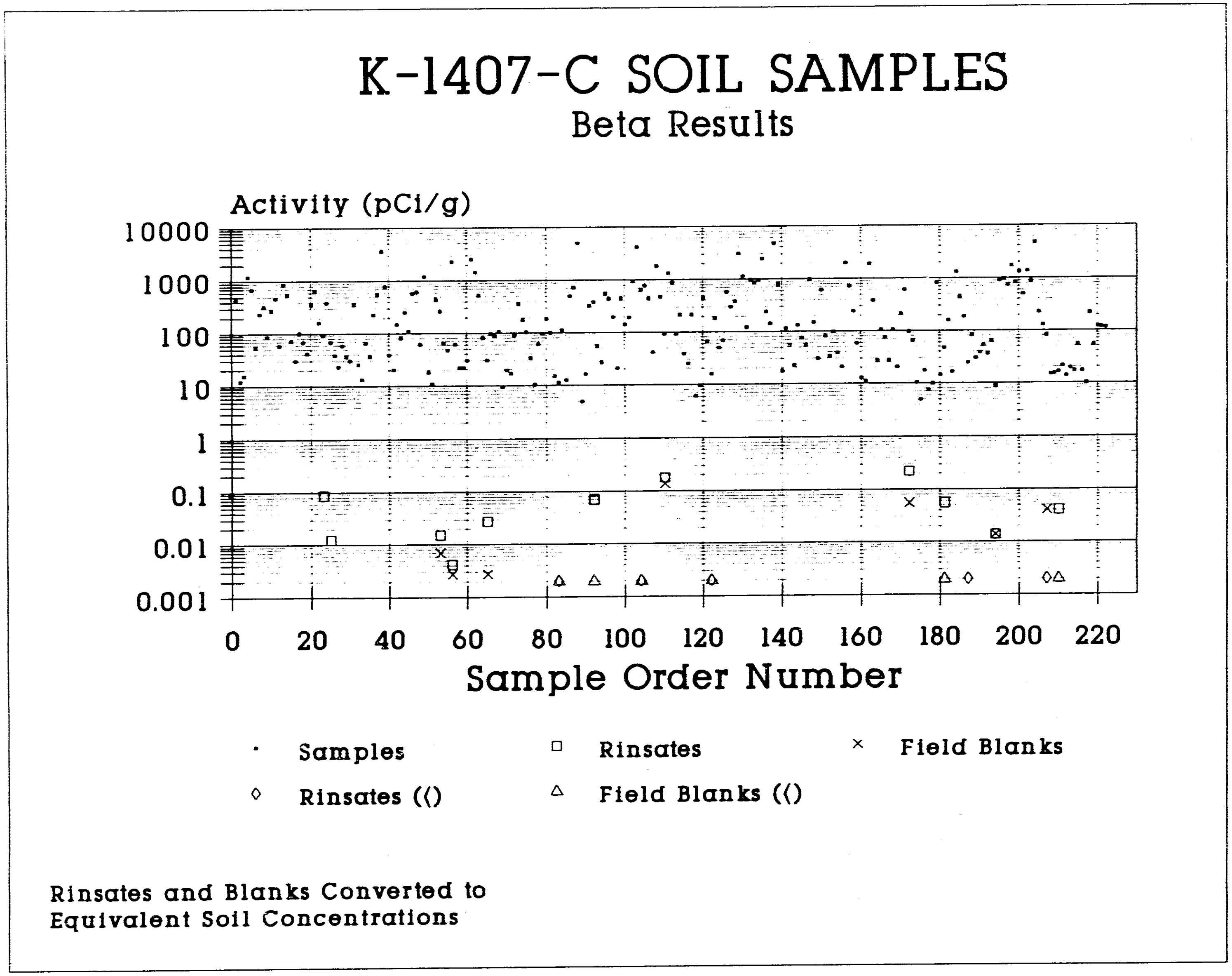

Fig. 15. Comparison of beta results for rinsates, blanks, and samples.

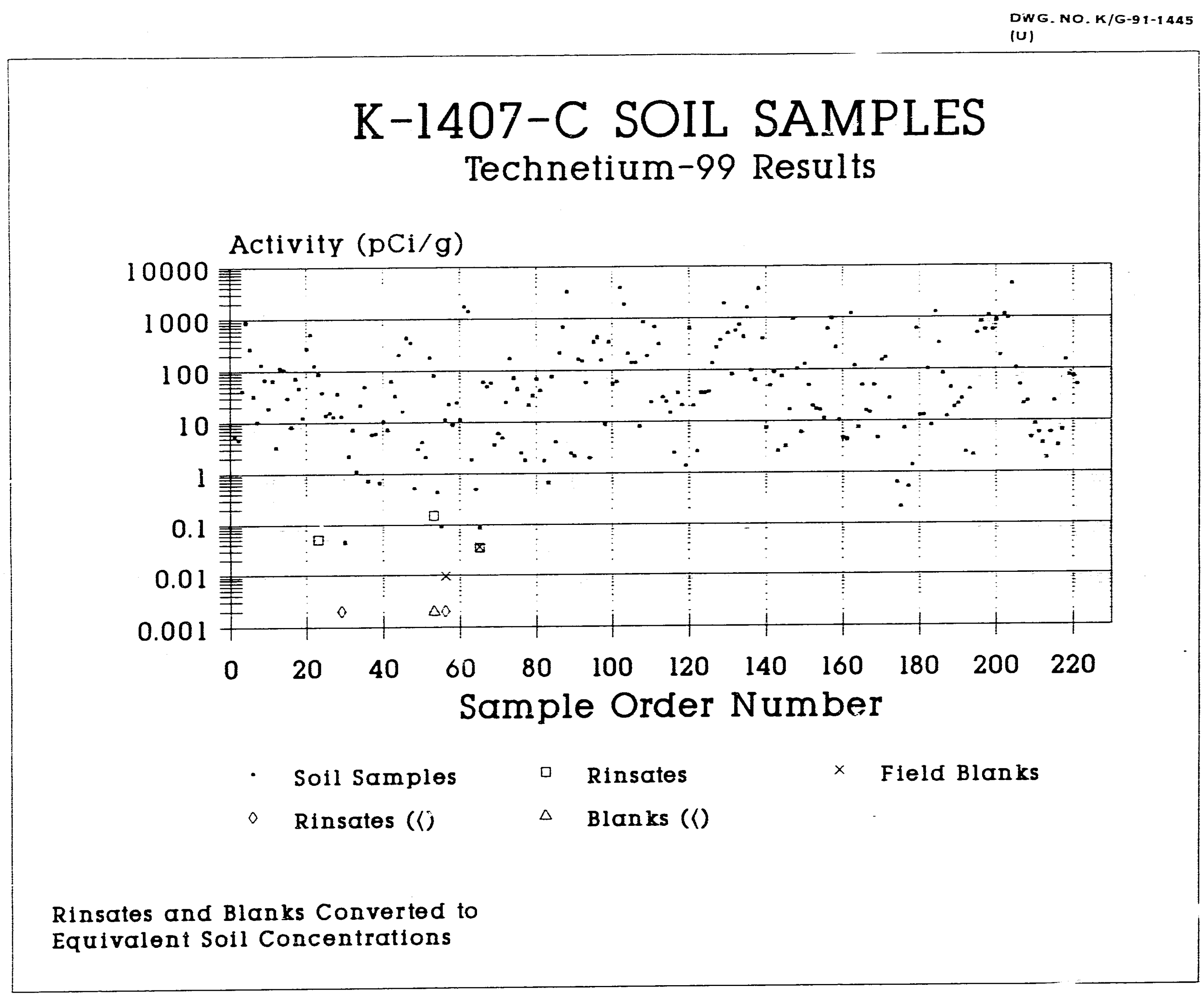

Fig. 16. Comparison of ^{99}Tc results for rinsates, blanks, and samples.

DWG. NO. K/G-91-1446
(U)

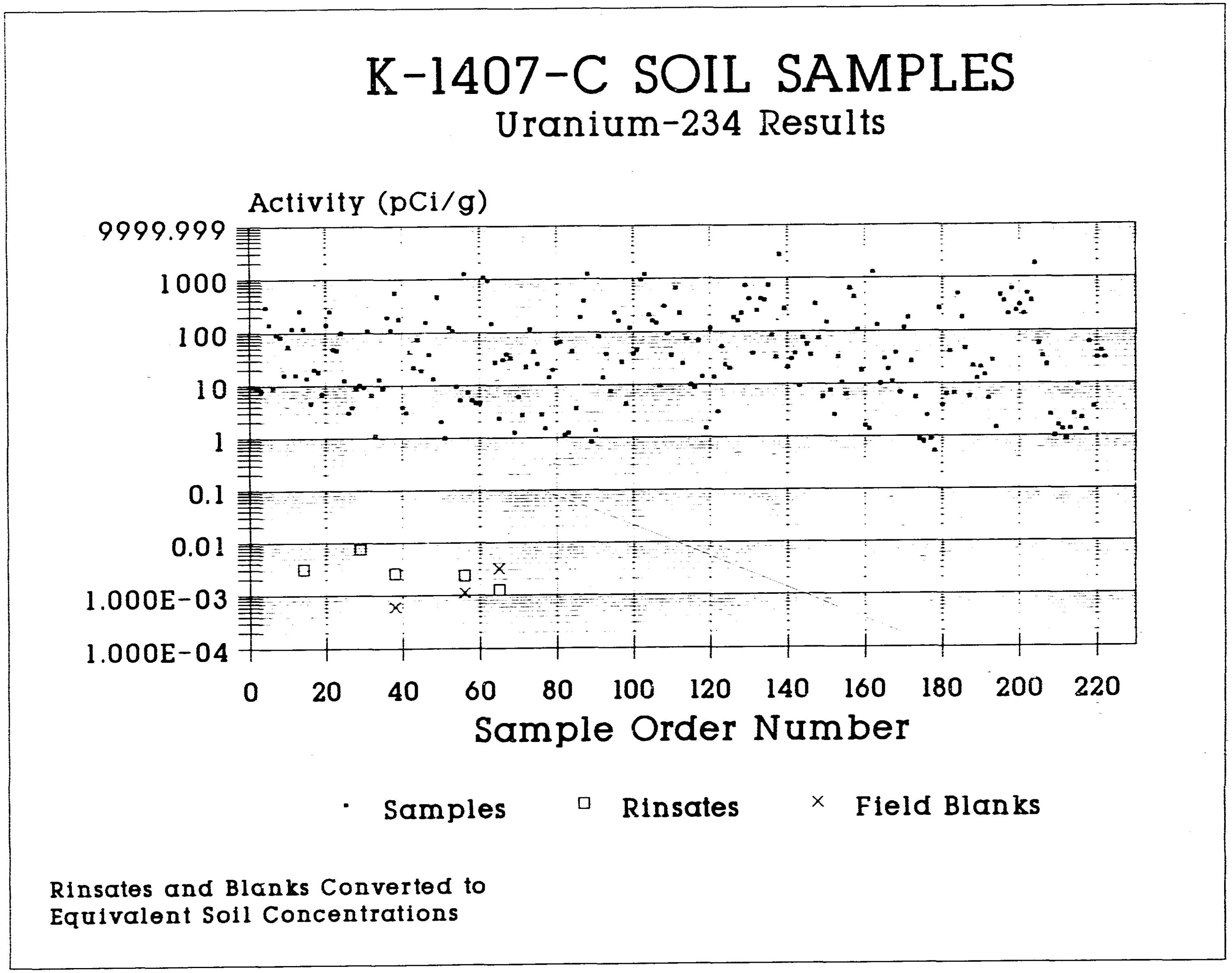

Fig. 17. Comparison of ^{234}U results for rinsates, blanks, and samples.

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(U)

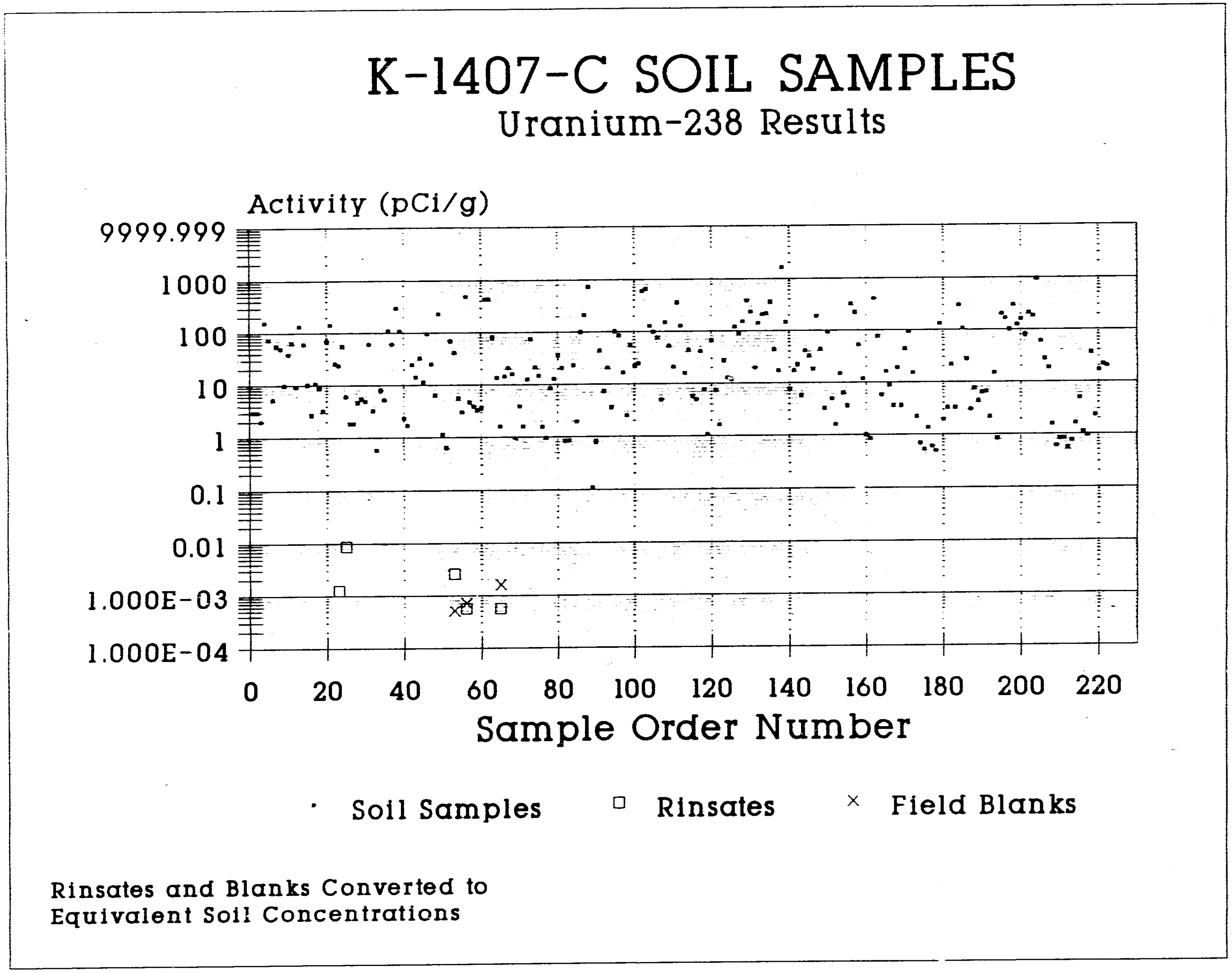

Fig. 18. Comparison of ^{238}U results for rinsates, blanks, and samples.

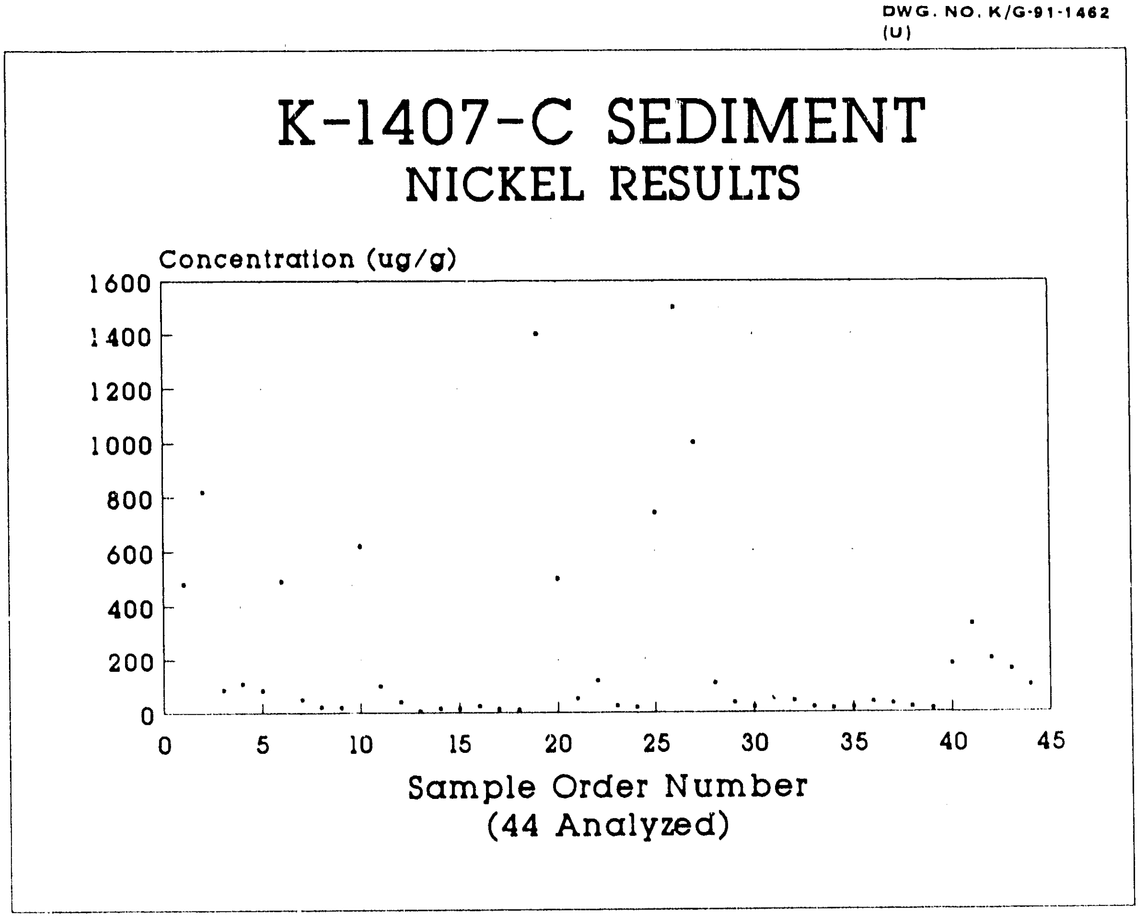

Fig. 19. Nickel results.

DWG. NO. K/G-91-1463
(U)

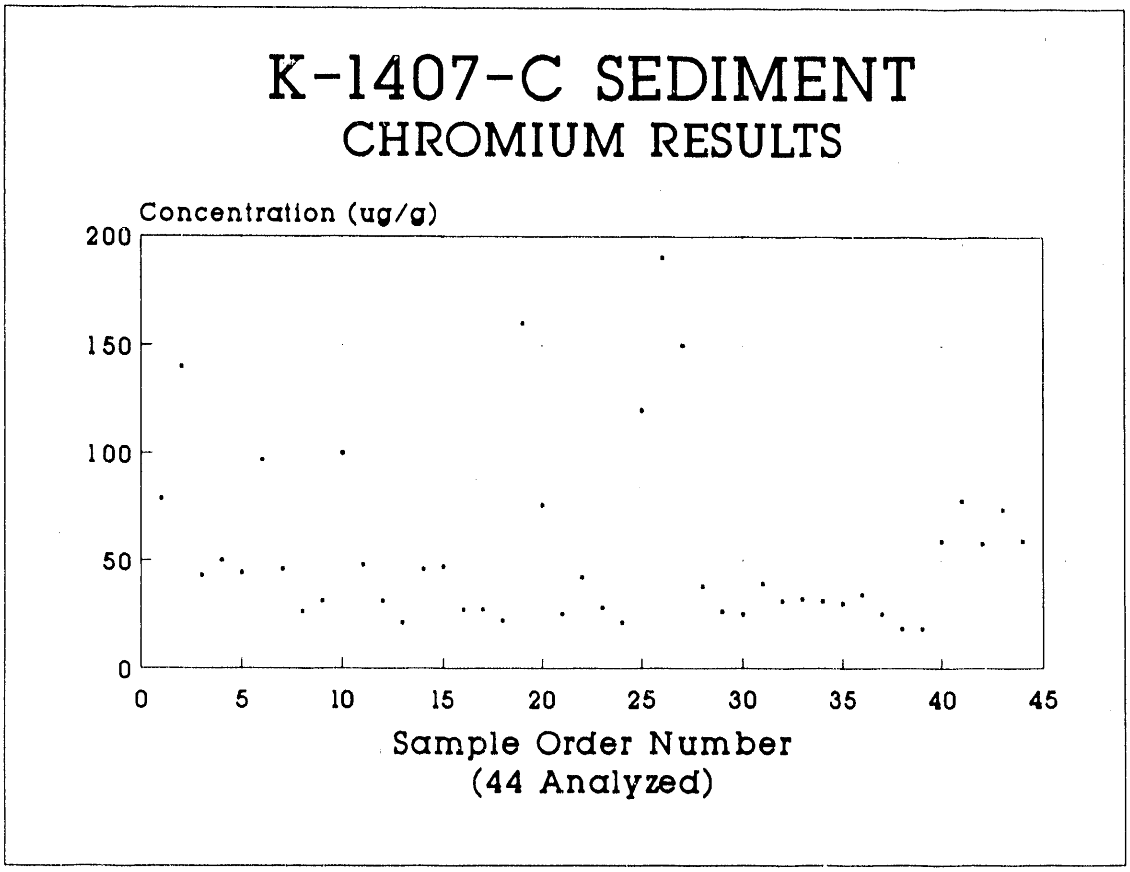

Fig. 20. Chromium results.

DWG. NO. K/G-91-1464
(U)

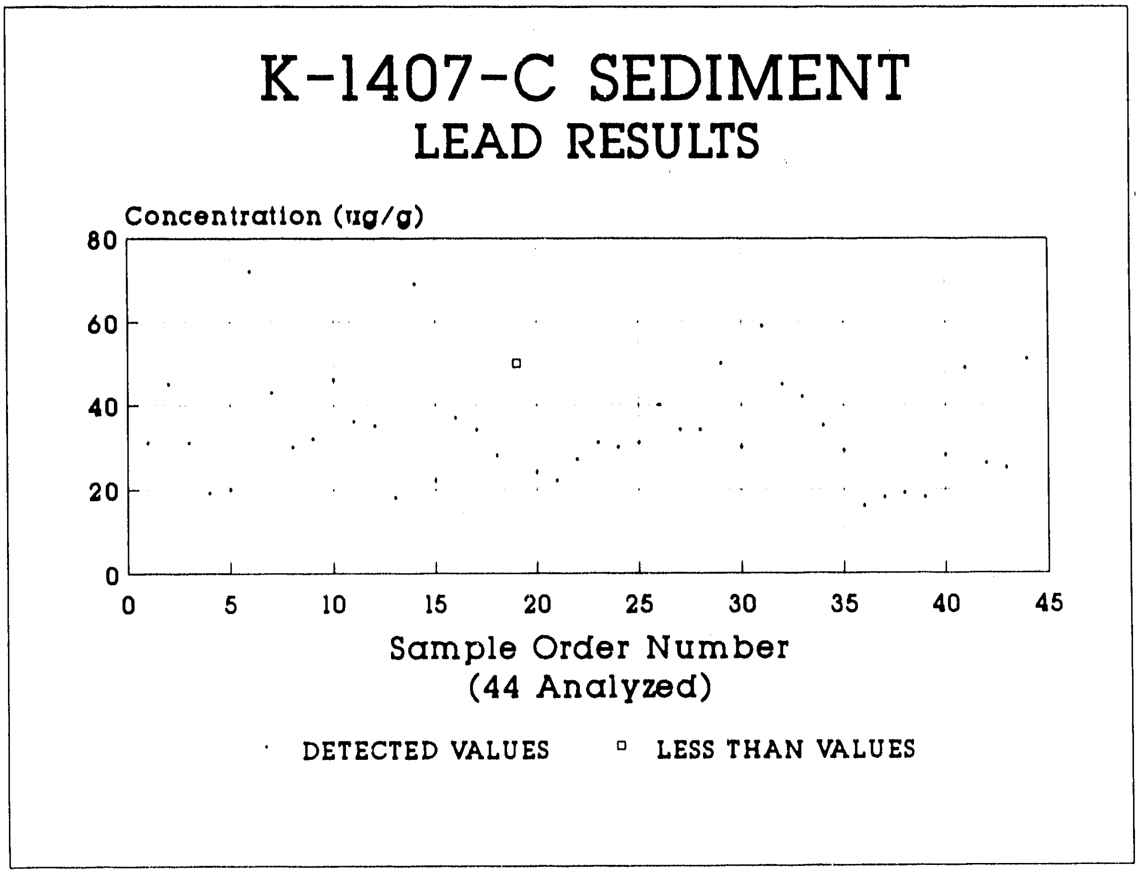

Fig. 21. Lead results.

DWG. NO. K/G-91-1465
(U)

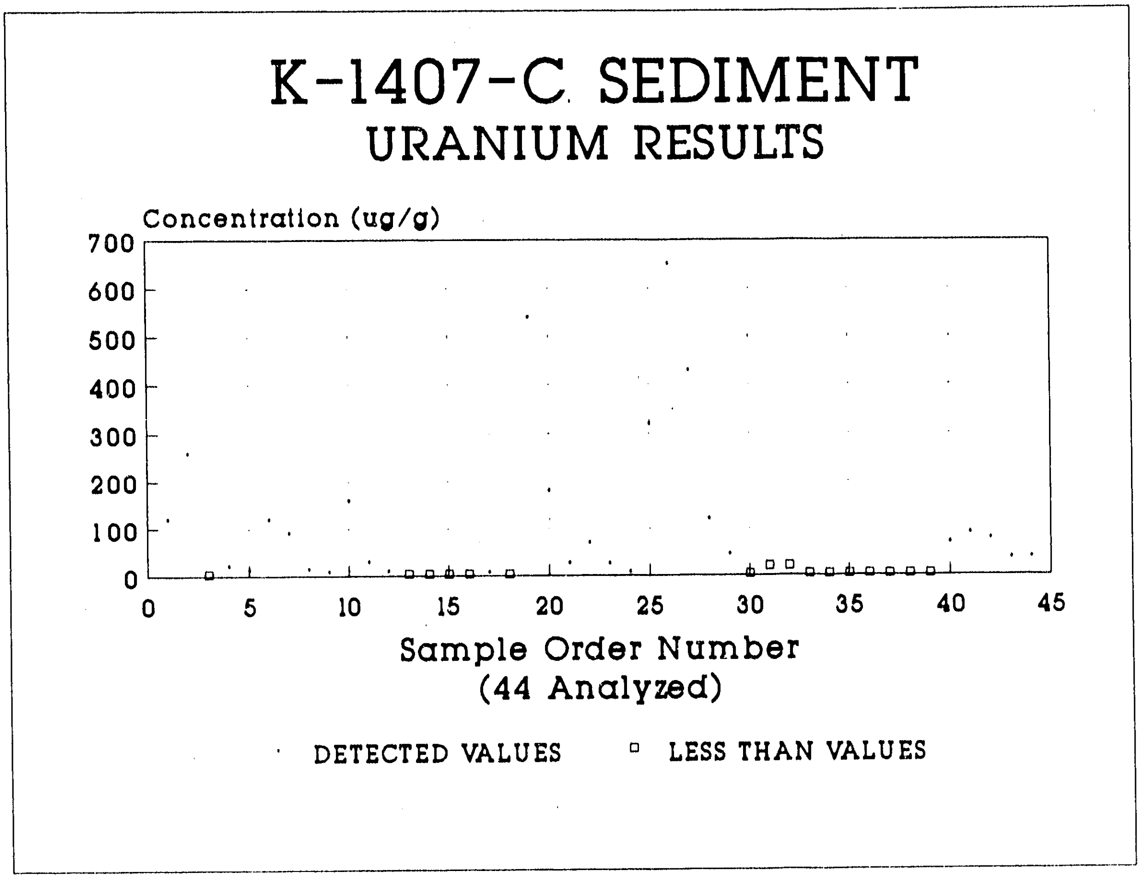

Fig. 22. Uranium results.

DWG. NO. K/G-91-1466
(U)

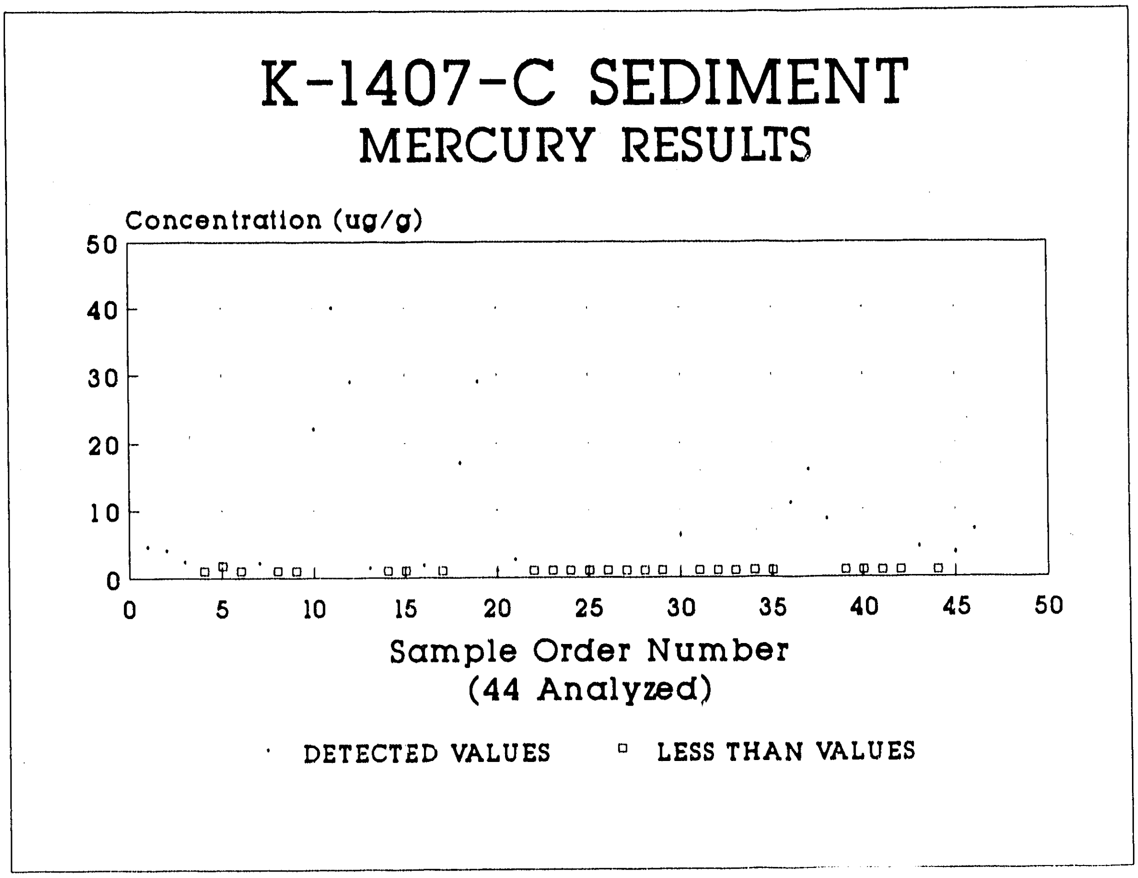

Fig. 23. Mercury results.

Table 6. Metals analysis sample log

Order number	Sample location	Sample depth (in.)
1	19D	6
2	17F	6
3	17B	6
4	19D	12
5	19D	18
6	17F	12
7	17F	18
8	17B	12
9	17B	18
10	15D	6
11	11D	6
12	11D	12
13	11D	18
14	15D	18
15	15D	12
16	13B	6
17	13B	12
18	13B	18
19	9B	6
20	9B	12
21	9B	18
22	9F	6
23	9F	12
24	9F	18
25	7D	6
26	7D	12
27	7D	18
28	5F	6
29	5F	12
30	5F	18
31	1F	6
32	1F	12
33	13B	6
34	13B	12
35	13B	18
36	3D	6
37	5B	6
38	5B	12
39	5B	18
40	2E	6
41	2E	12
42	1D	6
43	13E	18
44	13F	18

Table 7. Mercury analysis sample log

Order number	Sample location	Sample depth (in.)
1	19D	12
2	19D	18
3	17F	12
4	17F	18
5	17B	12
6	17B	18
7	9F	6
8	9F	12
9	9F	18
10	7D	6
11	7D	12
12	7D	18
13	5F	6
14	5F	12
15	5F	18
16	1F	6
17	1F	12
18	19D	6
19	17F	6
20	17B	6
21	15F-B	6
22	15F-B	12
23	15F-B	18
24	13B	6
25	13B	12
26	13B	18
27	11D	6
28	11D	12
29	11D	18
30	9B	6
31	9B	12
32	9B	18
33	9F[a]	6
34	9F[a]	12
35	9F[a]	18
36	7D[a]	6
37	7D[a]	12
38	7D[a]	18
39	3D	6
40	5B	6
41	5B	12
42	5B	18
43	2E	6
44	2E	12
45	1D	6
46	13E	18
47	13F	18

[a]Field duplicate.

The following show the possibility of contamination from preceding samples, which can be noted from the plots:

1. Nickel — samples with order numbers 20 (BH038ASO12B) and 27 (BH045SO18B).
2. Chromium — samples with order numbers 20 (BH038ASO12B) and 27 (BH045SO18B).
3. Lead — several samples exhibiting the pattern described above with levels above Table 2.2 of the General Document.[14]
4. Uranium — samples with order numbers 20 (BH038ASO12B) and 27 (BH045SO18B).
5. Mercury — sample with order number 12 (BH045SO18B), somewhat elevated and following a high sample, but below guideline values of Table 2.2 of the General Document and thus of no significance.

4.5 FIELD BLANKS

Field blanks are used during an investigation to determine if contamination found in equipment rinsates resulted from the use of contaminated rinse water. As with equipment rinsates, field blank data are only available for radiochemical analytes.

The field blank data for radiochemical analytes are shown in Figs. 14 to 20 along with the corresponding equipment rinsate data and sample data. No radiochemical contamination is present in any of the field blank samples.

4.6 MATRIX SPIKE RECOVERIES

Matrix spikes are added to samples that require some form of extraction as a preparation for analysis. Matrix spikes are solutions of known concentrations of specific representative compounds added to samples in specific amounts. Comparison of the measured concentration of the compounds in the spiked samples and the corresponding original samples is used to determine the effect of the sample matrix on the extraction efficiency.

4.6.1 Inorganic Matrix Spikes

Inorganic matrix spike solutions were added to samples to check the recovery of the metallic analytes analyzed by ICP. Matrix spikes of cadmium, chromium, copper, lead, manganese, nickel, and zinc were added although not every matrix spike sample was analyzed for all seven elements. Matrix spikes were analyzed on 4 of the 47 samples collected for mercury analysis. Figure 24 shows the matrix spike recoveries for both ICP metals and mercury. The sample order number on the plot is the order number correlated to the sample identification in Table 6 for ICP metals or Table 7 for mercury. All matrix spikes for ICP metals and mercury were within the acceptable limits of 75 to 125% recovery.

DWG. NO. K/G-91-1442
(U)

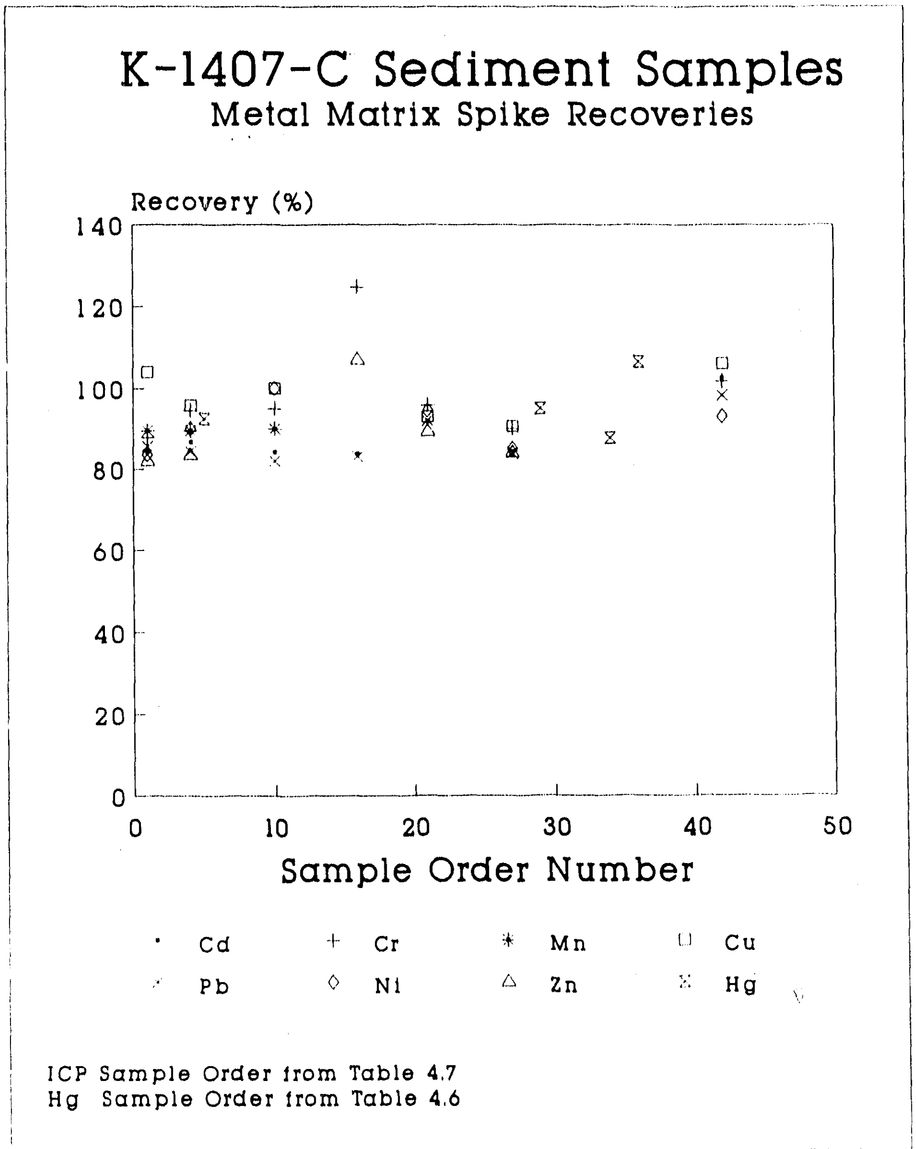

Fig. 24. Metal matrix spike recoveries.

4.6.2 Radiochemical Matrix Spikes

No matrix data exist for radiochemical analytes, and thus no estimate of matrix effects on the extraction of the analytes can be determined.

4.7 SUMMARY OF RESULTS

4.7.1 Inorganic

All metal analyses (excluding mercury) were performed within recognized holding times, and matrix spike data were within acceptable limits. Six of the 47 mercury analyses were performed outside the established holding times. However, they were only 2 or 3 days past the 28-day holding time, and the quality of the data would not be expected to be reduced. The mercury matrix spike data are within acceptable limits. Because of the absence of equipment rinsate data for metal and mercury samples, contamination of samples from incompletely cleaned equipment is a possibility, as described in Sect. 4.2.4.1. Those data are of questionable quality and should be used only as estimated concentrations if other information is available which indicates the measurements to be correct.

4.7.2 Radiochemical

A complete evaluation of the K-1407-C site is impossible because of the lack of complete radiochemical data. Although there are no established holding times for radiochemical analyses, some holding times have approached or exceeded 1 year, and data from those analyses should be used cautiously. Equipment rinsates collected for the early samples show no evidence of sample-to-sample contamination for any of the radiochemical analytes. Data were not present for each individual analyte for the entire sampling period. The alpha and beta activity data for equipment rinsate samples collected over the entire sampling period, however, indicate no sample-to-sample contamination for any of the alpha- or beta-emitting radiochemical analytes. Since no radiochemical matrix spike data are available, there is no way to determine whether preparation procedures for the analytes are free from matrix interference effects. Because of the length of time for analysis and the lack of any data that would show matrix effects on the radiochemical analyses, the data should be considered as estimates only. They could be used for determining general trends or potential locations to concentrate on in future sampling, but they should not be used for determining exact concentrations.

5. PRELIMINARY RISK ASSESSMENT

This chapter examines the ability of the Phase 1 investigation to provide the data necessary to conduct a comprehensive assessment of the potential adverse human health effects from exposure to soil contamination at the K-1407-C Retention Basin. A conservative human health-based screening of soil contaminant concentrations is employed to indicate the contaminants that pose the greatest potential for producing adverse human health effects. This screening method is used to evaluate contaminant distribution and the effectiveness of the Phase 1 investigation to adequately characterize the extent of contamination at the site. Additionally, this chapter includes an evaluation of the ability of the data to characterize contamination as it relates to the environmental and exposure pathways that influence the nature of exposure. This chapter is concluded with a summarization of the Phase 1 data limitations affecting the production of a baseline risk assessment.

5.1 DATA EVALUATION/POTENTIAL CONTAMINANTS OF CONCERN

The evaluation of data for risk assessment is an iterative process that involves not only following set procedures, but also making decisions and assumptions concerning the data based on historical information, disposal records, and "best professional judgment." Soil data for the K-1407-C Retention Basin were compiled by the data base manager in accordance with the specifications outlined in the *Oak Ridge Gaseous Diffusion Plant Remedial Action Program Data Management Plan*, K/HS-232, Revision 1.[15] The following discussion addresses the primary steps in the evaluation of data for use in a risk assessment, with regard to the appropriateness of the data and identification of data limitations. Also, as a result of the data evaluation, a list of chemicals of potential concern has been compiled.

Evaluation of the analytical methods was the first step in the data evaluation process. Specificity, sensitivity, accuracy, and precision of the instruments and methods used for sample analysis were factors considered in determining the appropriateness and validity of the laboratory data. For Contract Laboratory Program analytical results, qualifiers and codes were attached to data by either the laboratory or by data validation personnel. These codes are related to QA/QC controls or question the reported chemical identities and concentrations. All qualifiers and codes were addressed before a chemical was included in the screening assessment.

The potential for the adulteration of soil samples due to collection practices or laboratory preparation is evaluated prior to the use of data in risk assessment. The assessment of the likelihood of sample contamination during collection is addressed in Chap. 4. Contamination of samples during laboratory procedures is not applicable to the K-1407-C soil data because organics that are the most common laboratory contaminants were not analyzed for in soil samples.

A comparison of sample concentrations to background concentrations is essential to identify indigenous constituents detected in site samples. The operational history of the

K-1407-C Retention Basin indicates that it is the likely source of radionuclides detected in soil samples. However, the source of the nonradioactive metals detected in soil from the retention basin cannot be absolutely determined because most of the metals are indigenous in regional soils. The concentrations of chromium, mercury, and nickel are highest in samples taken from the east end, where flow entered the retention basin, suggesting site activities as the source. However, there is no indication of a correlation between metal and radionuclide distributions, which might be expected if metals were site-related. The inability to distinguish between site-related and naturally occurring metal concentrations should not have a significant influence on the present evaluation. Additionally, because the source of radionuclides can be related to site operations and because the source of nonradioactive metals has not been definitively identified, it is logical to place a greater emphasis on the screening of radionuclides.

A primary goal of the Phase 1 review is to determine the ability of the analytical data to represent accurately the nature (contaminants and their concentrations) and extent of the contaminants in soil at the K-1407-C Retention Basin. The sampling array is believed to have been adequate to identify the analytes present in K-1407-C soil. However, because there are no data below a depth of 18 in., the assessment of potential health hazards is limited.

The potential contaminants of concern for the K-1407-C Retention Basin were derived using the methodology outlined in Chap. 5 of *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual*, EPA/540/1-89/002, December 1989.[16] The following is a list of potential contaminants of concern detected in the soil at K-1407-C.

Radionuclides

Americium-241	Neptunium-237	Technetium-99
Cesium-137	Plutonium-238	Uranium-234
Cobalt-60	Plutonium-239	Uranium-235
Curium-244	Potassium-40	Uranium-238
Europium-154		

Metals

Antimony	Cobalt	Potassium
Arsenic	Lead	Selenium
Barium	Manganese	Silver
Beryllium	Mercury	Strontium
Boron	Molybdenum	Vanadium
Cadmium	Nickel	Zinc
Chromium		

Of the analytes detected in the soil samples, calcium, copper, iron, magnesium, silicon, and sodium are naturally occurring essential nutrients that have little or no toxic effects at the detected levels and consequently are not considered potential contaminants of concern.

5.2 DOSE/RESPONSE INFORMATION EMPLOYED IN SCREENING

The screening of soil contamination at the K-1407-C Retention Basin involves a comparison of contaminant concentrations with guideline values that are based on chemical- or element-specific dose/response information. Potential carcinogenic effects are characterized by estimating the probability that an individual will develop cancer over a lifetime of exposure from projected intakes and chemical-specific dose/response data or slope factors. Potential noncarcinogenic effects are characterized by comparing projected intakes of contaminants to reference doses (RfDs). The following discussion is a brief explanation of the significance of slope factors and RfDs in the context of the screening assessment.

For carcinogens, risks are estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the carcinogen (i.e., incremental or excess individual lifetime cancer risk). Cancer risk from the exposure to contamination is expressed as excess cancer risk, that is, cancer incurred in addition to normally expected rates of cancer development. An excess cancer risk of 1×10^{-6} indicates that one person in 1,000,000 is predicted to develop cancer from exposure to this contamination level. Excess cancer risks falling between 1×10^{-4} and 1×10^{-6} are within the range of concern, and cancer risks above 1×10^{-4} are considered unacceptable by EPA.[17]

The excess cancer risk is determined by the application of a slope factor, which is a chemical-specific value based on carcinogenic dose/response data. The slope factors and the estimated daily intake of site constituents, averaged over a lifetime of exposure, are used to estimate the incremental risk of an individual's developing cancer. Because the slope factors are the upper 95th percentile confidence limit on the probability of a carcinogenic response, the carcinogenic risk estimate represents an upper-bound estimate. The screening of the carcinogenic toxicity of contaminants is based on determining the samples in which concentrations producing a risk of 1×10^{-5} or greater were detected.

Slope factors used in the evaluation of risk from exposure to contaminants in K-1407-C soil are listed in Tables 8 and 9. Slope factors for the radionuclides are from *Health Effects Assessment Summary Tables*.[17] The slope factors for nonradioactive carcinogens are from the *Integrated Risk Information System* data base.[18] Slope factors are not currently available for all potential contaminants of concern. Several contaminants are not indicated by epidemiological studies to be carcinogenic; consequently, these contaminants do not have slope factors. Furthermore, slope factors are not available for several potential contaminants of concern because their carcinogenicity has not been determined. These contaminants may contribute to carcinogenic effects from exposure to the soil, but their effect cannot be quantified. The unavailability of slope factors precludes a comprehensive screening assessment of the risk from exposure to site contaminants. The toxicity information available limits the screening of carcinogenic contaminants to the radionuclides, arsenic, beryllium, cadmium, and chromium, a definite limitation with regard to the assessment of risk from exposure to soil at the site.

Noncarcinogenic effects are evaluated by comparing an exposure level over a 5-year period with an RfD derived for a chronic exposure. The RfDs available for the contaminants of concern in K-1407-C soil are given in Table 10. RfDs are representative of daily exposure levels that cause no deleterious effects during a lifetime. A chronic exposure duration is considered to be from 7 years to a lifetime. The use of the chronic RfDs assures that the screening is based on a conservative evaluation of adverse health effects. To evaluate the noncarcinogenic effects of exposure to soil contaminants, the dose is compared to the RfD. The noncarcinogen hazard quotient (dose/RfD) assumes that there is a level of exposure (i.e.,

Table 8. Slope factors for radionuclides detected in K-1407-C Retention Basin soil

Element	Ingestion $(pCi)^{-1}$	Ground surface $(pCi/m^2/year)^{-1}$	Inhalation $(pCi)^{-1}$
Americium-241	3.10E-10	1.60E-12	4.00E-08
Cesium-137	2.80E-11	0.00E+00	1.90E-11
Cobalt-60	1.50E-11	1.30E-10	1.60E-10
Curium-244	2.00E-10	5.80E-14	2.70E-08
Europium-154	3.00E-12	6.80E-11	1.40E-10
Neptunium-237	2.70E-10	1.80E-12	3.60E-08
Plutonium-238	2.80E-10	6.10E-14	4.20E-08
Plutonium-239	3.10E-11	2.60E-14	4.10E-08
Potassium-40	1.10E-11	7.80E-12	7.60E-12
Technetium-99	1.30E-12	3.40E-17	8.30E-12
Uranium-234	1.40E-10	5.70E-14	2.70E-08
Uranium-235	1.30E-10	9.60E-12	2.50E-08
Uranium-238	1.30E-10	4.60E-14	2.40E-08

Source: Adapted from U.S. Environmental Protection Agency, *Health Effects Assessment Summary Tables*, OERR 9200.6-303 (90-3), U.S. Environmental Protection Agency, Washington, D. C., July 1990.

Table 9. Available slope factors for nonradioactive metals detected in K-1407-C Retention Basin soil

Element	Ingestion $(mg/kg/day)^{-1}$	Ground surface	Inhalation $(mg/kg/day)^{-1}$
Arsenic	ND[a]	NA[b]	50.0
Beryllium	4.3	NA	8.4
Cadmium	ND	NA	6.1

[a]ND = No data available.

[b]NA = Not applicable.

Source: Adapted from *Integrated Risk Information System* [data base], U.S. Environmental Protection Agency, Environmental Criteria Assessment Office, Cincinnati, Ohio, December 1990.

Table 10. Available reference doses for K-1407-C Retention Basin soil contaminants

Chemical	Ingestion reference dose (mg/kg/day)	Inhalation reference dose (mg/kg/day)
Antimony	0.0004	ND[a]
Arsenic	0.0010	ND
Barium	0.0700	0.000625
Beryllium	0.0050	ND
Boron	0.0900	ND
Cadmium	0.0005	ND
Manganese	0.1000	0.001250
Mercury	0.0003	0.000375
Nickel	0.0200	ND
Silver	0.0030	ND
Vanadium	0.0070	ND
Zinc	0.2000	ND

[a]ND = No data available.

the RfD) below which it is unlikely for even sensitive populations to experience adverse health effects. If the exposure level (dose) exceeds this threshold (i.e., if dose/RfD exceeds 1), there may be concern for potential noncarcinogenic health effects.

RfDs are not available for some of the potential contaminants of concern. These contaminants may contribute to noncarcinogenic effects from exposure to the soil, but their effect cannot be quantified. Therefore, a comprehensive screening of the noncarcinogenic effects from exposure to soil at K-1407-C is not possible.

5.3 CONTAMINANT SCREENING

The screening of K-1407-C soil is a comparison of contaminant concentrations detected in soil to a guideline value, following the methodology outlined in the *Data Analysis Approach Report for K-1407-B Holding Pond and K-1407-C Retention Basin*, K/ER-23.[7] The guideline value is derived from very conservative exposure scenarios (high intake rates) and chemical- and element-specific dose/response information.

The screening of the contaminants detected during the Phase 1 investigation was initiated to indicate the contaminants that may pose an imminent health hazard. Additionally, screening indicates the contaminants most likely to influence risk management decisions and cleanup goals. This prioritization of contaminants may be used to emphasize analytes in future soil samples that should be considered critical to the investigation of the site. It should be emphasized that screening is not used to eliminate any contaminants from consideration in future risk assessment. An evaluation of all contaminants detected in soil samples from the K-1407-C Retention Basin will be included in the baseline risk assessment. Therefore, all contaminants detected at the site during preliminary phases of sampling must be included as analytes in subsequent phases of the investigation.

The screening of contamination at K-1407-C is not intended to serve as a quantitative assessment of the potential adverse health effects incurred from exposure to soil at the site. The conservative exposure scenarios used in screening do not consider site-specific factors influencing the exposure to site contamination; consequently, the screening scenarios do not represent possible circumstances of exposure that may occur at the site. There are no activities currently taking place that involve the potential for exposure to soil contamination at K-1407-C.

The parameters applied to the screening of soil data from the K-1407-C Retention Basin are defined in the following discussion. A listing of the exposure pathways applied in the screening assessment is included, as well as the derivation of the contaminant concentrations in air for screening against inhalation guideline values. This is followed by a discussion of the duration of exposure and intake rates employed in the calculation of guideline values for the radioactive and the nonradioactive contaminants. Last, the guideline values are listed for radionuclides and nonradionuclides, and the screening results are presented.

5.3.1 Exposure Pathways

Screening is conducted for all exposure pathways for which exposure at the site is feasible in order to indicate the pathways that present the greatest potential for the incidence of adverse health effects. Because the conditions of exposure and the slope factor and/or RfD vary with the nature of intake (ingestion, inhalation, dermal contact, and/or external exposure to radiation), the guideline value is different for each exposure pathway. The screening of radionuclides entails a comparison of contaminant concentrations against ingestion, inhalation, and external guidelines values. The screening of nonradioactive contaminants is conducted against ingestion and inhalation guideline values.

Screening against ingestion and external guidelines is straightforward; contaminant concentrations detected in each soil sample (Appendix B) are compared with the guideline values. However, because contaminant concentrations in air have not been measured, the concentrations applied in the inhalation screening must be calculated from soil concentrations. The following is an explanation of the derivation of air concentrations based on measured soil concentrations.

Inhalation exposure to soil contaminants is evaluated by considering the suspension of site soil by wind. The fugitive dust generated is estimated by the method described by Eckerman and Young.[19] The contamination in the air generated by the wind is determined by applying an empirically derived resuspension factor for windborne contamination of 2×10^{-7}/m to the contaminant levels in surface soil.[20] The resuspension factor is the ratio of the concentration in air (m^3) to the concentration on the surface (m^2).

For calculating the exposure concentrations in air due to dust, the contaminant levels in the soil must be converted from picocuries per gram for radionuclides or milligrams per kilogram for metals to picocuries per cubic meter or milligrams per cubic meter for use in this equation. The density of soil reported in the Blount County Soil Survey (series No. 7, 1953), 1.6×10^6 g/m^3, is applied to convert the representative surface soil concentrations.[21] For example, the following calculation employs units of radioactive contamination to determine the amount of contaminant in a cubic meter of soil:

$$1.6 \times 10^6 \text{ g/m}^3 \times \text{concentration (pCi/g soil)} = \text{pCi contaminant/m}^3.$$

It is assumed that only a thin veneer of soil actually releases dust due to wind; therefore, only the amount of contaminants in the surface layer should be used to determine concentrations in air. The concentration of the contaminant at the surface is represented by assuming the depth of the soil surface layer to be 1 cm. Therefore, the contaminant "density" (the amount of contaminant per cubic meter) is multiplied by 0.01 m to estimate the surface soil contaminant level (milligrams per square meter):

$$\text{pCi contaminant/m}^3 \times 0.01 \text{ m} = \text{concentration in surface layer of soil (pCi/m}^2\text{)}.$$

The concentration of the contaminant in a square meter of the soil surface is converted to a concentration in air by the application of the resuspension factor. Resuspension factors are determined empirically and represent the amount of surface material (milligrams per square meter) that becomes airborne (milligrams per cubic meter) due to specific activities. The resuspension factor reported in Ref. 20 due to wind ranges from 3×10^{-4} to 9×10^{-11}/m. A value of 2×10^{-7}/m is applied in the inhalation screening of contaminants. With the quantity of surface material suspended due to wind and the estimated amount of contaminant per surface area of soil determined in the calculations above, the contaminant's concentration in air is determined:

$$(2 \times 10^{-7}\text{/m}) \times \text{surface concentration (pCi/m}^2\text{)} = \text{concentration in air (pCi/m}^3\text{)}.$$

This concentration is compared to screening values based on contaminant inhalation toxicity.

5.3.2 Radionuclide Screening

Radionuclides are classified by EPA as human carcinogens based on epidemiological studies of ionizing-radiation-induced cancers in humans. The evaluation of radioactive carcinogens considers exposure via ingestion, inhalation, and external exposure pathways. The external exposure pathway is a critical pathway for radiation exposure; however, for the screening of nonradioactive carcinogenicity, dermal exposure is ineffective relative to screening based on oral and inhalation exposure.

The calculation of guideline values follows the methodology outlined in the *Data Analysis Approach Report for K-1407-B Holding Pond and K-1407-C Retention Basin*, K/ER-23.[7] For screening carcinogenic toxicity, the exposure model assumes a lifetime duration of exposure. The exposure model employs the body weight of a 70-kg adult, an ingestion rate of 0.001 kg of soil a day, and an inhalation rate of 20 m^3/day (Ref. 1). Guideline values used in the screening of radionuclide concentrations are listed in Table 11.

The results of the screening for carcinogenic toxicity of the radionuclides are displayed in Table 12. The results are presented as a ratio of samples in which concentrations equal to or greater than the guideline value were detected to the total number of samples analyzed for the contaminant. The ratios for each exposure pathway are presented by analyte and sample depth.

The screening of radionuclide concentrations against ingestion guideline values indicates that the potential risk will be dominated by the effects of exposure to ^{234}U and ^{238}U. The frequency of samples exceeding guideline values decreases with depth. However, there are still a considerable number of 18-in. samples in which concentrations exceed guidelines. Specifically, ^{234}U was detected at or above the ingestion guideline in 23 of 70 samples taken at the 18-in. depth.

Table 11. Guideline values for radionuclide screening

Radionuclide	Soil ingestion (pCi/g)	External (pCi/g)	Inhalation (pCi/g)
Americium-241	11.90	0.63	0.00048
Cesium-137	131.58	NA[a]	1.04167
Cobalt-60	243.90	0.01	0.12346
Curium-244	18.52	16.95	0.00071
Europium-154	1234.57	0.01	0.13889
Neptunium-237	13.70	0.56	0.00056
Plutonium-238	13.16	16.95	0.00048
Plutonium-239	119.05	38.46	0.00038
Potassium-40	333.33	0.13	2.50000
Technetium-99	2857.14	29411.76	2.38095
Uranium-234	26.32	17.86	0.00071
Uranium-235	28.57	0.10	0.00077
Uranium-238	28.57	22.22	0.00083

[a]Not applicable.

Table 12. Frequency of radioactive soil samples exceeding carcinogenic toxicity guideline values

Analyte	6-in. samples[a]	12-in. samples[a]	18-in. samples[a]
	Oral exposure		
Americium-241	5/78	1/43	0/40
Cesium-137	1/78	0/61	0/58
Neptunium-237	12/78	1/43	0/40
Plutonium-238	3/78	0/43	0/40
Plutonium-239	2/78	0/43	0/40
Technetium-99	4/78	0/73	0/70
Uranium-234	57/78	37/74	23/70
Uranium-235	7/78	4/74	1/70
Uranium-238	46/78	27/74	12/70

Table 12 (continued)

Analyte	6-in. samples[a]	12-in. samples[a]	18-in. samples[a]
External exposure			
Americium-241	38/78	16/43	7/40
Cobalt-60	53/75	1/1	0/0
Europium-154	1/1	0/0	0/0
Neptunium-237	54/78	20/43	12/40
Plutonium-239	8/78	2/43	1/40
Potassium-40	76/76	61/61	58/58
Uranium-234	61/78	40/74	31/70
Uranium-235	75/78	70/74	59/70
Uranium-238	48/78	32/74	15/70
Inhalation exposure			
Americium-241	53/78	28/43	22/40
Neptunium-237	63/78	27/43	19/40
Plutonium-238	30/78	11/43	5/40
Plutonium-239	69/78	34/43	28/40
Technetium-99	11/78	5/73	4/70
Uranium-234	78/78	74/74	70/70
Uranium-235	73/78	58/74	53/70
Uranium-238	78/78	73/74	70/70

[a]Samples ≥ guideline values/total samples analyzed.

In screening based on the external exposure, a majority of the 6-in. samples for all contaminants except ^{239}Pu were equal to or greater than the guideline value. The number of samples exceeding the guideline value decreases with sample depth except in the case of ^{40}K, which exceeds the guidelines in all samples. All analytes were detected at or above the guidelines in at least one 18-in. sample. The potential risk from external exposure to contamination in the 18-in. soil samples will be dominated by the effects incurred from the exposure to ^{40}K, ^{234}U, and ^{235}U.

Inhalation screening results indicate that all analytes will contribute to the potential cancer risk from exposure to wind-generated dust. While the number of samples exceeding guideline values decreases with depth, a majority of the analytes are present at or above the guideline value in the 18-in. samples.

The screening of radionuclides suggests that the extent of contamination in the K-1407-C Retention Basin soil has not been sufficiently delineated to support a comprehensive assessment of the risk from exposure to site soil. Soil samples were terminated at a depth of 18 in.; therefore, the risk incurred from exposure to soil below the 18-in. depth cannot be quantified. Based on the detection of radionuclide concentrations equal to or greater than the guideline values in 18-in. samples, it is presumed that concentrations greater than the guideline value may be present in soil below this depth. Consequently, radionuclide concentrations in the soil below the 18-in. depth may contribute to the risk incurred from exposure to site soil. Therefore, the screening of radionuclide contamination indicates the need for additional sampling to determine the extent and concentration of the radioactive isotopes below the 18-in. depth.

5.3.3 Metal Screening

In the screening of nonradioactive carcinogenicity, oral and inhalation exposures are considered. Contaminant concentrations are not screened against dermal exposure guideline values because the screening of nonradioactive carcinogenicity based on dermal exposure is considered ineffective relative to screening based on oral and inhalation exposure. In addition, dermal exposure at the site is not likely to occur.

For screening carcinogenic toxicity, the exposure model assumes a lifetime duration of exposure. The exposure model for carcinogens employs the body weight of a 70-kg adult, an ingestion rate of 0.0001 kg of soil per day, and an inhalation rate of 20 m^3/day (Ref. 1). The screening for systemic toxicity employs an exposure duration of 5 years. The exposure model for systemic toxicants employs a body weight of a 16-kg child, an ingestion rate of 0.0002 kg of soil a day, and an inhalation rate of 20 m^3/day (Ref. 1). Guideline values used in the screening of nonradioactive metal concentrations are listed in Table 13.

Table 13. Guideline values for nonradioactive metals

Element	Ingestion (mg/kg)	Inhalation (mg/kg)
Carcinogenic guideline values		
Arsenic	NA[a]	0.0000007
Beryllium	1.62791	0.0000042
Cadmium	NA	0.0000057
Systemic toxicity guideline values		
Antimony	32	NA
Arsenic	80	NA
Barium	5600	0.0005
Beryllium	400	NA
Boron	7200	NA
Cadmium	40	NA
Manganese	8000	0.0010
Mercury	24	0.0003
Nickel	1600	NA
Silver	240	NA
Vanadium	560	NA
Zinc	16000	NA

[a]NA = Not applicable.

The results of the screening for the carcinogenicity and systemic toxicity of the nonradioactive contaminants are included in Table 14. The most significant result is the presence of the carcinogens arsenic, beryllium, and cadmium at levels at or above the inhalation guidelines in all samples. The results of the inhalation screening of the systemic toxicants barium, manganese, and mercury indicate that all samples contain concentrations at or above the guidelines. In addition, mercury is above the guideline value in a single sample at the 18-in. depth. Because the guidelines for metals are exceeded in 18-in. soil samples and because the soil below 18 in. has not been characterized, a thorough assessment of the health hazards based on the Phase 1 investigation of the K-1407-C Retention Basin is not possible.

Table 14. Frequency of nonradioactive soil analytes exceeding guideline values

Analyte	6-in. samples[a]	12-in. samples[a]	18-in. samples[a]
Screening for carcinogenic toxicity[b]			
Inhalation exposure			
Arsenic	16/16	14/14	14/14
Beryllium	16/16	14/14	14/14
Cadmium	16/16	14/14	14/14
Screening for noncarcinogenic systemic toxicity			
Oral exposure			
Antimony	1/16	0/14	0/14
Mercury	1/17	1/15	0/15
Inhalation exposure			
Barium	16/16	14/14	14/14
Manganese	16/16	14/14	14/14
Mercury	16/17	15/15	15/15

[a]Number of samples > guideline values/total number of samples analyzed.

[b]No nonradioactive analytes exceeded guideline values for carcinogenic toxicity by oral exposure.

5.4 DATA LIMITATIONS

The lack of background samples and samples below 18 in. limits the ability of the investigation to comprehensively address the data needs of a Remedial Investigation Report/Baseline Risk Assessment. Additionally, the analytical data for radionuclides for the samples taken are incomplete. At the time this screening evaluation was undertaken, some of the 6- and 12-in. soil samples had not been analyzed for ^{241}Am, ^{137}Cs, ^{60}Co, ^{237}Np, ^{238}Pu, ^{239}Pu, and/or ^{40}K.

Because no background samples are available, statistical differentiation between metal concentrations resulting from site activities and naturally occurring concentrations cannot be established. Therefore, because of the inability to discern between site-related and naturally occurring metal concentrations, all are considered as potentially related to the site.

Several limitations were found during the QA/QC review of the data. Although there are no established holding times for radiochemical analyses, some holding times have approached or exceeded 1 year. Data were not available for each individual radiochemical analyte for all samples. In addition, there is some uncertainty about the accuracy of radionuclide data because there are no matrix spike data. The low level of confidence in the data resulting from the lack of matrix spike information will greatly increase the uncertainty of an assessment of risk determined from the exposure to radionuclides in the K-1407-C Retention Basin soil.

The health-based screening of contaminants detected in soil at the K-1407-C Retention Basin indicates that samples taken from the 12- to 18-in. interval contain contaminant concentrations exceeding guideline values. The results of the screening suggest that soil below 18 in. may contain contamination above guideline values and could feasibly contribute to risk from exposure to site soil. However, because soil sampling was terminated at a depth of 18 in., the extent of contamination below this depth cannot be determined. Therefore, a thorough assessment of risk from exposure to soil at the site cannot be conducted.

Dose/response information for many of the metals is not available, limiting the screening assessment for adverse health effects. Additionally, slope factors and RfDs are not available for all exposure pathways for all metals; health risks posed by exposure to contaminants without these values cannot be comprehensively quantified. A major limitation to the comprehensive quantification of risk from exposure to contamination at K-1407-C is the lack of chemical-specific slope factors and RfDs for all exposure pathways and contaminants. Therefore, the total risk resulting from the exposure to contaminants at the site cannot be determined.

The evaluation of environmental pathways at the K-1407-C Retention Basin is restricted to the consideration of soil contamination. The K-1407-C environmental pathway evaluation is not complete until the human-health consequences of the potential transport of contamination via groundwater are considered. The evaluation of groundwater environmental and exposure pathways will be included in the Area 1 investigation.

6. STATISTICAL EVALUATION OF DATA

This chapter discusses the statistical evaluation of the analytical data produced from the latest soil sampling effort at the K-1407-C Retention Basin. Data are presented graphically and statistically analyzed. Section 6.1 is a statistical summary of the analytical data, and Sect. 6.2 describes the methodology and implications of two graphical studies.

6.1 DATA SUMMARY

The statistical data analysis began by exploring the available soil data for obvious errors, such as incorrect units, analytical procedures used, missing data, duplicated data, co-located samples with no corresponding regular soil sample, misspellings, etc. A complete list of these data observations was documented and given to the Remedial Action Program data base manager.

Approximately 21% of the available data were from biased samples. Biased samples are those taken where the field sampler measured high readings of radioactivity while scanning the surface of the soil. While these biased sample results are valid for use in probability kriging and contour plots, they were excluded in estimating the mean concentration of an analyte across the site or by depth. Including these samples could result in a positive bias in the estimation of the mean and variance. That is, including these biased samples would increase the mean and variance.

In order to estimate the mean and variance of the concentrations of each analyte across the site, the nondetected results had to be estimated. A nondetected result is a detection limit given by the laboratory with a "<" qualifier. The sample was analyzed for the particular analyte, but the analyte was not detected at the detection limit. Therefore, the true quantity x in the sample could be any value $0 \leq x < D$, where D is the reported detection limit.

The distributions of the unbiased detected results of those analytes that had at least one nondetected result were examined. Histograms and plots of the data by analyte revealed that the lognormal distribution should be an adequate model to fit the detected results. All of these analytes exhibited a distribution heavily skewed to the right. A distribution is skewed to the right when there are many low concentrations and few very high concentrations. These few high concentrations cause the mean of the distribution to be greater than the median. The median of the distribution is that value for which half of the data are below and half are above. Although the shapes of the distributions were unique for each analyte, the versatile shape of the lognormal distribution should fit the data well. Details concerning the lognormal distribution and the procedure for estimating means and variances for the different populations of results are included in Appendix C.

Before the nondetected results could be estimated, one issue had to be resolved. A small sampling campaign was initiated immediately after the first sampling period to collect samples for mercury analysis. The sample locations were those that had samples analyzed for the metals analyses. Samples from one of the boreholes (13B) inadvertently were also submitted for the ICP metals analyses. This gave two sets of metals results for this borehole. Two other boreholes (09F and 07D) have two sets of mercury results. These data were then averaged to yield one result per analyte, sampling location, and depth.

Once the data were reduced to one result per analyte, sampling location, and sample depth, the remaining nondetected results were estimated using the lognormal distributions fit for each analyte. These estimates along with the detected results were then used in estimating the mean concentration of each analyte both across the site and by sample depth.

6.1.1 Summary by Analyte

Summary statistics on all of the soil data by analyte are given in Table 15. The analytes are grouped into metals, mercury, and radiochemical analyses and are listed alphabetically within each type of analysis. Summary information includes the total number of results, the number of biased results, the number of detection limits, the smallest and largest detection limits, the smallest and largest detected results, the estimated mean of the unbiased results as described earlier, the associated units, and the analytical procedure used in the analysis. When one compares the largest detected results of each analyte to the health-based guideline values, it can be seen that the radionuclides ^{241}Am, ^{137}Cs, ^{237}Np, ^{238}Pu, ^{239}Pu, ^{99}Tc, ^{234}U, ^{235}U, and ^{238}U all have at least one sample result that exceeds its associated guideline value. In fact, ^{234}U and ^{238}U each have an estimated *average* concentration that exceeds the guideline value. Therefore, many uranium results must exceed this guideline value. While the average concentration for ^{238}U only slightly exceeded its guideline value of 28.5 pCi/g, the average concentration for ^{234}U is almost three times its guideline value of 26.5 pCi/g.

6.1.2 Summary by Analyte and Sample Depth

A similar summary of the data by analyte and sample depth is given in Table 16. As in Table 15, the analytes are grouped into metals, mercury, and radiochemical analyses and are listed alphabetically within each type of analysis. Then, within each analyte, the data are summarized by sample depth at the 6-, 12-, and 18-in. depths. The number of results, number of biased results, number of detection limits, smallest and largest detection limits, smallest and largest detected results, estimated mean of the unbiased results, and the associated units are given for each depth. As one compares the mean concentrations at each depth, the general trend is that the highest concentrations are at the 6-in. depth, the next highest at the 12-in. depth, and the lowest at the 18-in. depth. While the concentration decreases with depth, the 18-in. samples still contain contamination for some analytes. In fact, all nine of the radionuclides mentioned before as having exceeded guideline values (^{241}Am, ^{137}Cs, ^{237}Np, ^{238}Pu, ^{239}Pu, ^{99}Tc, ^{234}U, ^{235}U, and ^{238}U) exceed their associated guideline values at the 6-in. depth. In addition, ^{237}Np also exceeds its guideline value of 13.7 pCi/g at the 12-in. depth, while ^{234}U, ^{235}U, and ^{238}U exceed their guideline values at the 12- and 18-in. depths as well. For ^{234}U and ^{235}U, the largest detected result at the 18-in. level exceeds the guideline value by more than one order of magnitude.

6.1.3 Significant Differences Between Sample Depths

In order to determine whether the concentrations at the 6-, 12-, and 18-in. depths are statistically different, a Kruskal-Wallis Test was utilized. This test was chosen for several

Table 15. Summary statistics on all K-1407-C soil data by analyte

Analysis type	Analysis name	Number of results	Number of biased results	Number of detection limits	Detection limits		Detected results		Estimated mean of unbiased results	Units	Procedure
					Smallest	Largest	Smallest	Largest			
ICP-metals	Aluminum	44	0	0			7,600.00	64,000.00	29,343.90	mg/kg	EPA-6010
ICP-metals	Antimony	44	0	43	5.00	50.00	9.40	9.40	2.71	mg/kg	EPA-6010
ICP-metals	Arsenic	44	0	21	5.00	50.00	6.40	32.00	12.26	mg/kg	EPA-6010
ICP-metals	Barium	44	0	0			25.00	170.00	95.65	mg/kg	EPA-6010
ICP-metals	Beryllium	44	0	0			0.25	1.60	0.81	mg/kg	EPA-6010
ICP-metals	Boron	44	0	29	0.40	0.57	1.10	34.00	4.75	mg/kg	EPA-6010
ICP-metals	Cadmium	44	0	11	0.30	1.90	0.33	7.40	1.09	mg/kg	EPA-6010
ICP-metals	Calcium	44	0	0			480.00	160,000.00	18,241.71	mg/kg	EPA-6010
ICP-metals	Chromium	44	0	0			18.00	190.00	56.77	mg/kg	EPA-6010
ICP-metals	Cobalt	44	0	0			8.50	33.00	16.98	mg/kg	EPA-6010
ICP-metals	Copper	44	0	0			6.00	190.00	50.89	mg/kg	EPA-6010
ICP-metals	Iron	44	0	0			19,000.00	56,000.00	29,304.88	mg/kg	EPA-6010
ICP-metals	Lead	44	0	1	50.00	50.00	16.00	72.00	33.88	mg/kg	EPA-6010
ICP-metals	Magnesium	44	0	0			300.00	8,000.00	2,949.39	mg/kg	EPA-6010
ICP-metals	Manganese	44	0	0			360.00	3,600.00	1,397.56	mg/kg	EPA-6010
ICP-metals	Molybdenum	44	0	18	1.00	10.00	1.00	4.30	1.73	mg/kg	EPA-6010
ICP-metals	Nickel	44	0	0			5.00	1,500.00	236.54	mg/kg	EPA-6010
ICP-metals	Potassium	44	0	0			420.00	8,900.00	3,772.68	mg/kg	EPA-6010
ICP-metals	Selenium	44	0	43	5.00	50.00	9.50	9.50	2.71	mg/kg	EPA-6010
ICP-metals	Silicon	44	0	0			220.00	1,700.00	752.80	mg/kg	EPA-6010
ICP-metals	Silver	44	0	34	0.60	6.00	0.69	1.70	0.67	mg/kg	EPA-6010
ICP-metals	Sodium	44	0	0			69.00	3,600.00	589.88	mg/kg	EPA-6010
ICP-metals	Strontium	44	0	0			1.80	64.00	18.43	mg/kg	EPA-6010
ICP-metals	Thorium	44	0	44	20.00	200.00			9.40	mg/kg	EPA-6010
ICP-metals	Uranium (total)	44	0	16	3.00	19.00	8.00	650.00	88.43	mg/kg	EPA-6010
ICP-metals	Vanadium	44	0	0			27.00	73.00	44.44	mg/kg	EPA-6010
ICP-metals	Zinc	44	0	0			11.00	120.00	61.65	mg/kg	EPA-6010
Mercury	Mercury	47	3	26	1.00	1.70	1.10	40.00	4.31	mg/kg	EPA-7471
Radiochem	Alpha activity	222	66	0			3.24	1,890.00	97.27	pCi/g	EPA-900.0
Radiochem	Americium-241	161	50	4	0.05	0.32	-1.08	56.70	1.00	pCi/g	ORNL 31034
Radiochem	Beta activity	222	66	0			4.86	4,860.00	214.45	pCi/g	EPA-900.0

Table 15 (continued)

Analysis type	Analysis name	Number of results	Number of biased results	Number of detection limits	Detection limits		Detected results		Estimated mean of unbiased results	Units	Procedure
					Smallest	Largest	Smallest	Largest			
Radiochem	Cesium-137	197	60	10	0.05	0.14	-0.02	178.20	3.71	pCi/g	EPA-901.1
Radiochem	Cobalt-60	76	24	0			-0.20	0.35	0.04	pCi/g	EPA-901.1
Radiochem	Curium-244	25	7	0			-0.35	0.06	0.00	pCi/g	ORNL 31034
Radiochem	Europium-154	1	1	0			2.13	2.13		pCi/g	EPA-901.1
Radiochem	Neptunium-237	161	50	2	0.03	0.03	0.00	143.10	2.02	pCi/g	ORNL 31535
Radiochem	Plutonium-238	161	50	14	0.02	0.54	-2.43	16.20	0.15	pCi/g	ORNL 31625
Radiochem	Plutonium-239	161	50	6	0.03	0.05	-0.09	162.00	3.65	pCi/g	ORNL 31625
Radiochem	Potassium-40	195	58	0			3.24	23.76	10.07	pCi/g	EPA-901.1
Radiochem	Strontium (total)	196	58	6	0.40	0.81	-0.54	132.30	4.48	pCi/g	EPA-905.0
Radiochem	Technetium-99	221	66	0			0.04	4,320.00	118.51	pCi/g	ORNL 21833
Radiochem	Uranium-234	222	66	1	0.81	0.81	0.51	2,673.00	71.36	pCi/g	ORNL 31923
Radiochem	Uranium-235	222	66	1	0.81	0.81	0.01	62.10	3.54	pCi/g	ORNL 31923
Radiochem	Uranium-238	222	66	0			0.11	1,620.00	38.28	pCi/g	ORNL 31923
Total		3900	807	330							

Table 16. Summary statistics on all K-1407-C soil data by analyte and sample depth

Analysis type	Analysis name	Sample depth (in.)	Number of results	Number of biased results	Number of detection limits	Detection limits		Detected results		Estimated mean of unbiased results	Units
						Smallest	Largest	Smallest	Largest		
ICP-metals	Aluminum	6	16	0	0			15,000.00	56,000.00	34,700.00	mg/kg
ICP-metals	Aluminum	12	14	0	0			15,000.00	64,000.00	27,653.85	mg/kg
ICP-metals	Aluminum	18	14	0	0			7,600.00	52,000.00	24,853.85	mg/kg
ICP-metals	Antimony	6	16	0	16	5.00	50.00			2.78	mg/kg
ICP-metals	Antimony	12	14	0	13	5.00	31.00	9.40	9.40	2.83	mg/kg
ICP-metals	Antimony	18	14	0	14	5.00	6.00			2.51	mg/kg
ICP-metals	Arsenic	6	16	0	10	5.00	50.00	7.00	30.00	10.05	mg/kg
ICP-metals	Arsenic	12	14	0	7	5.00	31.00	6.40	28.00	10.09	mg/kg
ICP-metals	Arsenic	18	14	0	4	5.20	6.00	8.40	32.00	16.96	mg/kg
ICP-metals	Barium	6	16	0	0			59.00	160.00	100.13	mg/kg
ICP-metals	Barium	12	14	0	0			31.00	170.00	107.00	mg/kg
ICP-metals	Barium	18	14	0	0			25.00	120.00	79.12	mg/kg
ICP-metals	Beryllium	6	16	0	0			0.48	1.60	0.90	mg/kg
ICP-metals	Beryllium	12	14	0	0			0.42	1.50	0.86	mg/kg
ICP-metals	Beryllium	18	14	0	0			0.25	1.40	0.67	mg/kg
ICP-metals	Boron	6	16	0	8	0.40	0.57	3.50	34.00	8.72	mg/kg
ICP-metals	Boron	12	14	0	9	0.40	0.47	1.10	20.00	3.25	mg/kg
ICP-metals	Boron	18	14	0	12	0.40	0.48	8.50	13.00	1.66	mg/kg
ICP-metals	Cadmium	6	16	0	4	0.30	1.90	0.57	7.40	1.43	mg/kg
ICP-metals	Cadmium	12	14	0	4	0.30	1.90	0.37	2.20	0.86	mg/kg
ICP-metals	Cadmium	18	14	0	3	0.30	0.30	0.33	2.20	0.93	mg/kg
ICP-metals	Calcium	6	16	0	0			2,000.00	160,000.00	31,746.67	mg/kg
ICP-metals	Calcium	12	14	0	0			530.00	52,000.00	13,829.23	mg/kg
ICP-metals	Calcium	18	14	0	0			480.00	38,000.00	7,071.54	mg/kg

Table 16 (continued)

Analysis type	Analysis name	Number of results	Number of biased results	Number of detection limits	Detection limits		Detected results		Estimated mean of unbiased results	Units	Procedure
					Smallest	Largest	Smallest	Largest			
ICP-metals	Chromium	6	16	0	0			25.00	160.00	67.63	mg/kg
ICP-metals	Chromium	12	14	0	0			18.00	190.00	55.92	mg/kg
ICP-metals	Chromium	18	14	0	0			18.00	150.00	45.08	mg/kg
ICP-metals	Cobalt	6	16	0	0			8.50	29.00	17.73	mg/kg
ICP-metals	Cobalt	12	14	0	0			9.00	30.00	17.00	mg/kg
ICP-metals	Cobalt	18	14	0	0			8.50	33.00	16.09	mg/kg
ICP-metals	Copper	6	16	0	0			14.00	190.00	68.90	mg/kg
ICP-metals	Copper	12	14	0	0			12.00	160.00	51.96	mg/kg
ICP-metals	Copper	18	14	0	0			6.00	110.00	29.04	mg/kg
ICP-metals	Iron	6	16	0	0			23,000.00	36,000.00	29,500.00	mg/kg
ICP-metals	Iron	12	14	0	0			21,000.00	50,000.00	29,192.31	mg/kg
ICP-metals	Iron	18	14	0	0			19,000.00	56,000.00	29,192.31	mg/kg
ICP-metals	Lead	6	16	0	1	50.00	50.00	16.00	59.00	33.20	mg/kg
ICP-metals	Lead	12	14	0	0			19.00	72.00	36.19	mg/kg
ICP-metals	Lead	18	14	0	0			18.00	69.00	32.35	mg/kg
ICP-metals	Magnesium	6	16	0	0			1,200.00	7,800.00	3,973.33	mg/kg
ICP-metals	Magnesium	12	14	0	0			660.00	8,000.00	3,136.15	mg/kg
ICP-metals	Magnesium	18	14	0	0			300.00	3,900.00	1,581.15	mg/kg
ICP-metals	Manganese	6	16	0	0			550.00	2,700.00	1,128.67	mg/kg
ICP-metals	Manganese	12	14	0	0			360.00	3,600.00	1,613.08	mg/kg
ICP-metals	Manganese	18	14	0	0			390.00	2,400.00	1,492.31	mg/kg
ICP-metals	Molybdenum	6	16	0	8	1.00	10.00	1.00	4.30	1.72	mg/kg
ICP-metals	Molybdenum	12	14	0	6	1.00	6.20	1.50	3.70	1.82	mg/kg
ICP-metals	Molybdenum	18	14	0	4	1.00	1.20	1.40	2.90	1.66	mg/kg

Table 16 (continued)

Analysis type	Analysis name	Number of results	Number of biased results	Number of detection limits	Detection limits: Smallest	Detection limits: Largest	Detected results: Smallest	Detected results: Largest	Estimated mean of unbiased results	Units	Procedure
ICP-metals	Nickel	6	16	0	0			20.00	1,400.00	333.27	mg/kg
ICP-metals	Nickel	12	14	0	0			13.00	1,500.00	242.19	mg/kg
ICP-metals	Nickel	18	14	0	0			5.00	1,000.00	119.29	mg/kg
ICP-metals	Potassium	6	16	0	0			1,400.00	8,700.00	4,636.67	mg/kg
ICP-metals	Potassium	12	14	0	0			720.00	7,300.00	3,440.00	mg/kg
ICP-metals	Potassium	18	14	0	0			420.00	8,900.00	3,108.46	mg/kg
ICP-metals	Selenium	6	16	0	16	5.00	50.00			2.54	mg/kg
ICP-metals	Selenium	12	14	0	13	5.00	31.00	9.50	9.50	3.13	mg/kg
ICP-metals	Selenium	18	14	0	14	5.00	6.00			2.50	mg/kg
ICP-metals	Silicon	6	16	0	0			230.00	1,700.00	732.67	mg/kg
ICP-metals	Silicon	12	14	0	0			280.00	1,200.00	776.54	mg/kg
ICP-metals	Silicon	18	14	0	0			220.00	1,000.00	752.31	mg/kg
ICP-metals	Silver	6	16	0	15	0.60	6.00	0.90	0.90	0.64	mg/kg
ICP-metals	Silver	12	14	0	9	0.60	3.70	0.69	1.70	0.74	mg/kg
ICP-metals	Silver	18	14	0	10	0.60	0.73	0.72	1.10	0.63	mg/kg
ICP-metals	Sodium	6	16	0	0			89.00	1,300.00	450.13	mg/kg
ICP-metals	Sodium	12	14	0	0			69.00	2,400.00	606.08	mg/kg
ICP-metals	Sodium	18	14	0	0			69.00	3,600.00	734.92	mg/kg
ICP-metals	Strontium	6	16	0	0			8.40	64.00	26.62	mg/kg
ICP-metals	Strontium	12	14	0	0			3.20	37.00	16.89	mg/kg
ICP-metals	Strontium	18	14	0	0			1.80	26.00	10.52	mg/kg
ICP-metals	Thorium	6	16	0	16	20.00	200.00			9.82	mg/kg
ICP-metals	Thorium	12	14	0	14	20.00	120.00			8.60	mg/kg
ICP-metals	Thorium	18	14	0	14	20.00	24.00			9.70	mg/kg

Table 16 (continued)

Analysis type	Analysis name	Number of results	Number of biased results	Number of detection limits	Detection limits: Smallest	Detection limits: Largest	Detected results: Smallest	Detected results: Largest	Estimated mean of unbiased results	Units	Procedure
ICP-metals	Uranium (total)	6	16	0	6	3.00	19.00	29.00	540.00	118.83	mg/kg
ICP-metals	Uranium (total)	12	14	0	4	3.00	19.00	8.00	650.00	90.68	mg/kg
ICP-metals	Uranium (total)	18	14	0	6	3.00	3.50	8.90	430.00	51.11	mg/kg
ICP-metals	Vanadium	6	16	0	0			28.00	61.00	46.53	mg/kg
ICP-metals	Vanadium	12	14	0	0			29.00	73.00	42.35	mg/kg
ICP-metals	Vanadium	18	14	0	0			27.00	67.00	44.12	mg/kg
ICP-metals	Zinc	6	16	0	0			37.00	120.00	76.93	mg/kg
ICP-metals	Zinc	12	14	0	0			25.00	98.00	58.42	mg/kg
ICP-metals	Zinc	18	14	0	0			11.00	86.00	47.23	mg/kg
Mercury	Mercury	6	17	1	5	1.00	1.00	1.10	29.00	6.09	mg/kg
Mercury	Mercury	12	15	1	11	1.00	1.70	2.40	40.00	3.42	mg/kg
Mercury	Mercury	18	15	1	10	1.00	1.00	2.90	29.00	3.11	mg/kg
Radiochem	Alpha activity	6	78	23	0			4.86	1,890.00	109.60	pCi/g
Radiochem	Alpha activity	12	74	22	0			3.24	1,404.00	92.47	pCi/g
Radiochem	Alpha activity	18	70	21	0			3.51	945.00	88.53	pCi/g
Radiochem	Americium-241	6	78	23	0			-1.08	32.40	1.27	pCi/g
Radiochem	Americium-241	12	13	14	2	0.05	0.22	-0.62	56.70	0.70	pCi/g
Radiochem	Americium-241	18	40	13	2	0.19	0.32	0.01	11.88	0.80	pCi/g
Radiochem	Beta activity	6	78	23	0			12.15	4,860.00	295.61	pCi/g
Radiochem	Beta activity	12	74	22	0			4.86	4,050.00	176.41	pCi/g
Radiochem	Beta activity	18	70	21	0			4.86	1,431.00	163.70	pCi/g
Radiochem	Cesium-137	6	78	23	0			0.02	178.20	5.03	pCi/g
Radiochem	Cesium-137	12	61	19	3	0.05	0.14	0.03	81.00	3.24	pCi/g
Radiochem	Cesium-137	18	58	18	7	0.05	0.14	-0.02	43.20	2.39	pCi/g

Table 16 (continued)

Analysis type	Analysis name	Number of results	Number of biased results	Number of detection limits	Detection limits: Smallest	Detection limits: Largest	Detected results: Smallest	Detected results: Largest	Estimated mean of unbiased results	Units	Procedure
Radiochem	Cobalt-60	6	75	23	0			-0.20	0.35	0.04	pCi/g
Radiochem	Cobalt-60	12	1	1	0			0.03	0.03		pCi/g
Radiochem	Curium-244	6	25	7	0			-0.35	0.06	0.00	pCi/g
Radiochem	Europium-154	6	1	1	0			2.13	2.13		pCi/g
Radiochem	Neptunium-237	6	78	23	0			0.00	143.10	2.94	pCi/g
Radiochem	Neptunium-237	12	43	14	0			0.00	35.10	1.27	pCi/g
Radiochem	Neptunium-237	18	40	13	2	0.03	0.03	0.00	10.53	0.95	pCi/g
Radiochem	Plutonium-238	6	78	23	0			-2.43	16.20	0.21	pCi/g
Radiochem	Plutonium-238	12	43	14	5	0.08	0.54	-0.35	0.97	0.10	pCi/g
Radiochem	Plutonium-238	18	40	13	9	0.02	0.30	-0.57	2.11	0.06	pCi/g
Radiochem	Plutonium-239	6	78	23	0			0.00	162.00	4.23	pCi/g
Radiochem	Plutonium-239	12	43	14	3	0.03	0.05	-0.09	110.70	3.36	pCi/g
Radiochem	Plutonium-239	18	40	13	3	0.03	0.05	-0.01	48.60	2.80	pCi/g
Radiochem	Potassium-40	6	76	21	0			3.24	23.76	10.83	pCi/g
Radiochem	Potassium-40	12	61	19	0			4.86	21.06	9.72	pCi/g
Radiochem	Potassium-40	18	58	18	0			4.05	21.87	9.40	pCi/g
Radiochem	Strontium (total)	6	78	23	0			-0.54	132.30	5.26	pCi/g
Radiochem	Strontium (total)	12	61	18	3	0.40	0.81	-0.16	124.20	4.16	pCi/g
Radiochem	Strontium (total)	18	57	17	3	0.49	0.81	-0.43	43.20	3.74	pCi/g
Radiochem	Technetium-99	6	78	23	0			0.04	4,320.00	122.76	pCi/g
Radiochem	Technetium-99	12	73	22	0			0.51	1,836.00	112.31	pCi/g
Radiochem	Technetium-99	18	70	21	0			0.21	1,377.00	120.20	pCi/g

Table 16 (continued)

Analysis type	Analysis name	Number of results	Number of biased results	Number of detection limits	Detection limits		Detected results		Estimated mean of unbiased results	Units	Procedure
					Smallest	Largest	Smallest	Largest			
Radiochem	Uranium-234	6	78	23	0			1.32	2,673.00	97.55	pCi/g
Radiochem	Uranium-234	12	74	22	1	0.81	0.81	0.86	1,188.00	60.09	pCi/g
Radiochem	Uranium-23[illegible]	18	70	21	0			0.51	918.00	53.92	pCi/g
Radiochem	Uranium-235	6	78	23	0			0.06	62.10	4.18	pCi/g
Radiochem	Uranium-235	12	74	22	1	0.81	0.81	0.03	45.90	3.30	pCi/g
Radiochem	Uranium-235	18	70	21	0			0.01	62.10	3.07	pCi/g
Radiochem	Uranium-238	6	78	23	0			0.81	1,620.00	52.08	pCi/g
Radiochem	Uranium-238	12	74	22	0			0.11	648.00	30.96	pCi/g
Radiochem	Uranium-238	18	70	21	0			0.49	432.00	30.58	pCi/g
Total		3900	807	330							

reasons. Because the data for each analyte are heavily skewed, not normally distributed, and have unequal variances, a standard analysis of variance could not be used. Instead, the nonparametric Kruskal-Wallis was more appropriate since it does not assume a particular underlying distribution when testing for equal means across several groups. Instead, it assumes that the shape of the distributions for each group is identical. This assumption is reasonable for the soil data since all analytes are heavily skewed to the right and resemble a lognormal shape.

Since Kruskal-Wallis is a nonparametric test, it ranks the data from lowest to highest and calculates a test statistic on the ranks instead of the actual results. This method was used to test the hypotheses:

H_0: The means at each sample depth are equal for a given analyte.
H_1: At least one mean is statistically different from the other two.

The results of the Kruskal-Wallis Test are given in Table 17. The analytes are grouped into metals, mercury, and radiochemical analyses and are listed alphabetically within each type of analysis. For each analyte the estimated mean concentrations at the 6-, 12-, and 18-in. depths are given, as are the units, the probability that the means at all depths are equal, and which depths have means that are statistically different at the 0.05 significance level. A probability exceeding 0.05 indicates that the mean concentrations at the three depths are not statistically different. A probability below 0.05 indicates that at least one of the three mean concentrations is statistically different from one of the other two. In this case, Dunn's distribution-free multiple comparison based on Kruskal-Wallis rank sums was utilized to compare the three pairs of means to determine which pairs of means are statistically different since all means are not equal. This multiple comparison procedure is valid for unequal sample sizes and is specific to Kruskal-Wallis rank sums.[22] As Table 17 shows, all analytes with mean concentrations statistically different at the three depths are also different between the 6- and 18-in. depths, where the 6-in. depth concentrations are always greater than the 18-in. depth concentrations. For ^{137}Cs, ^{234}U, ^{235}U, and ^{238}U, the 6-in. depth is also statistically different from the 12-in. depth mean. This is further evidence that the top 6 in. of soil exhibits the greatest amount of contamination, and the concentration decreases with depth. However, the 18-in. depth still exhibits evidence of contamination. For example, the estimated mean concentration of ^{234}U at the 18-in. depth is more than twice the health-based guideline value of 26.5 pCi/g. Similarly, the estimated mean concentration of ^{238}U at the 18-in. depth exceeds its guideline value of 28.5 pCi/g. Since contamination still exists at the 18-in. level, the depth of contamination has not been fully characterized. Therefore, deeper sampling will be necessary in order to determine the depth of contamination.

6.2 DATA PRESENTATION

The data from the K-1407-C sampling campaign are presented in two different graphical formats. First, concentrations of selected analytes are represented at each depth in a three-dimensional format. The data are also examined by way of two-dimensional contour plots that indicate the probability of exceeding a health-based guideline value at locations within the retention basin at a certain depth.

Table 17. A statistical comparison of the mean concentration per sample depth of all analytes at the K-1407-C Retention Basin

Analysis type	Analysis name	Estimated mean of unbiased results at the 6-in. depth	Estimated mean of unbiased results at the 12-in. depth	Estimated mean of unbiased results at the 18-in. depth	Units	Probability that the means at all depths are equal	Depth means that are statistically different at the 0.05 level
ICP-metals	Aluminum	34,700.00	27,653.85	24,853.85	mg/kg	0.0529	
ICP-metals	Antimony	2.78	2.83	2.51	mg/kg	0.2974	
ICP-metals	Arsenic	10.05	10.09	16.96	mg/kg	0.0770	
ICP-metals	Barium	100.13	107.00	79.12	mg/kg	0.0735	
ICP-metals	Beryllium	0.90	0.86	0.67	mg/kg	0.1700	
ICP-metals	Boron	8.72	3.25	1.66	mg/kg	0.0427	
ICP-metals	Cadmium	1.43	0.86	0.93	mg/kg	0.5574	
ICP-metals	Calcium	31,746.67	13,829.23	7,071.54	mg/kg	0.0062	6 and 18
ICP-metals	Chromium	67.63	55.92	45.08	mg/kg	0.1299	
ICP-metals	Cobalt	17.73	17.00	16.09	mg/kg	0.4811	
ICP-metals	Copper	68.90	51.96	29.04	mg/kg	0.0557	
ICP-metals	Iron	29,500.00	29,192.31	29,192.31	mg/kg	0.6995	
ICP-metals	Lead	33.20	36.19	32.35	mg/kg	0.6099	
ICP-metals	Magnesium	3,973.33	3,136.15	1,581.15	mg/kg	0.0078	6 and 18
ICP-metals	Manganese	1,128.67	1,613.08	1,492.31	mg/kg	0.5906	
ICP-metals	Molybdenum	1.72	1.82	1.66	mg/kg	0.9596	
ICP-metals	Nickel	333.27	242.19	119.29	mg/kg	0.0193	6 and 18
ICP-metals	Potassium	4,636.67	3,440.00	3,108.46	mg/kg	0.2373	
ICP-metals	Selenium	2.54	3.13	2.50	mg/kg	0.8129	
ICP-metals	Silicon	732.67	776.54	752.31	mg/kg	0.7472	
ICP-metals	Silver	0.64	0.74	0.63	mg/kg	0.8264	
ICP-metals	Sodium	450.13	606.08	734.92	mg/kg	0.8133	
ICP-metals	Strontium	26.62	16.89	10.52	mg/kg	0.0081	6 and 18
ICP-metals	Thorium	9.82	8.60	9.70	mg/kg	0.6445	
ICP-metals	Uranium (total)	118.83	90.68	51.11	mg/kg	0.2191	
ICP-metals	Vanadium	46.53	42.35	44.12	mg/kg	0.1549	
ICP-metals	Zinc	76.93	58.42	47.23	mg/kg	0.0116	6 and 18
Mercury	Mercury	6.09	3.42	3.11	mg/kg	0.1445	
Radiochem	Alpha Activity	109.60	92.47	88.53	pCi/g	0.0168	6 and 18
Radiochem	Americium-241	1.27	0.70	0.80	pCi/g	0.0237	6 and 18
Radiochem	Beta Activity	295.61	176.41	163.70	pCi/g	0.0004	6 and 12, 6 and 18
Radiochem	Cesium-137	5.03	3.24	2.39	pCi/g	0.0002	6 and 18
Radiochem	Neptunium-237	2.94	1.27	0.95	pCi/g	0.0005	6 and 18
Radiochem	Plutonium-238	0.21	0.10	0.06	pCi/g	0.7514	

Table 17 (continued)

Analysis type	Analysis name	Estimated mean of unbiased results at the 6-in. depth	Estimated mean of unbiased results at the 12-in. depth	Estimated mean of unbiased results at the 18-in. depth	Units	Probability that the means at all depths are equal	Depth means that are statistically different at the 0.05 level
Radiochem	Plutonium-239	4.23	3.36	2.80	pCi/g	0.0049	6 and 18
Radiochem	Potassium-40	10.83	9.72	9.40	pCi/g	0.1724	
Radiochem	Strontium (total)	5.26	4.16	3.74	pCi/g	0.1644	
Radiochem	Technetium-99	122.76	112.31	120.20	pCi/g	0.6937	
Radiochem	Uranium-234	97.55	60.09	53.92	pCi/g	0.0010	6 and 12, 6 and 18
Radiochem	Uranium-235	4.18	3.30	3.07	pCi/g	0.0045	6 and 12, 6 and 18
Radiochem	Uranium-238	52.08	30.96	30.58	pCi/g	0.0021	6 and 12, 6 and 18

6.2.1 Three-Dimensional Sample Concentration Plots

6.2.1.1 Construction of plots

The concentrations of selected analytes have been plotted three-dimensionally to identify trends or patterns of analyte concentrations within a certain sampling depth. Each sample in the three-dimensional plots is represented by a separate needle. The height of the needle indicates the concentration of the analyte detected in the sample. Pyramid symbols represent concentrations below detection limits, and diamonds represent positive data. The value of the detection limit is used as the plotting value for analyses that indicated concentrations below detection limits. Negative results for radionuclides concentrations are set equal to zero for plotting purposes. Figure 25 illustrates the orientation of the three-dimensional plots on the base map that was presented earlier in this report. Figure 26 is a three-dimensional map of the sampling locations and the berm in the retention basin.

In Figs. 26 to 39 the dimensions of the retention basin are altered to improve the graphical presentation. Otherwise, the long length and narrow width of the retention basin would cause crowding of the needles, and perception of trends would be more difficult. The vertical scale of the plots, which indicates analyte concentration, is also altered for different depths of the same analyte. The largest value on the concentration axis is the highest concentration of that analyte for that depth. Allowing the scale to change over depths makes trends within a certain depth more evident. These plots are meant to indicate general areas of elevated concentrations and trends but do not easily lend themselves to identifying particular locations and concentrations.

6.2.1.2 Findings

The radionuclide plots indicate higher concentrations in the area of the berm, along the north side of the retention basin, and along the west end. This trend is evident at all sampling depths. The distribution of ^{99}Tc, ^{234}U, and ^{235}U is presented in Figs. 27 to 35. A similar distribution pattern is indicated by the plots of other radionuclides, which are included in Appendix D.

The metals data are less conclusive. For some analytes, there may be slightly higher concentrations in the east end of the retention basin at the 6-in. depth, as indicated by the plots for chromium, mercury, nickel and uranium at the 6-in. depth, Figs. 36 to 39. However, most of the metal concentrations do not exhibit any definite pattern or trend. Increases in metal concentrations, unlike the radionuclides, are not indicated in the area of the berm. Additional metals plots can be found in Appendix D.

6.2.2 Illustration of Contamination Probability Contours

A drawback in the use of these three-dimensional figures that use only raw data is that they cannot be used for inference and therefore do not demonstrate the influence a high concentration might have on the surrounding area. Contour plots are one method of evaluating the effect that a high value may have on surrounding values. They provide an additional tool to help visualize the "surface" of chemical concentrations in the retention basin.

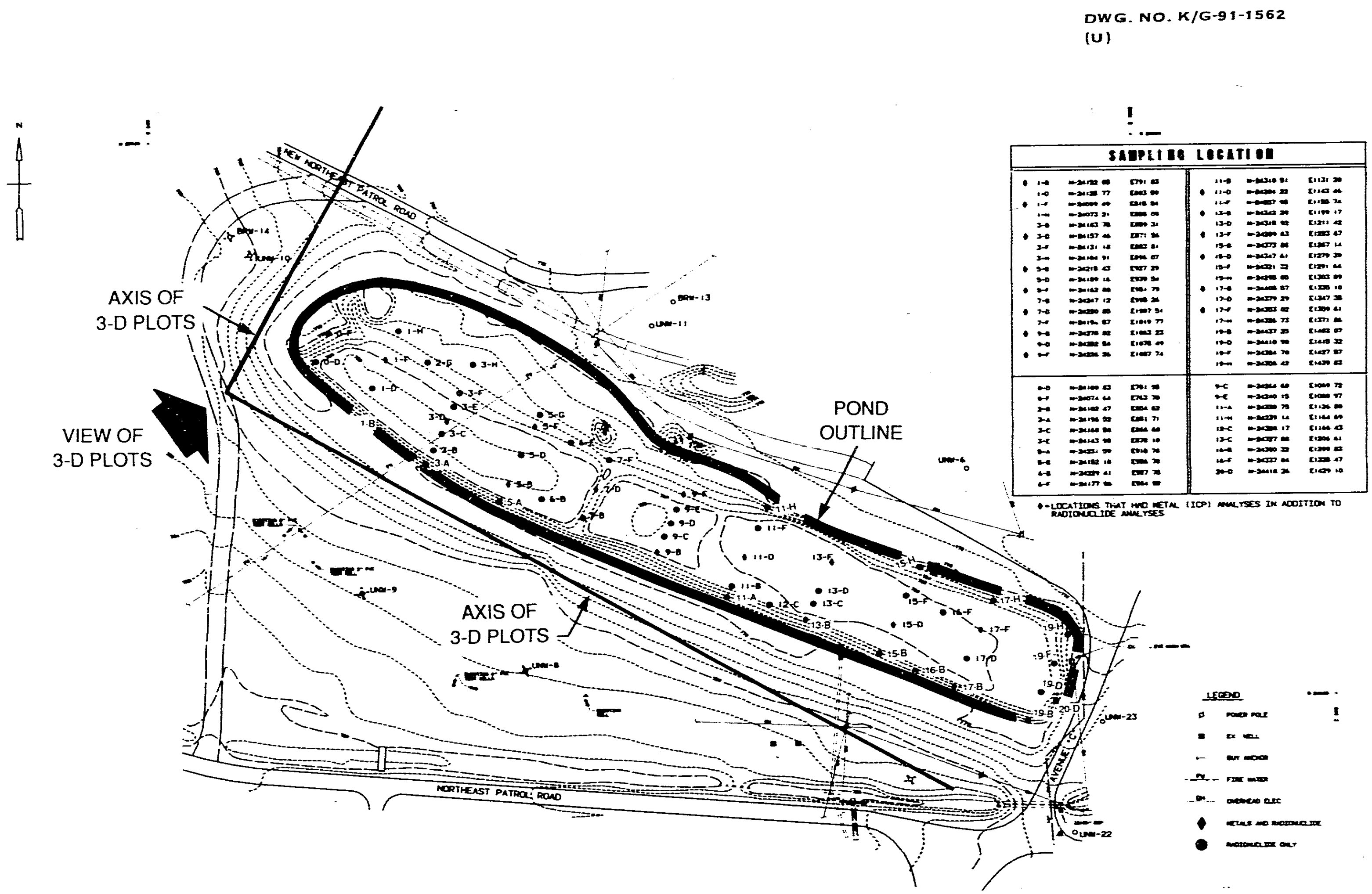

Fig. 25. Sampling locations.

DWG. NO. K/G-91-1448
(U)

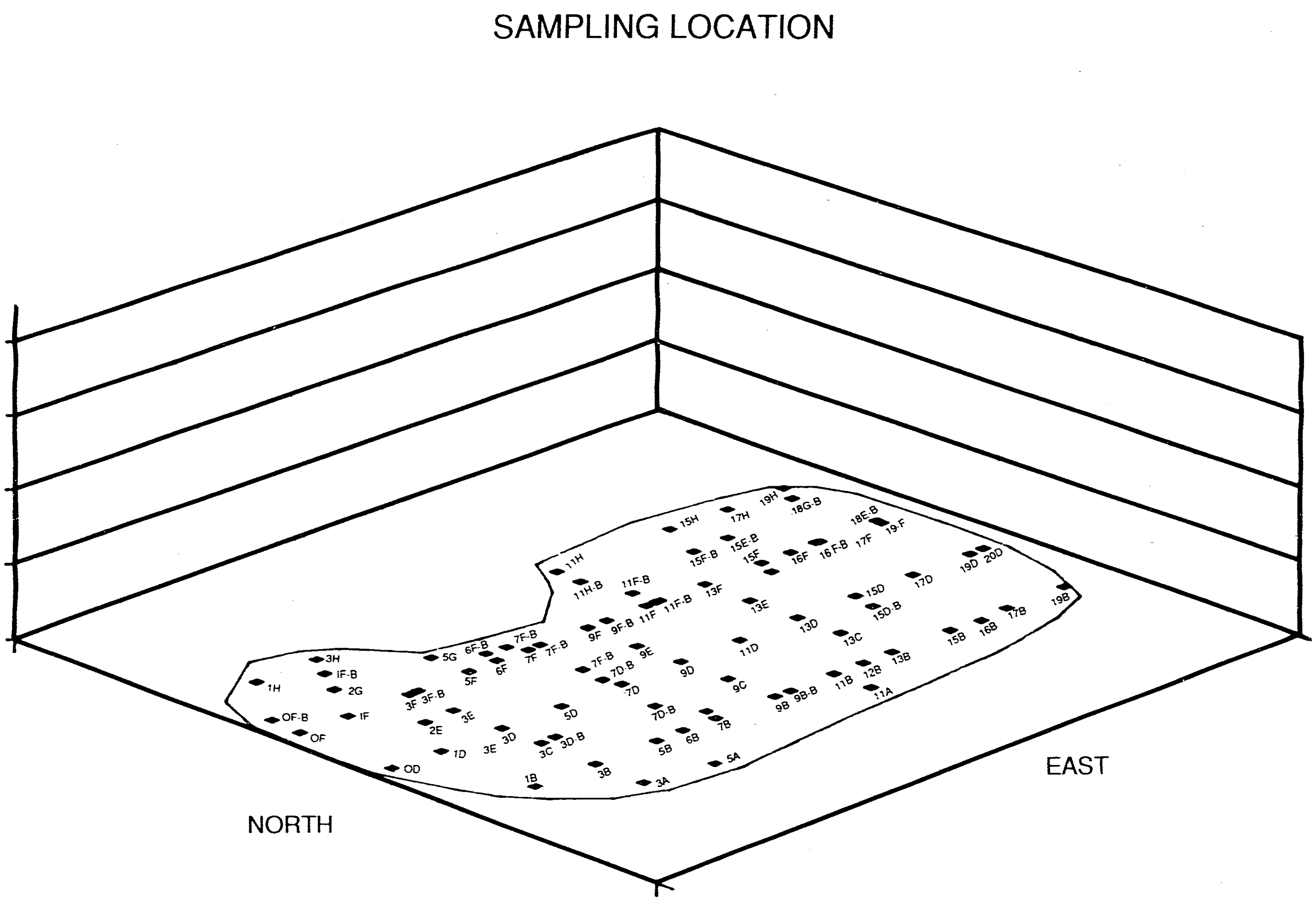

Fig. 26. Three-dimensional perspective of K-1407-C Retention Basin.

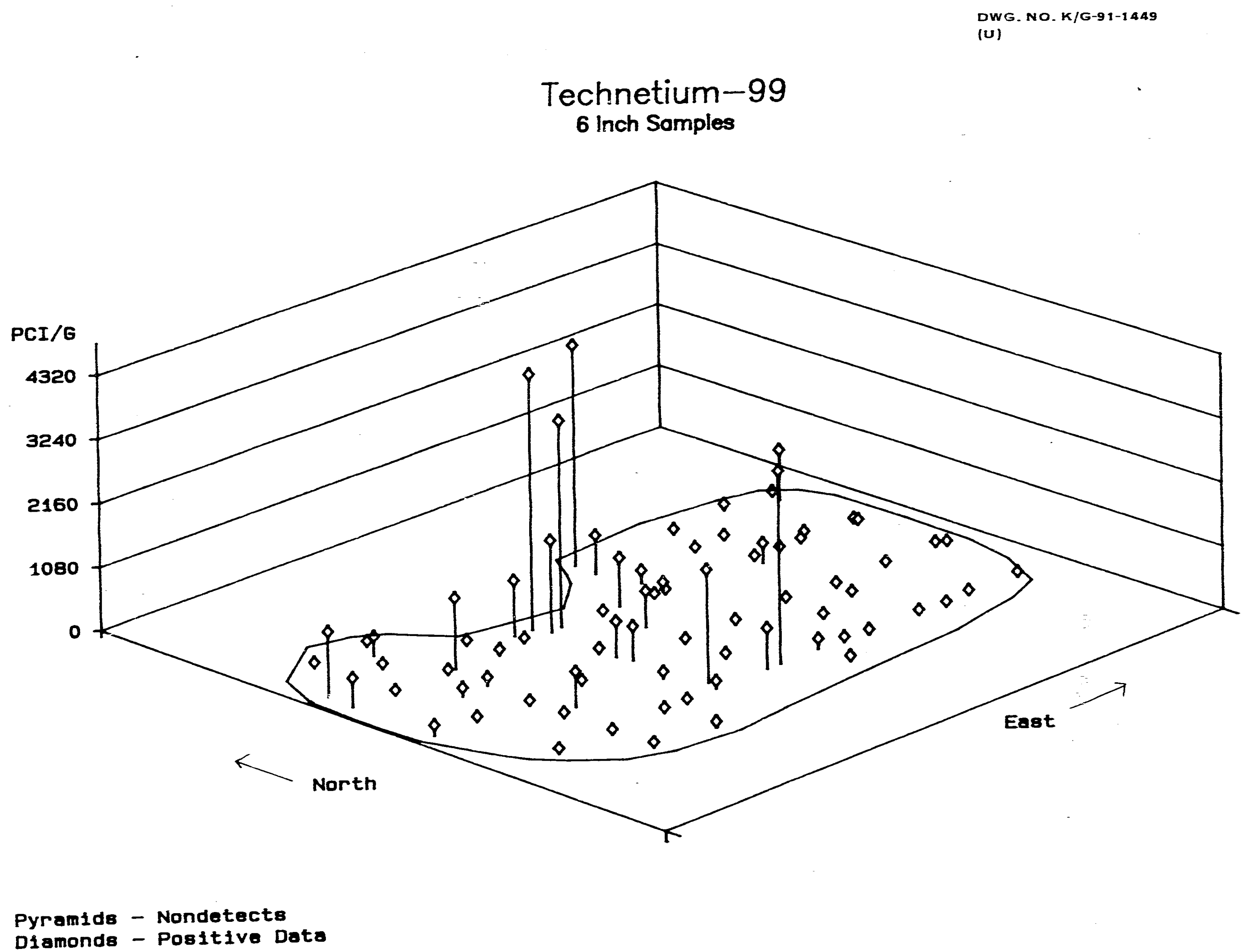

Fig. 27. ^{99}Tc, 6-in. samples.

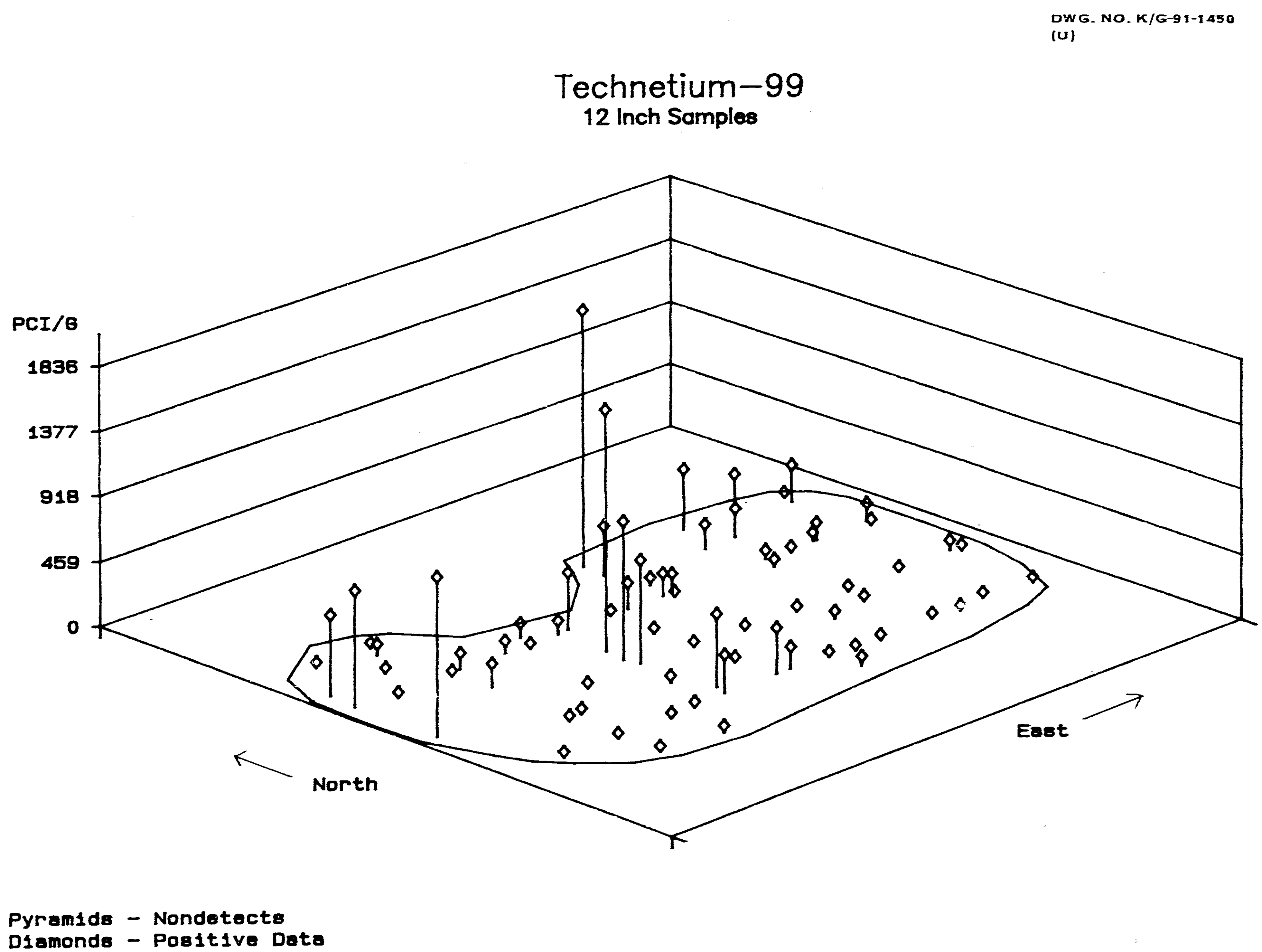

Fig. 28. ^{99}Tc, 12-in. samples.

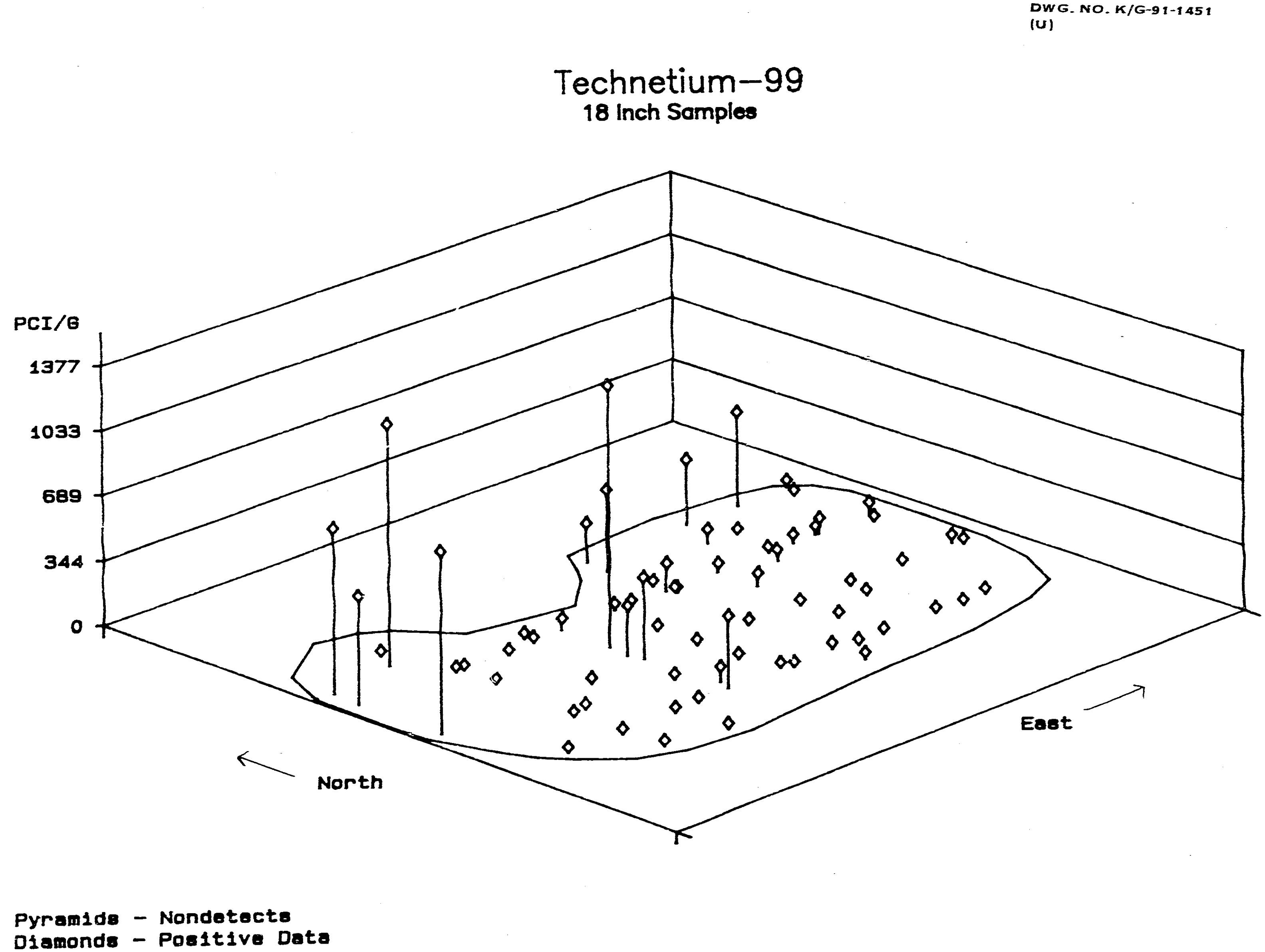

Fig. 29. ^{99}Tc, 18-in. samples.

DWG. NO. K/G-91-1452
(U)

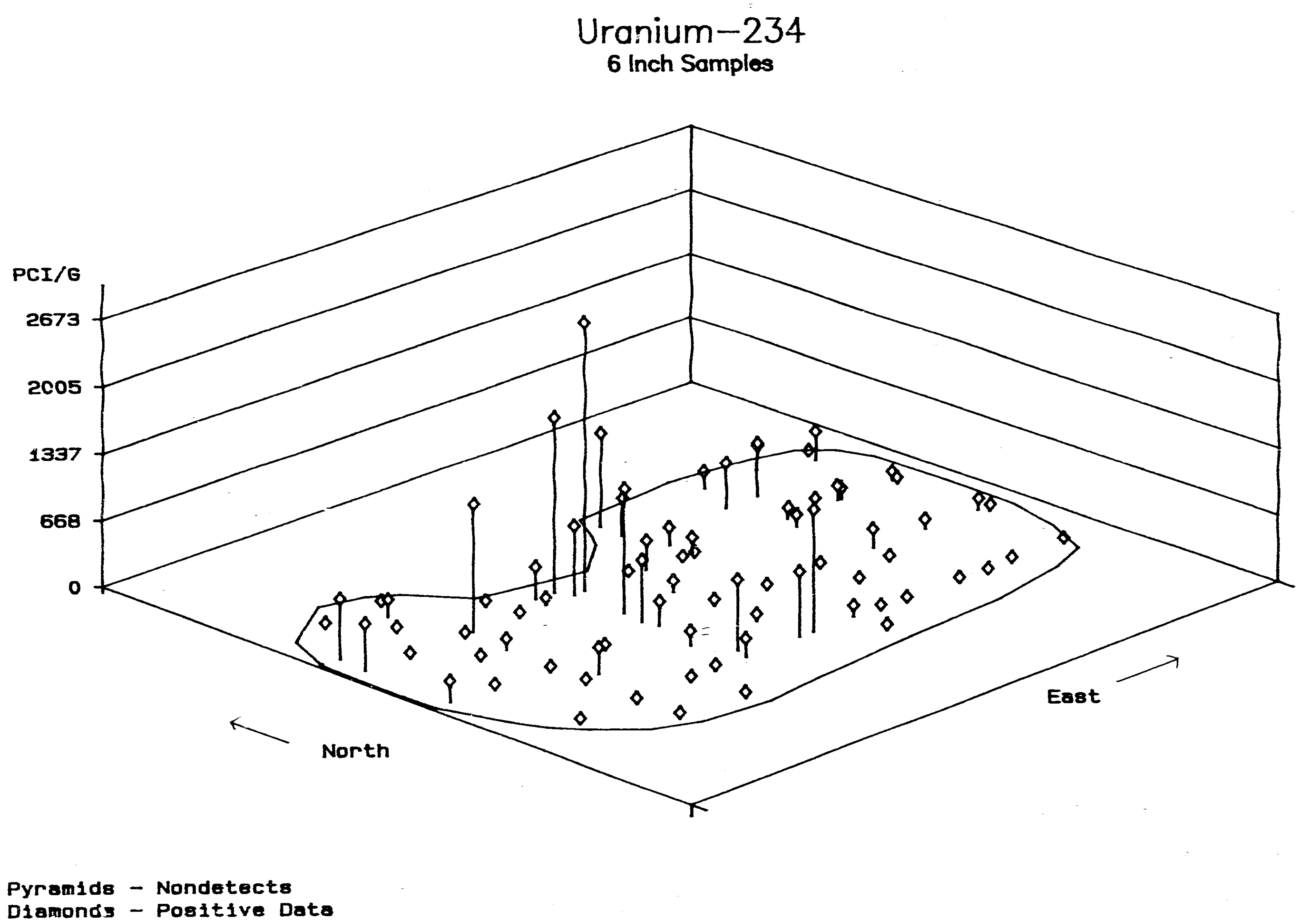

Fig. 30. ^{234}U, 6-in. samples.

DWG. NO. K/G-91-1453
(U)

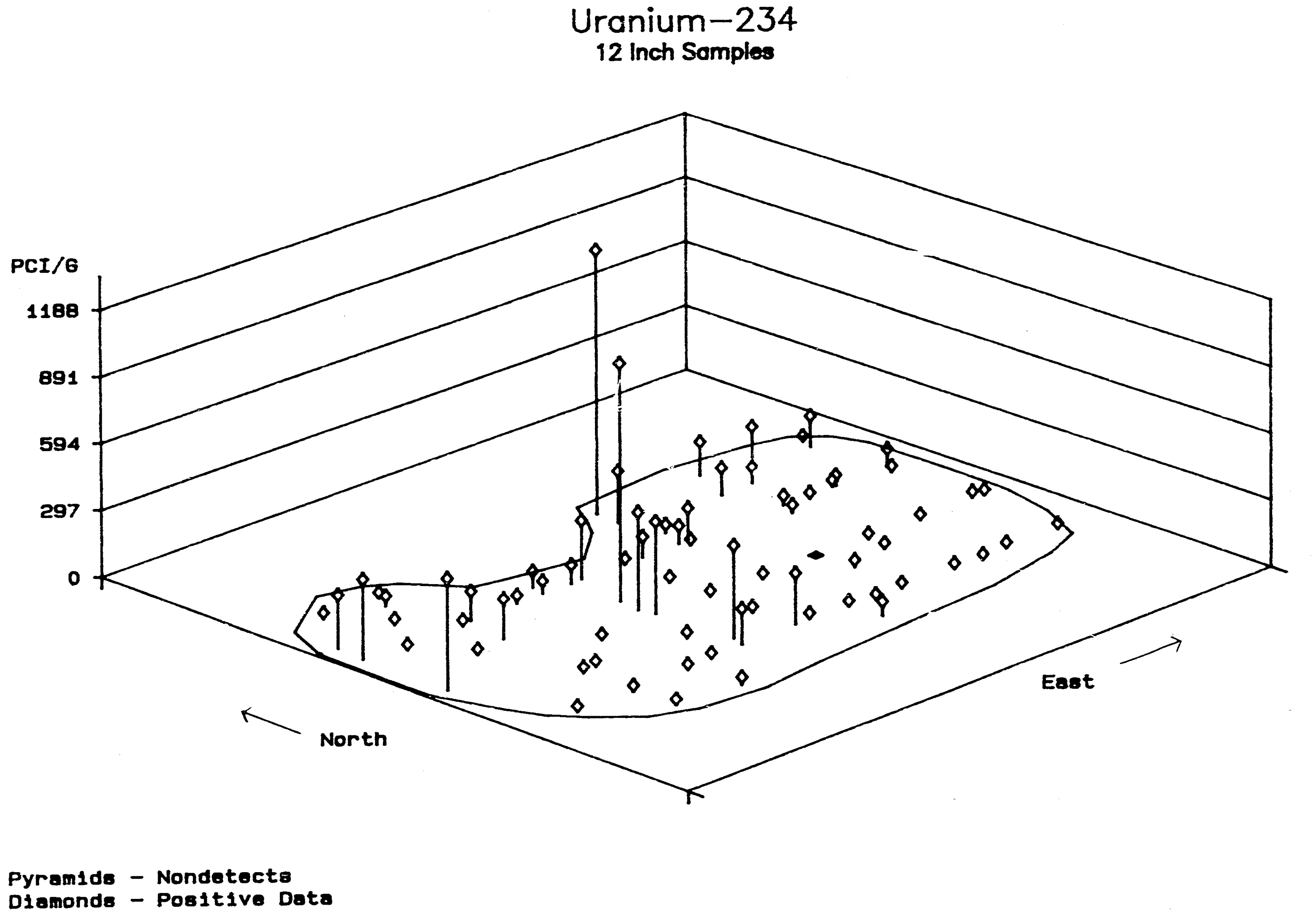

Fig. 31. ^{234}U, 12-in. samples.

DWG. NO. K/G-91-1454
(U)

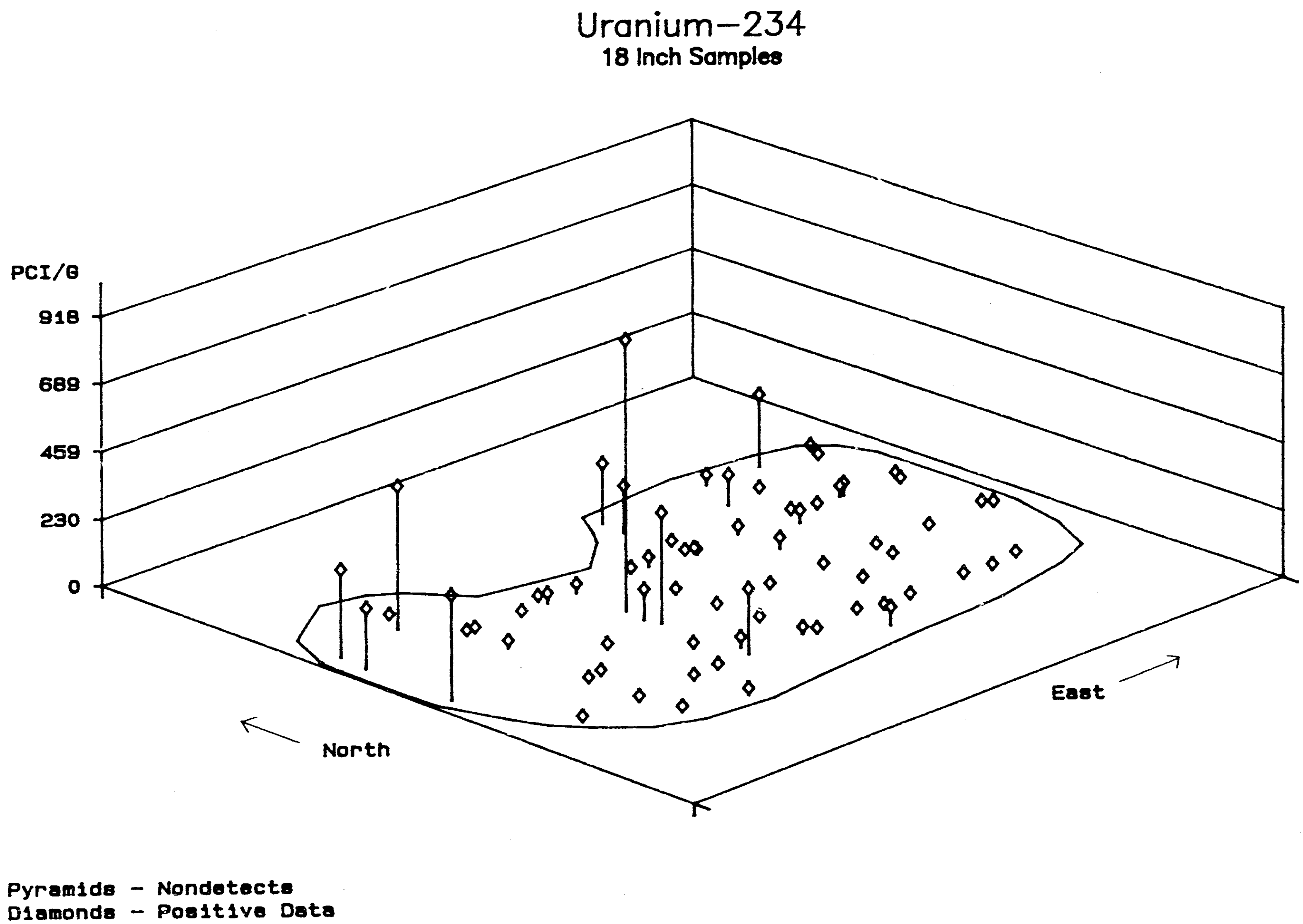

Fig. 32. ^{234}U, 18-in. samples.

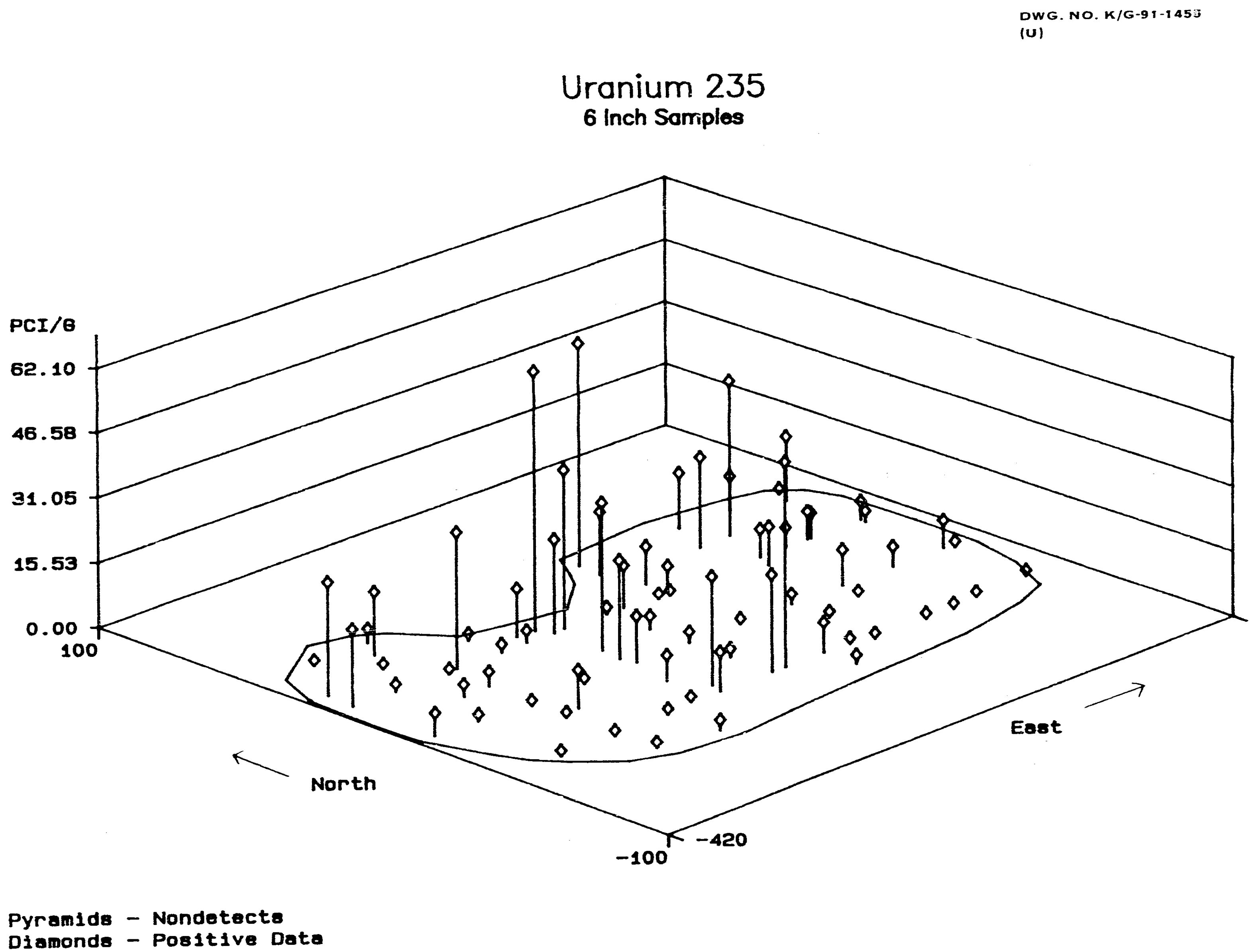

Fig. 33. ^{235}U, 6-in. samples.

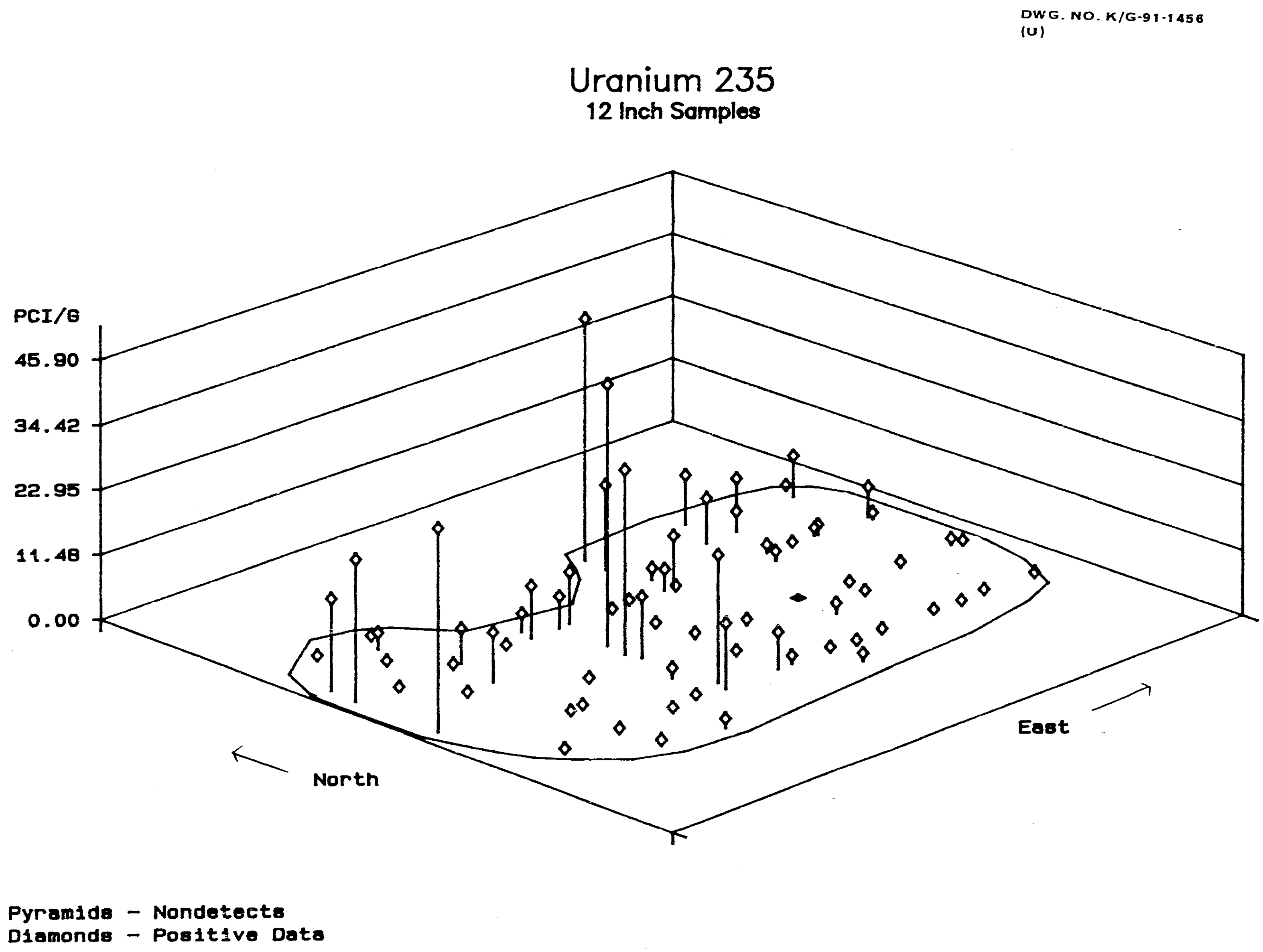

Fig. 34. ^{235}U, 12-in. samples.

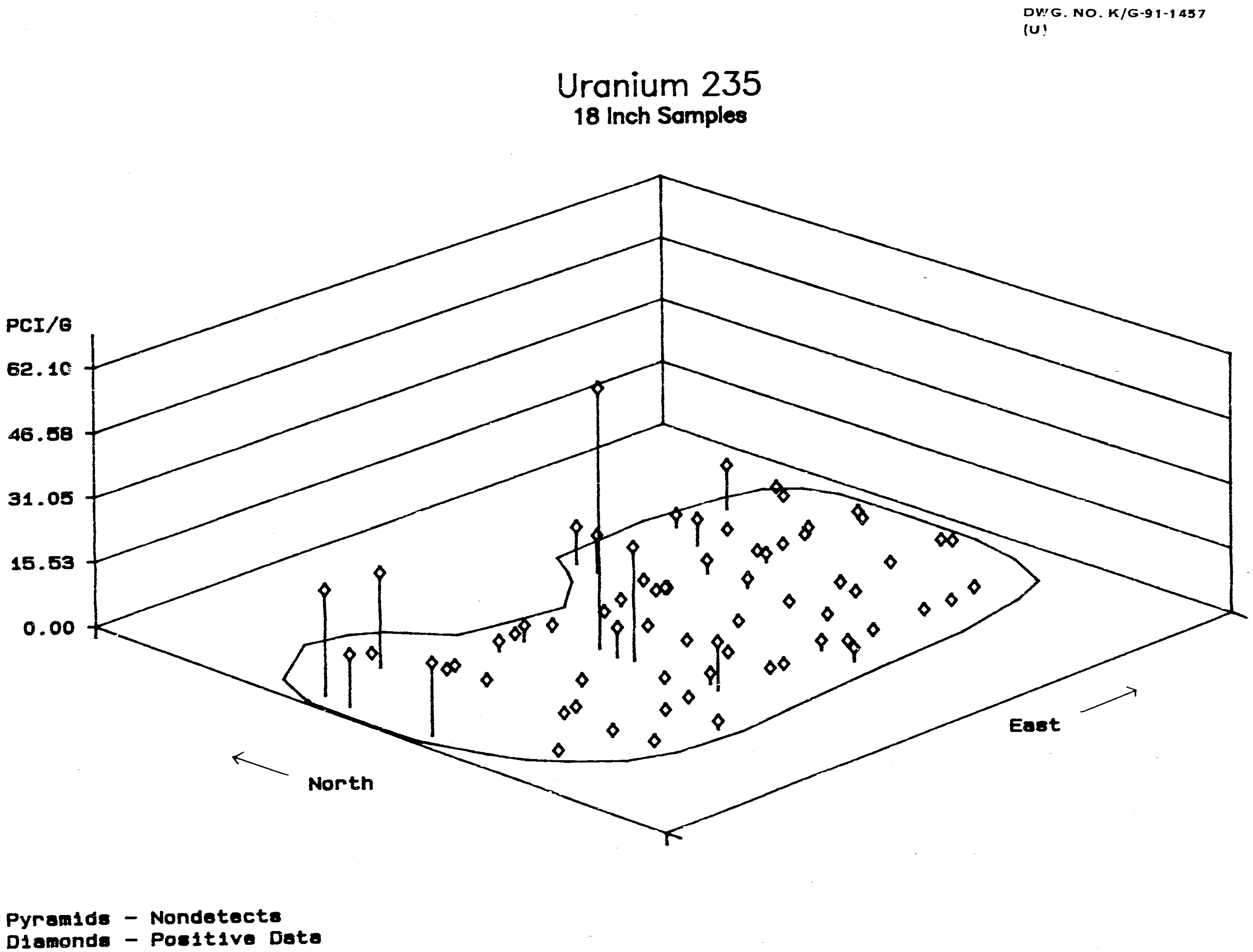

Fig. 35. ^{235}U, 18-in. samples.

DWG. NO. K/G-91-1458
(U)

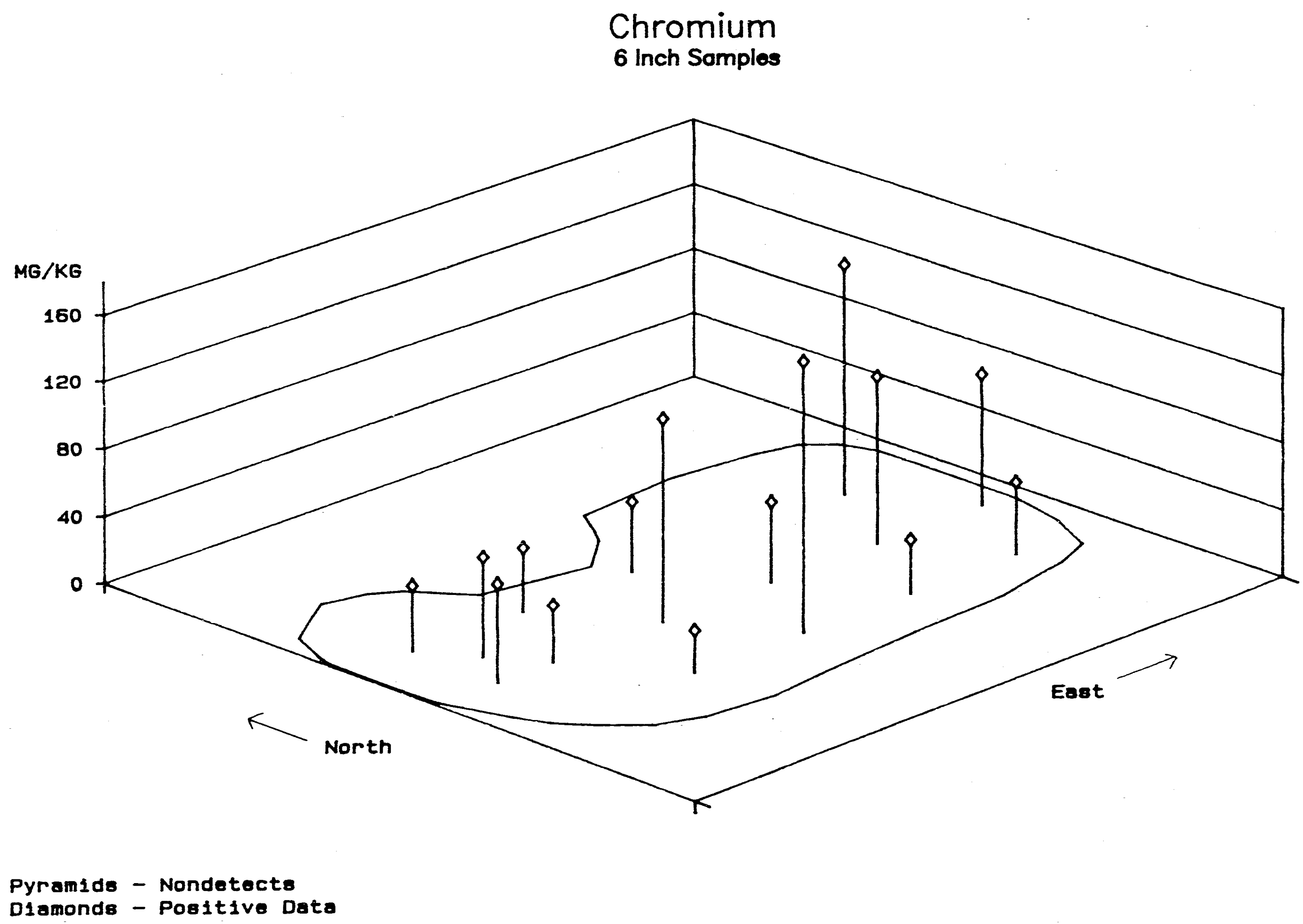

Fig. 36. Chromium, 6-in. samples.

DWG. NO. K/G-91-1459
(U)

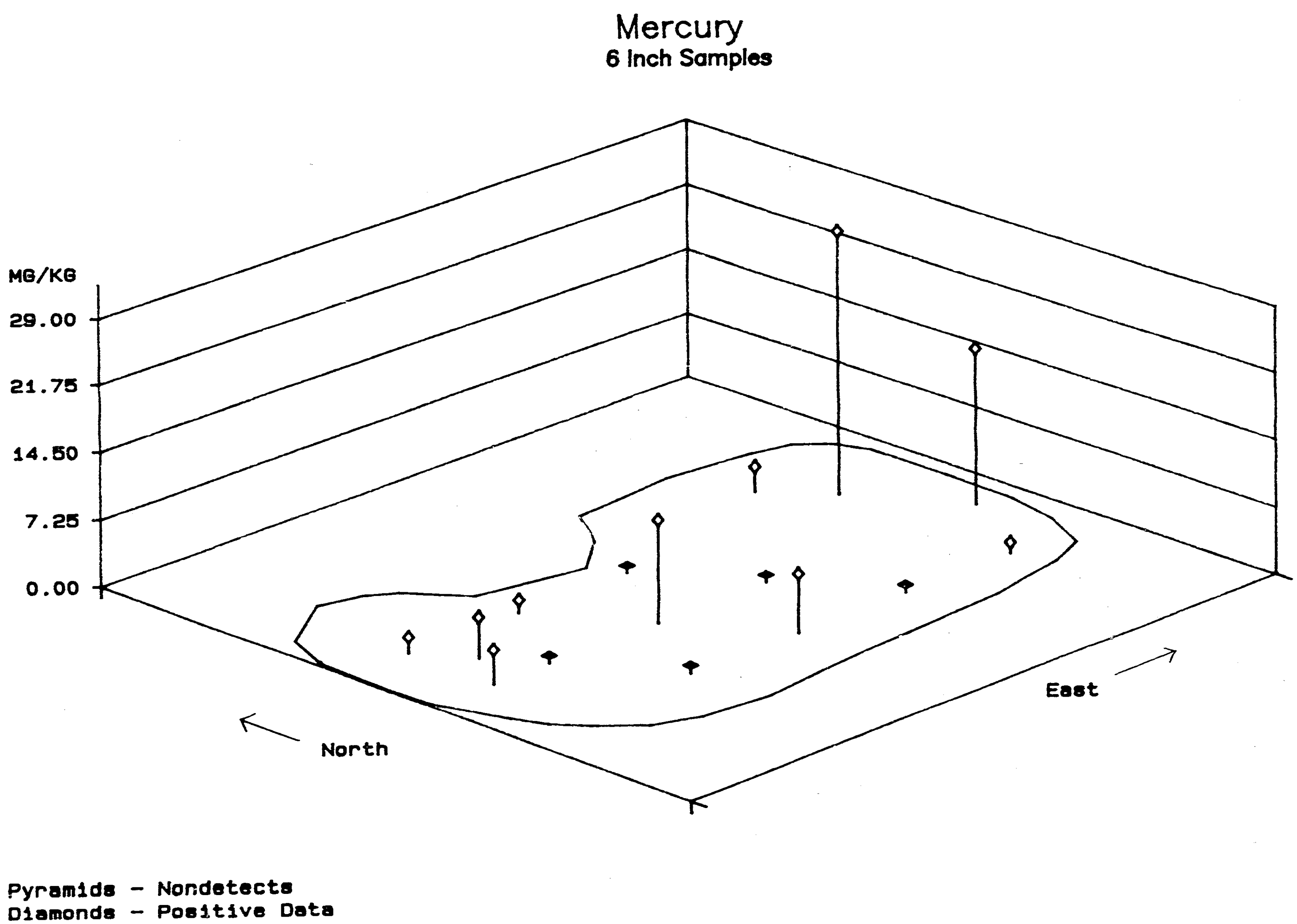

Fig. 37. Mercury, 6-in. samples.

DWG. NO. K/G-91-1460
(U)

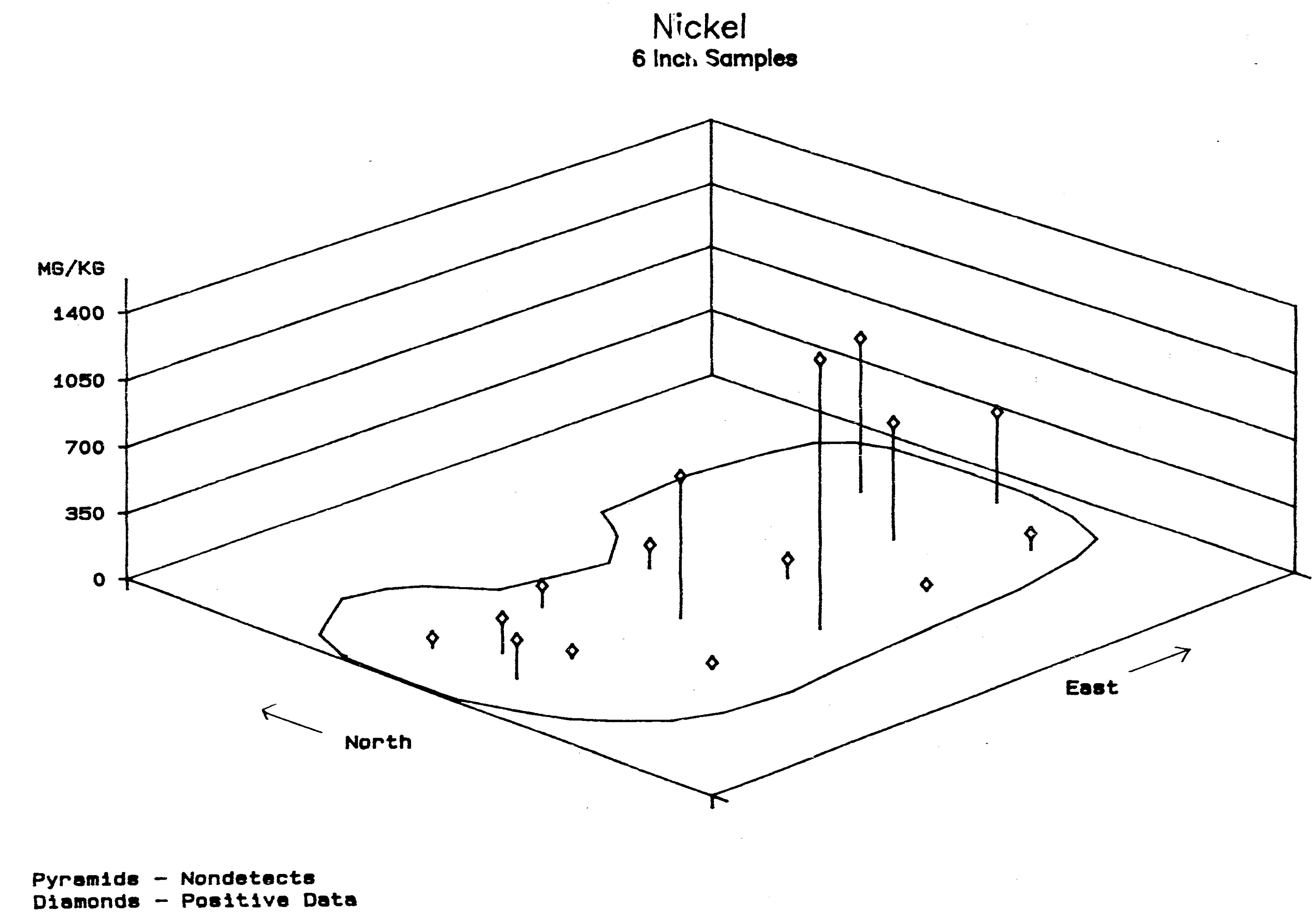

Fig. 38. Nickel, 6-in. samples.

DWG. NO. K/G-91-1461
(U)

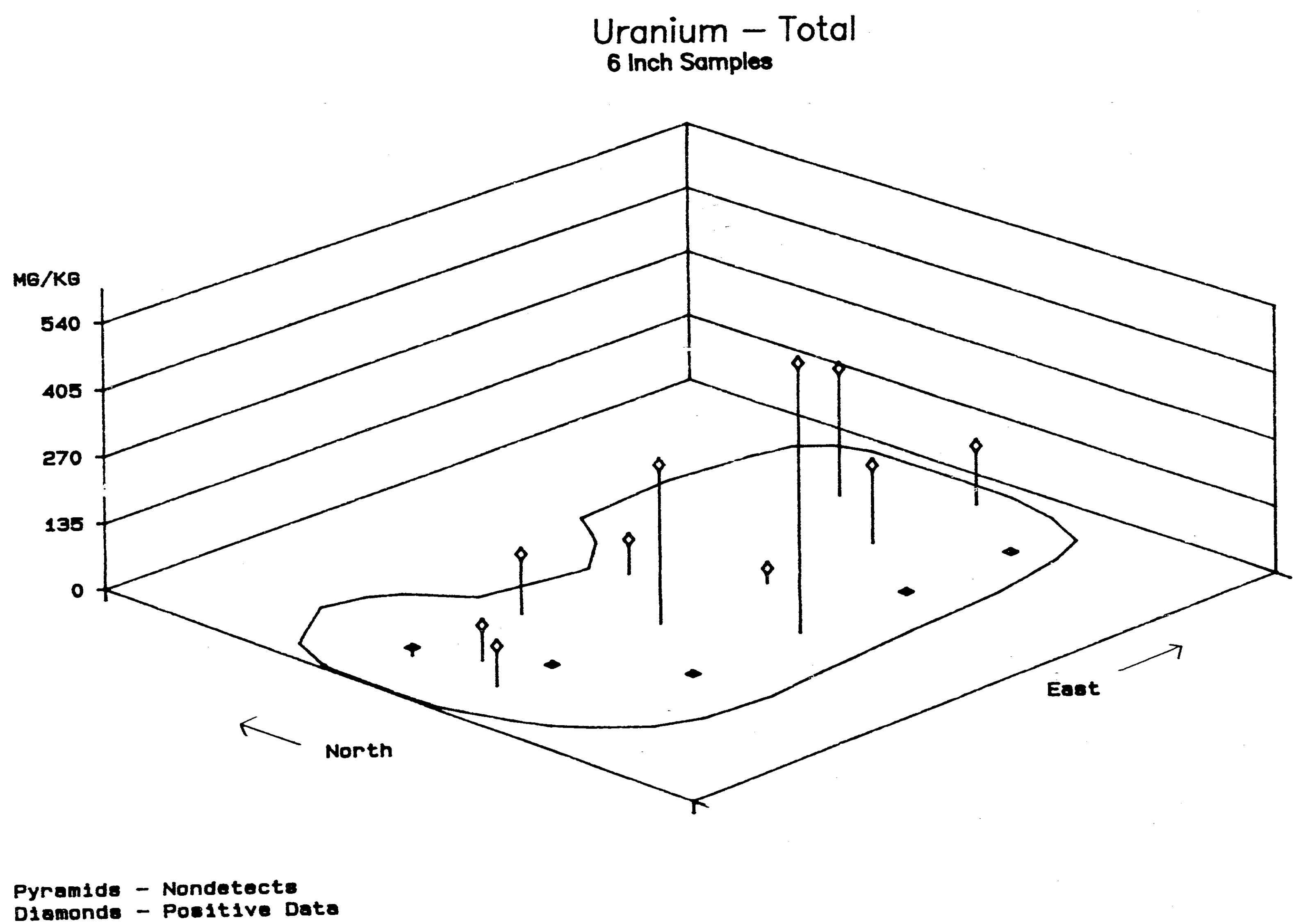

Fig. 39. Total uranium, 6-in. samples.

6.2.2.1 Interpretation of contour plots

Contour plots of the probability of exceeding a health-based guideline value for radionuclide concentrations were prepared for nine sets of data from the K-1407-C Retention Basin. Americium-241, ^{237}Np, and ^{235}U were considered at only the 6-in. level, while ^{234}U and ^{238}U were appraised at 6, 12, and 18 in. There are insufficient data values greater than the health-based value in the remaining radiochemical data to contour probabilities with any degree of confidence. The contour lines in the figures do not represent estimated concentrations at a specific location, but rather probabilities of exceeding the threshold value. For instance, areas that coincide with the 0.50 line on the plot represent areas where the average concentration has a probability of 0.50 of being greater than the health-based guideline value for the particular analyte. The lines of equal probability on the plots are displayed in increments of 0.10. The guideline values used in this study were obtained from Table 4, "Guideline values for radionuclides," in *Data Analysis Approach Report for K-1407-B Holding Pond and K-1407-C Retention Basin* (K/ER-23).[7]

6.2.2.2 Methodology

The method used to prepare the probability contour plots is known as kriging. Kriging is a method of using weighted moving averages to estimate values for unsampled locations,

$$z^*(x_u)=\sum \delta_i \, z(x_i) \; ; \qquad 0< \delta_i <1$$

within a certain area of interest. $z^*(x_u)$ is the kriging estimate at the unsampled location x_u, where $z(x_i)$ is the observed datum at the location x_i, and δ_i is the weight, between 0 and 1, attached to that datum derived from the kriging process. The weights that are chosen depend on two things. One is the spatial relationship between the point for which an estimate is to be calculated and nearby points for which a data value is known. The other is the correlational structure in the data. This correlational structure must then be modeled. A typical type of structure might be that samples close together have data values that are similar and that samples further apart are more variable. This trend continues until the samples reach a certain distance apart, called the range of correlation, after which the variability between samples remains constant. The kriging process generates a regular grid of estimates that are used by a standard contouring software package to generate contour plots. The estimation grid that was laid out for K-1407-C has a grid spacing of 10 ft by 20 ft.

The specific type of kriging that has been used with the K-1407-C Retention Basin data is called indicator kriging. For indicator kriging, the data values are transformed to indicator data (0 or 1) depending on whether the particular datum is less than or equal to or is greater than some predefined guideline value. Ordinary kriging is then performed on these transformed data. The estimates that are obtained are not estimated concentrations at a specific location, but rather probabilities of exceeding the guideline value. The kriging calculations were done using the Geostatistical Environmental Assessment Software from EPA Environmental Monitoring Systems Laboratory in Las Vegas. This software is public domain personal computer software provided by EPA for use in environmental assessments. At the end of this chapter, references have been provided to give the interested reader a source of material describing the theory of kriging in general and of indicator kriging specifically.

6.2.2.3 Findings

Probabilities for exceeding guideline values of more than 0.80 along the berm can be seen in Figs. 40 to 45 for ^{234}U and ^{238}U at 6, 12, and 18 in. Figure 40 exhibits probabilities of 1.00 for ^{234}U on the berm at 6 in. Uranium-234 and ^{238}U at 6, 12, and 18 in. (Figs. 40 to 45) have probabilities as high as 0.90 of exceeding the respective guideline values at the west end of the retention basin and on the north bank. As illustrated in Fig. 46, the probability that ^{237}Np concentrations at 6 in. will exceed 13.7 pCi/g at the north end of the berm is greater than 0.70 and greater than 0.40 near the north bank at the east end of the retention basin. The probability of exceeding guideline levels for ^{235}U is not as great as some other radiological contaminants, but the largest probabilities do occur along the berm (Fig. 47). The plot for ^{241}Am (Fig. 48) does not exhibit a higher probability of exceeding guideline levels in the area of the berm. However, ^{241}Am concentrations are higher in the berm than elsewhere.

The plots indicate a high degree of correlation among the radionuclides. Generally, areas of higher concentrations are the north bank, west end, and the berm. All the contour plots exhibit higher probabilities of exceeding the health-based guideline values along the north side of the retention basin, and almost all show higher probabilities on the berm. These probability contour estimates of the K-1407-C radiochemical data also demonstrate that the initial sampling campaign has failed to encompass completely the contamination left behind by the sludge removal process. Further sampling efforts are needed to extend the sampling region to the north and west as well as in depth.

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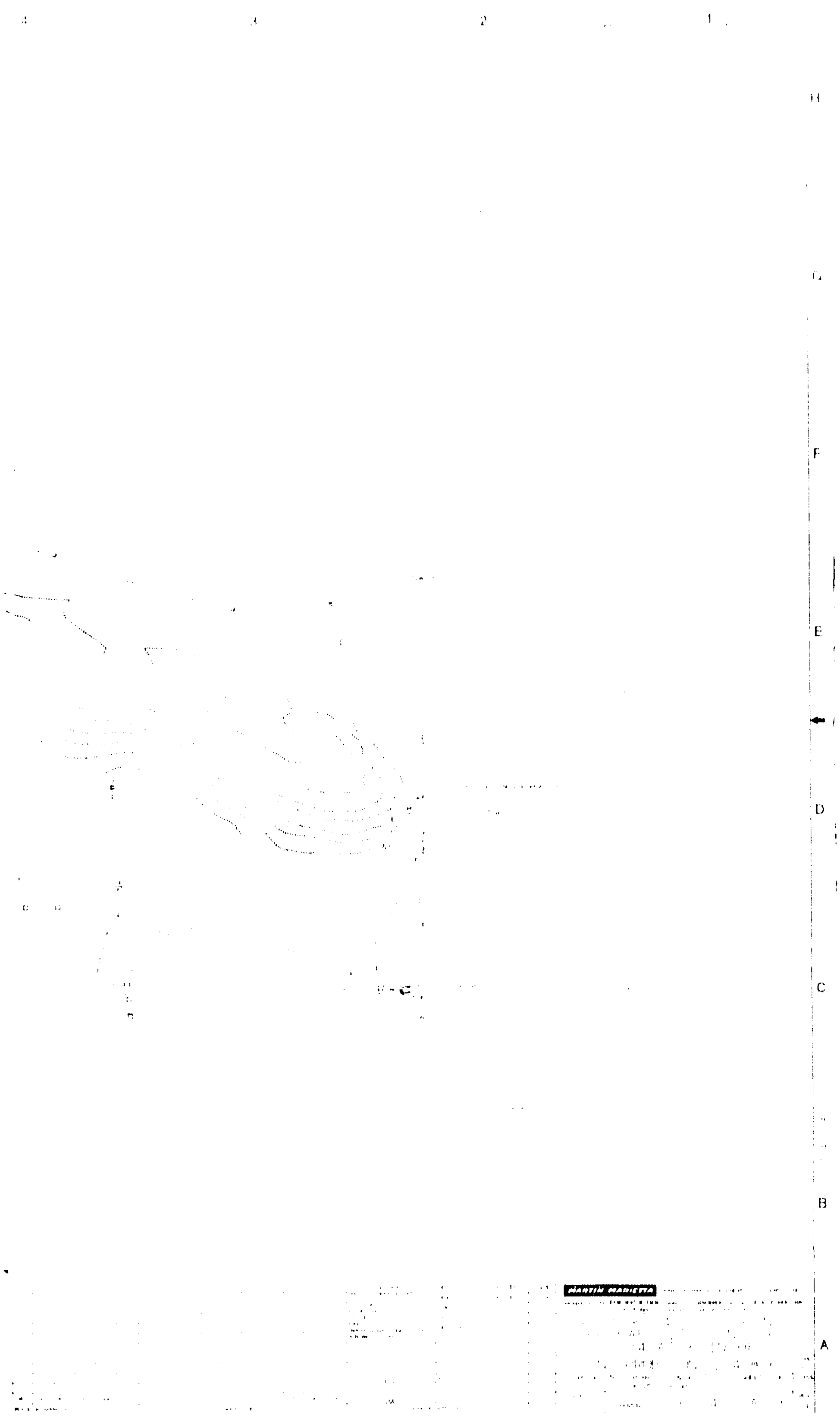
Fig. 40. Probability contour plot fo



^{234}U, 6 in. samples.

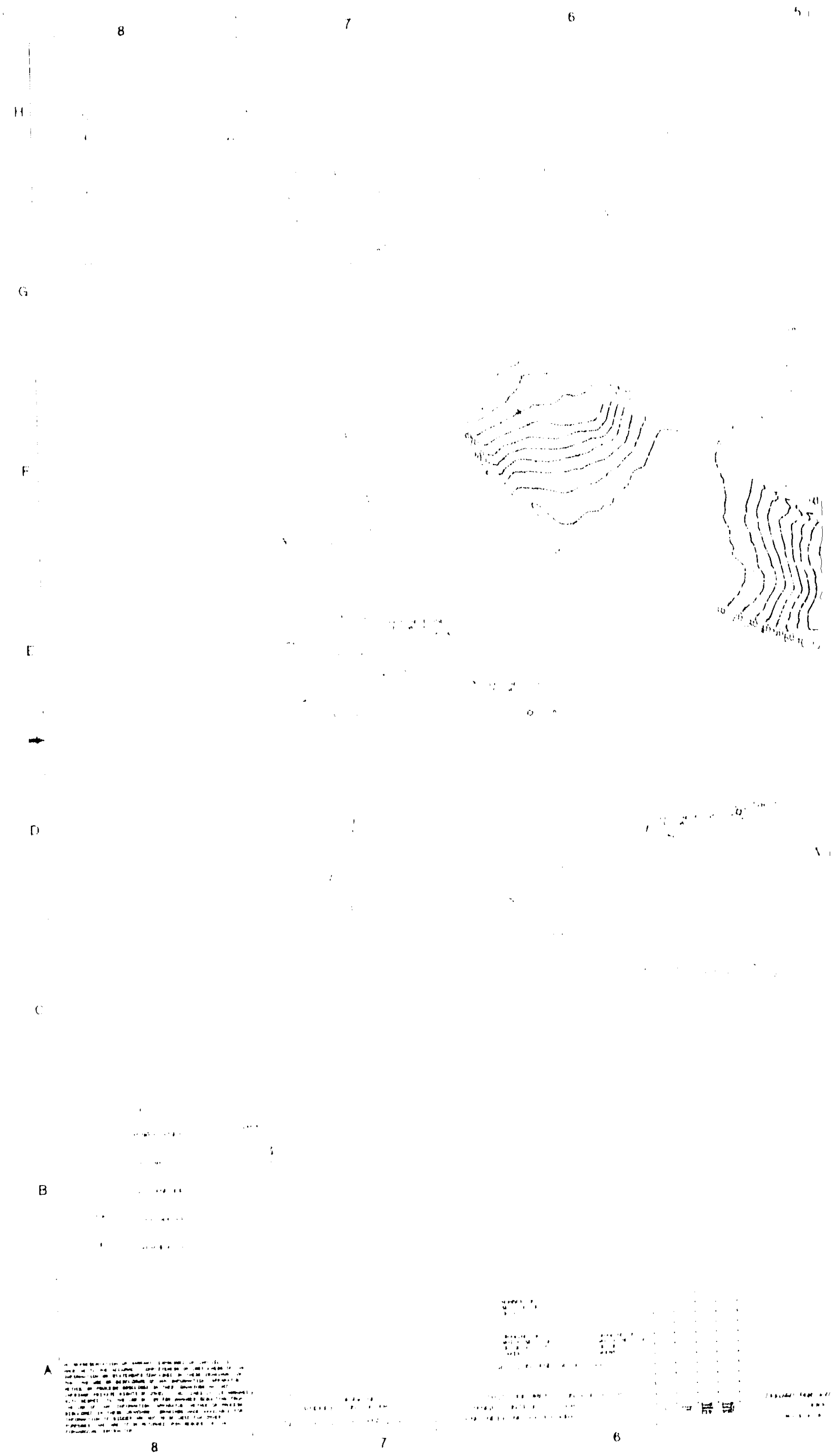
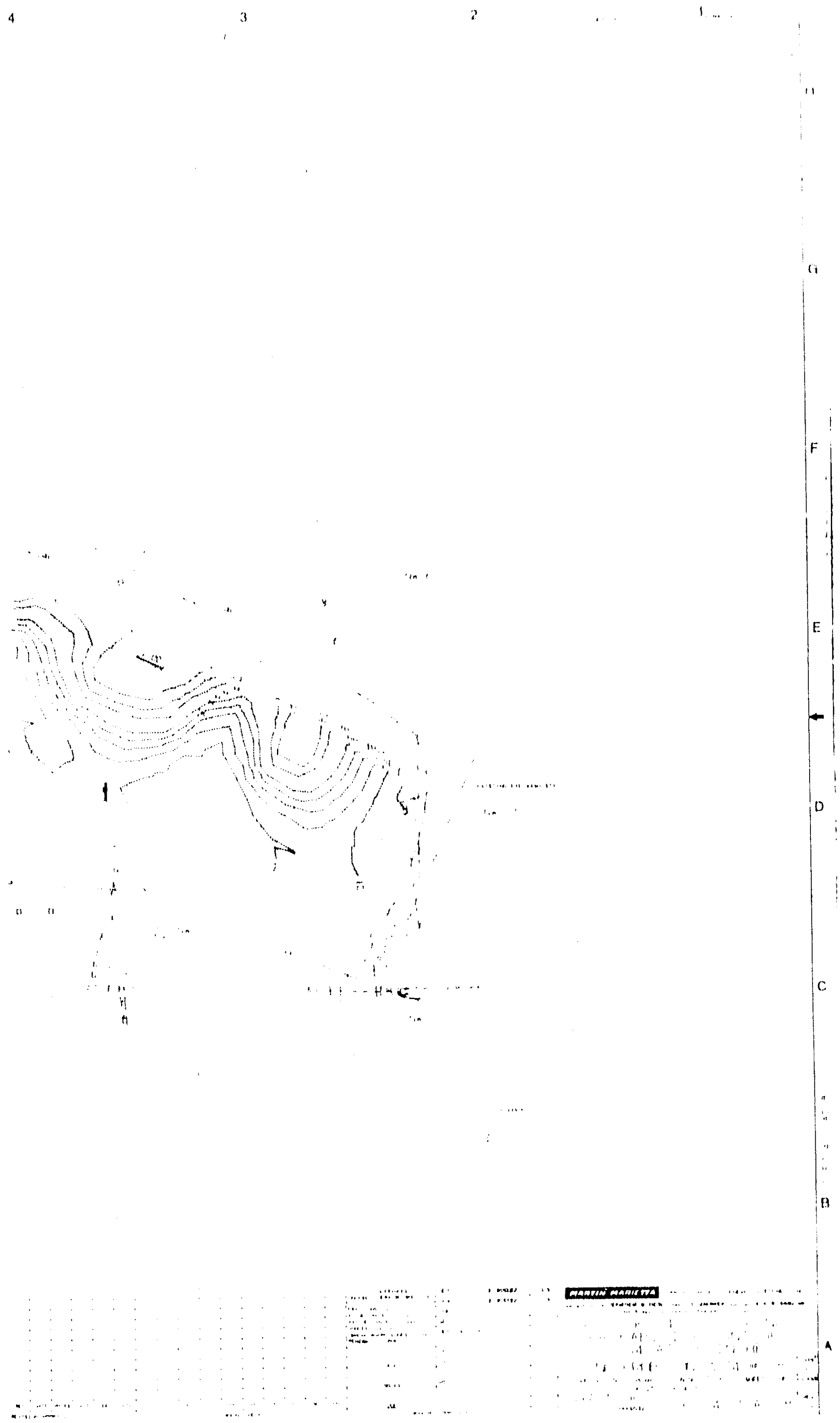


Fig. 41. Probabi

y contour plot for ^{234}U, 12-in. samples.

Fig. 42. Probability contour pl



for ^{234}U, 18-in. samples.

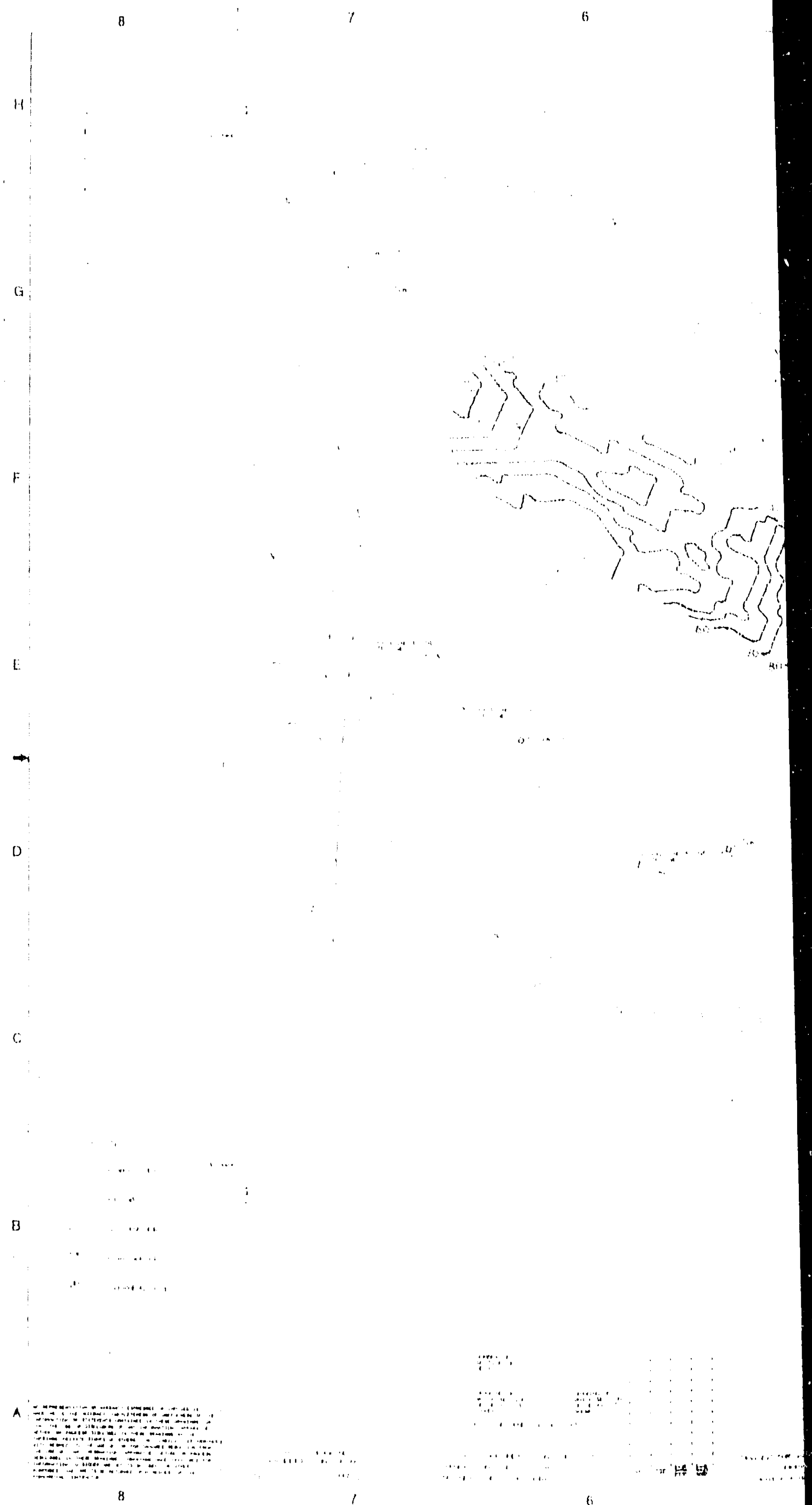
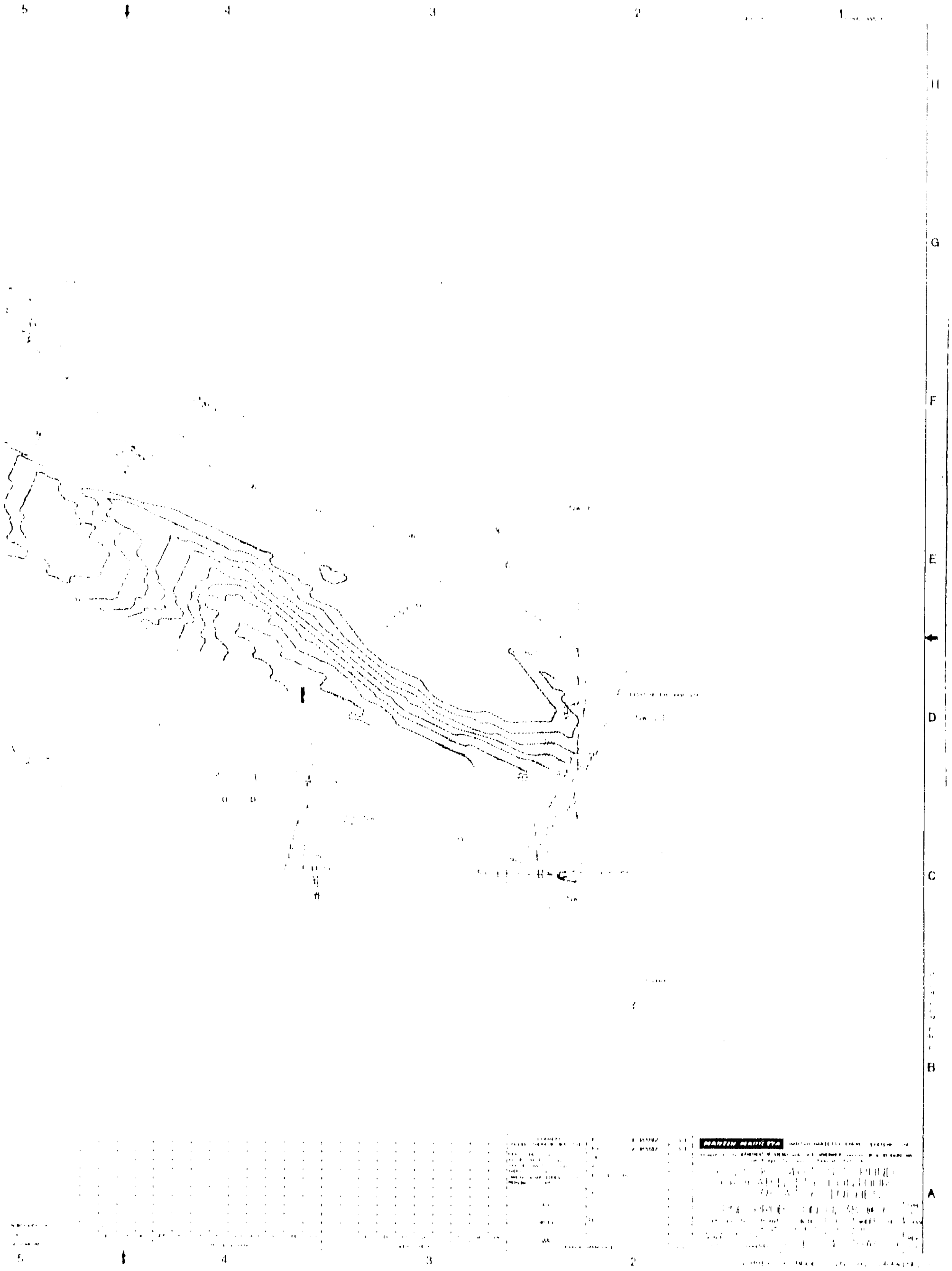


Fig. 43. Probabi



lity contour plot for ^{238}U, 6 in. samples.

lity contour plot for [illegible]I [illegible] samples

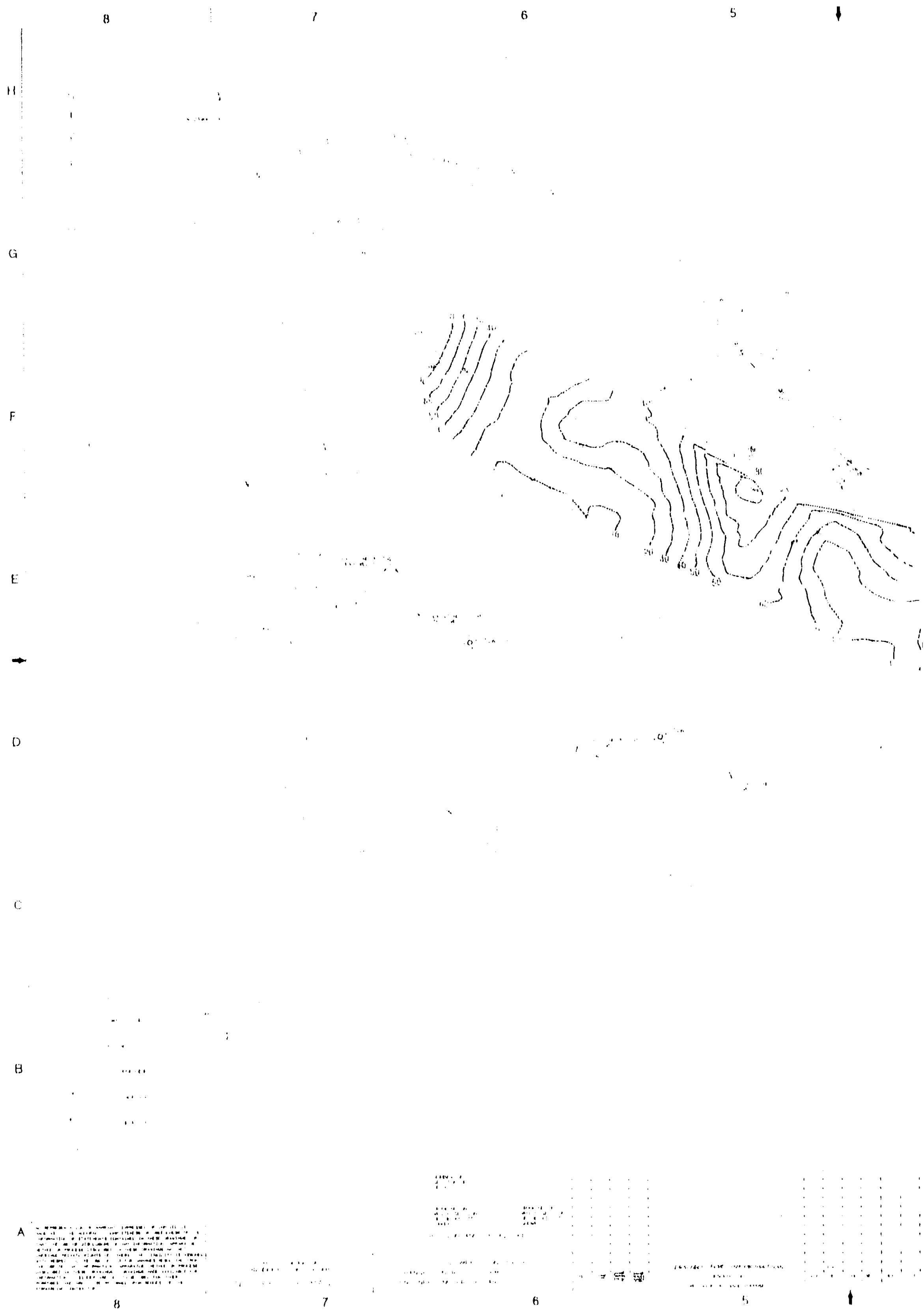
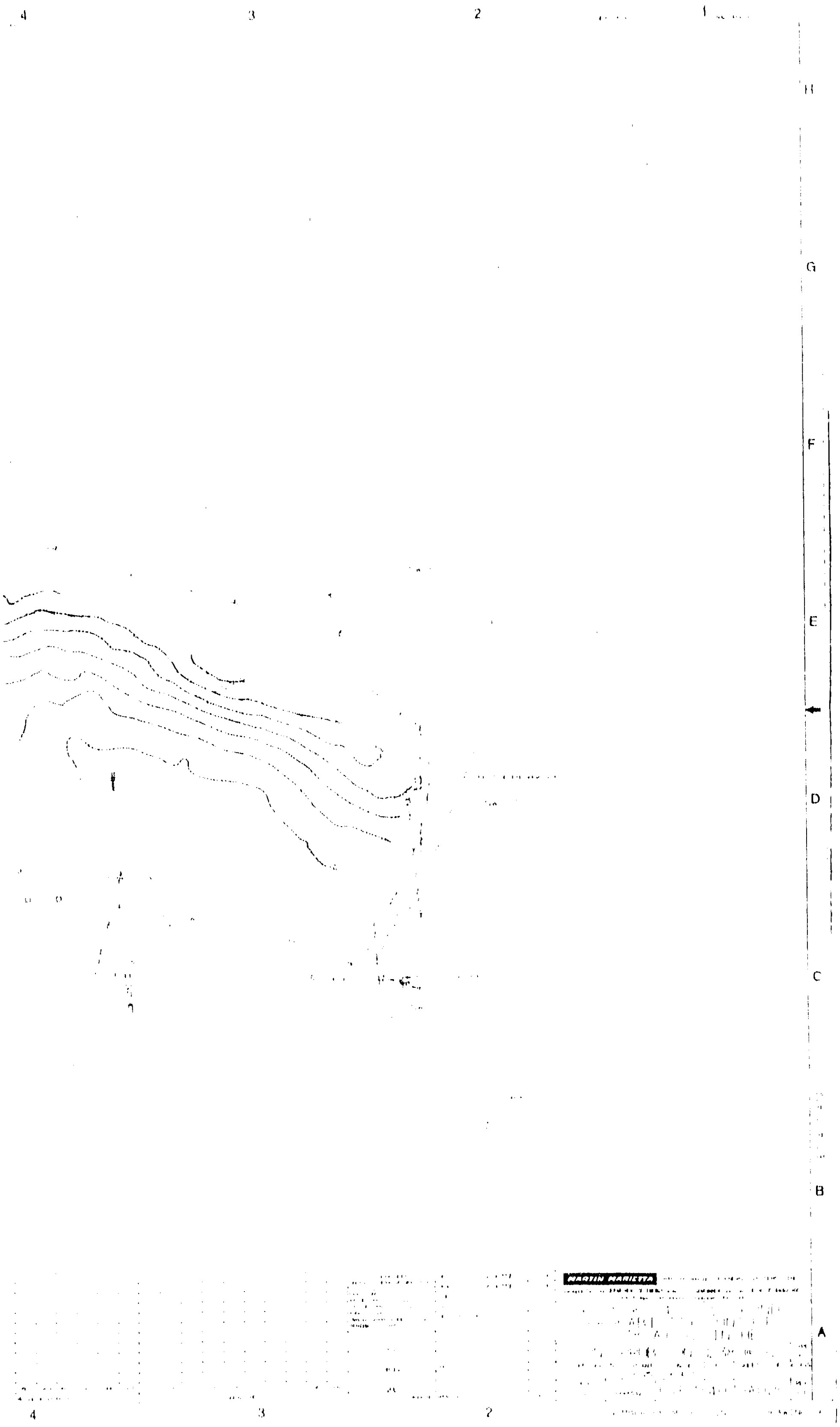
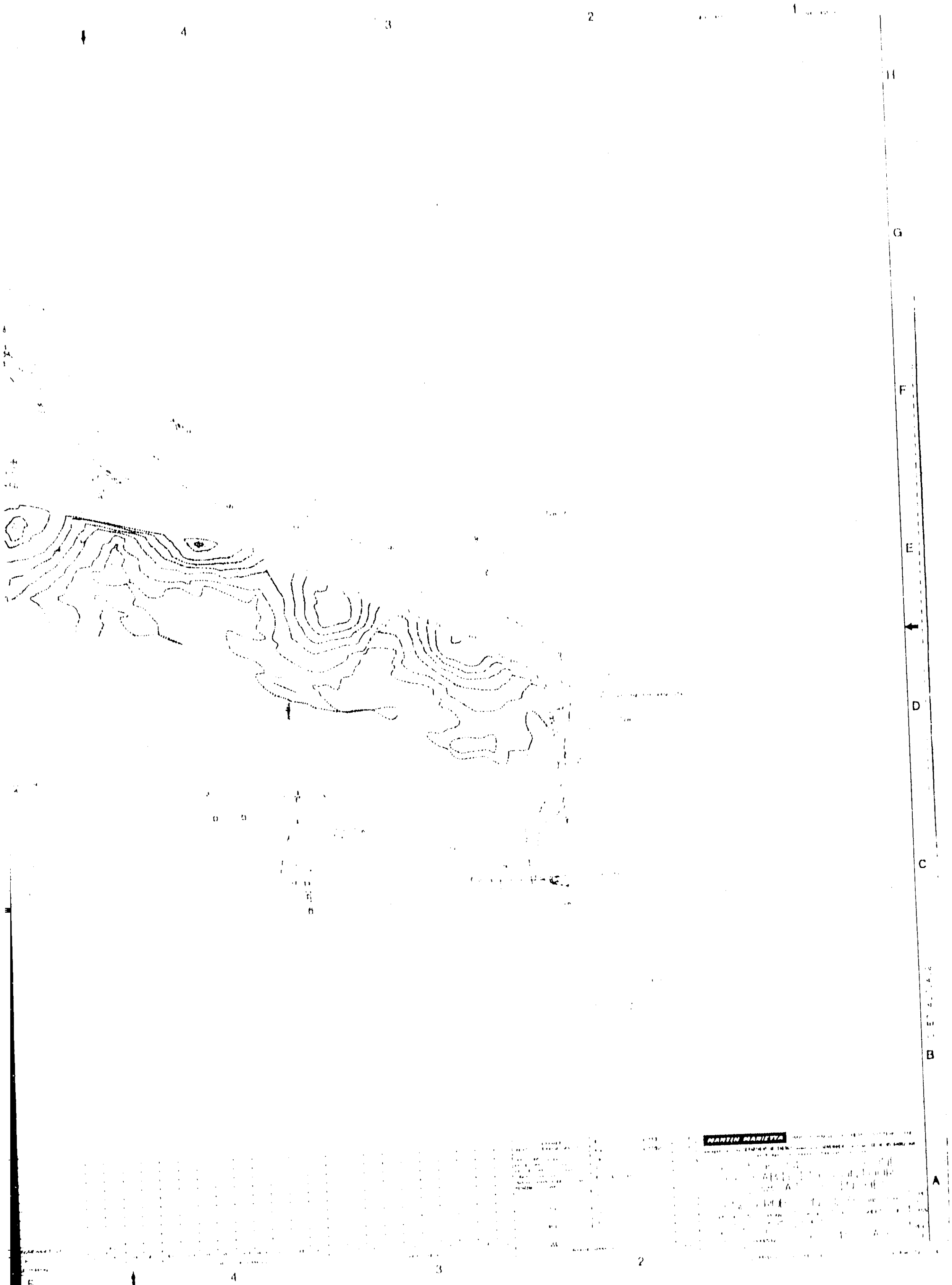


Fig. 44. Probability contour plot for



^{238}U, 12-in. samples.

Fig. 45. Probab



ity contour plot for ^{238}U, 18-in. samples.

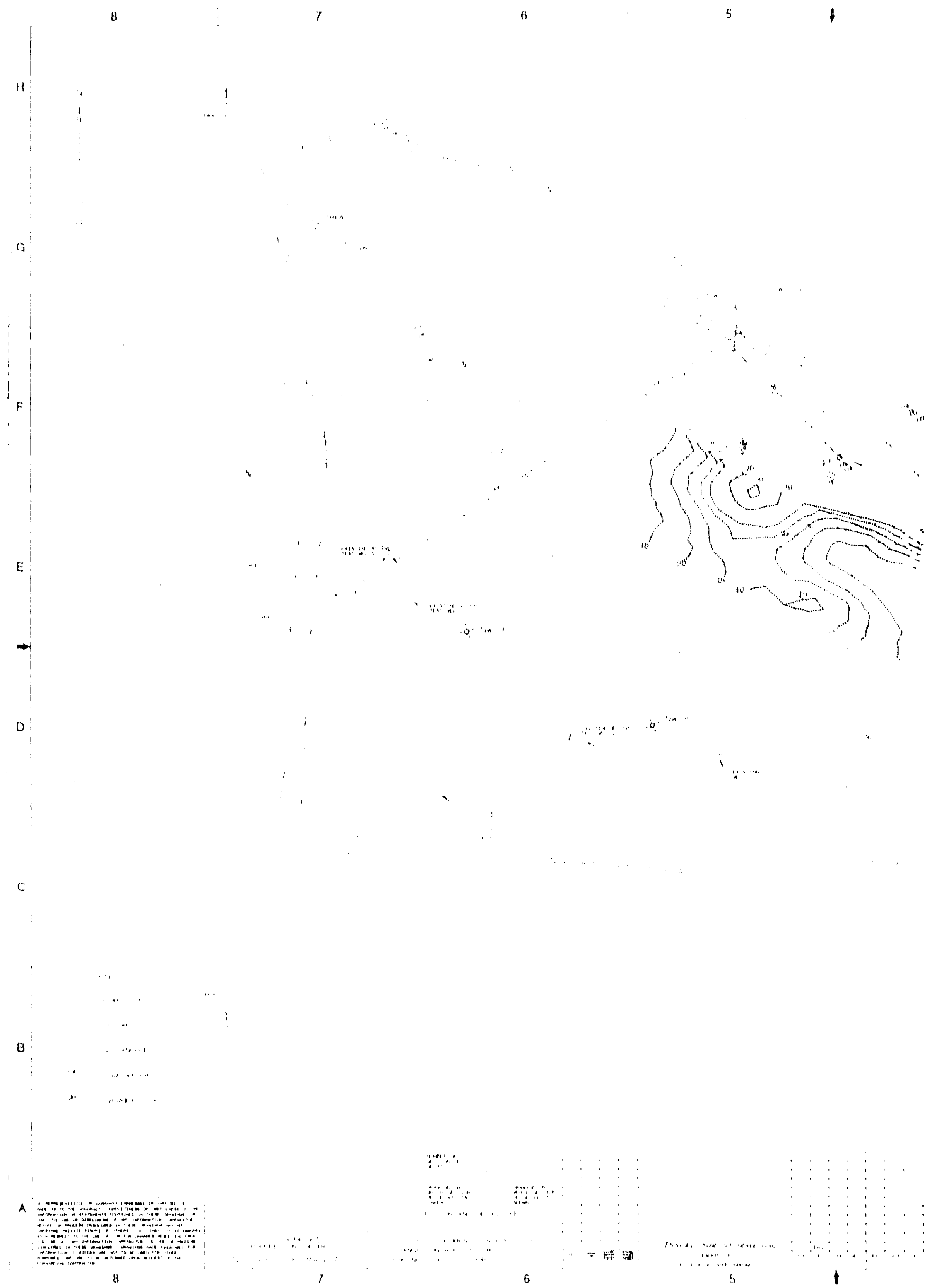
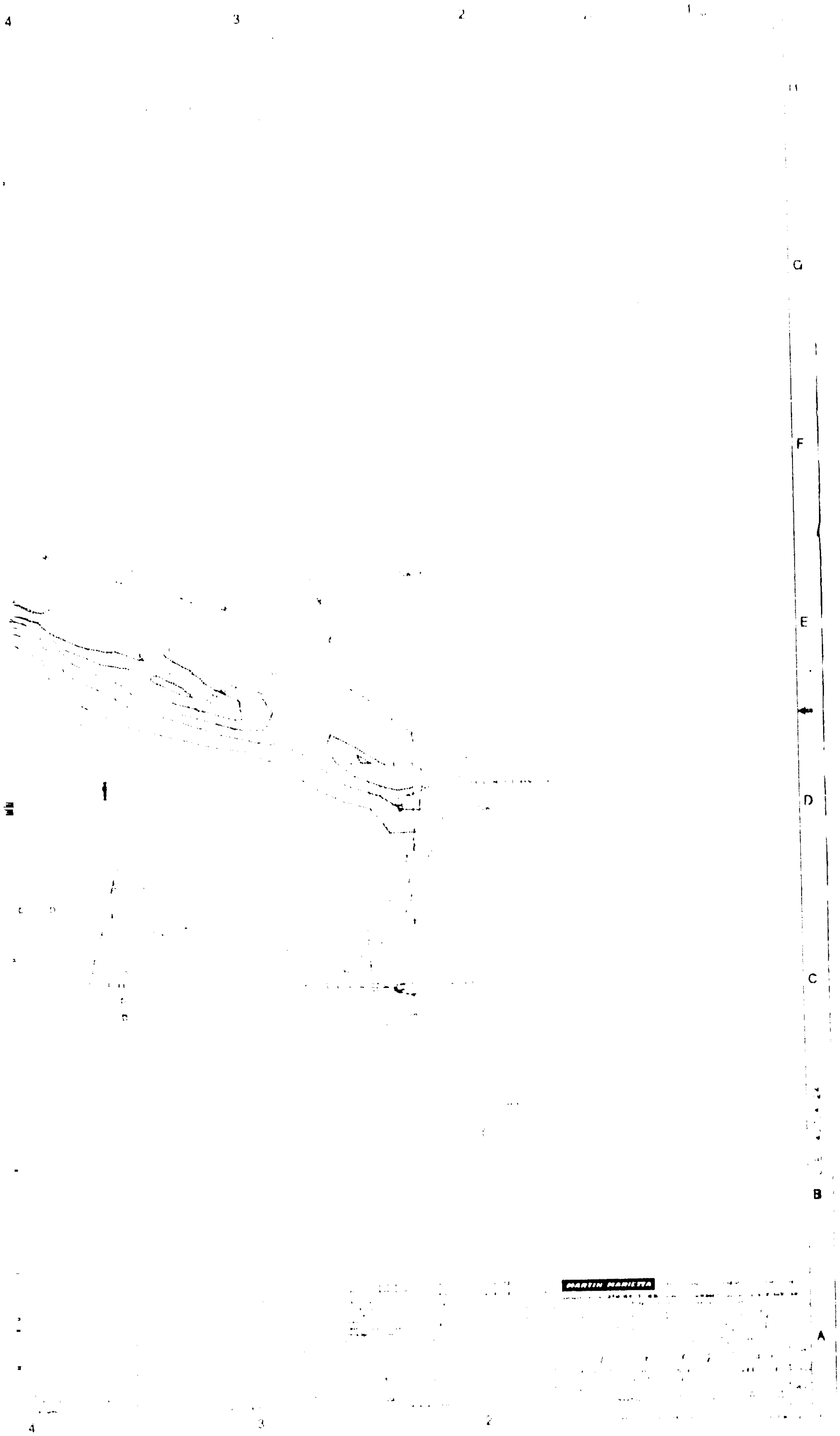


Fig. 46. Probability contour pk



for ^{237}Np, 6-in. samples.

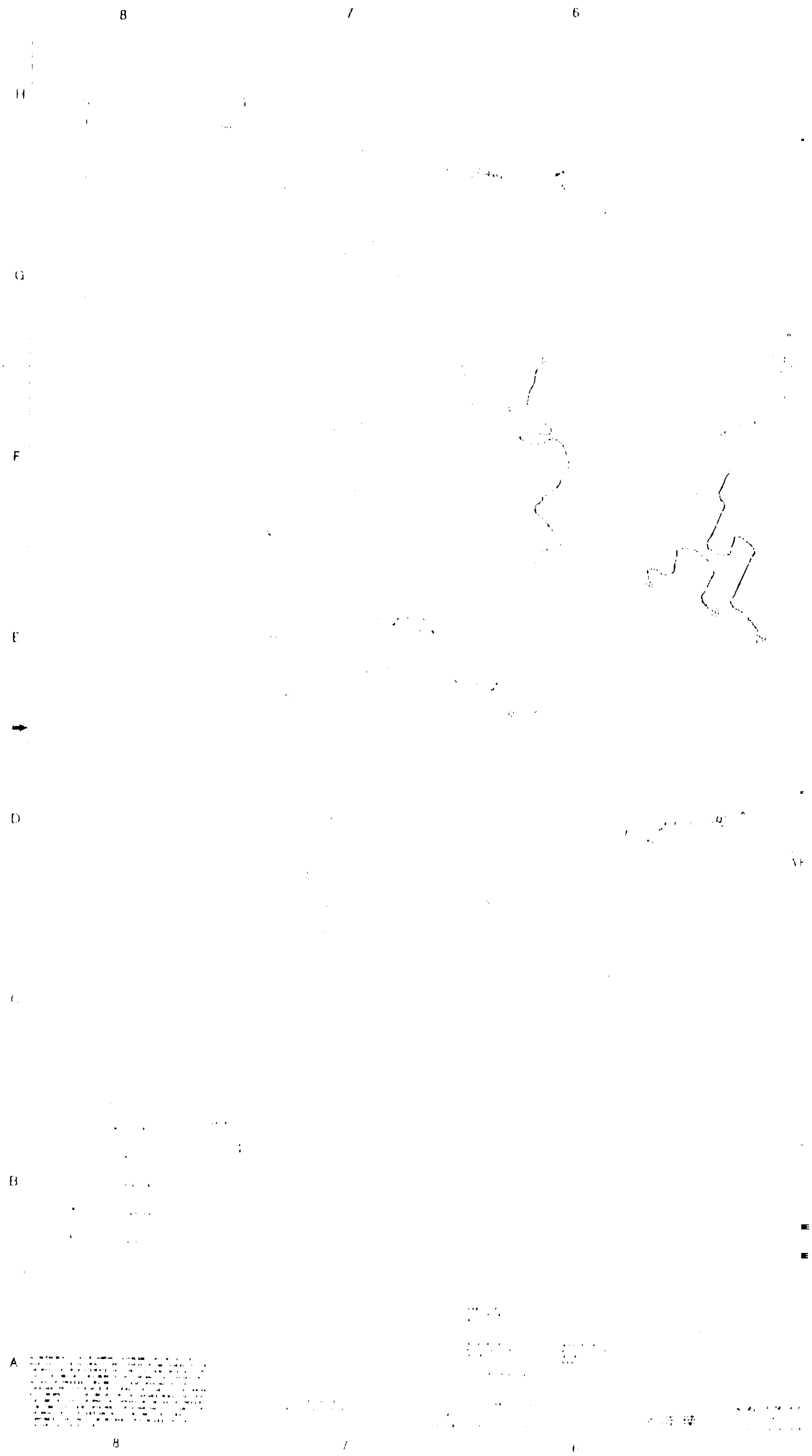
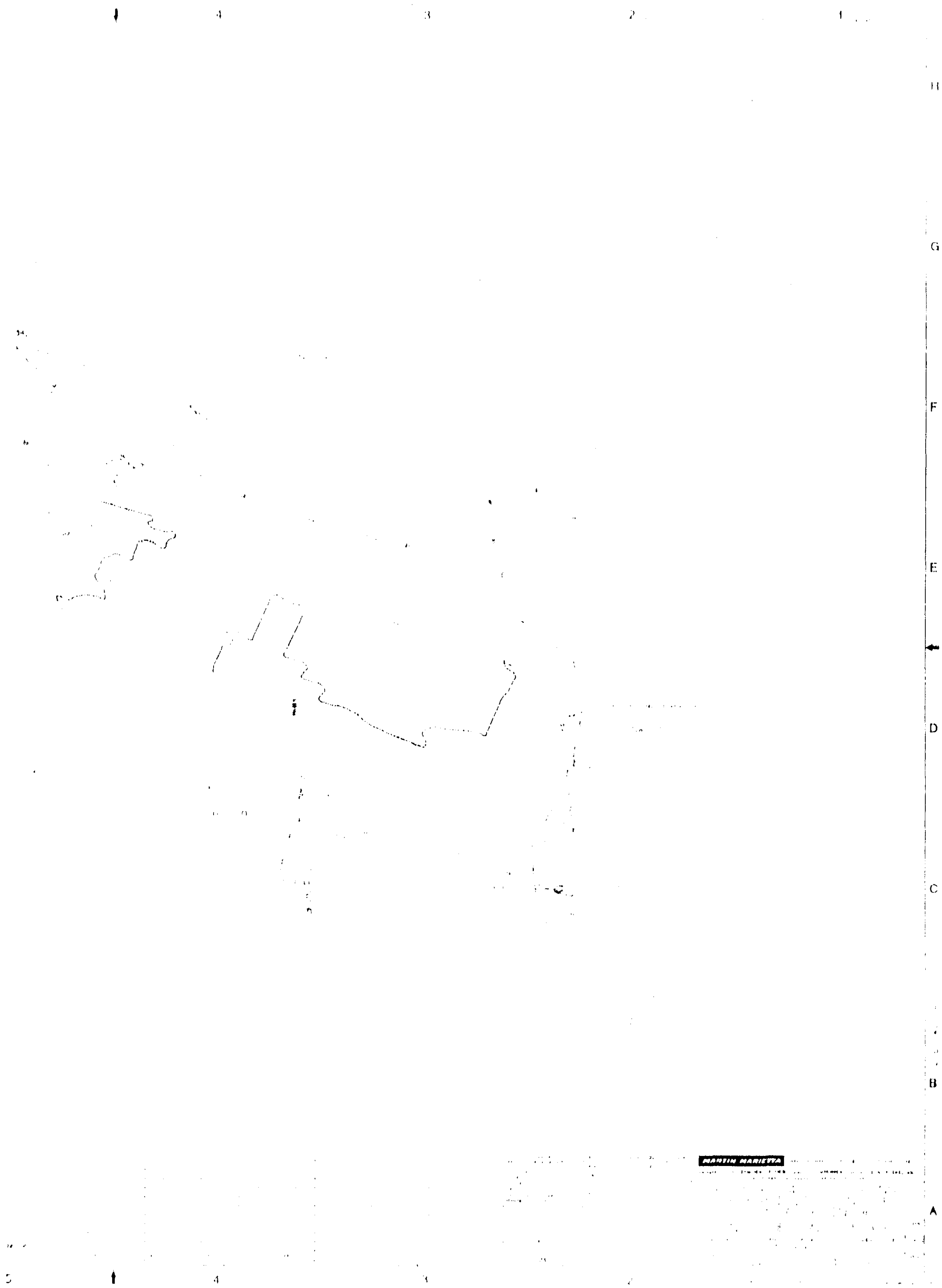


Fig. 47. Probabil



ty contour plot for ^{235}U, 6 in. samples.

ty contour plot for ^{235}U 6 in samples

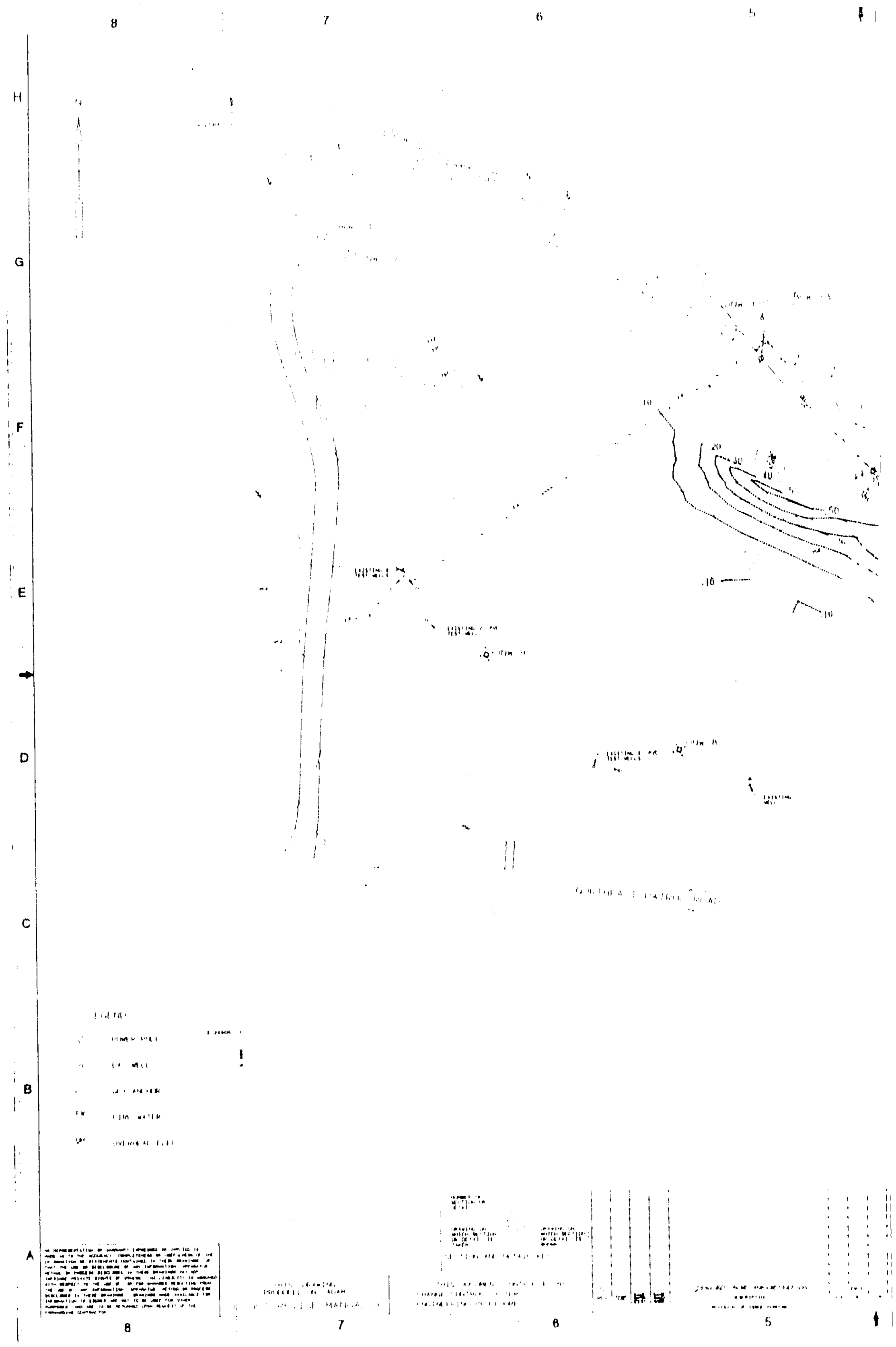
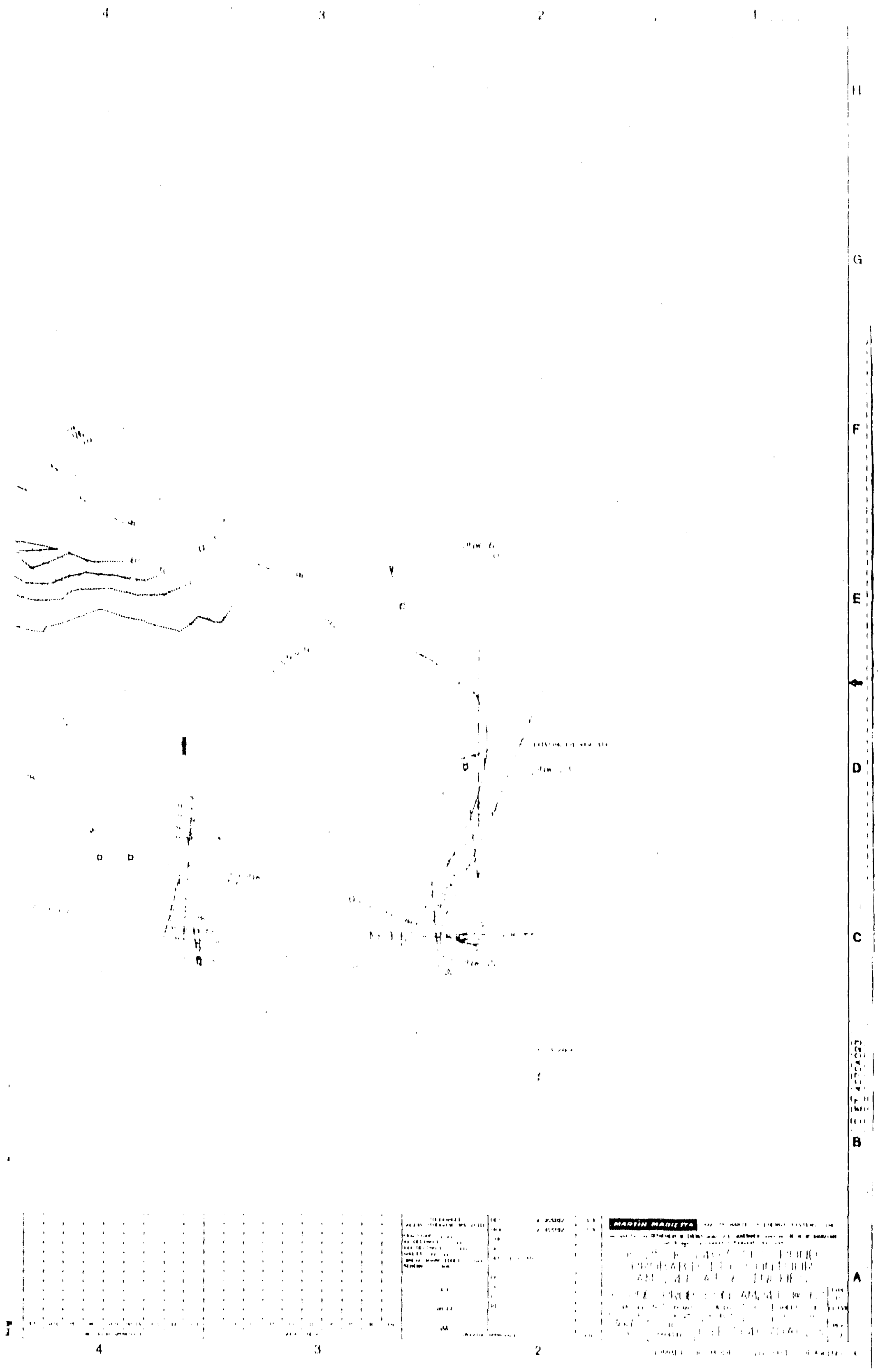


Fig. 48. Probability conto



our plot for ^{241}Am, 6-in. samples.

7. CONCLUSIONS AND RECOMMENDATIONS

The investigation of the K-1407-C Retention Basin has not characterized the site well enough to support a Remedial Investigation Report/Baseline Risk Assessment. There are several data gaps in the investigation of the K-1407-C Retention Basin that must be alleviated before characterization of the site is complete:

- Additional characterization of the hydrogeology of the area is needed in order to determine the potential for contaminant transport via groundwater. Additionally, to quantify the migration potential of contaminants via groundwater or surface water, soil parameters influencing transport must be determined.

- Because samples were not taken below 18 in., the depth to which soil contamination extends is unknown.

- Because soil sampling was restricted to the retention basin, the lateral extent of contamination is uncertain. The lateral extent of contamination is generally believed to be confined to the retention basin; however, sludge removal operations in the area of the northwest bank may have spread contaminants beyond the retention basin.

- It is difficult to differentiate between naturally occurring background metal concentrations and metal concentrations related to site operations because no background samples are available. The results of the Oak Ridge Reservation Hydrology and Geology Study, which is currently being conducted, will include information on natural concentrations of metals in regional soils.

- The radiochemical analysis of soil samples is not complete. Several analytes have not been analyzed for in all samples.

- Equipment rinsate data were not available for metal and mercury samples; consequently, the possibility that samples were contaminated in the field due to incompletely cleaned equipment cannot be evaluated.

- Although there are no established holding times for radiochemical analyses, some holding times have approached or exceeded 1 year. In addition, since no radiochemical matrix spike data are available, there is no way to determine whether preparation procedures for the analytes are free from matrix interference effects.

- The health-based screening of contaminants detected in soil at the K-1407-C Retention Basin indicates that samples taken from the 12- to 18-in. interval contain contaminant concentrations exceeding guideline values. Because soil sampling was terminated at a depth of 18 in., the extent of contamination below this depth and the potential adverse health effects associated with exposure to soil below 18 in. cannot be determined.

Because of the deficiency of information regarding the physical and contaminant characterization at the site, a comprehensive evaluation of site contamination is not possible. Therefore, additional soil sampling is recommended to determine the lateral extent and depth of radioactive contamination. Additionally, the analysis of any soil samples should include rinsate and matrix spike data. These recommendations will be addressed in the Phase 2 sampling plan.

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Appendix A

GAMMA EXPOSURE RATES AND BETA-GAMMA DOSE RATES

Table A.1. Gamma exposure rates and beta-gamma dose rates of samples collected at the K-1407-C Retention Basin

Sample No.	Stake No.[a]	Location North	Location East	Date	Time	Analysis	Interval (in.)	Gamma exposure rates (depth: μR/h)	Beta-gamma dose rates (depth: mrad/h)	Comments (HNU = ppm, OVM = ppm)[b]
BH001ASO06A	19H	24358.42	1439.83	09/27/89	1530	Rad	0–6	Surf: 12	Surf.: 0.023	Maximum depth sampled ~14 in.
BH001ASO12A	19H	24358.42	1439.83	09/27/89	1535	Rad	6–12	6 in.: 13	6 in.: 0.023	
BH001ASO18A	19H	24358.42	1439.83	09/27/89	1540	Rad	12–18	12 in.: 13	12 in.: 0.025	
								18 in.: 14	18 in.: 0.028	
BH002ASO06A		Biased sample, ~15 ft W of 19H		09/28/89	1045	Rad	0–6	Surf: 54	Surf.: 0.35	
BH002ASO12A				09/28/89	1055	Rad	6–12	6 in.: 52	6 in.: 0.39	
BH002ASO18A				09/28/89	1100	Rad	12–18	12 in.: 42	12 in.: 0.16	
								18 in.: 18	18 in.: 0.064	
BH003ASO06A	19F	24384.70	1427.57	10/02/89	1405	Rad	0–6	Surf: 64	Surf.: 0.24	Beta-gamma reading from side at bottom of hole
BH003ASO12A	19F	24384.70	1427.57	10/02/89	1420	Rad	6–12	6 in.: 44	6 in.: 0.19	
BH003ASO18A	19F	24384.70	1427.57	10/02/89	1435	Rad	12–18	12 in.: 26	12 in.: 0.047	
								18 in.: 23	18 in.: 0.051	
BH004ASO06A		Biased sample, ~2 ft SW of 19F		10/03/89	1005	Rad	0–6	Surf: 67	Surf.: 0.34	
BH004ASO12A				10/03/89	1020	Rad	6–12	6 in.: 36	6 in.: 0.072	
BH004ASO18A				10/03/89	1030	Rad	12–18	12 in.: 23	12 in.: 0.072	
								18 in.: 20	18 in.: 0.036	
BH005ASO06A	19D	24410.98	1415.32	10/03/89	1100	Rad	0–6	Surf: 23	Surf: 0.036	Hole filled with ooze, no rad readings
BH005ASO06B	19D	24410.98	1415.32	10/03/89	1100	Metals	0–6			
BH005ASO12A	19D	24410.98	1415.32	10/03/89	1105	Rad	6–12			
BH005ASO12B	19D	24410.98	1415.32	10/03/89	1105	Metals	6–12			
BH005ASO18A	19D	24410.98	1415.32	10/03/89	1110	Rad	12–18			
BH005ASO18B	19D	24410.98	1415.32	10/03/89	1110	Metals	12–18			

Table A.1. Gamma exposure rates and beta-gammma dose rates of samples collected at the K-1407-C Retention Basin (continued)

Sample No.	Stake No.[a]	Location North	Location East	Date	Time	Analysis	Interval (in.)	Gamma exposure rates (depth: μR/h)	Beta–gamma dose rates (depth: mrad/h)	Comments (HNU = ppm, OVM = ppm)[b]
BH006ASO06A	19B	24437.25	1403.07	10/03/89	1355	Rad	0–6	Surf: 13	Surf.: 0.047	Steep hillside,
BH006ASO12A	19B	24437.25	1403.07	10/03/89	1410	Rad	6–18	6 in.: 13	6 in.: 0.036	sample 12A
								18 in.: 13	18 in.: 0.029	contained soil
										from 6–18 in.
BH007ASO06A	17H	24326.73	1371.86	10/03/89	1425	Rad	0–6	Surf: 29	Surf.: 0.13	
BH007ASO12A	17H	24326.73	1371.86	10/03/89	1430	Rad	6–12	6 in.: 48	6 in.: 0.11	
BH007ASO18A	17H	24326.73	1371.86	10/03/89	1435	Rad	12–18	12 in.: 42	12 in.: 0.083	
								18 in.: 48	18 in.: 0.15	
BH008ASO06A	17F	24353.02	1359.61	10/03/89	1450	Rad	0–6	Surf: 29	Surf.: 1.3	
BH008ASO06B	17F	24353.02	1359.61	10/03/89	1450	Metals	0–6	6 in.: 23	6 in.: 0.083	
BH008ASO12A	17F	24353.02	1359.61	10/03/89	1520	Rad	6–12	12 in.: 23	12 in.: 0.054	
BH008ASO12B	17F	24353.02	1359.61	10/03/89	1520	Metals	6–12			
BH008ASO18A	17F	24353.02	1359.61	10/03/89	1530	Rad	12–18	18 in.: 23	18 in.: 0.058	
BH008ASO18B	17F	24353.02	1359.61	10/03/89	1530	Metals	12–18			
BH008AWO18B				10/04/89	1000	Rad				Eqpt. rinsate
BH008AWO18C				10/04/89	1000	Rad				Distil. water
BH009ASO06A	17D	24379.29	1347.35	10/04/89	1400	Rad	0–6	Surf: 23	Surf.: 0.098	
BH009ASO12A	17D	24379.29	1347.35	10/04/89	1400	Rad	6–12	6 in.: 23	6 in.: 0.054	
BH009ASO18A	17D	24379.29	1347.35	10/04/89	1400	Rad	12–18	12 in.: 20	12 in.: 0.036	
								18 in.: 17	18 in.: 0.036	

Table A.1. Gamma exposure rates and beta-gammma dose rates of samples collected at the K-1407-C Retention Basin (continued)

Sample No.	Stake No.[a]	Location North	Location East	Date	Time	Analysis	Interval (in.)	Gamma exposure rates (depth: μR/h)	Beta-gamma dose rates (depth: mrad/h)	Comments (HNU = ppm, OVM = ppm)[b]
BH010ASO06A	17B	24405.57	1335.10	10/04/89	1445	Rad	0–6	Surf: 13	Surf.: 0.034	Steep hillside
BH010ASO06B	17B	24405.57	1335.10	10/04/89	1445	Metals	0–6	6 in.: 13	6 in.: 0.029	
BH010ASO12A	17B	24405.57	1335.10	10/04/89	1445	Rad	6–12	12 in.: 13	12 in.: 0.029	
BH010ASO12B	17B	24405.57	1335.10	10/04/89	1445	Metals	6–12			
BH010ASO18A	17B	24405.57	1335.10	10/04/89	1445	Rad	12–18	18 in.: 13	18 in.: 0.025	
BH010ASO18B	17B	24405.57	1335.10	10/04/89	1445	Metals	12–18			
BH010AWO18A				10/04/89	1530	Rad				Eqpt. rinsate
BH010AWO18B				10/04/89	1530	Rad				Distil. water
BH011ASO06A	20D	~20 ft E of 19D		10/09/89	1410	Rad	0–6	Surf: 13	Surf.: 0.032	Steep hillside,
BH011ASO12A	20D			10/09/89	1420	Rad	6–12	6 in.: 13	6 in.: 0.025	soil fell into
BH011ASO18A	20D			10/09/89	1440	Rad	12–18	12 in.: 14	12 in.: 0.020	hole from
								18 in.: 14	18 in.: 0.018	above
BH012ASO06A	16F	~35 Ft W of 17F		10/09/89	1500	Rad	0–6	Surf.: 23	Surf: 0.077	
BH012ASO12A	16F			10/09/89	1515	Rad	6–12	6 in.: 23	6 in.: 0.058	
BH012ASO18A	16F			10/09/89	1525	Rad	12–18	12 in.: 21	12 in.: 0.047	
								18 in.: 20	18 in.: 0.036	
BH012AWO18A				10/09/89	1540	Rad				Eqpt. rinsate
BH012AWO18B				10/09/89	1540	Rad				Distil. water
BH013ASO06A	15D	24347.61	1279.39	10/10/89	1130	Rad	0–6	Surf: 22	Surf.: 0.097	
BH013ASO06B	15D	24347.61	1279.39	10/10/89	1130	Metals	0–6	6 in.: 20	6 in.: 0.061	
BH013ASO12A	15D	24347.61	1279.39	10/10/89	1140	Rad	6–12	12 in.: 17	12 in.: 0.032	
BH013ASO12B	15D	24347.61	1279.39	10/10/89	1140	Metals	6–12			
BH013ASO18A	15D	24347.61	1279.39	10/10/89	1200	Rad	12–18	18 in.: 17	18 in.: 0.032	
BH013ASO18B	15D	24347.61	1279.39	10/10/89	1200	Metals	12–18			

Table A.1. Gamma exposure rates and beta-gamma dose rates of samples collected at the K-1407-C Retention Basin (continued)

Sample No.	Stake No.[a]	Location North	Location East	Date	Time	Analysis	Interval (in.)	Gamma exposure rates (depth: μR/h)	Beta-gamma dose rates (depth: mrad/h)	Comments (HNU = ppm, OVM = ppm)[b]
BH014ASO06A	15F	24321.32	1291.64	10/10/89	1430	Rad	0–6	Surf.: 26	Surf.: 0.13	
BH014ASO12A	15F	24321.32	1291.64	10/10/89	1445	Rad	6–12	6 in.: 27	6 in.: 0.094	
BH014ASO18A	15F	24321.32	1291.64	10/10/89	1455	Rad	12–18	12 in.: 23	12 in.: 0.043	
BH015ASO06A		Biased sample,		10/10/89	1515	Rad	0–6	Surf.: 67	Surf.: 1.3	
BH015ASO12A		~28 ft NE of 15F		10/10/89	1525	Rad	6–12	6 in.: 61	6 in.: 0.30	
BH015ASO18A				10/10/89	1530	Rad	12–18	12 in.: 29	12 in.: 0.072	
								18 in.: 20	18 in.: 0.072	
BH016ASO06A	15H	24295.05	828.09	10/10/89	1550	Rad	0–6	Surf.: 29	Surf.: 0.20	
BH016ASO12A	15H	24295.05	828.09	10/10/89	1610	Rad	6–12	6 in.: 36	6 in.: 0.25	
BH016ASO18A	15H	24295.05	828.09	10/10/89	1615	Rad	12–18	12 in.: 23	12 in.: 0.11	
								18 in.: 17	18 in.: 0.076	
BH016AWO18A				10/10/89	1625	Rad				Eqpt. rinsate
BH016AWO18C				10/10/89	1630	Rad				Distil. water
BH017ASO06A		Biased sample,		10/11/89	1500	Rad	0–6	Surf.: 48	Surf.: 0.23	
BH017ASO12A		~10 ft SW of 15D		10/11/89	1510	Rad	6–12	6 in.: 13	6 in.: 0.027	
BH017ASO18A				10/11/89	1520	Rad	12–18	12 in.: 15	12 in.: 0.016	
								18 in.: 16	18 in.: 0.016	
BH018ASO06A		Biased sample,		10/11/89	1555	Rad	0–6	Surf.: 37	Surf.: 0.53	
BH018ASO12A		~28 ft NW of 15F		10/11/89	1605	Rad	6–12	6 in.: 46	6 in.: 0.13	
BH018ASO18A				10/11/89	1620	Rad	12–18	12 in.: 36	12 in.: 0.072	
								18 in.: 23	18 in.: 0.036	
BH018AWO18A				10/11/89	1635	Rad				Eqpt. rinsate
BH018AWO18B				10/11/89	1640	Rad				Distil. water

Table A.1. Gamma exposure rates and beta-gamma dose rates of samples collected at the K-1407-C Retention Basin (continued)

Sample No.	Stake No.[a]	Location North	Location East	Date	Time	Analysis	Interval (in.)	Gamma exposure rates (depth: μR/h)	Beta-gamma dose rates (depth: mrad/h)	Comments (HNU = ppm, OVM = ppm)[b]
BH019ASO06A	16B	~35 ft W of 17B		10/12/89	1010	Rad	0–6	Surf.: 13	Surf.: 0.040	
BH019ASO12A	16B			10/12/89	1020	Rad	6–12	6 in.: 13	6 in.: 0.032	
BH019ASO18A	16B			10/12/89	1030	Rad	12–18	12 in.: 13	12 in.: 0.032	
								18 in.: 13	18 in.: 0.029	
BH020ASO06A	15B	24373.88	1267.14	10/12/89	1055	Rad	0–6	Surf.: 13	Surf.: 0.032	
BH020ASO12A	15B	24373.88	1267.14	10/12/89	1105	Rad	6–12	6 in.: 13	6 in.: 0.032	
BH020ASO18A	15B	24373.88	1267.14	10/12/89	1115	Rad	12–18	12 in.: 13	12 in.: 0.032	
								18 in.: 13	18 in.: 0.029	
BH021ASO06A		Biased sample,		10/12/89	1140	Rad	0–6	Surf.: 48	Surf.: 0.47	On top of dike
BH021ASO12A		~12 ft S of 7F		10/12/89	1150	Rad	6–12	6 in.: 100	6 in.: 0.51	
BH021ASO18A				10/12/89	1200	Rad	12–18	12 in.: 130	12 in.: 0.40	
								18 in.: 130	18 in.: 0.43	
BH021AWO18A				10/12/89	1515	Rad				Eqpt. rinsate
BH021AWO18B				10/12/89	1520	Rad				Distil. water
BH022ASO06A		Biased sample,		10/13/89	1030	Rad	0–6	Surf.: 29	Surf.: 0.10	
BH022ASO12A		~4 ft W of 17F		10/13/89	1040	Rad	6–12	6 in.: 26	6 in.: 0.072	
BH022ASO18A				10/13/89	1050	Rad	12–18	12 in.: 23	12 in.: 0.054	
								18 in.: 21	18 in.: 0.054	
BH023ASO06A	13C	~15 ft N of 13B		10/13/89	1110	Rad	0–6	Surf.: 18	Surf.: 0.58	6 in. readings
BH023ASO12A	13C			10/13/89	1120	Rad	6–12	6 in.: 17	6 in.: 0.047	taken on side
BH023ASO18A	13C			10/13/89	1130	Rad	12–18	12 in.: 17	12 in.: 0.043	of hole
								18 in.: 14	18 in.: 0.022	

Table A.1. Gamma exposure rates and beta-gammma dose rates of samples collected at the K-1407-C Retention Basin (continued)

Sample No.	Stake No.[a]	Location North	Location East	Date	Time	Analysis	Interval (in.)	Gamma exposure rates (depth: μR/h)	Beta–gamma dose rates (depth: mrad/h)	Comments (HNU = ppm, OVM = ppm)[b]
BH024ASO06A	13B	24342.20	1199.17	10/13/89	1145	Rad	0–6	Surf.: 12	Surf.: 0.032	
BH024ASO06B	13B	24342.20	1199.17	10/13/89	1145	Metals	0–6	6 in.: 13	6 in.: 0.022	
BH024ASO12A	13B	24342.20	1199.17	10/13/89	1155	Rad	6–12	12 in.: 13	12 in.: 0.025	
BH024ASO12B	13B	24342.20	1199.17	10/13/89	1155	Metals	6–12			
BH024ASO18A	13B	24342.20	1199.17	10/13/89	1200	Rad	12–18	18 in.: 13	18 in.: 0.025	
BH024ASO18B	13B	24342.20	1199.17	10/13/89	1200	Metals	12–18			
BH024AWO18A				10/13/89	1230	Rad				Eqpt. rinsate
BH024AWO18C				10/13/89	1230	Rad				Distil. water
BH025ASO06A	11D	24284.22	1143.46	10/16/89	1440	Rad	0–6	Surf.: 17	Surf.: 0.043	HNU 1.0
BH025ASO06B	11D	24284.22	1143.46	10/16/89	1440	Metals	0–6	6 in.: 13	6 in.: 0.025	
BH025ASO12A	11D	24284.22	1143.46	10/16/89	1450	Rad	6–12	12 in.: 13	12 in.: 0.025	
BH025ASO12B	11D	24284.22	1143.46	10/16/89	1450	Metals	6–12			
BH025ASO18A	11D	24284.22	1143.46	10/16/89	1500	Rad	12–18	18 in.: 13	18 in.: 0.025	
BH025ASO18B	11D	24284.22	1143.46	10/16/89	1500	Metals	12–18			
BH026ASO06A	11B	24310.51	1131.20	10/16/89	1520	Rad	0–6	Surf.: 27	Surf.: 0.065	HNU 1.0–1.4
BH026ASO12A	11B	24310.51	1131.20	10/16/89	1530	Rad	6–12	6 in.: 42	6 in.: 0.12	
BH026ASO18A	11B	24310.51	1131.20	10/16/89	1540	Rad	12–18	12 in.: 26	12 in.: 0.054	
								18 in.: 21	18 in.: 0.036	
BH027ASO06A	11A	~15 ft S of 11B		10/16/89	1600	Rad	0–6	Surf.: 25	Surf.: 0.11	Steep hillside,
BH027ASO12A	11A			10/16/89	1610	Rad	6–12	6 in.: 23	6 in.: 0.054	HNU 2.2,
BH027ASO18A	11A			10/16/89	1620	Rad	12–18	12 in.: 21	12 in.: 0.043	began raining
								18 in.: 14	18 in.: 0.036	

Table A.1. Gamma exposure rates and beta-gammma dose rates of samples collected at the K-1407-C Retention Basin (continued)

Sample No.	Stake No.[a]	Location North	Location East	Date	Time	Analysis	Interval (in.)	Gamma exposure rates (depth: μR/h)	Beta-gamma dose rates (depth: mrad/h)	Comments (HNU = ppm, OVM = ppm)[b]
BH028ASO06A	12B	~35 ft W of 13B		10/16/89	1700	Rad	0–6	Surf.: 13	Surf.: 0.036	Water in hole
BH028ASO12A	12B			10/16/89	1710	Rad	6–12	6 in.: 14	6 in.: 0.043	at 18 in.
BH028ASO18A	12B			10/16/89	1720	Rad	12–18	12 in.: 13	12 in.: 0.025	
BH028AWO18A				10/17/89	1500	Rad				Eqpt. rinsate
BH028AWO13C				10/17/89	1510	Rad				Distil. water
BH029ASO06A	13D	24315.92	1211.42	10/18/89	1100	Rad	0–6	Surf.: 18	Surf.: 0.046	No subsurface
BH029ASC12A	13D	24315.92	1211.42	10/18/89	1110	Rad	6–12			rad readings,
BH029ASO18A	13D	24315.92	1211.42	10/18/89	1120	Rad	12–18			water in hole
BH030ASO06A	11F	24257.95	1155.74	10/18/89	1140	Rad	0–6	Surf.: 13	Surf.: 0.030	
BH030ASO12A	11F	24257.95	1155.74	10/18/89	1150	Rad	6–12	6 in.: 20	6 in.: 0.029	
BH030ASO18A	11F	24257.95	1155.74	10/18/89	1200	Rad	12–18	12 in.: 29	12 in.: 0.061	
								18 in.: 32	18 in.: 0.081	
BH030AWO18A				10/18/89	1220	Rad				Eqpt. rinsate
BH030AWO18C				10/18/89	1230	Rad				Distil. water
BH031ASO06A		Biased sample,		10/18/89	1540	Rad	0–6	Surf.: 36	Surf.: 0.19	
BH031ASO12A		~15 ft NE of 11F		10/18/89	1550	Rad	6–12	6 in.: 32	6 in.: 0.12	
BH031ASO18A				10/18/89	1600	Rad	12–18	12 in.: 20	12 in.: 0.054	
								18 in.: 14	18 in.: 0.036	
BH032ASO06A	11H	~20 ft N of 11F		10/18/89	1620	Rad	0–6	Surf.: 32	Surf.: 0.11	
BH032ASO12A	11H			10/18/89	1630	Rad	6–12	6 in.: 54	6 in.: 0.17	
BH032ASO18A	11H			10/18/89	1640	Rad	12–18	12 in.: 42	12 in.: 0.11	
								18 in.: 42	18 in.: 0.097	

Table A.1. Gamma exposure rates and beta-gammma dose rates of samples collected at the K-1407-C Retention Basin (continued)

Sample No.	Stake No.[a]	Location: North	Location: East	Date	Time	Analysis	Interval (in.)	Gamma exposure rates (depth: μR/h)	Beta–gamma dose rates (depth: mrad/h)	Comments (HNU = ppm, OVM = ppm)[b]
BH033ASO06A		Biased sample,		10/18/89	1650	Rad	0–6	Surf.: 110	Surf.: 1.7	
BH033ASO12A		-19 ft E of 9B		10/18/89	1700	Rad	6–12	6 in.: 85	6 in.: 0.36	
BH033ASO18A				10/18/89	1710	Rad	12–18	12 in.: 22	12 in.: 0.046	
								18 in.: 13	18 in.: 0.12	
BH034ASO06A		Biased sample,		10/23/89	1400	Rad	0–6	Surf.: 25	Surf.: 0.21	Muddy, water
BH034ASO12A		-11 ft WSW of 15F		10/23/89	1415	Rad	6–12	6 in.: 27	6 in.: 0.14	in bottom of
BH034ASO18A				10/23/89	1430	Rad	12–18	12 in.: 20	12 in.: 0.090	hole at 18 in.
BH035ASO06A		Biased sample,		10/23/89	1455	Rad	0–6	Surf.: 61	Surf.: 0.47	
BH035ASO12A		-3 ft E of 11H		10/23/89	1505	Rad	6–12	6 in.: 73	6 in.: 0.54	
BH035ASO18A				10/23/89	1515	Rad	12–18	12 in.: 54	12 in.: 0.32	
								18 in.: 48	18 in.: 0.14	
BH035AWO18A				10/23/89	1520	Rad				Eqpt. rinsate
BH035AWO18C				10/23/89	1530	Rad				Distil. water
BH036ASO06A		Biased sample,		10/24/89	1610	Rad	0–6	Surf.: 25	Surf.: 0.12	
BH036ASO12A		-13 ft E of 11F		10/24/89	1620	Rad	6–12	6 in.: 29	6 in.: 0.094	
BH036ASO18A				10/24/89	1630	Rad	12–18	12 in.: 27	12 in.: 0.090	
								18 in.: 16	18 in.: 0.018	
BH037ASO06A		Biased sample,		10/24/89	1650	Rad	0–6	Surf.: 36	Surf.: 0.11	
BH037ASO12A		-24 ft E of 9F		10/24/89	1700	Rad	6–12	6 in.: 62	6 in.: 0.14	
BH037ASO18A				10/24/89	1710	Rad	12–18	12 in.: 32	12 in.: 0.054	
								18 in.: 20	18 in.: 0.036	
BH037AWO18A				10/24/89	1725	Rad				Eqpt. rinsate
BH037AWO18C				10/24/89	1730	Rad				Distil. water

Table A.1. Gamma exposure rates and beta-gammma dose rates of samples collected at the K-1407-C Retention Basin (continued)

Sample No.	Stake No.[a]	Location North	Location East	Date	Time	Analysis	Interval (in.)	Gamma exposure rates (depth: μR/h)	Beta–gamma dose rates (depth: mrad/h)	Comments (HNU = ppm, OVM = ppm)[b]
BH038ASO06A	9B	24278.82	1063.23	10/25/89	1500	Rad	0–6	Surf.: 32	Surf.: 0.21	
BH038ASO06B	9B	24278.82	1063.23	10/25/89	1500	Metals	0–6	6 in.: 58	6 in.: 0.24	
BH038ASO12A	9B	24278.82	1063.23	10/25/89	1510	Rad	6–12	12 in.: 32	12 in.: 0.048	
BH038ASO12B	9B	24278.82	1063.23	10/25/89	1510	Metals	6–12			
BH038ASO18A	9B	24278.82	1063.23	10/25/89	1520	Rad	12–18	18 in.: 20	18 in.: 0.032	
BH038ASO18B	9B	24278.82	1063.23	10/25/89	1520	Metals	12–18			
BH039ASO06A	9C	~15 ft N of 9B		10/25/89	1540	Rad	0–6	Surf.: 17	Surf.: 0.055	
BH039ASO12A	9C			10/25/89	1550	Rad	6–12	6 in.: 18	6 in.: 0.051	
BH039ASO18A	9C			10/25/89	1600	Rad	12–18	12 in.: 17	12 in.: 0.030	
								18 in.: 17	18 in.: 0.034	
BH040ASO06A	9D	24252.54	1075.49	10/25/89	1615	Rad	0–6	Surf.: 17	Surf.: 0.036	
BH040ASO12A	9D	24252.54	1075.49	10/25/89	1625	Rad	6–12	6 in.: 25	6 in.: 0.045	
BH040ASO18A	9D	24252.54	1075.49	10/25/89	1635	Rad	12–18	12 in.: 20	12 in.: 0.027	
								18 in.: 17	18 in.: 0.024	
BH041ASO06A	9E	~15 ft N of 9D		10/25/89	1730	Rad	0–6	Surf.: 23	Surf.: 0.077	
BH041ASO12A	9E			10/25/89	1740	Rad	6–12	6 in.: 22	6 in.: 0.052	
BH041ASO18A	9E			10/25/89	1750	Rad	12–18	12 in.: 16	12 in.: 0.023	
								18 in.: 13	18 in.: 0.029	
BH041AWO18A				10/25/89	1800	Rad				Eqpt. rinsate
BH041AWO18C				10/25/89	1800	Rad				Distil. water

Table A.1. Gamma exposure rates and beta-gammma dose rates of samples collected at the K-1407-C Retention Basin (continued)

Sample No.	Stake No.[a]	Location North	Location East	Date	Time	Analysis	Interval (in.)	Gamma exposure rates (depth: μR/h)	Beta–gamma dose rates (depth: mrad/h)	Comments (HNU = ppm, OVM = ppm)[b]
BH042ASO06A	9F	24226.26	1087.74	10/30/89	1030	Rad	0–6	Surf.: 20	Surf.: 0.053	HNU 0.2–0.3
BH042ASO06B	9F	24226.26	1087.74	10/30/89	1030	Metals	0–6	6 in.: 20	6 in.: 0.047	
BH042ASO12A	9F	24226.26	1087.74	10/30/89	1040	Rad	6–12	12 in.: 17	12 in.: 0.036	
BH042ASO12B	9F	24226.26	1087.74	10/30/89	1040	Metals	6–12			
BH042ASO18A	9F	24226.26	1087.74	10/30/89	1050	Rad	12–18	18 in.: 17	18 in.: 0.036	
BH042ASO18B	9F	24226.26	1087.74	10/30/89	1050	Metals	12–18			
BH043ASO06A	7B	24247.12	995.26	10/30/89	1105	Rad	0–6	Surf.: 36	Surf.: 0.093	HNU 0.4
BH043ASO12A	7B	24247.12	995.26	10/30/89	1115	Rad	6–12	6 in.: 54	6 in.: 0.14	
BH043ASO18A	7B	24247.12	995.26	10/30/89	1125	Rad	12–18	12 in.: 57 18 in.: 53	12 in.: 0.17 18 in.: 0.13	
BH044ASO06A		Biased sample,		10/30/89	1135	Rad	0–6	Surf.: 61	Surf.: 0.34	HNU 0.3
BH044ASO12A		–8 ft ENE of 7B		10/30/89	1145	Rad	6–12	6 in.: 130	6 in.: 0.29	
BH044ASO18A				10/30/89	1150	Rad	12–18	12 in.: 69 18 in.: 26	12 in.: 0.17 18 in.: 0.090	
BH045ASO06A	7D	24220.85	1007.51	10/30/89	1450	Rad	0–6	Surf.: 29	Surf.: 0.14	HNU 0.3
BH045ASO06B	7D	24220.85	1007.51	10/30/89	1450	Metals	0–6	6 in.: 54	6 in.: 0.10	
BH045ASO12A	7D	24220.85	1007.51	10/30/89	1500	Rad	6–12	12 in.: 63	12 in.: 0.22	
BH045ASO12B	7D	24220.85	1007.51	10/30/89	1500	Metals	6–12			
BH045ASO18A	7D	24220.85	1007.51	10/30/89	1510	Rad	12–18	18 in.: 67	18 in.: 0.17	
BH045ASO18B	7D	24220.85	1007.51	10/30/89	1510	Metals	12–18			
BH046ASO06A	7F	–2 ft S of 7F		10/30/89	1610	Rad	0–6	Surf.: 29		HNU 0.3
BH046ASO12A	7F			10/30/89	1620	Rad	6–12		6 in.: 0.21	
BH046ASO18A	7F			10/30/89	1630	Rad	12–18	12 in.: 52 18 in.: 23	12 in.: 0.077 18 in.: 0.054	

Table A.1. Gamma exposure rates and beta-gammma dose rates of samples collected at the K-1407-C Retention Basin (continued)

Sample No.	Stake No.[a]	Location: North	Location: East	Date	Time	Analysis	Interval (in.)	Gamma exposure rates (depth: μR/h)	Beta–gamma dose rates (depth: mrad/h)	Comments (HNU = ppm, OVM = ppm)[b]
BH047ASO06A		~16 ft E of 7F		10/30/89	1645	Rad	0–6	Surf.: 73	Surf.: 0.48	HNU 0.3,
BH047ASO12A				10/30/89	1705	Rad	6–12	6 in.: 130	6 in.: 0.56	refusal at 12 in.
								12 in.: 100	12 in.: 0.36	
BH047AWO12A				11/01/89	1600	Rad				Eqpt. rinsate
BH047AWO12C				11/01/89	1600	Rad				Distil. water
BH048ASO06A	5G	~15 N of 5F		11/01/89	1610	Rad	0–6	Surf.: 10	Surf.: 0.041	OVM 0.0,
								6 in.: 10	6 in.: 0.030	refusal at 6 in.
BH049ASO06A	5F	24162.88	951.79	11/01/89	1640	Rad	0–6	Surf.: 13	Surf.: 0.039	OVM 0.1–0.8
BH049ASO06B	5F	24162.88	951.79	11/01/89	1645	Metals	0–6	6 in.: 17	6 in.: 0.049	
BH049ASO12A	5F	24162.88	951.79	11/01/89	1700	Rad	6–12	12 in.: 13	12 in.: 0.036	
BH049ASO12B	5F	24162.88	951.79	11/01/89	1700	Metals	6–12			
BH049ASO18A	5F	24162.88	951.79	11/01/89	1710	Rad	12–18	18 in.: 13	18 in.: 0.032	
BH049ASO18B	5F	24162.88	951.79	11/01/89	1710	Metals	12–18			
BH049AW018A					1715	Rad				Eqpt. rinsate
BH049AW018C					1715	Rad				Distil. water
BH050ASO06A	6F	~35 ft W of 7F		11/02/89	1040	Rad	0–6	Surf.: 17	Surf.: 0.072	OVM 0.0
BH050ASO12A	6F			11/02/89	1050	Rad	6–12	6 in.: 16	6 in.: 0.054	
BH050ASO18A	6F			11/02/89	1100	Rad	12–18	12 in.: 17	12 in.: 0.036	
								18 in.: 17	18 in.: 0.029	
BH051ASO06A		Biased sample,		11/02/89	1130	Rad	0–6	Surf.: 36	Surf.: 0.22	OVM 0.0–0.3
BH051ASO12A		~6 ft W of 6F		11/02/89	1140	Rad	6–12	6 in.: 42	6 in.: 0.19	
BH051ASO18A				11/02/89	1150	Rad	12–18	12 in.: 20	12 in.: 0.043	
								18 in.: 17	18 in.: 0.036	

Table A.1. Gamma exposure rates and beta-gammma dose rates of samples collected at the K-1407-C Retention Basin (continued)

Sample No.	Stake No.[a]	Location		Date	Time	Analysis	Interval (in.)	Gamma exposure rates (depth: μR/h)	Beta–gamma dose rates (depth: mrad/h)	Comments (HNU = ppm, OVM = ppm)[b]
		North	East							
BH052ASO06A		Biased sample,		11/03/89	1050	Rad	0–6	Surf.: 77	Surf.: 0.37	OVM 0.0,
BH052ASO12A		~22 ft SW of 7D		11/03/89	1100	Rad	6–12	6 in.: 46	6 in.: 0.12	highest gamma
BH052ASO18A				11/03/89	1110	Rad	12–18	12 in.: 17	12 in.: 0.036	92 μR/h at 4 in.
								18 in.: 17	18 in.: 0.029	
BH053ASO06A	6B	~35 ft W of 7B		11/03/89	1130	Rad	0–6	Surf.: 17	Surf.: 0.077	OVM 0.0
BH053ASO12A	6B			11/03/89	1140	Rad	6–12	6 in.: 14	6 in.: 0.029	
BH053ASO18A	6B			11/03/89	1200	Rad	12–18	12 in.: 13	12 in.: 0.040	
								18 in.: 12	18 in.: 0.032	
BH054ASO06A		Biased sample,		11/03/89	1340	Rad	0–6	Surf.: 54	Surf.: 0.26	OVM 0.0
BH054ASO12A		~7 ft NW of 7D		11/03/89	1350	Rad	6–12	6 in.: 73	6 in.: 0.19	
BH054ASO18A				11/03/89	1400	Rad	12–18	12 in.: 88	12 in.: 0.44	
								18 in.: 42	18 in.: 0.12	
BH055ASO06A	5D	24189.16	939.54	11/03/89	1415	Rad	0–6	Surf.: 13	Surf.: 0.059	OVM 0.0
BH055ASO12A	5D	24189.16	939.54	11/03/89	1425	Rad	6–12	6 in.: 13	6 in.: 0.045	
BH055ASO18A	5D	24189.16	939.54	11/03/89	1430	Rad	12–18	12 in.: 12	12 in.: 0.036	
								18 in.: 12		
BH055AWO18A				11/03/89	1440	Rad				Eqpt. rinsate
BH055AWO18C				11/03/89	1440	Rad				Distil. water
BH056ASO06A		Biased sample,		11/08/89	0945	Rad	0–6	Surf.: 44	Surf.: 0.12	OVM 0.0–0.3,
BH056ASO12A		~12 ft E of 3F		11/09/89	1340	Rad	6–12	6 in.: 57	6 in.: 0.19	exceeded 1.0 at
BH056ASO18A				11/09/89	1350	Rad	12–18	12 in.: 20	12 in.: 0.072	sampling hole
								18 in.: 17	18 in.: 0.040	

Table A.1. Gamma exposure rates and beta-gammma dose rates of samples collected at the K-1407-C Retention Basin (continued)

Sample No.	Stake No.[a]	Location		Date	Time	Analysis	Interval (in.)	Gamma exposure rates (depth: μR/h)	Beta-gamma dose rates (depth: mrad/h)	Comments (HNU = ppm, OVM = ppm)[b]
		North	East							
BH057ASO06A	3F	24131.18	883.81	11/09/89	1410	Rad	0–6	Surf.: 13	Surf.: 0.051	OVM 0.0,
BH057ASO12A	3F	24131.18	883.81	11/09/89	1425	Rad	6–12	6 in.: 17	6 in.: 0.036	refusal at 3F,
BH057ASO18A	3F	24131.18	883.81	11/09/89	1435	Rad	12–18	12 in.: 20	12 in.: 0.043	sample taken
								18 in.: 13	18 in.: 0.036	1 ft W of 3F
BH058ASO06A	3H	24104.91	896.07	11/09/89	1600	Rad	0–6	Surf.: 13	Surf.: 0.034	OVM 0.0–0.2,
BH058ASO12A	3H	24104.91	896.07	11/09/89	1610	Rad	6–12	6 in.: 12	6 in.: 0.029	refusal at 12 in.
								12 in.: 11	12 in.: 0.026	
BH059ASO06A	3E	~15 ft N of 3D		11/09/89	1635	Rad	0–6	Surf.: 20	Surf.: 0.062	OVM 0.0–0.2
BH059ASO12A	3E			11/09/89	1645	Rad	6–12	6 in.: 29	6 in.: 0.072	
BH059ASO18A	3E			11/09/89	1655	Rad	12–18	12 in.: 32	12 in.: 0.086	
								18 in.: 18	18 in.: 0.043	
BH059AWO18A				11/09/89	1710	Rad				Eqpt. rinsate
BH059AWO18C				11/09/89	1715	Rad				Distil. water
BH060ASO06A	3C	~15 ft N of 3B		11/13/89	1615	Rad	0–6	Surf.: 12	Surf.: 0.035	HNU 0.0–0.2
BH060ASO12A	3C			11/13/89	1630	Rad	6–12	6 in.: 13	6 in.: 0.029	
BH060ASO18A	3C			11/13/89	1640	Rad	12–18	12 in.: 13	12 in.: 0.022	
								18 in.: 13	18 in.: 0.022	
BH061ASO06A	3B	24183.75	359.31	11/13/89	1655	Rad	0–6	Surf.: 12	Surf.: 0.050	HNU 0.0–0.2
BH061ASO12A	3B	24183.75	359.31	11/13/89	1705	Rad	6–12	6 in.: 13	6 in.: 0.036	
BH061ASO18A	3B	24183.75	359.31	11/13/89	1715	Rad	12–18	12 in.: 14	12 in.: 0.018	
								18 in.: 13	18 in.: 0.014	

Table A.1. Gamma exposure rates and beta-gammma dose rates of samples collected at the K-1407-C Retention Basin (continued)

Sample No.	Stake No.[a]	Location North	Location East	Date	Time	Analysis	Interval (in.)	Gamma exposure rates (depth: μR/h)	Beta–gamma dose rates (depth: mrad/h)	Comments (HNU = ppm, OVM = ppm)[b]
BH062ASO06A		Biased sample,		11/13/89	1735	Rad	0–6	Surf.: 36	Surf.: 0.088	HNU 0.0–0.2
BH062ASO12A		~22 ft SE of 3D		11/13/89	1740	Rad		6 in.: 23	6 in.: 0.050	
BH062ASO18A				11/13/89	1750	Rad	6–12	12 in.: 16	12 in.: 0.025	
							12–18	18 in.: 14	18 in.: 0.025	
BH062AWO18A				11/13/89	1810	Rad				Eqpt. rinsate
BH062AWO18C				11/13/89	1810	Rad				Distil. water
BH063ASO06A	2G	~35 ft NW of 3F		11/15/89	1350	Rad	0–6	Surf.: 14	Surf.: 0.034	HNU 0.0–0.3
BH063ASO12A	2G			11/15/89	1400	Rad	6–12	6 in.: 16	6 in.: 0.033	
BH063ASO18A	2G			11/15/89	1410	Rad	12–18	12 in.: 29	12 in.: 0.050	
								18 in.: 61	18 in.: 0.022	
BH064ASO06A		Biased sample,		11/15/89	1430	Rad	0–6	Surf.: 42	Surf.: 0.062	HNU 0.0–0.3
BH064ASO12A		~20 ft NE of 1F		11/15/89	1440	Rad	6–12	6 in.: 27	6 in.: 0.067	
BH064ASO18A				11/15/89	1450	Rad	12–18	12 in.: 20	12 in.: 0.043	
								18 in.: 16	18 in.: 0.044	
BH064AWO18A				11/15/89	1500	Rad				Eqpt. rinsate
BH064AWO18A				11/15/18	1500	Rad				Distil. water
BH065ASO06A	3A			11/16/89	1540	Rad	0–6	Surf.: 13	Surf.: 0.030	Steep hillside,
BH065ASO12A	3A			11/16/89	1550	Rad	6–12	6 in.: 17	6 in.: 0.031	HNU 0.0–0.3
BH065ASO18A	3A			11/16/89	1600	Rad	12–18	12 in.: 17	12 in.: 0.029	
								18 in.: 17	18 in.: 0.029	
BH066ASO06A	1H	24073.21	828.09	11/16/89	1615	Rad	0–6	Surf.: 15	Surf.: 0.054	HNU 0.0–0.2,
BH066ASO12A	1H	24073.21	828.09	11/16/89	1630	Rad	6–12	6 in.: 17	6 in.: 0.036	very rocky,
								12 in.: 17	12 in.: 0.025	refusal at 12 in.

Table A.1. Gamma exposure rates and beta-gammmma dose rates of samples collected at the K-1407-C Retention Basin (continued)

Sample No.	Stake No.[a]	Location North	Location East	Date	Time	Analysis	Interval (in.)	Gamma exposure rates (depth: μR/h)	Beta–gamma dose rates (depth: mrad/h)	Comments (HNU = ppm, OVM = ppm)[b]
BH067ASO06A	1F	24099.49	815.84	11/16/89	1650	Rad	0–10	Surf.: 17	Surf.: 0.056	HNU 0.0–0.2,
BH067ASO06B	1F	24099.49	815.84	11/16/89	1650	Metals	0–10	6 in.: 17	6 in.: 0.029	large rock
BH067ASO12A	1F	24099.49	815.84	11/16/89	1700	Rad	10–18	10 in.: 17	10 in.: 0.026	occupied
BH067ASO12B	1F	24099.49	815.84	11/16/89	1700	Metals	10–18			6–10 in. depth
BH067AWO12A				11/17/89	1140	Rad				Eqpt. rinsate
BH067AWO12C				11/17/89	1140	Rad				Distil. water
BH068ASO06A	0F			11/20/89	1030	Rad	0–6	Surf.: 42	Surf.: 0.16	HNU 0.0–0.2,
BH068ASO12A	0F			11/20/89	1040	Rad	6–12	6 in.: 61	6 in.: 0.15	near metal pipe
BH068ASO18A	0F			11/20/89	1100	Rad	12–18	12 in.: 64	12 in.: 0.17	measuring
								18 in.: 73	18 in.: 0.18	79 μR/h and
										5.8 mrad/h
BH069ASO06A		Biased sample,		11/20/89	1405	Rad	0–6	Surf.: 44	Surf.: 0.25	HNU 0.0–0.2
BH069ASO12A		~10 ft NNE of 0F		11/20/89	1415	Rad	6–12	6 in.: 79	6 in.: 0.21	
BH069ASO18A				11/20/89	1430	Rad	12–18	12 in.: 73	12 in.: 0.17	
								18 in.: 69	18 in.: 0.16	
BH070ASO06A	0D			11/20/89	1450	Rad	0–6	Surf.: 44	Surf.: 0.13	HNU 0.0–0.2
BH070ASO12A	0D			11/20/89	1500	Rad	6–12	6 in.: 73	6 in.: 0.17	
BH070ASO18A	0D			11/20/89	1510	Rad	12–18	12 in.: 82	12 in.: 0.19	
								18 in.: 79	18 in.: 0.20	
BH071ASO06A		Biased sample,		11/20/89	1630	Rad	0–4	Surf.: 100	Surf.: 0.60	HNU 0.0–0.3,
		~10 ft NW of 7F						4 in.: 130	4 in.: 0.59	rocky soil,
										refusal at 4 in.,
										slab of asphalt
										below surface

Table A.1. Gamma exposure rates and beta-gammma dose rates of samples collected at the K-1407-C Retention Basin (continued)

Sample No.	Stake No.[a]	Location North	Location East	Date	Time	Analysis	Interval (in.)	Gamma exposure rates (depth: μR/h)	Beta–gamma dose rates (depth: mrad/h)	Comments (HNU = ppm, OVM = ppm)[b]
BH072ASO06A	5A			11/20/89	1700	Rad	0–6	Surf.: 17	Surf.: 0.055	HNU 0.3–0.6,
BH072ASO12A	5A			11/20/89	1710	Rad	6–12	6 in.: 23	6 in.: 0.047	steep
BH072ASO18A	5A			11/20/89	1720	Rad	12–18			
BH072AWO18A				11/20/89	1800	Rad				Eqpt. rinsate
BH072AWO18C				11/20/89	1800	Rad				Distil. water
BH073ASO06A	1B	24152.05	791.83	11/21/89	1110	Rad	0–6	Surf.: 12	Surf.: 0.021	HNU 0.0–0.1,
BH073ASO12A	1B	24152.05	791.83	11/21/89	1130	Rad	6–12	6 in.: 14	6 in.: 0.022	steep hillside,
BH073ASO18A	1B	24152.05	791.83	11/21/89	1150	Rad	12–18	12 in.: 14	12 in.: 0.022	unsafe footing,
								18 in.: 16	18 in.: 0.025	no metal sample
BH073AWO18A				11/21/89	1220	Rad				Eqpt. rinsate (possibly contaminated)
BH073AWO18C				11/21/89	1220	Rad				Distil. water
BH074ASO06A		~17 ft E of 11F		01/03/90	1415	Rad	0–6		Surf.: 0.032	12F covered
BH074ASO12A		for stake 12F		01/03/90	1430	Rad	6–12		6 in.: 0.036	with water,
BH074ASO18A				01/03/90	1445	Rad	12–18		12 in.: 0.036	sample taken at
									18 in.: 0.036	closest possible location
BH075ASO06A	3D	24157.46	871.56	01/10/90	1450	Rad	0–6	Surf.: 11		Refusal at 6 in.
BH075ASO06B	3D	24157.46	871.56	01/10/90	1450	Metals	0–6	6 in.: 13		

Table A.1. Gamma exposure rates and beta-gammma dose rates of samples collected at the K-1407-C Retention Basin (continued)

Sample No.	Stake No.[a]	Location North	Location East	Date	Time	Analysis	Interval (in.)	Gamma exposure rates (depth: μR/h)	Beta-gamma dose rates (depth: mrad/h)	Comments (HNU = ppm, OVM = ppm)[b]
BH076ASO06A	5B	24215.43	927.29	01/10/90	1505	Rad	0–6	Surf.: 14		Hole located at edge of water, water seeping into hole
BH076ASO06B	5B	24215.43	927.29	01/10/90	1505	Metals	0–6			
BH076ASO12A	5B	24214.43	927.29	01/10/90	1515	Rad	6–12			
BH076ASO12B	5B	24215.43	927.29	01/10/90	1515	Metals	6–12			
BH076ASO18A	5B	24215.43	927.29	01/10/90	1525	Rad	12–18			
BH076ASO18B	5B	24215.43	927.29	01/10/90	1525	Metals	12–18			
BH077ASO06A	2E			01/10/90	1530	Rad	0–6	Surf.: 11		Near water, no water in hole, refusal at 13 in.
BH077ASO06B	2E			01/10/90	1530	Metals	0–6	6 in.: 17		
BH077ASO12A	2E			01/10/90	1540	Rad	6–12	12 in.: 14		
BH077ASO12B	2E			01/10/90	1540	Metals	6–12			
BH078ASO06A	1D	24125.77	803.59	01/10/90	1600	Rad	0–6	Surf.: 12		Surface covered by water, refusal at 6 in.
BH078ASO06B	1D	24125.77	803.59	01/10/90	1600	Metals	0–6			
BH078AWO06A				01/10/90	1610	Rad				Eqpt. rinsate
BH078AWO06B				01/10/90	1620	Rad				Distil. water
BH079ASO18A	13E			01/11/90	1450	Rad	0–18			Covered with water, no rad readings
BH079ASO18B	13E			01/11/90	1450	Metals	0–18			
BH080ASO18A	13F	24289.63	1223.67	01/11/90	1520	Rad	0–18			Covered with water, no rad readings
BH080ASO18B	13F	24289.63	1223.67	01/11/90	1520	Metals	0–18			
BH080AWO18A				01/11/90	1600	Rad				Eqpt. rinsate
BH080AWO18B				01/11/90	1600	Rad				Distil. water
BH005BSO06B	19D	24410.98	1415.32	12/18/89	1400	Metals	0–6			Resample, hole had filled

Table A.1. Gamma exposure rates and beta-gamma dose rates of samples collected at the K-1407-C Retention Basin (continued)

Sample No.	Stake No.[a]	Location: North	Location: East	Date	Time	Analysis	Interval (in.)	Gamma exposure rates (depth: μR/h)	Beta–gamma dose rates (depth: mrad/h)	Comments (HNU = ppm, OVM = ppm)[b]
BH008BSO06B	17F	24353.02	1359.61	12/18/89	1500	Metals	0–6			Resample, hole had filled
BH010BSO06B	17B	24405.57	1335.10	12/18/89	1430	Metals	0–6			Resample, beside original hole
BH015BSO06B	15D	24347.61	1279.39	12/18/89	1515	Metals	0–6			Resample, beside original hole
BH015BSO12B	15D	24347.61	1279.39	12/18/89	1530	Metals	6–12			
BH015BSO18B	15D	24347.61	1279.39	12/18/89	1545	Metals	12–18			
BH024BSO06B	13B	24342.20	1199.17	12/18/89	1400	Metals	0–6			Resample, beside original hole
BH024BSO12B	13B	24342.20	1199.17	12/18/89	1415	Metals	6–12			
BH024BSO18B	13B	24342.20	1199.17	12/18/89	1430	Metals	12–18			
BH025BSO06B	11D	24284.22	1143.46	12/20/89	1345	Metals	0–6			Resample, beside original hole
BH025BSO12B	11D	24284.22	1143.46	12/20/89	1400	Metals	6–12			
BH025BSO18B	11D	24284.22	1143.46	12/20/89	1415	Metals	12–18			
BH038BSO06B	9B	24278.82	1063.23	12/20/89	1430	Metals	0–6			Resample, beside original hole
BH038BSO12B	9B	24278.82	1063.23	12/20/89	1445	Metals	6–12			
BH038BSO18B	9B	24278.82	1063.23	12/20/89	1500	Metals	12–18			
BH042BSO06B	9F	24226.26	1087.74	12/20/89	1530	Metals	0–6			Resample, beside original hole
BH042BSO12B	9F	24226.26	1087.74	12/20/89	1545	Metals	6–12			
BH042BSO18B	9F	24226.26	1087.74	12/20/89	1555	Metals	12–18			

Table A.1. Gamma exposure rates and beta-gammma dose rates of samples collected at the K-1407-C Retention Basin (continued)

Sample No.	Stake No.[a]	Location		Date	Time	Analysis	Interval (in.)	Gamma exposure rates (depth: μR/h)	Beta-gamma dose rates (depth: mrad/h)	Comments (HNU = ppm, OVM = ppm)[b]
		North	East							
BH045BSO06B	7D	24220.85	1007.51	12/20/89	1600	Metals	0–6			Resample, hole had filled
BH045BSO12B	7D	24220.85	1007.51	12/20/89	1615	Metals	6–12			
BH045BSO18B	7D	24220.85	1007.51	12/20/89	1630	Metals	12–18			

[a] Sampling points shown on Figs. 12 and 13.

[b] HNU and OVM are photoionization detectors (PIDs) that measure total concentrations of trace gases and vapors in ambient air. PID measurements recorded in this column were taken in the breathing zone.

Appendix B

ANALYTICAL DATA

Table B.1. K-1407-C Retention Basin sediment sample analysis—elemental analysis

Date	Hole	Location	6-in. (mg/kg)	12-in. (mg/kg)	18-in. (mg/kg)
			Aluminum		
01/11/90	BH078	01D	35000	—	—
11/16/89	BH067	01F	39000	21000	—
01/11/90	BH077	02E	36000	30000	—
01/11/90	BH075	03D	26000	—	—
01/11/90	BH076	05B	25000	21000	18000
11/07/89	BH049	05F	15000	15000	19000
10/30/89	BH045	07D	32000	36000	36000
10/26/89	BH038	09B	45000	31000	18000
10/30/89	BH042	09F	30000	24000	21000
10/18/89	BH025	11D	26000	16000	7600
10/13/89	BH024	13B	16000	19000	16000
12/20/89	BH024	13B	27000	26000	33000
01/12/90	BH079	13E	—	—	32000
01/12/90	BH080	13F	—	—	52000
10/11/89	BH013	15D	54000	19000	12000
10/04/89	BH010	17B	30000	25000	23000
10/04/89	BH008	17F	56000	64000	29000
10/04/89	BH005	19D	50000	35000	31000
			Antimony		
01/11/90	BH078	01D	< 7.1	—	—
11/16/89	BH067	01F	< 32	< 31	—
01/11/90	BH077	02E	< 6.1	< 5.5	—
01/11/90	BH075	03D	< 6.1	—	—
01/11/90	BH076	05B	< 6	< 5.9	< 5.4
11/07/89	BH049	05F	< 5	< 5	< 5
10/30/89	BH045	07D	< 5	< 5	< 5
10/26/89	BH038	09B	< 50	< 5	< 5
10/30/89	BH042	09F	< 5	< 5	< 5
10/18/89	BH025	11D	< 5	< 5	< 5
10/13/89	BH024	13B	< 5	< 5	< 5
12/20/89	BH024	13B	< 5.7	< 5.2	< 5.8
01/12/90	BH079	13E	—	—	< 6
01/12/90	BH080	13F	—	—	< 5.2
10/11/89	BH013	15D	< 5	< 5	< 5
10/04/89	BH010	17B	< 5	< 5	< 5
10/04/89	BH008	17F	< 5	9.4	< 5
10/04/89	BH005	19D	< 5	< 5	< 5

Table B.1. K-1407-C Retention Basin sediment sample analysis—elemental analysis (continued)

Date	Hole	Location	6-in. (mg/kg)	12-in. (mg/kg)	18-in. (mg/kg)
			Arsenic		
01/11/90	BH078	01D	13	—	—
11/16/89	BH067	01F	< 32	< 31	—
01/11/90	BH077	02E	< 6.1	7.7	—
01/11/90	BH075	03D	< 6.1	—	—
01/11/90	BH076	05B	< 6	< 5.9	< 5.4
11/07/89	BH049	05F	29	28	24
10/30/89	BH045	07D	< 5	20	8.4
10/26/89	BH038	09B	< 50	6.4	17
10/30/89	BH042	09F	30	< 5	23
10/18/89	BH025	11D	12	< 5	24
10/13/89	BH024	13B	< 5	< 5	14
12/20/89	BH024	13B	< 5.7	< 5.2	< 5.8
01/12/90	BH079	13E	—	—	< 6
01/12/90	BH080	13F	—	—	< 5.2
10/11/89	BH013	15D	7	< 5	26
10/04/89	BH010	17B	8.1	14	20
10/04/89	BH008	17F	< 5	14	24
10/04/89	BH005	19D	< 5	7.7	32
			Barium		
01/11/90	BH078	01D	120	—	—
11/16/89	BH067	01F	59	110	—
01/11/90	BH077	02E	110	170	—
01/11/90	BH075	03D	120	—	—
01/11/90	BH076	05B	77	72	65
11/07/89	BH049	05F	100	130	94
10/30/89	BH045	07D	110	130	120
10/26/89	BH038	09B	94	140	85
10/30/89	BH042	09F	110	84	72
10/18/89	BH025	11D	76	68	45
10/13/89	BH024	13B	140	130	83
12/20/89	BH024	13B	160	150	100
01/12/90	BH079	13E	—	—	72
01/12/90	BH080	13F	—	—	110
10/11/89	BH013	15D	80	31	25
10/04/89	BH010	17B	66	120	110
10/04/89	BH008	17F	110	96	39
10/04/89	BH005	19D	120	100	100

Table B.1. K-1407-C Retention Basin sediment sample analysis—elemental analysis (continued)

Date	Hole	Location	6-in. (mg/kg)	12-in. (mg/kg)	18-in. (mg/kg)
			Beryllium		
01/11/90	BH078	01D	1.3	—	—
11/16/89	BH067	01F	0.78	1.3	—
01/11/90	BH077	02E	1.2	1.3	—
01/11/90	BH075	03D	1.6	—	—
01/11/90	BH076	05B	0.48	0.42	0.31
11/07/89	BH049	05F	0.92	0.64	0.71
10/30/89	BH045	07D	0.65	0.77	0.88
10/26/89	BH038	09B	0.61	0.95	0.57
10/30/89	BH042	09F	0.8	0.51	0.39
10/18/89	BH025	11D	0.5	0.42	0.25
10/13/89	BH024	13B	0.71	0.88	0.47
12/20/89	BH024	13B	0.9	1	0.58
01/12/90	BH079	13E	—	—	0.6
01/12/90	BH080	13F	—	—	1.4
10/11/89	BH013	15D	0.93	0.49	0.49
10/04/89	BH010	17B	0.58	0.94	0.74
10/04/89	BH008	17F	1.2	1.5	0.99
10/04/89	BH005	19D	1.1	1	0.85
			Boron		
01/11/90	BH078	01D	< 0.57	—	—
11/16/89	BH067	01F	5.8	4.2	—
01/11/90	BH077	02E	< 0.49	< 0.44	—
01/11/90	BH075	03D	< 0.49	—	—
01/11/90	BH076	05B	< 0.48	< 0.47	< 0.43
11/07/89	BH049	05F	3.5	7.6	< 0.4
10/30/89	BH045	07D	12	20	13
10/26/89	BH038	09B	33	1.1	< 0.4
10/30/89	BH042	09F	9.7	< 0.4	< 0.4
10/18/89	BH025	11D	< 0.4	< 0.4	< 0.4
10/13/89	BH024	13B	< 0.4	< 0.4	< 0.4
12/20/89	BH024	13B	< 0.46	< 0.42	8.5
01/12/90	BH079	13E	—	—	< 0.48
01/12/90	BH080	13F	—	—	< 0.42
10/11/89	BH013	15D	14	< 0.4	< 0.4
10/04/89	BH010	17B	< 0.4	< 0.4	< 0.4
10/04/89	BH008	17F	34	6.6	< 0.4
10/04/89	BH005	19D	16	< 0.4	< 0.4

Table B.1. K-1407-C Retention Basin sediment sample analysis—elemental analysis (continued)

Date	Hole	Location	6-in. (mg/kg)	12-in. (mg/kg)	18-in. (mg/kg)
			Cadmium		
01/11/90	BH078	01D	1.2	—	—
11/16/89	BH067	01F	< 1.9	< 1.9	—
01/11/90	BH077	02E	1.9	1.7	—
01/11/90	BH075	03D	1.5	—	—
01/11/90	BH076	05B	0.81	0.74	0.94
11/07/89	BH049	05F	< 0.3	< 0.3	< 0.3
10/30/89	BH045	07D	< 0.3	0.43	0.82
10/26/89	BH038	09B	7.4	0.5	0.42
10/30/89	BH042	09F	< 0.3	< 0.3	< 0.3
10/18/89	BH025	11D	1	0.37	0.36
10/13/89	BH024	13B	0.57	0.38	0.33
12/20/89	BH024	13B	1.2	0.64	0.95
01/12/90	BH079	13E	—	—	1.2
01/12/90	BH080	13F	—	—	2.2
10/11/89	BH013	15D	1.8	< 0.3	< 0.3
10/04/89	BH010	17B	0.58	1.2	1.1
10/04/89	BH008	17F	1.7	2.2	2
10/04/89	BH005	19D	1.3	1.8	1.8
			Calcium		
01/11/90	BH078	01D	24000	—	—
11/16/89	BH067	01F	37000	13000	—
01/11/90	BH077	02E	28000	26000	—
01/11/90	BH075	03D	11000	—	—
01/11/90	BH076	05B	2000	1200	670
11/07/89	BH049	05F	15000	15000	2900
10/30/89	BH045	07D	25000	52000	38000
10/26/89	BH038	09B	160000	19000	5100
10/30/89	BH042	09F	9400	2600	2600
10/18/89	BH025	11D	6900	3000	480
10/13/89	BH024	13B	10000	3100	1500
12/20/89	BH024	13B	5800	3600	1100
01/12/90	BH079	13E	—	—	15000
01/12/90	BH080	13F	—	—	11000
10/11/89	BH013	15D	35000	530	480
10/04/89	BH010	17B	11000	5100	5200
10/04/89	BH008	17F	65000	29000	3000
10/04/89	BH005	19D	39000	10000	6200

Table B.1. K-1407-C Retention Basin sediment sample analysis—elemental analysis (continued)

Date	Hole	Location	6-in. (mg/kg)	12-in. (mg/kg)	18-in. (mg/kg)
			Chromium		
01/11/90	BH078	01D	58	—	—
11/16/89	BH067	01F	39	31	—
01/11/90	BH077	02E	59	78	—
01/11/90	BH075	03D	34	—	—
01/11/90	BH076	05B	25	18	18
11/07/89	BH049	05F	38	26	25
10/30/89	BH045	07D	120	190	150
10/26/89	BH038	09B	160	76	25
10/30/89	BH042	09F	42	28	21
10/18/89	BH025	11D	48	31	21
10/13/89	BH024	13B	27	27	22
12/20/89	BH024	13B	32	31	30
01/12/90	BH079	13E	—	—	74
01/12/90	BH080	13F	—	—	59
10/11/89	BH013	15D	100	47	46
10/04/89	BH010	17B	43	26	31
10/04/89	BH008	17F	140	97	46
10/04/89	BH005	19D	79	50	44
			Cobalt		
01/11/90	BH078	01D	19	—	—
11/16/89	BH067	01F	29	16	—
01/11/90	BH077	02E	18	24	—
01/11/90	BH075	03D	18	—	—
01/11/90	BH076	05B	8.5	11	11
11/07/89	BH049	05F	14	12	15
10/30/89	BH045	07D	22	30	24
10/26/89	BH038	09B	21	19	16
10/30/89	BH042	09F	19	16	16
10/18/89	BH025	11D	22	19	8.5
10/13/89	BH024	13B	15	17	15
12/20/89	BH024	13B	16	19	15
01/12/90	BH079	13E	—	—	18
01/12/90	BH080	13F	—	—	33
10/11/89	BH013	15D	16	9	19
10/04/89	BH010	17B	11	15	15
10/04/89	BH008	17F	18	21	8.7
10/04/89	BH005	19D	15	11	10

Table B.1. K-1407-C Retention Basin sediment sample analysis—elemental analysis (continued)

Date	Hole	Location	6-in. (mg/kg)	12-in. (mg/kg)	18-in. (mg/kg)
		Copper			
01/11/90	BH078	01D	43	—	—
11/16/89	BH067	01F	33	24	—
01/11/90	BH077	02E	44	57	—
01/11/90	BH075	03D	28	—	—
01/11/90	BH076	05B	14	12	11
11/07/89	BH049	05F	56	110	22
10/30/89	BH045	07D	81	160	110
10/26/89	BH038	09B	190	58	13
10/30/89	BH042	09F	25	13	13
10/18/89	BH025	11D	24	14	6
10/13/89	BH024	13B	17	13	27
12/20/89	BH024	13B	16	12	14
01/12/90	BH079	13E	—	—	31
01/12/90	BH080	13F	—	—	39
10/11/89	BH013	15D	130	19	15
10/04/89	BH010	17B	29	18	17
10/04/89	BH008	17F	180	130	41
10/04/89	BH005	19D	140	48	39
		Iron			
01/11/90	BH078	01D	30000	—	—
11/16/89	BH067	01F	34000	34000	—
01/11/90	BH077	02E	32000	33000	—
01/11/90	BH075	03D	31000	—	—
01/11/90	BH076	05B	25000	22000	20000
11/07/89	BH049	05F	25000	24000	23000
10/30/89	BH045	07D	25000	26000	27000
10/26/89	BH038	09B	30000	21000	20000
10/30/89	BH042	09F	25000	27000	26000
10/18/89	BH025	11D	29000	25000	19000
10/13/89	BH024	13B	23000	24000	25000
12/20/89	BH024	13B	26000	23000	28000
01/12/90	BH079	13E	—	—	27000
01/12/90	BH080	13F	—	—	40000
10/11/89	BH013	15D	36000	34000	35000
10/04/89	BH010	17B	31000	25000	27000
10/04/89	BH008	17F	34000	50000	56000
10/04/89	BH005	19D	31000	35000	33000

Table B.1. K-1407-C Retention Basin sediment sample analysis—elemental analysis (continued)

Date	Hole	Location	6-in. (mg/kg)	12-in. (mg/kg)	18-in. (mg/kg)
		Lead			
01/11/90	BH078	01D	26	—	—
11/16/89	BH067	01F	59	45	—
01/11/90	BH077	02E	28	49	—
01/11/90	BH075	03D	16	—	—
01/11/90	BH076	05B	18	19	18
11/07/89	BH049	05F	34	50	30
10/30/89	BH045	07D	31	40	34
10/26/89	BH038	09B	< 50	24	22
10/30/89	BH042	09F	27	31	30
10/18/89	BH025	11D	36	35	18
10/13/89	BH024	13B	37	34	28
12/20/89	BH024	13B	42	35	29
01/12/90	BH079	13E	—	—	25
01/12/90	BH080	13F	—	—	51
10/11/89	BH013	15D	46	22	69
10/04/89	BH010	17B	31	30	32
10/04/89	BH008	17F	45	72	43
10/04/89	BH005	19D	31	19	20
		Magnesium			
01/11/90	BH078	01D	6200	—	—
11/16/89	BH067	01F	4600	8000	—
01/11/90	BH077	02E	7000	7200	—
01/11/90	BH075	03D	7800	—	—
01/11/90	BH076	05B	1800	1500	1000
11/07/89	BH049	05F	3600	6300	1300
10/30/89	BH045	07D	2100	2800	3100
10/26/89	BH038	09B	3500	1600	750
10/30/89	BH042	09F	1500	850	720
10/18/89	BH025	11D	1200	660	300
10/13/89	BH024	13B	5700	1500	810
12/20/89	BH024	13B	2900	2000	1600
01/12/90	BH079	13E	—	—	1800
01/12/90	BH080	13F	—	—	3200
10/11/89	BH013	15D	3500	810	380
10/04/89	BH010	17B	1300	1500	1800
10/04/89	BH008	17F	6300	3600	1100
10/04/89	BH005	19D	4900	4200	3900

Table B.1. K-1407-C Retention Basin sediment sample analysis—elemental analysis (continued)

Date	Hole	Location	6-in. (mg/kg)	12-in. (mg/kg)	18-in. (mg/kg)
			Manganese		
01/11/90	BH078	01D	870	—	—
11/16/89	BH067	01F	550	460	—
01/11/90	BH077	02E	750	1700	—
01/11/90	BH075	03D	560	—	—
01/11/90	BH076	05B	830	1500	2200
11/07/89	BH049	05F	730	1200	2400
10/30/89	BH045	07D	2000	2200	2000
10/26/89	BH038	09B	1100	2900	2300
10/30/89	BH042	09F	2200	2000	2200
10/18/89	BH025	11D	2000	1600	550
10/13/89	BH024	13B	2100	3000	1700
12/20/89	BH024	13B	2700	3600	1900
01/12/90	BH079	13E	—	—	1300
01/12/90	BH080	13F	—	—	1300
10/11/89	BH013	15D	650	360	510
10/04/89	BH010	17B	1100	2700	2000
10/04/89	BH008	17F	640	650	450
10/04/89	BH005	19D	550	400	390
			Mercury		
01/11/90	BH078	01D	3.6	—	—
11/16/89	BH067	01F	1.8	< 1	—
01/11/90	BH077	02E	4.5	< 1	—
01/11/90	BH075	03D	< 1	—	—
01/11/90	BH076	05B	< 1	< 1	< 1
11/07/89	BH049	05F	1.4	< 1	< 1
10/30/89	BH045	07D	22	40	29
12/20/89	BH045	07D	11	16	8.6
12/20/89	BH038	09B	6.3	< 1	< 1
10/30/89	BH042	09F	2.2	< 1	< 1
12/20/89	BH042	09F	< 1	< 1	< 1
12/20/89	BH025	11D	< 1	< 1	< 1
12/20/89	BH024	13B	< 1	< 1	< 1
01/12/90	BH079	13E	—	—	7
01/12/90	BH080	13F	—	—	2.9
12/20/89	BH015	15F-B	2.7	< 1	< 1
10/04/89	BH010	17B	—	< 1.7	< 1
12/20/89	BH010	17B	1.1	—	—
10/04/89	BH008	17F	—	2.4	< 1
12/20/89	BH008	17F	29	—	—
10/04/89	BH005	19D	—	4.7	4.1
12/20/89	BH005	19D	17	—	—

Table B.1. K-1407-C Retention Basin sediment sample analysis— elemental analysis (continued)

Date	Hole	Location	6-in. (mg/kg)	12-in. (mg/kg)	18-in. (mg/kg)
		Molybdenum			
01/11/90	BH078	01D	< 1.4	—	—
11/16/89	BH067	01F	< 6.4	< 6.2	—
01/11/90	BH077	02E	< 1.2	< 1.1	—
01/11/90	BH075	03D	< 1.2	—	—
01/11/90	BH076	05B	< 1.2	< 1.2	< 1.1
11/07/89	BH049	05F	1.4	< 1	1.7
10/30/89	BH045	07D	4.3	1.8	1.5
10/26/89	BH038	09B	< 10	3.4	2.9
10/30/89	BH042	09F	1.3	1.5	1.5
10/18/89	BH025	11D	1	2.9	1.4
10/13/89	BH024	13B	1.1	1.7	2.1
12/20/89	BH024	13B	< 1.1	< 1	< 1.2
01/12/90	BH079	13E	—	—	< 1.2
01/12/90	BH080	13F	—	—	< 1
10/11/89	BH013	15D	2	< 1	2.4
10/04/89	BH010	17B	2.4	1.9	1.4
10/04/89	BH008	17F	3.3	3.7	2.5
10/04/89	BH005	19D	< 1	1.6	1.8
		Nickel			
01/11/90	BH078	01D	200	—	—
11/16/89	BH067	01F	52	44	—
01/11/90	BH077	02E	180	330	—
01/11/90	BH075	03D	39	—	—
01/11/90	BH076	05B	31	20	12
11/07/89	BH049	05F	110	36	19
10/30/89	BH045	07D	740	1500	1000
10/26/89	BH038	09B	1400	500	53
10/30/89	BH042	09F	120	24	20
10/18/89	BH025	11D	100	42	5
10/13/89	BH024	13B	24	13	9.5
12/20/89	BH024	13B	20	16	18
01/12/90	BH079	13E	—	—	160
01/12/90	BH080	13F	—	—	100
10/11/89	BH013	15D	620	16	14
10/04/89	BH010	17B	85	22	19
10/04/89	BH008	17F	820	490	51
10/04/89	BH005	19D	480	110	84

Table B.1. K-1407-C Retention Basin sediment sample analysis—elemental analysis (continued)

Date	Hole	Location	6-in. (mg/kg)	12-in. (mg/kg)	18-in. (mg/kg)
			Potassium		
01/11/90	BH078	01D	7200	—	—
11/16/89	BH067	01F	5000	3700	—
01/11/90	BH077	02E	5700	7000	—
01/11/90	BH075	03D	4900	—	—
01/11/90	BH076	05B	1700	1300	960
11/07/89	BH049	05F	3000	2800	2200
10/30/89	BH045	07D	2700	3800	4400
10/26/89	BH038	09B	5800	2200	860
10/30/89	BH042	09F	3300	3500	3500
10/18/89	BH025	11D	1400	720	420
10/13/89	BH024	13B	3200	2400	3100
12/20/89	BH024	13B	2700	2600	4400
01/12/90	BH079	13E	—	—	3600
01/12/90	BH080	13F	—	—	8900
10/11/89	BH013	15D	6300	1600	820
10/04/89	BH010	17B	2300	2400	2800
10/04/89	BH008	17F	8700	7300	4000
10/04/89	BH005	19D	8600	5900	4200
			Selenium		
01/11/90	BH078	01D	< 7.1	—	—
11/16/89	BH067	01F	< 32	< 31	—
01/11/90	BH077	02E	< 6.1	< 5.5	—
01/11/90	BH075	03D	< 6.1	—	—
01/11/90	BH076	05B	< 6	< 5.9	< 5.4
11/07/89	BH049	05F	< 5	< 5	< 5
10/30/89	BH045	07D	< 5	< 5	< 5
10/26/89	BH038	09B	< 50	< 5	< 5
10/30/89	BH042	09F	< 5	< 5	< 5
10/18/89	BH025	11D	< 5	< 5	< 5
10/13/89	BH024	13B	< 5	< 5	< 5
12/20/89	BH024	13B	< 5.7	< 5.2	< 5.8
01/12/90	BH079	13E	—	—	< 6
01/12/90	BH080	13F	—	—	< 5.2
10/11/89	BH013	15D	< 5	< 5	< 5
10/04/89	BH010	17B	< 5	< 5	< 5
10/04/89	BH008	17F	< 5	9.5	< 5
10/04/89	BH005	19D	< 5	< 5	< 5

Table B.1. K-1407-C Retention Basin sediment sample analysis—elemental analysis (continued)

Date	Hole	Location	6-in. (mg/kg)	12-in. (mg/kg)	18-in. (mg/kg)
		Silicon			
01/11/90	BH078	01D	410	—	—
11/16/89	BH067	01F	410	390	—
01/11/90	BH077	02E	400	310	—
01/11/90	BH075	03D	280	—	—
01/11/90	BH076	05B	230	280	220
11/07/89	BH049	05F	850	860	930
10/30/89	BH045	07D	1000	1200	1000
10/26/89	BH038	09B	1700	950	940
10/30/89	BH042	09F	770	870	870
10/18/89	BH025	11D	560	570	600
10/13/89	BH024	13B	590	920	940
12/20/89	BH024	13B	570	630	520
01/12/90	BH079	13E	—	—	480
01/12/90	BH080	13F	—	—	370
10/11/89	BH013	15D	690	1000	950
10/04/89	BH010	17B	810	910	810
10/04/89	BH008	17F	1100	980	990
10/04/89	BH005	19D	1200	1000	890
		Silver			
01/11/90	BH078	01D	< 0.85	—	—
11/16/89	BH067	01F	< 3.9	< 3.7	—
01/11/90	BH077	02E	< 0.74	1.1	—
01/11/90	BH075	03D	< 0.73	—	—
01/11/90	BH076	05B	< 0.72	< 0.71	< 0.64
11/07/89	BH049	05F	< 0.6	< 0.6	< 0.6
10/30/89	BH045	07D	< 0.6	1.7	1.1
10/26/89	BH038	09B	< 6	0.69	< 0.6
10/30/89	BH042	09F	< 0.6	< 0.6	< 0.6
10/18/89	BH025	11D	< 0.6	< 0.6	< 0.6
10/13/89	BH024	13B	< 0.6	< 0.6	< 0.6
12/20/89	BH024	13B	< 0.69	< 0.62	< 0.7
01/12/90	BH079	13E	—	—	< 0.73
01/12/90	BH080	13F	—	—	0.72
10/11/89	BH013	15D	< 0.6	< 0.6	< 0.6
10/04/89	BH010	17B	< 0.6	< 0.6	< 0.6
10/04/89	BH008	17F	0.9	0.88	0.78
10/04/89	BH005	19D	< 0.6	0.72	0.74

Table B.1. K-1407-C Retention Basin sediment sample analysis—elemental analysis (continued)

Date	Hole	Location	6-in. (mg/kg)	12-in. (mg/kg)	18-in. (mg/kg)
			Sodium		
01/11/90	BH078	01D	330	—	—
11/16/89	BH067	01F	380	450	—
01/11/90	BH077	02E	300	330	—
01/11/90	BH075	03D	250	—	—
01/11/90	BH076	05B	310	380	230
11/07/89	BH049	05F	110	260	300
10/30/89	BH045	07D	180	330	280
10/26/89	BH038	09B	850	280	430
10/30/89	BH042	09F	320	290	280
10/18/89	BH025	11D	470	450	390
10/13/89	BH024	13B	96	140	190
12/20/89	BH024	13B	130	180	340
01/12/90	BH079	13E	—	—	700
01/12/90	BH080	13F	—	—	960
10/11/89	BH013	15D	1300	1700	1300
10/04/89	BH010	17B	89	69	69
10/04/89	BH008	17F	1200	2400	3600
10/04/89	BH005	19D	550	780	750
			Strontium		
01/11/90	BH078	01D	27	—	—
11/16/89	BH067	01F	42	18	—
01/11/90	BH077	02E	29	31	—
01/11/90	BH075	03D	18	—	—
01/11/90	BH076	05B	8.9	7.1	4.5
11/07/89	BH049	05F	25	24	9.4
10/30/89	BH045	07D	20	33	26
10/26/89	BH038	09B	64	18	9.5
10/30/89	BH042	09F	12	6.5	6
10/18/89	BH025	11D	9.6	5.6	2.5
10/13/89	BH024	13B	8.4	6.9	4.7
12/20/89	BH024	13B	9.2	9.5	8.8
01/12/90	BH079	13E	—	—	23
01/12/90	BH080	13F	—	—	17
10/11/89	BH013	15D	25	3.2	1.8
10/04/89	BH010	17B	13	10	10
10/04/89	BH008	17F	56	37	7.3
10/04/89	BH005	19D	41	18	13

Table B.1. K-1407-C Retention Basin sediment sample analysis— elemental analysis (continued)

Date	Hole	Location	6-in. (mg/kg)	12-in. (mg/kg)	18-in. (mg/kg)
			Thorium		
01/11/90	BH078	01D	< 28	—	—
11/16/89	BH067	01F	< 130	< 120	—
01/11/90	BH077	02E	< 25	< 22	—
01/11/90	BH075	03D	< 24	—	—
01/11/90	BH076	05B	< 24	< 24	< 21
11/07/89	BH049	05F	< 20	< 20	< 20
10/30/89	BH045	07D	< 20	< 20	< 20
10/26/89	BH038	09B	< 200	< 20	< 20
10/30/89	BH042	09F	< 20	< 20	< 20
10/18/89	BH025	11D	< 20	< 20	< 20
10/13/89	BH024	13B	< 20	< 20	< 20
12/20/89	BH024	13B	< 23	< 21	< 23
01/12/90	BH079	13E	—	—	< 24
01/12/90	BH080	13F	—	—	< 21
10/11/89	BH013	15D	< 20	< 20	< 20
10/04/89	BH010	17B	< 20	< 20	< 20
10/04/89	BH008	17F	< 20	< 20	< 20
10/04/89	BH005	19D	< 20	< 20	< 20
			Uranium - Total		
01/11/90	BH078	01D	78	—	—
11/16/89	BH067	01F	< 19	< 19	—
01/11/90	BH077	02E	69	89	—
01/11/90	BH075	03D	< 3.6	—	—
01/11/90	BH076	05B	< 3.6	< 3.5	< 3.2
11/07/89	BH049	05F	120	45	< 3
10/30/89	BH045	07D	320	650	430
10/26/89	BH038	09B	540	180	27
10/30/89	BH042	09F	69	25	8.9
10/18/89	BH025	11D	29	11	< 3
10/13/89	BH024	13B	< 3	8	< 3
12/20/89	BH024	13B	< 3.4	< 3.1	< 3.5
01/12/90	BH079	13E	—	—	36
01/12/90	BH080	13F	—	—	38
10/11/89	BH013	15D	160	< 3	< 3
10/04/89	BH010	17B	< 3	15	9.3
10/04/89	BH008	17F	260	120	91
10/04/89	BH005	19D	120	21	14

Table B.1. K-1407-C Retention Basin sediment sample analysis—elemental analysis (continued)

Date	Hole	Location	6-in. (mg/kg)	12-in. (mg/kg)	18-in. (mg/kg)
		Vanadium			
01/11/90	BH078	01D	42	—	—
11/16/89	BH067	01F	53	29	—
01/11/90	BH077	02E	46	39	—
01/11/90	BH075	03D	34	—	—
01/11/90	BH076	05B	46	39	35
11/07/89	BH049	05F	28	36	40
10/30/89	BH045	07D	47	48	47
10/26/89	BH038	09B	47	39	33
10/30/89	BH042	09F	48	47	43
10/18/89	BH025	11D	47	38	27
10/13/89	BH024	13B	34	38	37
12/20/89	BH024	13B	44	41	48
01/12/90	BH079	13E	—	—	53
01/12/90	BH080	13F	—	—	61
10/11/89	BH013	15D	54	44	45
10/04/89	BH010	17B	54	40	41
10/04/89	BH008	17F	61	73	67
10/04/89	BH005	19D	52	39	39
		Zinc			
01/11/90	BH078	01D	77	—	—
11/16/89	BH067	01F	120	80	—
01/11/90	BH077	02E	91	74	—
01/11/90	BH075	03D	70	—	—
01/11/90	BH076	05B	52	48	40
11/07/89	BH049	05F	63	67	33
10/30/89	BH045	07D	72	94	86
10/26/89	BH038	09B	120	62	32
10/30/89	BH042	09F	58	40	35
10/18/89	BH025	11D	48	28	11
10/13/89	BH024	13B	37	34	27
12/20/89	BH024	13B	51	47	61
01/12/90	BH079	13E	—	—	64
01/12/90	BH080	13F	—	—	86
10/11/89	BH013	15D	110	25	27
10/04/89	BH010	17B	48	41	38
10/04/89	BH008	17F	100	98	63
10/04/89	BH005	19D	81	62	55

Table B.2. K-1407-C Retention Basin sediment sample analysis—radionuclide analysis

Date	Hole	Location	6-in. (pCi/g)	12-in. (pCi/g)	18-in. (pCi/g)
		Americium-241			
11/20/89	BH070	00D	3.2	—	—
11/20/89	BH068	00F	8.1	—	—
11/20/89	BH069	00F-B	9.2	—	—
11/21/89	BH073	01B	0.076	—	—
01/10/90	BH078	01D	0.23	—	—
11/16/89	BH067	01F	0.068	—	—
11/15/89	BH064	01F-B	3.8	—	—
11/16/89	BH066	01H	0.16	—	—
01/10/90	BH077	02E	0.43	—	—
11/15/89	BH063	02G	0.35	—	—
11/16/89	BH065	03A	0.024	—	—
11/13/89	BH061	03B	0.084	0.049	0.043
11/13/89	BH060	03C	0.068	0.032	0.054
01/10/90	BH075	03D	0.027	—	—
11/13/89	BH062	03D-B	-0.5	—	—
11/09/89	BH059	03E	1.8	1.9	0.27
11/09/89	BH057	03F	0.15	0.22	0.022
11/09/89	BH056	03F-B	5.1	1.4	0.41
11/09/89	BH058	03H	0.59	0.084	—
11/20/89	BH072	05A	0.11	—	—
01/10/90	BH076	05B	0.065	—	—
11/03/89	BH055	05D	0.081	0.038	0.024
11/01/89	BH049	05F	1.3	0.19	0.062
11/01/89	BH048	05G	0.81	—	—
11/03/89	BH053	06B	0.1	0.089	0.17
11/02/89	BH050	06F	1.5	0.046	0.26
11/02/89	BH051	06F-B	16	1.1	0.12
10/30/89	BH043	07B	1.1	2.6	12
10/30/89	BH044	07B-B	10	8.9	0.46
10/30/89	BH045	07D	3.2	6.8	4.3
11/03/89	BH052	07D-B	2.2	0.3	0.11
11/03/89	BH054	07D-B	1.1	5.7	0.95
10/30/89	BH046	07F	8.1	0.43	0.16
10/12/89	BH021	07F-B	5.7	2	7
10/30/89	BH047	07F-B	16	2.2	—
11/20/89	BH071	07F-B	32	—	—
10/25/89	BH038	09B	3.8	4	0.11
10/18/89	BH033	09B-B	-0.03	—	—
10/25/89	BH039	09C	1.9	0.15	0.054
10/25/89	BH040	09D	3.2	0.32	< 0.19
10/25/89	BH041	09E	-0.05	0.35	0.16
10/30/89	BH042	09F	0.49	0.076	0.35
10/24/89	BH037	09F-B	13	3.2	0.14
10/16/89	BH027	11A	0.38	—	—

Table B.2. K-1407-C Retention Basin sediment sample analysis—radionuclide analysis (continued)

Date	Hole	Location	6-in. (pCi/g)	12-in. (pCi/g)	18-in. (pCi/g)
		Americium-241 (continued)			
10/16/89	BH026	11B	6.8	—	—
10/16/89	BH025	11D	0.2	—	—
10/18/89	BH030	11F	0.068	—	—
10/18/89	BH031	11F-B	1.9	—	—
10/24/89	BH036	11F-B	4	1.9	0.16
10/18/89	BH032	11H	0.07	—	—
10/23/89	BH035	11H-B	23	57	1.6
10/16/89	BH028	12B	0.3	—	—
01/03/90	BH074	12F	0.054	-0.6	0.07
10/13/89	BH024	13B	-0.005	—	—
10/13/89	BH023	13C	0.22	0.3	< 0.32
10/18/89	BH029	13D	0.35	—	—
10/12/89	BH020	15B	0.019	0.078	0.0089
10/10/89	BH013	15D	1.1	—	—
10/11/89	BH017	15D-B	0.12	—	—
10/10/89	BH014	15F	8.6	—	—
10/10/89	BH015	15F-B	0.59	—	—
10/11/89	BH018	15F-B	3.5	—	—
10/23/89	BH034	15F-B	-1	0.84	1
10/10/89	BH016	15H	3	—	—
10/12/89	BH019	16B	0.016	0.054	0.073
10/13/89	BH022	16E-B	1.4	0.26	0.15
10/09/89	BH012	16F	1.1	—	—
10/04/89	BH010	17B	0.12	< 0.054	0.016
10/04/89	BH009	17D	0.92	< 0.22	0.0086
10/03/89	BH008	17F	1.5	0.57	0.059
10/03/89	BH007	17H	2.5	0.26	2.7
10/03/89	BH004	18E-B	0.57	0.062	0.059
09/28/89	BH002	18G-B	4	4	0.59
10/03/89	BH006	19B	0.18	0.059	—
10/03/89	BH005	19D	0.81	0.2	0.22
10/02/89	BH003	19F	0.25	1.2	0.23
09/27/89	BH001	19H	0.073	0.1	0.07
10/09/89	BH011	20D	0.062	—	—
		Cesium-137			
11/20/89	BH070	00D	5.7	—	—
11/20/89	BH068	00F	16	—	—
11/20/89	BH069	00F-B	27	—	—
11/21/89	BH073	01B	0.12	—	—
01/10/90	BH078	01D	1.4	—	—
11/16/89	BH067	01F	0.65	—	—

Table B.2. K-1407-C Retention Basin sediment sample analysis—radionuclide analysis (continued)

Date	Hole	Location	6-in. (pCi/g)	12-in. (pCi/g)	18-in. (pCi/g)
			Cesium-137 (continued)		
11/15/89	BH064	01F-B	4.6	—	—
11/16/89	BH066	01H	0.68	—	—
01/10/90	BH077	02E	3	—	—
11/15/89	BH063	02G	1.9	—	—
11/16/89	BH065	03A	0.38	—	—
11/13/89	BH061	03B	0.054	< 0.054	< 0.054
11/13/89	BH060	03C	0.024	< 0.081	< 0.081
01/10/90	BH075	03D	0.21	—	—
11/13/89	BH062	03D-B	27	—	—
11/09/89	BH059	03E	4	9.4	1.6
11/09/89	BH057	03F	0.84	1.1	0.19
11/09/89	BH056	03F-B	26	4.9	0.41
11/09/89	BH058	03H	1.7	0.23	—
11/20/89	BH072	05A	2.3	—	—
01/10/90	BH076	05B	0.49	—	—
11/03/89	BH055	05D	0.76	0.11	< 0.054
11/01/89	BH049	05F	0.65	0.22	0.12
11/01/89	BH048	05G	0.19	—	—
11/03/89	BH053	06B	1.5	0.54	0.32
11/02/89	BH050	06F	0.86	0.14	0.11
11/02/89	BH051	06F-B	12	2.4	0.11
10/30/89	BH043	07B	15	9.4	13
10/30/89	BH044	07B-B	54	38	3.5
10/30/89	BH045	07D	23	30	22
11/03/89	BH052	07D-B	18	1	0.21
11/03/89	BH054	07D-B	43	38	15
10/30/89	BH046	07F	32	3.5	1.3
10/12/89	BH021	07F-B	49	59	43
10/30/89	BH047	07F-B	57	14	—
11/20/89	BH071	07F-B	110	—	—
10/25/89	BH038	09B	23	14	14
10/18/89	BH033	09B-B	180	4.9	0.22
10/25/89	BH039	09C	3	0.59	0.13
10/25/89	BH040	09D	3.8	1	0.051
10/25/89	BH041	09E	5.9	0.68	0.07
10/30/89	BH042	09F	2	0.46	0.95
10/24/89	BH037	09F-B	15	5.4	13
10/16/89	BH027	11A	1.6	2.5	1.1
10/16/89	BH026	11B	5.1	0.7	1.2
10/16/89	BH025	11D	1.2	0.17	0.043
10/18/89	BH030	11F	0.13	4.6	6.2
10/18/89	BH031	11F-B	12	1.9	0.086
10/24/89	BH036	11F-B	9.4	8.9	0.51

Table B.2. K-1407-C Retention Basin sediment sample analysis—radionuclide analysis (continued)

Date	Hole	Location	6-in. (pCi/g)	12-in. (pCi/g)	18-in. (pCi/g)
		Cesium-137 (continued)			
10/18/89	BH032	11H	25	15	7.3
10/23/89	BH035	11H-B	97	81	13
10/16/89	BH028	12B	1.8	0.03	< 0.14
01/03/90	BH074	12F	0.38	0.081	-0.003
10/13/89	BH024	13B	0.059	0.068	0.089
10/13/89	BH023	13C	1.6	2.2	< 0.11
10/18/89	BH029	13D	2.7	0.092	0.03
10/12/89	BH020	15B	0.076	0.12	< 0.14
10/10/89	BH013	15D	5.4	0.21	0.092
10/11/89	BH017	15D-B	0.76	0.19	0.041
10/10/89	BH014	15F	8.6	0.54	0.12
10/10/89	BH015	15F-B	84	5.7	1.8
10/11/89	BH018	15F-B	26	6.2	3.8
10/23/89	BH034	15F-B	16	1.5	1.4
10/10/89	BH016	15H	8.9	8.4	3
10/12/89	BH019	16B	0.22	0.059	0.035
10/13/89	BH022	16E-B	11	0.76	0.095
10/09/89	BH012	16F	8.9	0.19	0.086
10/04/89	BH010	17B	0.81	< 0.14	< 0.11
10/04/89	BH009	17D	12	0.43	0.24
10/03/89	BH008	17F	11	2.2	0.43
10/03/89	BH007	17H	19	10	17
10/03/89	BH004	18E-B	8.6	3.5	0.62
09/28/89	BH002	18G-B	76	19	0.89
10/03/89	BH006	19B	0.38	0.23	—
10/03/89	BH005	19D	7.6	1.4	1.2
10/02/89	BH003	19F	2.3	15	3
09/27/89	BH001	19H	0.21	0.084	0.076
10/09/89	BH011	20D	0.35	0.13	-0.02
		Cobalt-60			
11/20/89	BH070	00D	-0.01	—	—
11/20/89	BH068	00F	-0.005	—	—
11/20/89	BH069	00F-B	0.022	—	—
11/21/89	BH073	01B	-0.04	—	—
11/16/89	BH067	01F	0.03	—	—
11/15/89	BH064	01F-B	0.078	—	—
11/16/89	BH066	01H	0.035	—	—
11/15/89	BH063	02G	0.057	—	—
11/16/89	BH065	03A	0.022	—	—
11/13/89	BH061	03B	-0.03	—	—
11/13/89	BH060	03C	0.022	—	—

Table B.2. K-1407-C Retention Basin sediment sample analysis—radionuclide analysis (continued)

Date	Hole	Location	6-in. (pCi/g)	12-in. (pCi/g)	18-in. (pCi/g)
			Cobalt-60 (continued)		
01/10/90	BH075	03D	0.089	—	—
11/13/89	BH062	03D-B	0.022	—	—
11/09/89	BH059	03E	0.022	—	—
11/09/89	BH057	03F	0.0054	—	—
11/09/89	BH056	03F-B	0.032	—	—
11/09/89	BH058	03H	-0.008	—	—
11/20/89	BH072	05A	0.062	—	—
11/03/89	BH055	05D	-0.008	—	—
11/01/89	BH049	05F	-0.03	—	—
11/01/89	BH048	05G	-0.02	—	—
11/03/89	BH053	06B	-0.01	—	—
11/02/89	BH050	06F	0.022	—	—
11/02/89	BH051	06F-B	0.014	—	—
10/30/89	BH043	07B	0.092	—	—
10/30/89	BH044	07B-B	0.078	—	—
10/30/89	BH045	07D	0.0081	—	—
11/03/89	BH052	07D-B	0.0027	—	—
11/03/89	BH054	07D-B	0.11	—	—
10/30/89	BH046	07F	0.089	—	—
10/12/89	BH021	07F-B	-0.2	—	—
10/30/89	BH047	07F-B	0.0081	—	—
11/20/89	BH071	07F-B	0.12	—	—
10/25/89	BH038	09B	0.073	—	—
10/18/89	BH033	09B-B	0.068	—	—
10/25/89	BH039	09C	0.032	—	—
10/25/89	BH040	09D	0.049	—	—
10/25/89	BH041	09E	0.022	—	—
10/30/89	BH042	09F	-0.003	—	—
10/24/89	BH037	09F-B	0.065	—	—
10/16/89	BH027	11A	-0.03	—	—
10/16/89	BH026	11B	0.041	—	—
10/16/89	BH025	11D	0.016	—	—
10/18/89	BH030	11F	0.041	—	—
10/18/89	BH031	11F-B	0.03	—	—
10/24/89	BH036	11F-B	0.027	0.032	—
10/18/89	BH032	11H	-0.04	—	—
10/23/89	BH035	11H-B	0.14	—	—
10/16/89	BH028	12B	0.057	—	—
01/03/90	BH074	12F	0.35	—	—
10/13/89	BH024	13B	0.043	—	—
10/13/89	BH023	13C	-0.03	—	—
10/18/89	BH029	13D	0.046	—	—
10/12/89	BH020	15B	0.092	—	—

Table B.2. K-1407-C Retention Basin sediment sample analysis—radionuclide analysis (continued)

Date	Hole	Location	6-in. (pCi/g)	12-in. (pCi/g)	18-in. (pCi/g)
		Cobalt-60 (continued)			
10/10/89	BH013	15D	0.089	—	—
10/11/89	BH017	15D-B	-0.05	—	—
10/10/89	BH014	15F	0.011	—	—
10/10/89	BH015	15F-B	0.011	—	—
10/11/89	BH018	15F-B	-0.03	—	—
10/23/89	BH034	15F-B	0.032	—	—
10/10/89	BH016	15H	0.07	—	—
10/12/89	BH019	16B	0.027	—	—
10/13/89	BH022	16E-B	0.054	—	—
10/09/89	BH012	16F	-0.02	—	—
10/04/89	BH010	17B	0.019	—	—
10/04/89	BH009	17D	0.032	—	—
10/03/89	BH008	17F	0.065	—	—
10/03/89	BH007	17H	0.03	—	—
10/03/89	BH004	18E-B	0.016	—	—
09/28/89	BH002	18G-B	-0.003	—	—
10/03/89	BH006	19B	-0.005	—	—
10/03/89	BH005	19D	0.03	—	—
10/02/89	BH003	19F	0.081	—	—
09/27/89	BH001	19H	-0.04	—	—
10/09/89	BH011	20D	0.016	—	—
		Curium-244			
10/12/89	BH021	07F-B	-0.01	—	—
01/03/90	BH074	12F	-0.001	—	—
10/13/89	BH024	13B	-0.02	—	—
10/13/89	BH023	13C	-0.01	—	—
10/12/89	BH020	15B	-0.04	—	—
10/10/89	BH013	15D	-0.009	—	—
10/11/89	BH017	15D-B	-0.01	—	—
10/10/89	BH014	15F	0.059	—	—
10/10/89	BH015	15F-B	-0.04	—	—
10/11/89	BH018	15F-B	-0.08	—	—
10/10/89	BH016	15H	0.0027	—	—
10/12/89	BH019	16B	-0.03	—	—
10/13/89	BH022	16E-B	-0.04	—	—
10/09/89	BH012	16F	-0.04	—	—
10/04/89	BH010	17B	-0.003	—	—
10/04/89	BH009	17D	-0.02	—	—
10/03/89	BH008	17F	-0.04	—	—
10/03/89	BH007	17H	-0.04	—	—
10/03/89	BH004	18E-B	0.0081	—	—

Table B.2. K-1407-C Retention Basin sediment sample analysis—radionuclide analysis (continued)

Date	Hole	Location	6-in. (pCi/g)	12-in. (pCi/g)	18-in. (pCi/g)
		Curium-244 (continued)			
09/28/89	BH002	18G-B	-0.4	—	—
10/03/89	BH006	19B	-0.03	—	—
10/03/89	BH005	19D	0.024	—	—
10/02/89	BH003	19F	-0.2	—	—
09/27/89	BH001	19H	-0.005	—	—
10/09/89	BH011	20D	-0.03	—	—
		Europium-154			
10/18/89	BH033	09B-B	2.1	—	—
		Gross alpha			
11/20/89	BH070	00D	230	680	570
11/20/89	BH068	00F	510	540	410
11/20/89	BH069	00F-B	760	410	540
11/21/89	BH073	01B	11	12	9.2
01/10/90	BH078	01D	35	—	—
11/16/89	BH067	01F	35	14	—
11/15/89	BH064	01F-B	220	84	19
11/16/89	BH066	01H	22	12	—
01/10/90	BH077	02E	73	37	—
11/15/89	BH063	02G	54	13	650
11/16/89	BH065	03A	25	27	23
11/13/89	BH061	03B	14	8.4	8.9
11/13/89	BH060	03C	12	11	8.1
01/10/90	BH075	03D	4.9	—	—
11/13/89	BH062	03D-B	380	10	23
11/09/89	BH059	03E	110	260	49
11/09/89	BH057	03F	41	32	17
11/09/89	BH056	03F-B	1100	230	18
11/09/89	BH058	03H	59	13	—
11/20/89	BH072	05A	68	62	43
01/10/90	BH076	05B	20	8.1	7.8
11/03/89	BH055	05D	19	5.1	3.8
11/01/89	BH049	05F	65	54	27
11/01/89	BH048	05G	19	—	—
11/03/89	BH053	06B	54	22	14
11/02/89	BH050	06F	100	89	59
11/02/89	BH051	06F-B	320	110	11
10/30/89	BH043	07B	270	210	410
10/30/89	BH044	07B-B	810	570	78
10/30/89	BH045	07D	300	540	490

Table B.2. K-1407-C Retention Basin sediment sample analysis—radionuclide analysis (continued)

Date	Hole	Location	6-in. (pCi/g)	12-in. (pCi/g)	18-in. (pCi/g)
		Gross alpha (continued)			
11/03/89	BH052	07D-B	240	17	11
11/03/89	BH054	07D-B	810	680	170
10/30/89	BH046	07F	890	140	68
10/12/89	BH021	07F-B	1100	1400	950
10/30/89	BH047	07F-B	1900	380	—
11/20/89	BH071	07F-B	1900	—	—
10/25/89	BH038	09B	540	350	54
10/18/89	BH033	09B-B	1900	86	14
10/25/89	BH039	09C	100	18	13
10/25/89	BH040	09D	92	25	4.3
10/25/89	BH041	09E	92	17	7
10/30/89	BH042	09F	70	30	27
10/24/89	BH037	09F-B	1000	150	49
10/16/89	BH027	11A	65	65	41
10/16/89	BH026	11B	170	25	35
10/16/89	BH025	11D	41	15	5.4
10/18/89	BH030	11F	14	140	170
10/18/89	BH031	11F-B	190	25	18
10/24/89	BH036	11F-B	250	210	17
10/18/89	BH032	11H	380	350	300
10/23/89	BH035	11H-B	350	1400	270
10/16/89	BH028	12B	54	3.2	10
01/03/90	BH074	12F	8.6	7.8	5.1
10/13/89	BH024	13B	5.4	18	3.5
10/13/89	BH023	13C	32	54	5.9
10/18/89	BH029	13D	54	14	6.8
01/11/90	BH079	13E	—	—	57
01/11/90	BH080	13F	—	—	43
10/12/89	BH020	15B	14	15	11
10/10/89	BH013	15D	65	14	11
10/11/89	BH017	15D-B	49	10	11
10/10/89	BH014	15F	180	59	43
10/10/89	BH015	15F-B	1100	100	38
10/11/89	BH018	15F-B	410	130	120
10/23/89	BH034	15F-B	220	57	76
10/10/89	BH016	15H	200	220	95
10/12/89	BH019	16B	13	19	16
10/13/89	BH022	16E-B	170	38	46
10/09/89	BH012	16F	95	25	14
10/04/89	BH010	17B	22	19	13
10/04/89	BH009	17D	110	19	22
10/03/89	BH008	17F	130	76	59
10/03/89	BH007	17H	210	190	320

Table B.2. K-1407-C Retention Basin sediment sample analysis—radionuclide analysis (continued)

Date	Hole	Location	6-in. (pCi/g)	12-in. (pCi/g)	18-in. (pCi/g)
		Gross alpha (continued)			
10/03/89	BH004	18E-B	78	32	19
09/28/89	BH002	18G-B	16	260	30
10/03/89	BH006	19B	17	21	—
10/03/89	BH005	19D	97	30	41
10/02/89	BH003	19F	100	150	35
09/27/89	BH001	19H	17	18	16
10/09/89	BH011	20D	9.2	12	6.2
		Gross beta			
11/20/89	BH070	00D	490	1400	860
11/20/89	BH068	00F	890	950	730
11/20/89	BH069	00F-B	1700	810	1300
11/21/89	BH073	01B	15	15	16
01/10/90	BH078	01D	120	—	—
11/16/89	BH067	01F	62	8.6	—
11/15/89	BH064	01F-B	430	180	24
11/16/89	BH066	01H	51	35	—
01/10/90	BH077	02E	220	52	—
11/15/89	BH063	02G	160	16	1300
11/16/89	BH065	03A	81	30	38
11/13/89	BH061	03B	17	7.3	9.7
11/13/89	BH060	03C	65	10	4.9
01/10/90	BH075	03D	17	—	—
11/13/89	BH062	03D-B	810	14	46
11/09/89	BH059	03E	210	590	97
11/09/89	BH057	03F	110	73	26
11/09/89	BH056	03F-B	1900	380	26
11/09/89	BH058	03H	110	20	—
11/20/89	BH072	05A	220	130	78
01/10/90	BH076	05B	51	17	10
11/03/89	BH055	05D	57	12	11
11/01/89	BH049	05F	110	54	22
11/01/89	BH048	05G	17	—	—
11/03/89	BH053	06B	97	38	21
11/02/89	BH050	06F	130	73	54
11/02/89	BH051	06F-B	970	150	30
10/30/89	BH043	07B	570	300	380
10/30/89	BH044	07B-B	3000	1100	120
10/30/89	BH045	07D	970	840	950
11/03/89	BH052	07D-B	590	78	32
11/03/89	BH054	07D-B	1900	700	240
10/30/89	BH046	07F	2400	240	140

Table B.2. K-1407-C Retention Basin sediment sample analysis—radionuclide analysis (continued)

Date	Hole	Location	6-in. (pCi/g)	12-in. (pCi/g)	18-in. (pCi/g)
		Gross beta (continued)			
10/12/89	BH021	07F-B	2300	2500	1400
10/30/89	BH047	07F-B	4600	780	—
11/20/89	BH071	07F-B	4600	—	—
10/25/89	BH038	09B	1300	360	92
10/18/89	BH033	09B-B	4900	190	21
10/25/89	BH039	09C	220	38	25
10/25/89	BH040	09D	220	5.9	9.4
10/25/89	BH041	09E	430	65	16
10/30/89	BH042	09F	180	49	68
10/24/89	BH037	09F-B	1800	460	92
10/16/89	BH027	11A	170	180	100
10/16/89	BH026	11B	350	59	95
10/16/89	BH025	11D	89	32	10
10/18/89	BH030	11F	12	320	380
10/18/89	BH031	11F-B	490	54	26
10/24/89	BH036	11F-B	760	430	41
10/18/89	BH032	11H	700	540	430
10/23/89	BH035	11H-B	920	4100	620
10/16/89	BH028	12B	100	15	11
01/03/90	BH074	12F	21	14	19
10/13/89	BH024	13B	30	19	16
10/13/89	BH023	13C	78	110	9.2
10/18/89	BH029	13D	110	4.9	16
01/11/90	BH079	13E	—	—	120
01/11/90	BH080	13F	—	—	110
10/12/89	BH020	15B	46	21	30
10/10/89	BH013	15D	220	38	20
10/11/89	BH017	15D-B	59	18	11
10/10/89	BH014	15F	540	150	78
10/10/89	BH015	15F-B	3500	250	110
10/11/89	BH018	15F-B	1200	430	260
10/23/89	BH034	15F-B	430	140	190
10/10/89	BH016	15H	760	570	590
10/12/89	BH019	16B	62	59	22
10/13/89	BH022	16E-B	510	95	86
10/09/89	BH012	16F	350	65	35
10/04/89	BH010	17B	68	57	35
10/04/89	BH009	17D	380	38	23
10/03/89	BH008	17F	540	160	92
10/03/89	BH007	17H	840	350	620
10/03/89	BH004	18E-B	270	70	30
09/28/89	BH002	18G-B	1200	680	54
10/03/89	BH006	19B	57	41	—

Table B.2. K-1407-C Retention Basin sediment sample analysis—radionuclide analysis (continued)

Date	Hole	Location	6-in. (pCi/g)	12-in. (pCi/g)	18-in. (pCi/g)
		Gross beta (continued)			
10/03/89	BH005	19D	460	100	68
10/02/89	BH003	19F	230	320	84
09/27/89	BH001	19H	430	12	15
10/09/89	BH011	20D	30	25	13
		Neptunium-237			
11/20/89	BH070	00D	1	—	—
11/20/89	BH068	00F	3.5	—	—
11/20/89	BH069	00F-B	5.9	—	—
11/21/89	BH073	01B	0.0046	—	—
01/10/90	BH078	01D	0.81	—	—
11/16/89	BH067	01F	0.14	—	—
11/15/89	BH064	01F-B	0.81	—	—
11/16/89	BH066	01H	0.065	—	—
01/10/90	BH077	02E	0.95	—	—
11/15/89	BH063	02G	0.46	—	—
11/16/89	BH065	03A	0.032	—	—
11/13/89	BH061	03B	0.0051	0.0095	0.022
11/13/89	BH060	03C	0.023	0.01	< 0.027
01/10/90	BH075	03D	0.86	—	—
11/13/89	BH062	03D-B	6.8	—	—
11/09/89	BH059	03E	1.1	4.9	0.65
11/09/89	BH057	03F	0.23	0.35	0.065
11/09/89	BH056	03F-B	11	0.086	2.5
11/09/89	BH058	03H	0.54	0.13	—
11/20/89	BH072	05A	0.11	—	—
01/10/90	BH076	05B	1.6	—	—
11/03/89	BH055	05D	0.17	0.057	0.017
11/01/89	BH049	05F	0.27	0.068	0.051
11/01/89	BH048	05G	0.043	—	—
11/03/89	BH053	06B	0.49	0.14	0.049
11/02/89	BH050	06F	0.51	0.024	0.011
11/02/89	BH051	06F-B	9.7	0.62	0.065
10/30/89	BH043	07B	4.3	5.4	4.6
10/30/89	BH044	07B-B	35	12	0.46
10/30/89	BH045	07D	10	7.8	9.4
11/03/89	BH052	07D-B	7.6	0.51	0.051
11/03/89	BH054	07D-B	18	12	1.8
10/30/89	BH046	07F	30	1.1	0.65
10/12/89	BH021	07F-B	30	2.2	11
10/30/89	BH047	07F-B	59	3	—
11/20/89	BH071	07F-B	41	—	—

Table B.2. K-1407-C Retention Basin sediment sample analysis—radionuclide analysis (continued)

Date	Hole	Location	6-in. (pCi/g)	12-in. (pCi/g)	18-in. (pCi/g)
		Neptunium-237 (continued)			
10/25/89	BH038	09B	8.9	4.6	0.25
10/18/89	BH033	09B-B	140	—	—
10/25/89	BH039	09C	1.7	0.25	0.068
10/25/89	BH040	09D	1.5	0.3	0.0057
10/25/89	BH041	09E	3.8	0.3	0.041
10/30/89	BH042	09F	2.5	0.12	0.3
10/24/89	BH037	09F-B	7.3	2.2	0.26
10/16/89	BH027	11A	0.92	—	—
10/16/89	BH026	11B	2.2	—	—
10/16/89	BH025	11D	0.86	—	—
10/18/89	BH030	11F	0.13	—	—
10/18/89	BH031	11F-B	7.8	—	—
10/24/89	BH036	11F-B	6.2	3.2	0.19
10/18/89	BH032	11H	20	—	—
10/23/89	BH035	11H-B	46	35	1.9
10/16/89	BH028	12B	1.2	—	—
01/03/90	BH074	12F	0.011	0.54	0.014
10/13/89	BH024	13B	0.043	—	—
10/13/89	BH023	13C	1.4	0.57	0.03
10/18/89	BH029	13D	2	—	—
10/12/89	BH020	15B	0.046	0.0035	0.014
10/10/89	BH013	15D	3.8	—	—
10/11/89	BH017	15D-B	0.86	—	—
10/10/89	BH014	15F	7.3	—	—
10/10/89	BH015	15F-B	32	—	—
10/11/89	BH018	15F-B	14	—	—
10/23/89	BH034	15F-B	8.1	0.51	0.62
10/10/89	BH016	15H	9.4	—	—
10/12/89	BH019	16B	0.12	0.041	0.0024
10/13/89	BH022	16E-B	8.1	0.17	0.092
10/09/89	BH012	16F	4.9	—	—
10/04/89	BH010	17B	0.38	0.038	< 0.027
10/04/89	BH009	17D	5.1	0.07	0.07
10/03/89	BH008	17F	7.8	1.2	0.13
10/03/89	BH007	17H	12	4	7.6
10/03/89	BH004	18E-B	2.4	0.65	0.3[illegible]
09/28/89	BH002	18G-B	27	8.4	0.6[illegible]
10/03/89	BH006	19B	0.18	0.11	—
10/03/89	BH005	19D	5.1	0.65	0.41
10/02/89	BH003	19F	0.81	4	1.2
09/27/89	BH001	19H	0.24	0.015	0.011
10/0[illegible]/89	BH011	20D	0.16	—	—

Table B.2. K-1407-C Retention Basin sediment sample analysis—radionuclide analysis (continued)

Date	Hole	Location	6-in. (pCi/g)	12-in. (pCi/g)	18-in. (pCi/g)
		Plutonium-238			
11/20/89	BH070	00D	0.054	—	—
11/20/89	BH068	00F	0.49	—	—
11/20/89	BH069	00F-B	0.62	—	—
11/21/89	BH073	01B	0.0027	—	—
01/10/90	BH078	01D	0.014	—	—
11/16/89	BH067	01F	0.03	—	—
11/15/89	BH064	01F-B	0.3	—	—
11/16/89	BH066	01H	0.0027	—	—
01/10/90	BH077	02E	0.019	—	—
11/15/89	BH063	02G	0.043	—	—
11/16/89	BH065	03A	0.015	—	—
11/13/89	BH061	03B	-0.02	0.0054	< 0.054
11/13/89	BH060	03C	0.0054	0.016	< 0.054
01/10/90	BH075	03D	0.0019	—	—
11/13/89	BH062	03D-B	0.19	—	—
11/09/89	BH059	03E	0.16	< 0.54	0.089
11/09/89	BH057	03F	-0.005	< 0.27	0.035
11/09/89	BH056	03F-B	-1	< 0.54	0.12
11/09/89	BH058	03H	-0.01	0.03	—
11/20/89	BH072	05A	0.03	—	—
01/10/90	BH076	05B	0.0081	—	—
11/03/89	BH055	05D	0.018	-0.005	0.007
11/01/89	BH049	05F	1.1	-0.02	-0.008
11/01/89	BH048	05G	0.3	—	—
11/03/89	BH053	06B	0.1	-0.009	-0.04
11/02/89	BH050	06F	2.7	-0.08	-0.03
11/02/89	BH051	06F-B	16	0.022	-0.03
10/30/89	BH043	07B	0.19	-0.2	-0.2
10/30/89	BH044	07B-B	0.86	0.97	< 0.054
10/30/89	BH045	07D	0.3	< 0.54	0.41
11/03/89	BH052	07D-B	0.27	0.054	-0.02
11/03/89	BH054	07D-B	0.84	0.054	-0.6
10/30/89	BH046	07F	0.92	0.068	< 0.054
10/12/89	BH021	07F-B	-0.8	0.41	2.1
10/30/89	BH047	07F-B	1.5	0.38	—
11/20/89	BH071	07F-B	0.81	—	—
10/25/89	BH038	09B	0.092	0.51	< 0.054
10/18/89	BH033	09B-B	1.9	—	—
10/25/89	BH039	09C	0.07	0.013	0.0038
10/25/89	BH040	09D	0.027	0.018	< 0.019
10/25/89	BH041	09E	3.5	0.046	0.0041
10/30/89	BH042	09F	0.11	0.032	0.014
10/24/89	BH037	09F-B	14	-0.05	0.076

Table B.2. K-1407-C Retention Basin sediment sample analysis—radionuclide analysis (continued)

Date	Hole	Location	6-in. (pCi/g)	12-in. (pCi/g)	18-in. (pCi/g)
		Plutonium-238 (continued)			
10/16/89	BH027	11A	0.022	—	—
10/16/89	BH026	11B	0.027	—	—
10/16/89	BH025	11D	0.03	—	—
10/18/89	BH030	11F	-0.01	—	—
10/18/89	BH031	11F-B	0.18	—	—
10/24/89	BH036	11F-B	1.6	0.068	0.0024
10/18/89	BH032	11H	0.46	—	—
10/23/89	BH035	11H-B	14	0.35	0.51
10/16/89	BH028	12B	0.022	—	—
01/03/90	BH074	12F	0.013	-0.01	0.032
10/13/89	BH024	13B	-0.01	—	—
10/13/89	BH023	13C	0.0081	0.086	< 0.027
10/18/89	BH029	13D	0.0054	—	—
10/12/89	BH020	15B	-0.003	0.011	0.0011
10/10/89	BH013	15D	0.057	—	—
10/11/89	BH017	15D-B	0.016	—	—
10/10/89	BH014	15F	0.11	—	—
10/10/89	BH015	15F-B	0.7	—	—
10/11/89	BH018	15F-B	-2	—	—
10/23/89	BH034	15F-B	7.6	0.092	0.032
10/10/89	BH016	15H	0.14	—	—
10/12/89	BH019	16B	0.0092	0.022	0.0065
10/13/89	BH022	16E-B	0.59	0.017	0.035
10/09/89	BH012	16F	0.054	—	—
10/04/89	BH010	17B	-0.04	0.024	0.022
10/04/89	BH009	17D	0.041	< 0.081	0.054
10/03/89	BH008	17F	0.18	0.038	0.3
10/03/89	BH007	17H	0.18	0.22	< 0.3
10/03/89	BH004	18E-B	-0.06	0.041	0.032
09/28/89	BH002	18G-B	0.54	-0.4	0.049
10/03/89	BH006	19B	-0.04	0.089	—
10/03/89	BH005	19D	0.054	0.03	< 0.054
10/02/89	BH003	19F	0.03	0.22	0.041
09/27/89	BH001	19H	-0.005	-0.04	-0.02
10/09/89	BH011	20D	0.0027	—	—
		Plutonium-239			
11/20/89	BH070	00D	3.5	—	—
11/20/89	BH068	00F	8.6	—	—
11/20/89	BH069	00F-B	30	—	—
11/21/89	BH073	01B	0.03	—	—
01/10/90	BH078	01D	2	—	—

Table B.2. K-1407-C Retention Basin sediment sample analysis— radionuclide analysis (continued)

Date	Hole	Location	6-in. (pCi/g)	12-in. (pCi/g)	18-in. (pCi/g)
		Plutonium-239 (continued)			
11/16/89	BH067	01F	0.84	—	—
11/15/89	BH064	01F-B	7	—	—
11/16/89	BH066	01H	0.21	—	—
01/10/90	BH077	02E	3.5	—	—
11/15/89	BH063	02G	2.3	—	—
11/16/89	BH065	03A	0.032	—	—
11/13/89	BH061	03B	0.059	< 0.027	< 0.027
11/13/89	BH060	03C	0.084	0.019	< 0.054
01/10/90	BH075	03D	0.095	—	—
11/13/89	BH062	03D-B	18	—	—
11/09/89	BH059	03E	3.2	11	1.6
11/09/89	BH057	03F	0.97	1.1	0.22
11/09/89	BH056	03F-B	43	6.2	0.46
11/09/89	BH058	03H	2.2	0.17	—
11/20/89	BH072	05A	0.92	—	—
01/10/90	BH076	05B	0.46	—	—
11/03/89	BH055	05D	0.49	0.062	0.0049
11/01/89	BH049	05F	0.92	0.3	0.13
11/01/89	BH048	05G	0.21	—	—
11/03/89	BH053	06B	1.6	0.38	0.23
11/02/89	BH050	06F	0.7	-0.05	0.21
11/02/89	BH051	06F-B	24	3.5	0.17
10/30/89	BH043	07B	13	9.2	17
10/30/89	BH044	07B-B	59	43	1.7
10/30/89	BH045	07D	20	30	27
11/03/89	BH052	07D-B	20	1.4	0.089
11/03/89	BH054	07D-B	43	35	6.5
10/30/89	BH046	07F	54	4.9	2.5
10/12/89	BH021	07F-B	27	8.9	49
10/30/89	BH047	07F-B	92	15	—
11/20/89	BH071	07F-B	130	—	—
10/25/89	BH038	09B	2.6	17	0.81
10/18/89	BH033	09B-B	160	—	—
10/25/89	BH039	09C	8.6	0.7	0.24
10/25/89	BH040	09D	11	1.1	0.007
10/25/89	BH041	09E	7	0.84	0.025
10/30/89	BH042	09F	1.4	0.57	0.92
10/24/89	BH037	09F-B	14	6.5	0.89
10/16/89	BH027	11A	1.8	—	—
10/16/89	BH026	11B	4.3	—	—
10/16/89	BH025	11D	1.3	—	—
10/18/89	BH030	11F	0.13	—	—
10/18/89	BH031	11F-B	14	—	—

Table B.2. K-1407-C Retention Basin sediment sample analysis—radionuclide analysis (continued)

Date	Hole	Location	6-in. (pCi/g)	12-in. (pCi/g)	18-in. (pCi/g)
		Plutonium-239 (continued)			
10/24/89	BH036	11F-B	9.7	7.8	0.57
10/18/89	BH032	11H	26	—	—
10/23/89	BH035	11H-B	78	110	12
10/16/89	BH028	12B	1.7	—	—
01/03/90	BH074	12F	0.054	-0.002	0.049
10/13/89	BH024	13B	0.0027	—	—
10/13/89	BH023	13C	1.2	2.5	0.13
10/18/89	BH029	13D	2.1	—	—
10/12/89	BH020	15B	0.062	< 0.027	0.043
10/10/89	BH013	15D	3.5	—	—
10/11/89	BH017	15D-B	0.65	—	—
10/10/89	BH014	15F	4	—	—
10/10/89	BH015	15F-B	35	—	—
10/11/89	BH018	15F-B	17	—	—
10/23/89	BH034	15F-B	18	2.1	2.3
10/10/89	BH016	15H	6.8	—	—
10/12/89	BH019	16B	0.12	0.059	0.013
10/13/89	BH022	16E-B	10	0.73	0.38
10/09/89	BH012	16F	3.8	—	—
10/04/89	BH010	17B	0.59	< 0.054	< 0.027
10/04/89	BH009	17D	3.5	0.15	0.035
10/03/89	BH008	17F	6.5	2.7	0.35
10/03/89	BH007	17H	9.4	6.2	21
10/03/89	BH004	18E-B	1.8	0.7	0.41
09/28/89	BH002	18G-B	26	10	0.65
10/03/89	BH006	19B	0.17	0.15	—
10/03/89	BH005	19D	3.5	0.86	0.57
10/02/89	BH003	19F	0.57	7.3	2.1
09/27/89	BH001	19H	0.2	-0.09	-0.006
10/09/89	BH011	20D	0.3	—	—
		Potassium-40			
11/20/89	BH070	00D	6.2	—	—
11/20/89	BH068	00F	9.4	—	—
11/20/89	BH069	00F-B	8.1	—	—
11/21/89	BH073	01B	9.7	—	—
01/10/90	BH078	01D	22	—	—
11/16/89	BH067	01F	18	—	—
11/15/89	BH064	01F-B	24	—	—
11/16/89	BH066	01H	22	—	—
01/10/90	BH077	02E	15	—	—
11/15/89	BH063	02G	8.4	—	—

Table B.2. K-1407-C Retention Basin sediment sample analysis—radionuclide analysis (continued)

Date	Hole	Location	6-in. (pCi/g)	12-in. (pCi/g)	18-in. (pCi/g)
		Potassium-40 (continued)			
11/16/89	BH065	03A	9.4	—	—
11/13/89	BH061	03B	6.8	8.6	5.7
11/13/89	BH060	03C	21	21	13
01/10/90	BH075	03D	18	—	—
11/13/89	BH062	03D-B	11	—	—
11/09/89	BH059	03E	16	12	8.1
11/09/89	BH057	03F	11	8.6	6.8
11/09/89	BH056	03F-B	11	5.9	6.8
11/09/89	BH058	03H	8.1	10	—
11/20/89	BH072	05A	6.5	—	—
01/10/90	BH076	05B	8.1	—	—
11/03/89	BH055	05D	5.7	5.1	6.2
11/01/89	BH049	05F	18	10	8.6
11/01/89	BH048	05G	8.4	—	—
11/03/89	BH053	06B	6.8	6.8	6.5
11/02/89	BH050	06F	9.4	9.7	9.7
11/02/89	BH051	06F-B	9.2	13	8.6
10/30/89	BH043	07B	11	11	13
10/30/89	BH044	07B-B	7.3	7	5.7
10/30/89	BH045	07D	9.2	6.2	9.2
11/03/89	BH052	07D-B	8.4	8.1	6.8
11/03/89	BH054	07D-B	9.7	13	8.6
10/30/89	BH046	07F	6.2	7	7
10/12/89	BH021	07F-B	8.1	6.8	7
10/30/89	BH047	07F-B	4.3	5.9	—
11/20/89	BH071	07F-B	9.2	—	—
10/25/89	BH038	09B	4.6	5.9	5.9
10/18/89	BH033	09B-B	5.7	7.6	5.9
10/25/89	BH039	09C	8.4	9.2	9.2
10/25/89	BH040	09D	6.2	7	5.9
10/25/89	BH041	09E	6.2	5.7	4.9
10/30/89	BH042	09F	7.3	8.9	9.2
10/24/89	BH037	09F-B	—	7.3	6.2
10/16/89	BH027	11A	10	6.8	4.6
10/16/89	BH026	11B	7	7	7.8
10/16/89	BH025	11D	5.7	4.9	4
10/18/89	BH030	11F	5.4	6.5	6.2
10/18/89	BH031	11F-B	8.1	7.8	8.6
10/24/89	BH036	11F-B	—	8.6	7.8
10/18/89	BH032	11H	5.9	6.2	5.9
10/23/89	BH035	11H-B	3.2	5.4	6.2
10/16/89	BH028	12B	6.2	5.7	7.3
01/03/90	BH074	12F	8.9	8.4	8.4

Table B.2. K-1407-C Retention Basin sediment sample analysis—radionuclide analysis (continued)

Date	Hole	Location	6-in. (pCi/g)	12-in. (pCi/g)	18-in. (pCi/g)
			Potassium-40 (continued)		
10/13/89	BH024	13B	12	7.6	6.8
10/13/89	BH023	13C	10	7.6	5.7
10/18/89	BH029	13D	7.8	6.2	8.1
10/12/89	BH020	15B	10	8.6	8.4
10/10/89	BH013	15D	13	12	7
10/11/89	BH017	15D-B	11	14	16
10/10/89	BH014	15F	11	12	10
10/10/89	BH015	15F-B	9.7	13	11
10/11/89	BH018	15F-B	4.3	12	14
10/23/89	BH034	15F-B	12	9.2	10
10/10/89	BH016	15H	11	12	13
10/12/89	BH019	16B	10	8.1	7.6
10/13/89	BH022	16E-B	14	14	14
10/09/89	BH012	16F	14	6.8	9.7
10/04/89	BH010	17B	7.8	8.1	8.4
10/04/89	BH009	17D	13	15	17
10/03/89	BH008	17F	14	17	18
10/03/89	BH007	17H	12	11	11
10/03/89	BH004	18E-B	22	19	14
09/28/89	BH002	18G-B	16	18	17
10/03/89	BH006	19B	14	8.4	—
10/03/89	BH005	19D	13	19	19
10/02/89	BH003	19F	20	21	22
09/27/89	BH001	19H	8.6	10	11
10/09/89	BH011	20D	21	20	21
			Technetium-99		
11/20/89	BH070	00D	180	1100	950
11/20/89	BH068	00F	490	810	570
11/20/89	BH069	00F-B	1100	570	860
11/21/89	BH073	01B	23	4.6	8.4
01/10/90	BH078	01D	76	—	—
11/16/89	BH067	01F	41	2.1	—
11/15/89	BH064	01F-B	320	81	12
11/16/89	BH066	01H	26	2.4	—
01/10/90	BH077	02E	150	—	—
11/15/89	BH063	02G	100	8.1	1300
11/16/89	BH065	03A	43	18	21
11/13/89	BH061	03B	7	0.51	1.4
11/13/89	BH060	03C	2.7	0.62	0.21
01/10/90	BH075	03D	5.7	—	—
11/13/89	BH062	03D-B	590	12	13

Table B.2. K-1407-C Retention Basin sediment sample analysis—radionuclide analysis (continued)

Date	Hole	Location	6-in. (pCi/g)	12-in. (pCi/g)	18-in. (pCi/g)
			Technetium-99 (continued)		
11/09/89	BH059	03E	150	160	27
11/09/89	BH057	03F	49	16	14
11/09/89	BH056	03F-B	1200	120	7.3
11/09/89	BH058	03H	49	4.6	—
11/20/89	BH072	05A	100	49	21
01/10/90	BH076	05B	23	3.2	6.5
11/03/89	BH055	05D	10	4.6	4.3
11/01/89	BH049	05F	49	89	2.5
11/01/89	BH048	05G	7.3	—	—
11/03/89	BH053	06B	17	16	11
11/02/89	BH050	06F	73	3.2	16
11/02/89	BH051	06F-B	950	100	5.9
10/30/89	BH043	07B	130	270	380
10/30/89	BH044	07B-B	1900	510	81
10/30/89	BH045	07D	570	730	430
11/03/89	BH052	07D-B	120	49	19
11/03/89	BH054	07D-B	590	970	260
10/30/89	BH046	07F	1600	97	62
10/12/89	BH021	07F-B	11	1700	1400
10/30/89	BH047	07F-B	3500	410	—
11/20/89	BH071	07F-B	4300	—	—
10/25/89	BH038	09B	680	320	30
10/18/89	BH033	09B-B	3200	160	8.9
10/25/89	BH039	09C	24	15	2.4
10/25/89	BH040	09D	35	21	1.4
10/25/89	BH041	09E	620	20	2.5
10/30/89	BH042	09F	35	35	38
10/24/89	BH037	09F-B	840	190	23
10/16/89	BH027	11A	70	68	41
10/16/89	BH026	11B	170	21	32
10/16/89	BH025	11D	24	2.5	1.8
10/18/89	BH030	11F	4	160	150
10/18/89	BH031	11F-B	220	57	1.9
10/24/89	BH036	11F-B	140	140	7.8
10/18/89	BH032	11H	680	350	430
10/23/89	BH035	11H-B	3800	1800	210
10/16/89	BH028	12B	43	1.7	0.65
01/03/90	BH074	12F	5.7	3.5	1.8
10/13/89	BH024	13B	0.084	5.9	4.9
10/13/89	BH023	13C	0.49	57	3.5
10/18/89	BH029	13D	76	2.4	2.1
01/11/90	BH079	13E	—	—	70
01/11/90	BH080	13F	—	—	49

Table B.2. K-1407-C Retention Basin sediment sample analysis—radionuclide analysis (continued)

Date	Hole	Location	6-in. (pCi/g)	12-in. (pCi/g)	18-in. (pCi/g)
		Technetium-99 (continued)			
10/12/89	BH020	15B	0.089	23	11
10/10/89	BH013	15D	0.7	10	7
10/11/89	BH017	15D-B	0.51	4	2.1
10/10/89	BH014	15F	5.7	62	32
10/10/89	BH015	15F-B	5.9	200	16
10/11/89	BH018	15F-B	3	180	78
10/23/89	BH034	15F-B	350	54	59
10/10/89	BH016	15H	0.65	430	350
10/12/89	BH019	16B	0.43	22	8.9
10/13/89	BH022	16E-B	1.8	59	49
10/09/89	BH012	16F	2.2	21	49
10/04/89	BH010	17B	14	35	13
10/04/89	BH009	17D	38	15	13
10/03/89	BH008	17F	110	120	86
10/03/89	BH007	17H	110	270	510
10/03/89	BH004	18E-B	19	30	8.1
09/28/89	BH002	18G-B	860	260	32
10/03/89	BH006	19B	3.2	12	—
10/03/89	BH005	19D	65	70	46
10/02/89	BH003	19F	10	130	68
09/27/89	BH001	19H	5.1	4.6	41
10/09/89	BH011	20D	0.043	7	1.1
		Total strontium			
11/20/89	BH070	00D	10	20	19
11/20/89	BH068	00F	16	15	13
11/20/89	BH069	00F-B	22	10	15
11/21/89	BH073	01B	0.49	< 0.41	< 0.49
01/10/90	BH078	01D	2.4	—	—
11/16/89	BH067	01F	1.6	0.78	—
11/15/89	BH064	01F-B	3.8	0.73	0.51
11/16/89	BH066	01H	0.3	0.65	—
01/10/90	BH077	02E	2.6	0.76	—
11/15/89	BH063	02G	2	0.41	9.4
11/16/89	BH065	03A	0.43	< 0.49	0.51
11/13/89	BH061	03B	0.59	1.3	2.5
11/13/89	BH060	03C	0.54	3	< 0.81
01/10/90	BH075	03D	0.97	—	—
11/13/89	BH062	03D-B	17	0.65	0.62
11/09/89	BH059	03E	3.8	9.2	5.4
11/09/89	BH057	03F	0.81	0.95	0.49
11/09/89	BH056	03F-B	21	4.3	1.4

Table B.2. K-1407-C Retention Basin sediment sample analysis—radionuclide analysis (continued)

Date	Hole	Location	6-in. (pCi/g)	12-in. (pCi/g)	18-in. (pCi/g)
		Total strontium (continued)			
11/09/89	BH058	03H	1.6	0.81	—
11/20/89	BH072	05A	5.7	0.97	1.2
01/10/90	BH076	05B	2.6	< 0.81	< 0.81
11/03/89	BH055	05D	1.7	0.89	0.43
11/01/89	BH049	05F	1.9	2.1	0.19
11/01/89	BH048	05G	0.19	—	—
11/03/89	BH053	06B	2.7	0.89	1.1
11/02/89	BH050	06F	1.7	1.2	0.86
11/02/89	BH051	06F-B	11	3.2	1.6
10/30/89	BH043	07B	11	11	12
10/30/89	BH044	07B-B	46	35	7.3
10/30/89	BH045	07D	21	30	27
11/03/89	BH052	07D-B	54	14	5.1
11/03/89	BH054	07D-B	35	30	8.6
10/30/89	BH046	07F	46	8.6	2.2
10/12/89	BH021	07F-B	30	7.6	43
10/30/89	BH047	07F-B	46	13	—
11/20/89	BH071	07F-B	130	—	—
10/25/89	BH038	09B	18	12	1.6
10/18/89	BH033	09B-B	130	—	—
10/25/89	BH039	09C	3.2	0.3	0.14
10/25/89	BH040	09D	3.2	0.81	0.35
10/25/89	BH041	09E	4.9	-0.1	-0.2
10/30/89	BH042	09F	2.4	3.2	3.2
10/24/89	BH037	09F-B	11	5.7	3
10/16/89	BH027	11A	3	—	—
10/16/89	BH026	11B	7.6	—	—
10/16/89	BH025	11D	1.2	—	—
10/18/89	BH030	11F	0.38	—	—
10/18/89	BH031	11F-B	12	—	—
10/24/89	BH036	11F-B	7.8	6.8	1.7
10/18/89	BH032	11H	25	—	—
10/23/89	BH035	11H-B	62	120	19
10/16/89	BH028	12B	1.8	—	—
01/03/90	BH074	12F	1.6	-0.1	-0.3
10/13/89	BH024	13B	-0.4	—	—
10/13/89	BH023	13C	1.4	1.7	0.14
10/18/89	BH029	13D	4.6	—	—
01/11/90	BH079	13E	—	—	3.8
01/11/90	BH080	13F	—	—	4.3
10/12/89	BH020	15B	0.89	0.81	0.73
10/10/89	BH013	15D	1.8	1.1	1.2
10/11/89	BH017	15D-B	1.2	—	—

Table B.2. K-1407-C Retention Basin sediment sample analysis—radionuclide analysis (continued)

Date	Hole	Location	6-in. (pCi/g)	12-in. (pCi/g)	18-in. (pCi/g)
		Total strontium (continued)			
10/10/89	BH014	15F	11	4	5.9
10/10/89	BH015	15F-B	30	6.2	5.9
10/11/89	BH018	15F-B	24	—	—
10/23/89	BH034	15F-B	13	4	3.5
10/10/89	BH016	15H	5.9	—	—
10/12/89	BH019	16B	3	0.38	1.1
10/13/89	BH022	16E-B	9.7	5.1	3.2
10/09/89	BH012	16F	4.9	5.4	4.6
10/04/89	BH010	17B	6.8	0.054	0.3
10/04/89	BH009	17D	-0.5	2.1	0.24
10/03/89	BH008	17F	6.5	5.9	1.5
10/03/89	BH007	17H	14	9.7	12
10/03/89	BH004	18E-B	20	4.9	1.4
09/28/89	BH002	18G-B	19	16	4.6
10/03/89	BH006	19B	-0.5	0.81	—
10/03/89	BH005	19D	7.8	10	4
10/02/89	BH003	19F	11	11	7.8
09/27/89	BH001	19H	0.054	0.054	-0.4
10/09/89	BH011	20D	-0.2	-0.2	0.38
		Uranium-234			
11/20/89	BH070	00D	210	490	350
11/20/89	BH068	00F	460	350	210
11/20/89	BH069	00F-B	590	230	300
11/21/89	BH073	01B	2.5	1	1.6
01/10/90	BH078	01D	30	—	—
11/16/89	BH067	01F	27	1.4	—
11/15/89	BH064	01F-B	180	46	5.7
11/16/89	BH066	01H	15	5.1	—
01/10/90	BH077	02E	59	3.5	—
11/15/89	BH063	02G	41	6.5	490
11/16/89	BH065	03A	22	12	21
11/13/89	BH061	03B	2.5	0.89	0.51
11/13/89	BH060	03C	5.4	0.86	0.78
01/10/90	BH075	03D	2.6	—	—
11/13/89	BH062	03D-B	260	3.8	6.2
11/09/89	BH059	03E	110	180	26
11/09/89	BH057	03F	30	19	11
11/09/89	BH056	03F-B	1300	130	10
11/09/89	BH058	03H	38	6.8	—
11/20/89	BH072	05A	57	32	23
01/10/90	BH076	05B	9.4	2.2	1.3

Table B.2. K-1407-C Retention Basin sediment sample analysis—radionuclide analysis (continued)

Date	Hole	Location	6-in. (pCi/g)	12-in. (pCi/g)	18-in. (pCi/g)
		Uranium-234 (continued)			
11/03/89	BH055	05D	18	1.6	1.4
11/01/89	BH049	05F	30	38	9.2
11/01/89	BH048	05G	21	—	—
11/03/89	BH053	06B	32	11	6.2
11/02/89	BH050	06F	76	57	35
11/02/89	BH051	06F-B	320	73	5.7
10/30/89	BH043	07B	180	160	220
10/30/89	BH044	07B-B	700	410	38
10/30/89	BH045	07D	240	410	380
11/03/89	BH052	07D-B	150	7.6	2.5
11/03/89	BH054	07D-B	620	430	110
10/30/89	BH046	07F	700	84	32
10/12/89	BH021	07F-B	1200	1100	920
10/30/89	BH047	07F-B	2700	260	—
11/20/89	BH071	07F-B	1800	—	—
10/25/89	BH038	09B	650	220	25
10/18/89	BH033	09B-B	1200	27	4.3
10/25/89	BH039	09C	73	10	8.9
10/25/89	BH040	09D	68	14	1.5
10/25/89	BH041	09E	110	14	3
10/30/89	BH042	09F	51	24	20
10/24/89	BH037	09F-B	300	92	35
10/16/89	BH027	11A	43	62	65
10/16/89	BH026	11B	110	14	19
10/16/89	BH025	11D	23	2.7	1.5
10/18/89	BH030	11F	3.5	81	14
10/18/89	BH031	11F-B	190	38	7.6
10/24/89	BH036	11F-B	160	150	9.4
10/18/89	BH032	11H	380	230	160
10/23/89	BH035	11H-B	950	1200	210
10/16/89	BH028	12B	25	1.1	1.2
01/03/90	BH074	12F	1.3	0.86	1.4
10/13/89	BH024	13B	2.3	5.9	2.7
10/13/89	BH023	13C	27	32	1.2
10/18/89	BH029	13D	43	< 0.81	1.4
01/11/90	BH079	13E	—	—	41
01/11/90	BH080	13F	—	—	30
10/12/89	BH020	15B	5.1	4.6	4.6
10/10/89	BH013	15D	190	3.8	3
10/11/89	BH017	15D-B	13	2	1
10/10/89	BH014	15F	110	43	22
10/10/89	BH015	15F-B	540	73	19
10/11/89	BH018	15F-B	460	120	110

Table B.2. K-1407-C Retention Basin sediment sample analysis—radionuclide analysis (continued)

Date	Hole	Location	6-in. (pCi/g)	12-in. (pCi/g)	18-in. (pCi/g)
		Uranium-234 (continued)			
10/23/89	BH034	15F-B	120	38	46
10/10/89	BH016	15H	170	150	38
10/12/89	BH019	16B	9.4	7.3	5.1
10/13/89	BH022	16E-B	150	30	38
10/09/89	BH012	16F	110	13	8.6
10/04/89	BH010	17B	12	8.6	10
10/04/89	BH009	17D	100	3	3.8
10/03/89	BH008	17F	120	49	46
10/03/89	BH007	17H	260	140	250
10/03/89	BH004	18E-B	54	14	4.6
09/28/89	BH002	18G-B	300	140	8.6
10/03/89	BH006	19B	16	6.8	—
10/03/89	BH005	19D	120	20	18
10/02/89	BH003	19F	92	81	16
09/27/89	BH001	19H	9.4	8.9	7.8
10/09/89	BH011	20D	9.2	6.5	1.1
		Uranium-235			
11/20/89	BH070	00D	5.4	35	17
11/20/89	BH068	00F	18	25	12
11/20/89	BH069	00F-B	27	16	25
11/21/89	BH073	01B	0.1	0.065	0.086
01/10/90	BH078	01D	1.7	—	—
11/16/89	BH067	01F	1.9	0.12	—
11/15/89	BH064	01F-B	15	3	0.23
11/16/89	BH066	01H	0.59	0.21	—
01/10/90	BH077	02E	3	0.22	—
11/15/89	BH063	02G	1.2	0.41	22
11/16/89	BH065	03A	1.1	0.86	1.2
11/13/89	BH061	03B	0.21	0.041	0.03
11/13/89	BH060	03C	0.38	0.032	0.011
01/10/90	BH075	03D	0.23	—	—
11/13/89	BH062	03D-B	9.2	0.16	0.26
11/09/89	BH059	03E	3.5	8.6	1.3
11/09/89	BH057	03F	0.84	0.62	0.43
11/09/89	BH056	03F-B	32	6.2	0.57
11/09/89	BH058	03H	3.5	0.35	—
11/20/89	BH072	05A	2.4	1.6	1.9
01/10/90	BH076	05B	0.54	0.23	0.1
11/03/89	BH055	05D	0.92	0.14	0.13
11/01/89	BH049	05F	2.1	0.54	2.4
11/01/89	BH048	05G	1.8	—	—

Table B.2. K-1407-C Retention Basin sediment sample analysis—radionuclide analysis (continued)

Date	Hole	Location	6-in. (pCi/g)	12-in. (pCi/g)	18-in. (pCi/g)
		Uranium-235 (continued)			
11/03/89	BH053	06B	1.3	0.95	0.84
11/02/89	BH050	06F	3	9.2	3.8
11/02/89	BH051	06F-B	12	3.2	0.41
10/30/89	BH043	07B	9.4	11	11
10/30/89	BH044	07B-B	26	22	2.5
10/30/89	BH045	07D	11	11	27
11/03/89	BH052	07D-B	6.2	1.7	0.41
11/03/89	BH054	07D-B	23	32	7
10/30/89	BH046	07F	22	5.7	1.6
10/12/89	BH021	07F-B	35	46	62
10/30/89	BH047	07F-B	38	9.2	—
11/20/89	BH071	07F-B	62	—	—
10/25/89	BH038	09B	23	6.5	0.46
10/18/89	BH033	09B-B	49	1.5	0.27
10/25/89	BH039	09C	2.1	0.59	0.76
10/25/89	BH040	09D	2.7	1.1	0.17
10/25/89	BH041	09E	3.2	0.43	0.38
10/30/89	BH042	09F	1.6	0.12	0.078
10/24/89	BH037	09F-B	10	0.68	1.6
10/16/89	BH027	11A	2.1	1.4	3.2
10/16/89	BH026	11B	7.3	0.49	2.3
10/16/89	BH025	11D	1.3	0.11	0.041
10/18/89	BH030	11F	0.3	3.8	0.62
10/18/89	BH031	11F-B	9.2	2.1	0.49
10/24/89	BH036	11F-B	6.2	9.2	0.49
10/18/89	BH032	11H	15	15	9.2
10/23/89	BH035	11H-B	54	43	9.2
10/16/89	BH028	12B	1.2	0.059	0.032
01/03/90	BH074	12F	0.062	0.18	0.16
10/13/89	BH024	13B	0.073	0.38	0.19
10/13/89	BH023	13C	1.4	1.9	0.032
10/18/89	BH029	13D	2.5	< 0.81	0.086
01/11/90	BH079	13E	—	—	2.2
01/11/90	BH080	13F	—	—	3.2
10/12/89	BH020	15B	0.25	0.41	0.38
10/10/89	BH013	15D	8.6	0.15	0.13
10/11/89	BH017	15D-B	0.78	0.14	0.025
10/10/89	BH014	15F	6.8	1.5	0.97
10/10/89	BH015	15F-B	38	3.8	1.1
10/11/89	BH018	15F-B	22	8.1	6.5
10/23/89	BH034	15F-B	9.2	1.7	2.2
10/10/89	BH016	15H	14	8.9	3
10/12/89	BH019	16B	0.57	0.54	0.65

Table B.2. K-1407-C Retention Basin sediment sample analysis—radionuclide analysis (continued)

Date	Hole	Location	6-in. (pCi/g)	12-in. (pCi/g)	18-in. (pCi/g)
		Uranium-235 (continued)			
10/13/89	BH022	16E-B	6.8	1.5	0.73
10/09/89	BH012	16F	4.9	0.41	0.41
10/04/89	BH010	17B	0.81	0.65	1.2
10/04/89	BH009	17D	4.9	0.3	0.35
10/03/89	BH008	17F	6.2	1.9	2.2
10/03/89	BH007	17H	8.4	5.1	11
10/03/89	BH004	18E-B	2.7	1.2	0.41
09/28/89	BH002	18G-B	16	7.6	0.68
10/03/89	BH006	19B	1.5	0.32	—
10/03/89	BH005	19D	6.8	1.3	1.5
10/02/89	BH003	19F	4.6	5.4	1.5
09/27/89	BH001	19H	0.76	0.51	0.73
10/09/89	BH011	20D	0.54	0.11	0.046
		Uranium-238			
11/20/89	BH070	00D	78	210	190
11/20/89	BH068	00F	210	170	100
11/20/89	BH069	00F-B	300	120	160
11/21/89	BH073	01B	1.5	0.59	0.81
01/10/90	BH078	01D	17	—	—
11/16/89	BH067	01F	15	0.81	—
11/15/89	BH064	01F-B	110	27	3
11/16/89	BH066	01H	6.5	2.2	—
01/10/90	BH077	02E	35	2.3	—
11/15/89	BH063	02G	22	3.2	300
11/16/89	BH065	03A	7.6	4.3	6.2
11/13/89	BH061	03B	1.4	0.59	0.49
11/13/89	BH060	03C	2.2	0.68	0.51
01/10/90	BH075	03D	1.6	—	—
11/13/89	BH062	03D-B	130	1.9	3.2
11/09/89	BH059	03E	43	92	15
11/09/89	BH057	03F	16	8.9	3.5
11/09/89	BH056	03F-B	410	76	5.7
11/09/89	BH058	03H	19	3.5	—
11/20/89	BH072	05A	59	27	18
01/10/90	BH076	05B	4.9	1.1	0.95
11/03/89	BH055	05D	12	1	0.84
11/01/89	BH049	05F	17	23	5.7
11/01/89	BH048	05G	7.6	—	—
11/03/89	BH053	06B	15	6.2	3.5
11/02/89	BH050	06F	41	32	18
11/02/89	BH051	06F-B	190	43	3.2

Table B.2. K-1407-C Retention Basin sediment sample analysis—radionuclide analysis (continued)

Date	Hole	Location	6-in. (pCi/g)	12-in. (pCi/g)	18-in. (pCi/g)
		Uranium-238 (continued)			
10/30/89	BH043	07B	120	89	150
10/30/89	BH044	07B-B	380	240	20
10/30/89	BH045	07D	140	210	220
11/03/89	BH052	07D-B	92	4.9	1.6
11/03/89	BH054	07D-B	320	230	51
10/30/89	BH046	07F	350	43	17
10/12/89	BH021	07F-B	490	430	430
10/30/89	BH047	07F-B	1600	150	—
11/20/89	BH071	07F-B	950	—	—
10/25/89	BH038	09B	350	130	16
10/18/89	BH033	09B-B	730	16	2.5
10/25/89	BH039	09C	43	5.7	4.9
10/25/89	BH040	09D	41	7.6	1.1
10/25/89	BH041	09E	65	7.3	1.6
10/30/89	BH042	09F	27	13	12
10/24/89	BH037	09F-B	150	51	21
10/16/89	BH027	11A	21	35	21
10/16/89	BH026	11B	73	8.4	13
10/16/89	BH025	11D	12	1.5	0.95
10/18/89	BH030	11F	1.9	43	7
10/18/89	BH031	11F-B	100	21	3.5
10/24/89	BH036	11F-B	97	76	4.9
10/18/89	BH032	11H	210	100	84
10/23/89	BH035	11H-B	590	650	130
10/16/89	BH028	12B	15	0.81	0.84
01/03/90	BH074	12F	0.81	0.54	0.76
10/13/89	BH024	13B	1.6	3.8	1.6
10/13/89	BH023	13C	14	16	0.86
10/18/89	BH029	13D	23	0.11	0.78
01/11/90	BH079	13E	—	—	22
01/11/90	BH080	13F	—	—	20
10/12/89	BH020	15B	3	3.2	3.5
10/10/89	BH013	15D	110	2.3	1.7
10/11/89	BH017	15D-B	6.2	1.1	0.62
10/10/89	BH014	15F	59	24	14
10/10/89	BH015	15F-B	300	32	11
10/11/89	BH018	15F-B	230	68	41
10/23/89	BH034	15F-B	54	22	24
10/10/89	BH016	15H	110	95	25
10/12/89	BH019	16B	5.4	4.6	3.8
10/13/89	BH022	16E-B	78	14	21
10/09/89	BH012	16F	59	7.8	5.1
10/04/89	BH010	17B	5.9	4.6	5.4

Table B.2. K-1407-C Retention Basin sediment sample analysis—radionuclide analysis (continued)

Date	Hole	Location	6-in. (pCi/g)	12-in. (pCi/g)	18-in. (pCi/g)
		Uranium-238 (continued)			
10/04/89	BH009	17D	54	1.8	1.8
10/03/89	BH008	17F	59	25	23
10/03/89	BH007	17H	130	68	140
10/03/89	BH004	18E-B	38	10	2.7
09/28/89	BH002	18G-B	150	73	5.1
10/03/89	BH006	19B	9.2	3.2	—
10/03/89	BH005	19D	62	11	8.6
10/02/89	BH003	19F	54	49	9.7
09/27/89	BH001	19H	3	3	2
10/09/89	BH011	20D	4.9	3.2	0.57

Table B.3. K-1407-C Retention Basin sediment sample analysis— field blanks and equipment rinsates

Date	Hole	Location	Blank (pCi/L)	Rinsate (pCi/L)
		Americium-241		
10/12/89	BH021	07F-B	0.19	0.16
10/13/89	BH024	13B	-0.09	0.014
10/11/89	BH018	15F-B	-0.04	-0.07
10/04/89	BH010	17B	—	0.51
10/03/89	BH008	17F	—	0.081
		Cesium-137		
11/21/89	BH073	01B	-6	1.1
01/10/90	BH078	01D	-0.001	0.00027
11/16/89	BH067	01F	1.4	0.54
11/15/89	BH064	01F-B	2.7	1.9
11/13/89	BH062	03D-B	2.2	0.81
11/09/89	BH059	03E	0.81	5.7
11/20/89	BH072	05A	-1	0.27
11/03/89	BH055	05D	0.00054	0.00081
11/01/89	BH049	05F	-0.0005	0.00027
10/12/89	BH021	07F-B	-0.0005	0.003
10/30/89	BH047	07F-B	-0.002	-0.0008
10/25/89	BH041	09E	0.81	4
10/24/89	BH037	09F-B	4.6	-4
10/18/89	BH030	11F	-5	2.4
10/23/89	BH035	11H-B	-2	-5
10/16/89	BH028	12B	0.27	1.1
10/13/89	BH024	13B	-0.0008	0.0022
01/11/90	BH080	13F	0.00054	-0.001
10/11/89	BH018	15F-B	-0.0003	3.8
10/04/89	BH010	17B	—	2.4
10/03/89	BH008	17F	—	1.4
		Cobalt-60		
11/21/89	BH073	01B	-3	2.7
01/10/90	BH078	01D	0.0046	0.0046
11/16/89	BH067	01F	4.3	0.54
11/15/89	BH064	01F-B	0.54	9.7
11/13/89	BH062	03D-B	0.81	0.81
11/09/89	BH059	03E	0.81	3
11/20/89	BH072	05A	-9	5.4
11/03/89	BH055	05D	-0.0005	-0.0003
11/01/89	BH049	05F	-0.001	0.0046
10/12/89	BH021	07F-B	-0.0008	-0.002
10/30/89	BH047	07F-B	-0.004	0.0032
10/25/89	BH041	09E	-0.3	1.4

Table B.3. K-1407-C Retention Basin sediment sample analysis— field blanks and equipment rinsates (continued)

Date	Hole	Location	Blank (pCi/L)	Rinsate (pCi/L)
		Cobalt-60 (continued)		
10/24/89	BH037	09F-B	-4	4.3
10/18/89	BH030	11F	4	3.8
10/23/89	BH035	11H-B	-7	1.4
10/16/89	BH028	12B	6.5	6.2
10/13/89	BH024	13B	0.0014	-0.007
01/11/90	BH080	13F	0.0049	0.0038
10/11/89	BH018	15F-B	0.00054	-3
10/04/89	BH010	17B	—	0.54
10/03/89	BH008	17F	—	-3
		Curium-244		
10/12/89	BH021	07F-B	-0.2	-0.2
10/13/89	BH024	13B	-0.2	-0.3
10/11/89	BH018	15F-B	-0.2	-0.2
10/04/89	BH010	17B	—	-0.1
10/03/89	BH008	17F	—	-0.2
		Gross alpha		
11/21/89	BH073	01B	0.54	11
01/10/90	BH078	01D	0.0015	0.0016
11/16/89	BH067	01F	-1	-8
11/15/89	BH064	01F-B	4	-2
11/13/89	BH062	03D-B	-4	-6
11/09/89	BH059	03E	-3	-6
11/20/89	BH072	05A	6.5	0.54
11/03/89	BH055	05D	-0.007	0.0065
11/01/89	BH049	05F	0.0081	0.0046
10/12/89	BH021	07F-B	2.3	1.6
10/30/89	BH047	07F-B	0.0095	0.0057
10/25/89	BH041	09E	2.4	14
10/24/89	BH037	09F-B	-1	0.81
10/18/89	BH030	11F	-3	-4
10/23/89	BH035	11H-B	4.9	0.81
10/16/89	BH028	12B	-3	-20000
10/13/89	BH024	13B	0.89	0.95
01/11/90	BH080	13F	0.0027	0.001
10/11/89	BH018	15F-B	-0.4	2.2
10/04/89	BH010	17B	—	1.6
10/03/89	BH008	17F	—	0

Table B.3. K-1407-C Retention Basin sediment sample analysis—field blanks and equipment rinsates (continued)

Date	Hole	Location	Blank (pCi/L)	Rinsate (pCi/L)
		Gross beta		
11/21/89	BH073	01B	-3	8.1
01/10/90	BH078	01D	0.0059	0.0035
11/16/89	BH067	01F	2.7	2.7
11/15/89	BH064	01F-B	0	-10
11/13/89	BH062	03D-B	-20	11
11/09/89	BH059	03E	11	43
11/20/89	BH072	05A	8.1	-3
11/03/89	BH055	05D	-0.02	-0.0005
11/01/89	BH049	05F	0.0019	0.022
10/12/89	BH021	07F-B	0.54	0.81
10/30/89	BH047	07F-B	-0.005	0.0081
10/25/89	BH041	09E	-20	-30
10/24/89	BH037	09F-B	27	35
10/18/89	BH030	11F	-20	14
10/23/89	BH035	11H-B	-20	-20
10/16/89	BH028	12B	-5	-20
10/13/89	BH024	13B	0.54	5.4
01/11/90	BH080	13F	0.0092	0.0089
10/11/89	BH018	15F-B	1.4	3
10/04/89	BH010	17B	—	2.4
10/03/89	BH008	17F	—	17
		Neptunium-237		
10/12/89	BH021	07F-B	< 2.7	< 2.7
10/13/89	BH024	13B	< 2.7	< 2.7
10/11/89	BH018	15F-B	< 2.7	< 2.7
10/04/89	BH010	17B	—	< 2.7
10/03/89	BH008	17F	—	< 2.7
		Plutonium-238		
10/12/89	BH021	07F-B	-0.08	0.0027
10/13/89	BH024	13B	-0.05	0.019
10/11/89	BH018	15F-B	-0.06	-0.1
10/04/89	BH010	17B	—	0.081
10/03/89	BH008	17F	—	-0.05
		Plutonium-239		
10/12/89	BH021	07F-B	-0.1	-0.08
10/13/89	BH024	13B	0.1	-0.01
10/11/89	BH018	15F-B	-0.01	0.019

Table B.3. K-1407-C Retention Basin sediment sample analysis—field blanks and equipment rinsates (continued)

Date	Hole	Location	Blank (pCi/L)	Rinsate (pCi/L)
		Plutonium-239 (continued)		
10/04/89	BH010	17B	—	-0.09
10/03/89	BH008	17F	—	-0.3
		Technetium-99		
10/12/89	BH021	07F-B	1.9	-0.5
10/13/89	BH024	13B	7	6.8
10/11/89	BH018	15F-B	-2	30
10/04/89	BH010	17B	—	0
10/03/89	BH008	17F	—	10
		Uranium-234		
10/12/89	BH021	07F-B	0.22	0.46
10/13/89	BH024	13B	0.62	0.25
10/11/89	BH018	15F-B	0.12	0.51
10/04/89	BH010	17B	—	1.5
10/03/89	BH008	17F	—	0.62
		Uranium-235		
10/12/89	BH021	07F-B	0.035	0.086
10/13/89	BH024	13B	0.23	0.097
10/11/89	BH018	15F-B	0.12	0.16
10/04/89	BH010	17B	—	0.076
10/03/89	BH008	17F	—	0.076
		Uranium-238		
10/12/89	BH021	07F-B	0.14	0.11
10/13/89	BH024	13B	0.32	0.11
10/11/89	BH018	15F-B	0.097	0.51
10/04/89	BH010	17B	—	1.7
10/03/89	BH008	17F	—	0.25

Appendix C

CALCULATIONS EMPLOYED IN THE STATISTICAL EVALUATION OF DATA

The lognormal distribution has two parameters. The location parameter, μ_N, controls where the center of the distribution is located. The shape parameter, σ_N, controls the overall shape of the distribution. For example, when $\sigma_N = 0.25$, the shape resembles the normal distribution with only a slight positive skew. However, for a $\sigma_N = 3$, the shape resembles a heavily skewed exponential distribution.

The concentration X of an analyte is distributed lognormal if $Y = \log X$ is normally distributed with mean μ_N and variance σ^2_N, where "log" is the natural logarithm ($\log_e$). It is known that the mean μ_L, variance σ^2_L, and cumulative distribution function $F(x)$ of a lognormal distribution are given by

$$\mu_L = e^{\mu_N + \frac{\sigma_N^2}{2}},$$

$$\sigma_L^2 = \mu_L^2 \left(e^{\sigma_N^2} - 1\right),$$

$$F(x) = \Phi\left[\frac{\log(x) - \mu_N}{\sigma_N}\right],$$

where $e \approx 2.718282$ and

$$\Phi(u) = \int_{-\infty}^{u} \frac{1}{\sqrt{2\pi}} e^{-\frac{t^2}{2}} dt .$$

$\Phi(u)$ is the cumulative standard normal distribution function with mean 0 and variance 1. In practice, one uses tabled values found in any elementary statistics textbook when evaluating $\Phi(u)$.

In order to find the value x such that $\Pr\{X \leq x\} = p$ for $0 < p < 1$, the inverse cumulative distribution function F^{-1} can be derived as follows.

$$p = F(x) = \Phi\left[\frac{\log(x) - \mu_N}{\sigma_N}\right]$$

implies that $x = F^{-1}(p)$, and therefore

$$\Phi^{-1}(p) = \frac{\log(x) - \mu_N}{\sigma_N}$$

and

$$x = F^{-1}(p) = e^{\sigma_N \Phi^{-1}(p) + \mu_N} .$$

One approach to modeling the soils data using the lognormal distribution is to "pin down" the theoretical distribution to two percentiles of the sample data. A percentile P_x of a distribution is that value for which x% of the data fall at or below P_x. For example, $P_{0.50}$ is the median of the distribution for which 50% of the data fall at or below $P_{0.50}$ and 50% are above it. If one desires the theoretical distribution to match the sample data at two specific percentiles P_a and P_b, the following equations are derived for a and b, where $a \neq b$, $0 < a < 1$ and $0 < b < 1$:

$$F(P_a) = \Phi\left[\frac{\log(P_a) - \mu_N}{\sigma_N}\right] = a$$

and

$$F(P_b) = \Phi\left[\frac{\log(P_b) - \mu_N}{\sigma_N}\right] = b ,$$

which implies that

$$\frac{\log(P_a) - \mu_N}{\sigma_N} = z_a$$

and

$$\frac{\log(P_b) - \mu_N}{\sigma_N} = z_b ,$$

where $z_u = \Phi^{-1}(u)$ is the standard normal critical value for which $\Pr(Z \leq z_u) = u$.

Therefore, the two equations to solve for μ_N and σ_N are

$$\log(P_a) = \mu_N + z_a \sigma_N$$
$$\log(P_b) = \mu_N + z_b \sigma_N$$

The solution to this system of equations is then

$$\mu_N = \frac{z_b \log(P_a) - z_a \log(P_b)}{z_b - z_a}$$

and

$$\sigma_N = \frac{\log(P_b) - \log(P_a)}{z_b - z_a} .$$

Hence, these equations ensure that the theoretical distribution will equal the sample detected results at the two chosen percentiles P_a and P_b.

Before determining the parameters of the lognormal distribution which would best fit the detected soils data for each analyte, all negative results were set to zero. Practically, this was necessary since there are no negative concentrations of an analyte in the soil. Also from a mathematical perspective, one cannot take the logarithms of negative or zero values. Hence, the percentiles chosen for the parameters of the distributions must have a positive concentration.

A Chi-square Goodness of Fit Test was utilized to determine how well a model fit the detected soils data. This test is widely used to test the adequacy of models and is found in many statistics textbooks. The test statistic T compares the observed frequencies of results from the data to what is expected under the hypothesized theoretical distribution. The test statistic becomes large when the differences between observed frequencies and expected frequencies are large. A large test statistic leads one to conclude that the model does not adequately fit the data.

The number of disjoint intervals k used to categorize the data were determined by the equation

$$k = \sqrt{n} - 1 ,$$

where n is the number of unbiased detected results for an analyte. A rule of thumb for the chi-square test is that the expected frequencies in each interval should be at least 5. This equation for k was found to best satisfy this criterion. The endpoints of each of the k intervals used to categorize the data were derived so that each interval represented approximately an equal amount of area under the theoretical distribution. The right endpoint R_i for each interval was calculated by

$$R_i = F^{-1}\left(\frac{i}{k}\right)$$

for $i = 1, 2, \ldots, k - 1$ where $R_k = \infty$.

The test statistic T was compared to a chi-square critical value χ^2_{k-3} with $k - 3$ degrees of freedom (df) at the 0.05 significance level. If $k \leq 3$, the chi-square critical value χ^2_1 with 1 degree of freedom, the 0.05 significance level was used. The formula for determining the degrees of freedom in a chi-square test is

$$\text{df} = k - 1 - \text{the number of estimated parameters.}$$

Here the parameters μ_N and σ_N are estimated from the data as the location and shape parameters, respectively, of the theoretical lognormal distribution. Hence, $k - 1 - 2$ degrees of freedom were used for the chi-square test when $k > 3$.

Several pairs of percentiles P_a and P_b were tried for modeling the soils data, using the chi-square test as the criterion. It became evident that the 25th and 75th percentiles provided the best fit to the metals and mercury data. The p values associated with the test statistic were above the assumed 0.05 significance level for the test. However, for the radiochemical analytes, the 10th and 75th percentiles were found to fit the data better. One reason for this may be that the radiochemical results were more highly skewed than the metals and mercury data. Hence, the parameters of the theoretical distribution needed to be chosen closer to the many low concentrations near the 10th percentile.

However, the detected ^{238}Pu results posed a particular problem. The first nonzero percentile of these results was the 22nd percentile. Of the 99 detected results, 22 were negative or zero. No percentile parameters were found to adequately fit these data to a lognormal distribution. Other attempts using the coefficient of variation (standard deviation divided by the mean) were equally futile. However, the largest of the 12 nondetected values was 0.54 pCi/g, which is far below the guideline value of 13.2 pCi/g. Hence, since no model was found to adequately fit the ^{238}Pu detected results, the detection limit was used. The estimated mean is an overestimate by using the detection limits, but since the nondetected values are nearly zero, there is no appreciable loss in accuracy.

Another problem with modeling the detected metals data arose when antimony, selenium, and thorium were found to have at most one detected result. In order to glean some information about the distribution of these analytes, the nondetected results had to be used. Since the true concentration X of an analyte could have any value $0 \leq X \leq D$, where D is the detection limit, and many results were tied at a few detection limits, for the purpose of estimating the distribution, these detection limits were replaced by values spread equally from zero to the detection limit, depending on the number of results tied at a particular detection limit. The formula used for distributing values of a detection limit is

$$x_{ij} = D\left(\frac{j}{n_i + 1}\right),$$

where

n_i = number of results tied at detection limit i,
$i = 1, 2, \ldots, d$,
d = number of distinct detection limits for an analyte,
$j = 1, 2, \ldots, n_i$.

For example, if there is only one "< 5" nondetected result for an analyte, the replaced value x_{ij} for estimating the distribution is 2.5. If there are two "< 6" results, then the replaced values are 2 and 4. Hence, using all unbiased results for antimony, selenium, and thorium, since there were an insufficient number of detected results to estimate the distribution of each, gave distributions resembling those of the other metals. Using the 25th and 75th percentiles on these three analytes as were utilized on the other metals gave an adequate fit from the lognormal distribution.

After adequately fitting all analytes except ^{238}Pu to a lognormal distribution, the nondetected values could be estimated. These estimates will be used along with the detected results to provide an unbiased estimate of the mean concentration per analyte across the site and by depth. The general formula for estimating the concentration x_{ij} from the detection limit D is

$$x_{ij} = F^{-1}\left[F(D)\left(\frac{j}{n_i + 1}\right)\right]$$

or

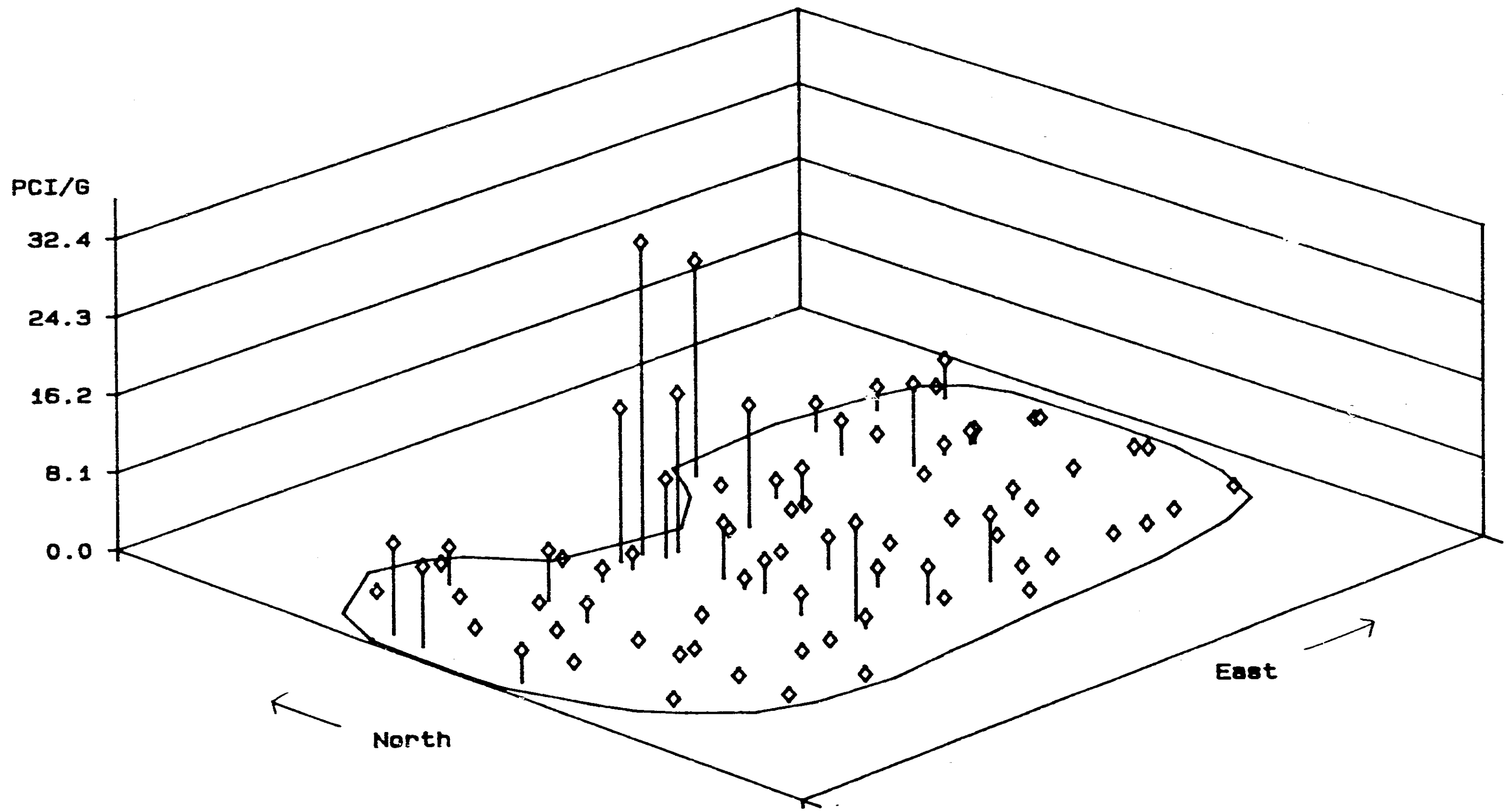
$$x_{ij} = e^{\sigma_N \Phi^{-1}\left\{\Phi\left[\frac{\log(D) - \mu_N}{\sigma_N}\right]\left(\frac{j}{n_i + 1}\right)\right\} + \mu_N} .$$

The idea of the above equation is first to find the area A such that $A = \Pr\{X \leq D\}$ from the lognormal distribution fit to the detected values. This area is then partitioned into $n_i + 1$ equal parts. Then the inverse function F^{-1} calculates the estimated concentration x_{ij} from the area under the curve.

Appendix D

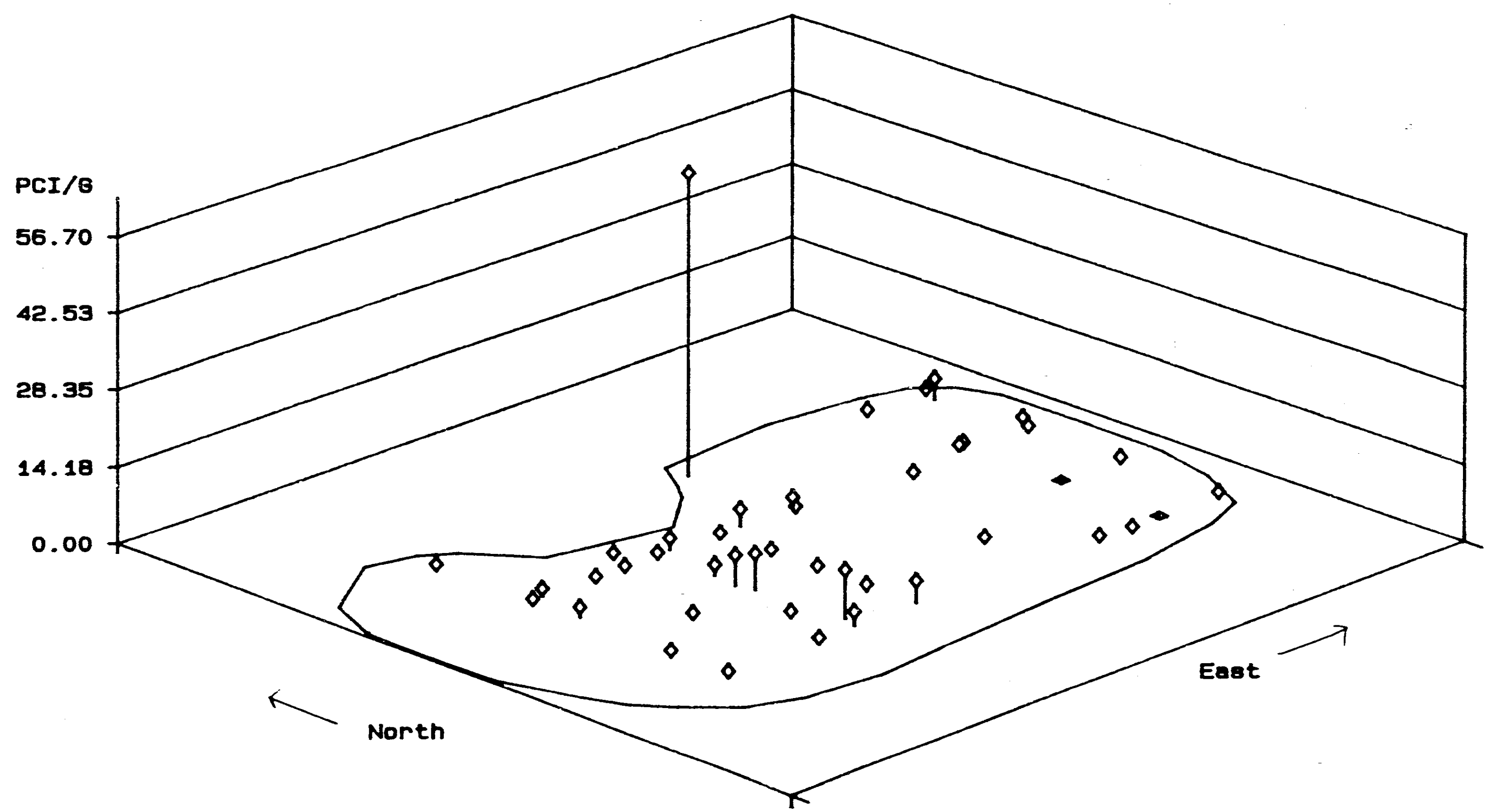
DIMENSIONAL CONCENTRATION PLOTS

Americium−241
6 Inch Samples

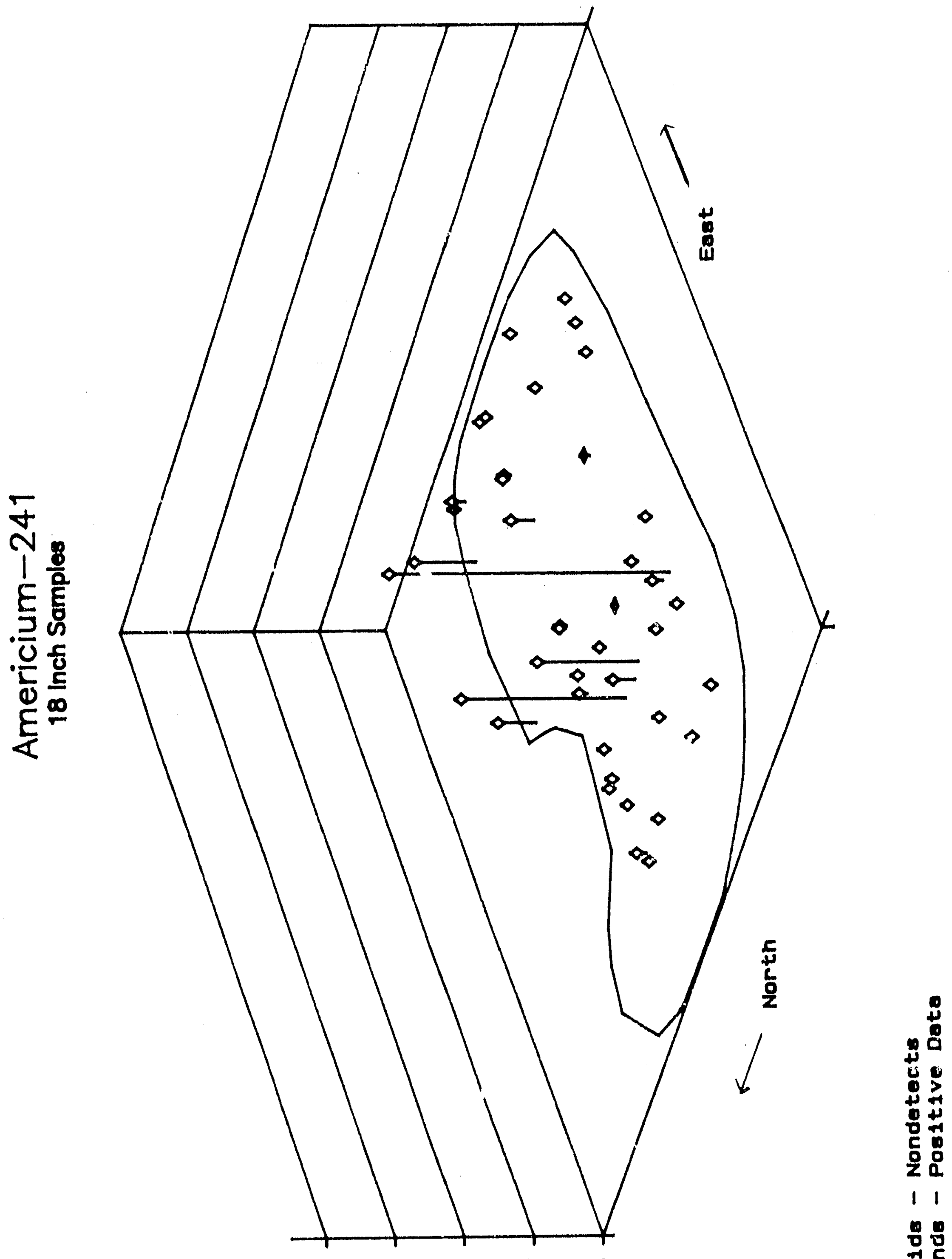


Pyramids − Nondetects
Diamonds − Positive Data

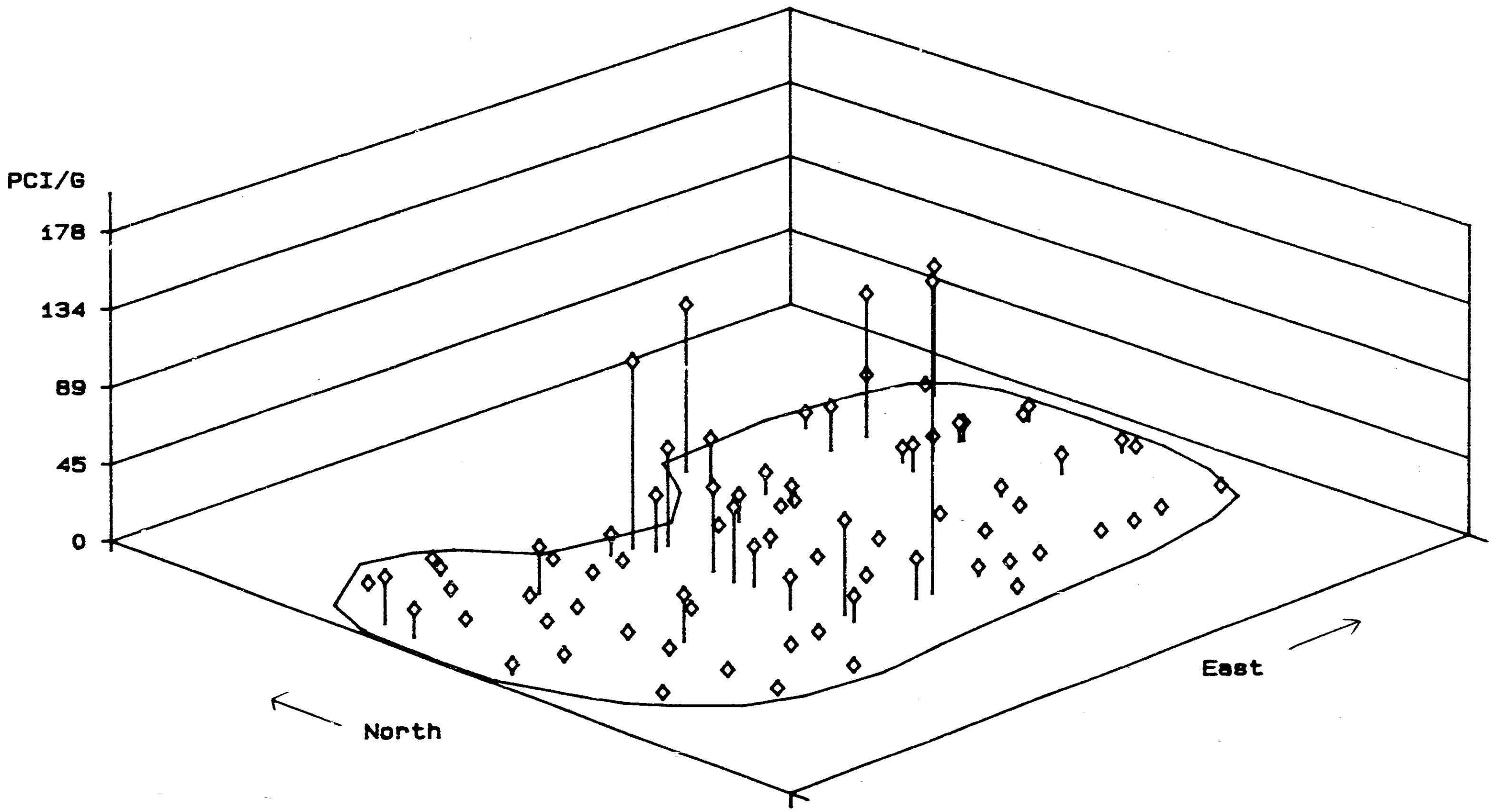
Americium—241
12 Inch Samples



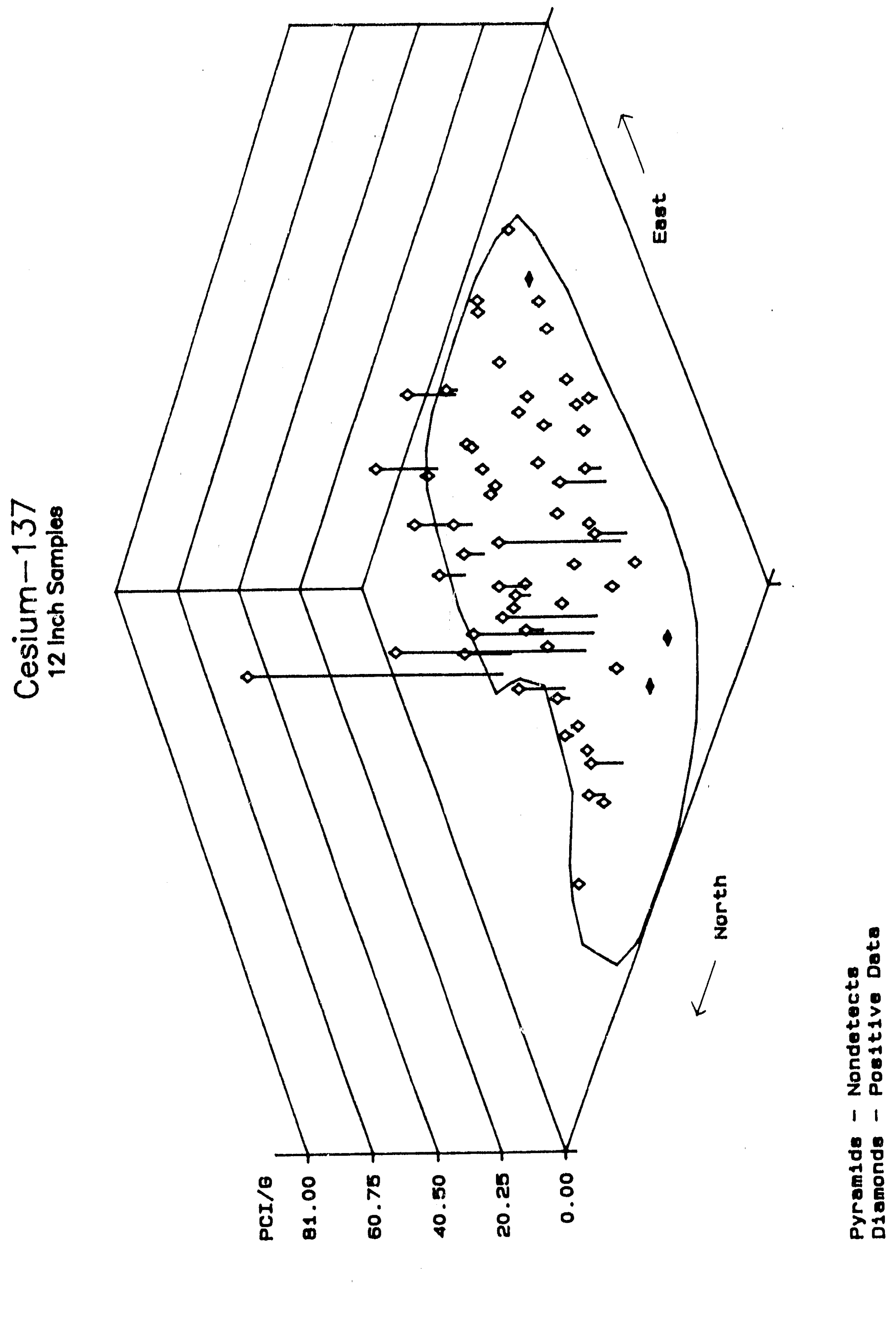
Pyramids – Nondetects
Diamonds – Positive Data


Americium–241
18 Inch Samples
PCI/G
11.88
8.91
5.94
2.97
0.00
East
North
Pyramids - Nondetects
Diamonds - Positive Data

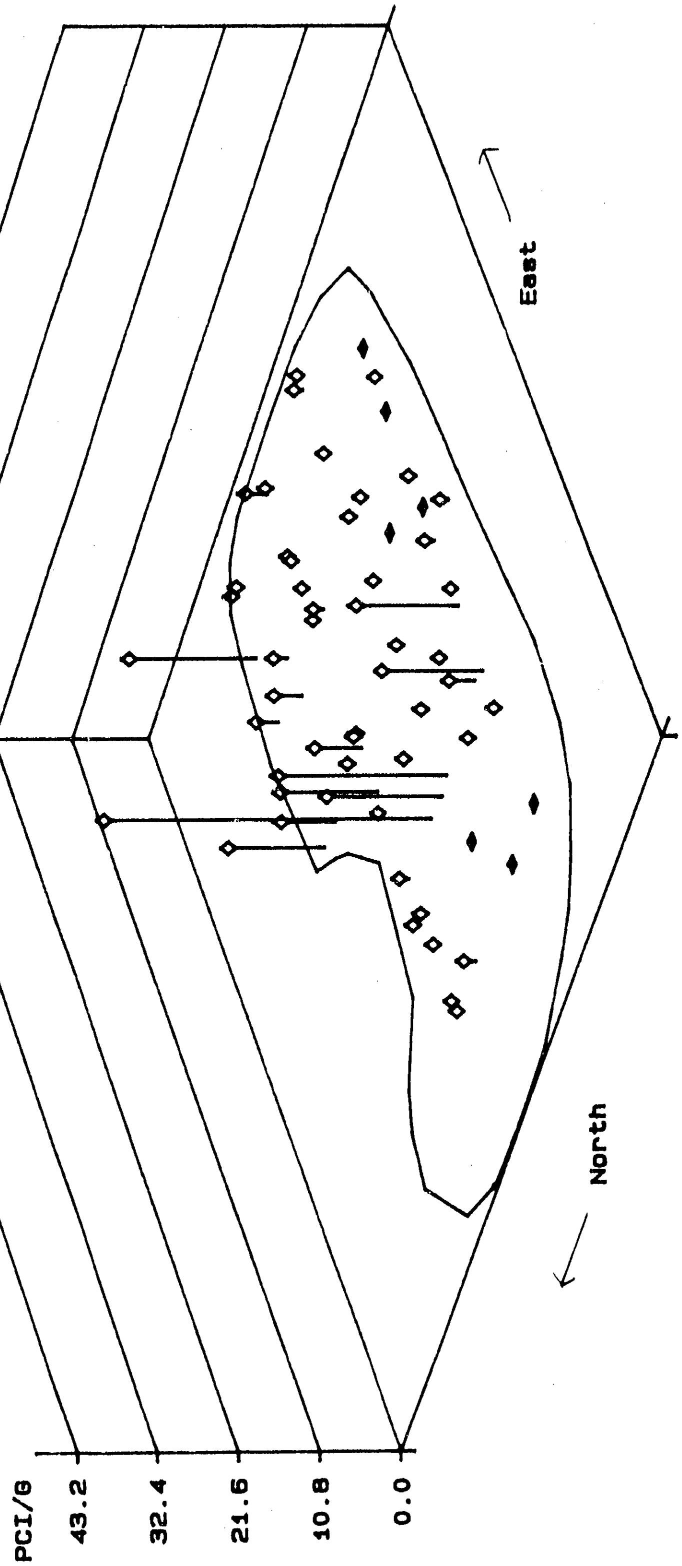
Cesium−137
6 Inch Samples



Pyramids - Nondetects
Diamonds - Positive Data

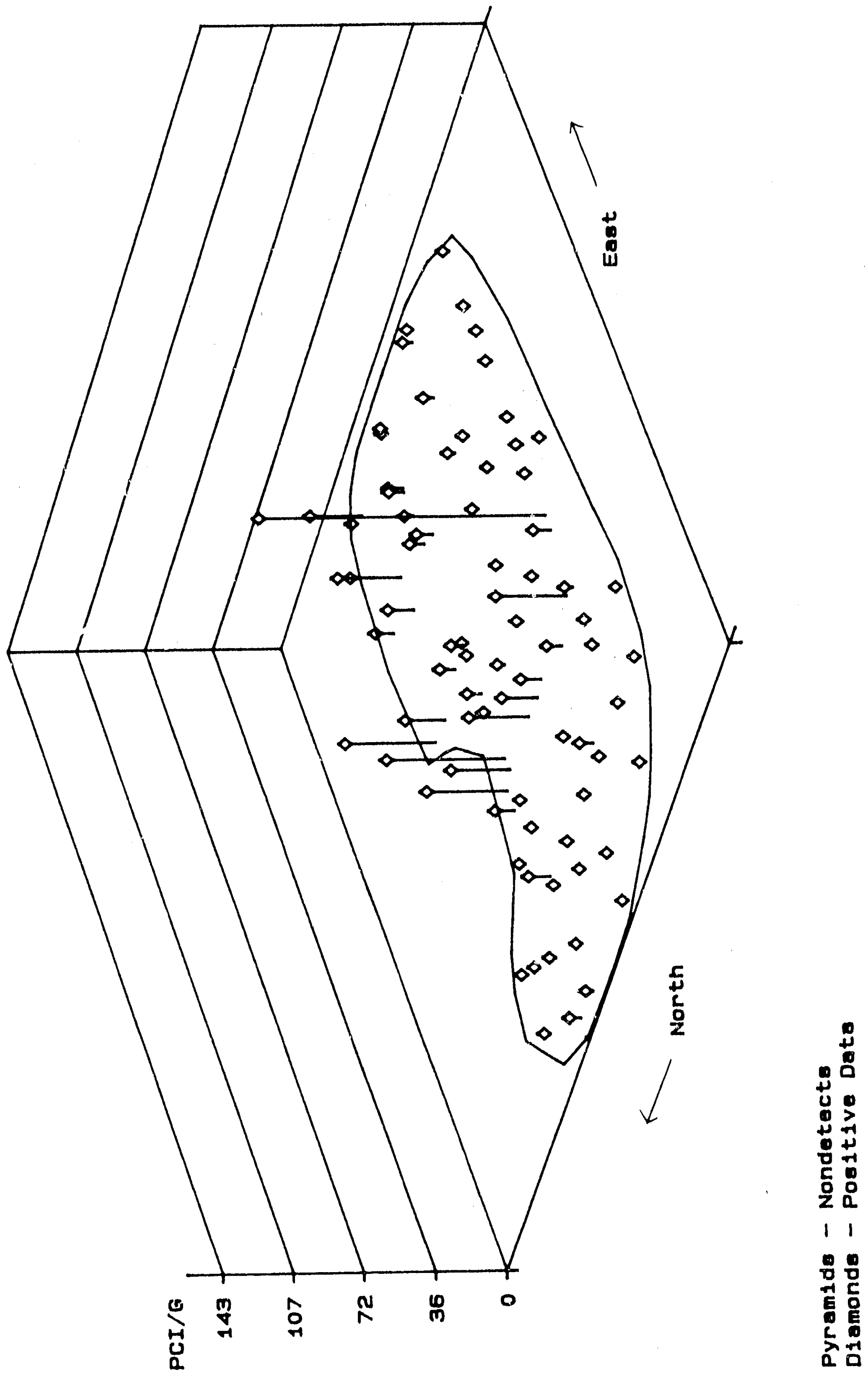

Cesium–137
12 Inch Samples
PCI/G
81.00
60.75
40.50
20.25
0.00
East
North
Pyramids - Nondetects
Diamonds - Positive Data

Cesium—137
18 Inch Samples

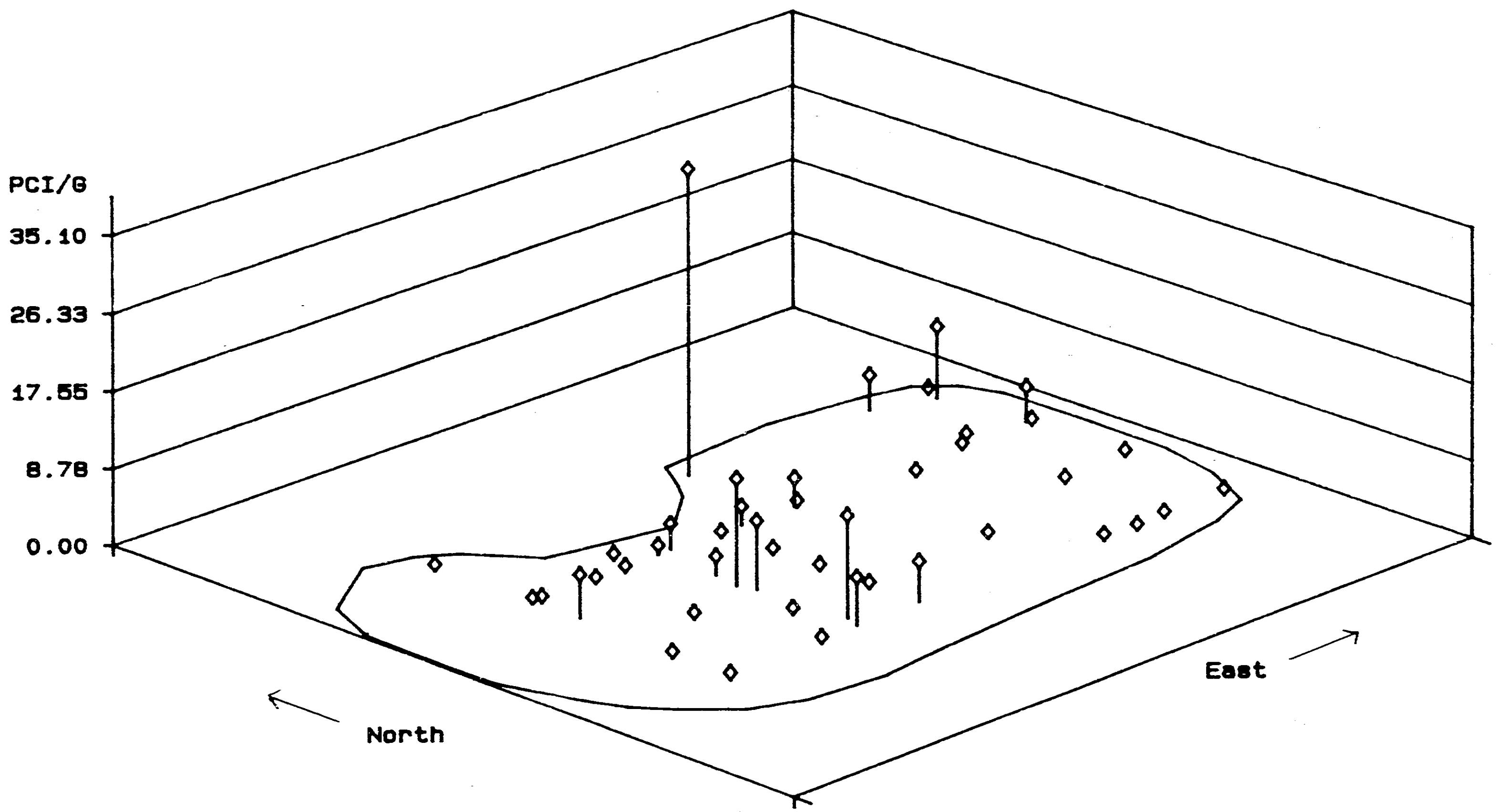


Pyramids - Nondetects
Diamonds - Positive Data

Neptunium—237
6 Inch Samples

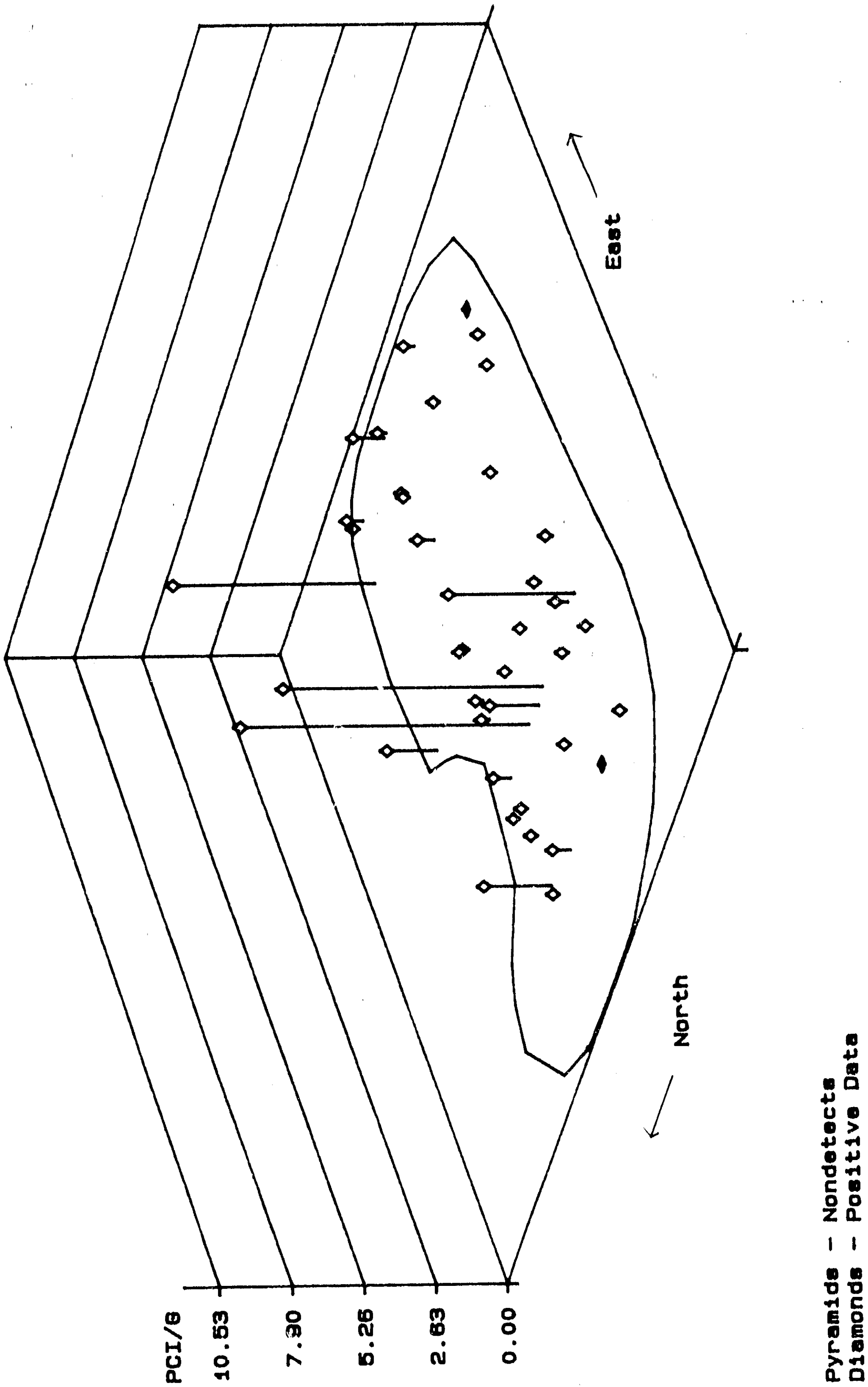


Neptunium−237
12 Inch Samples

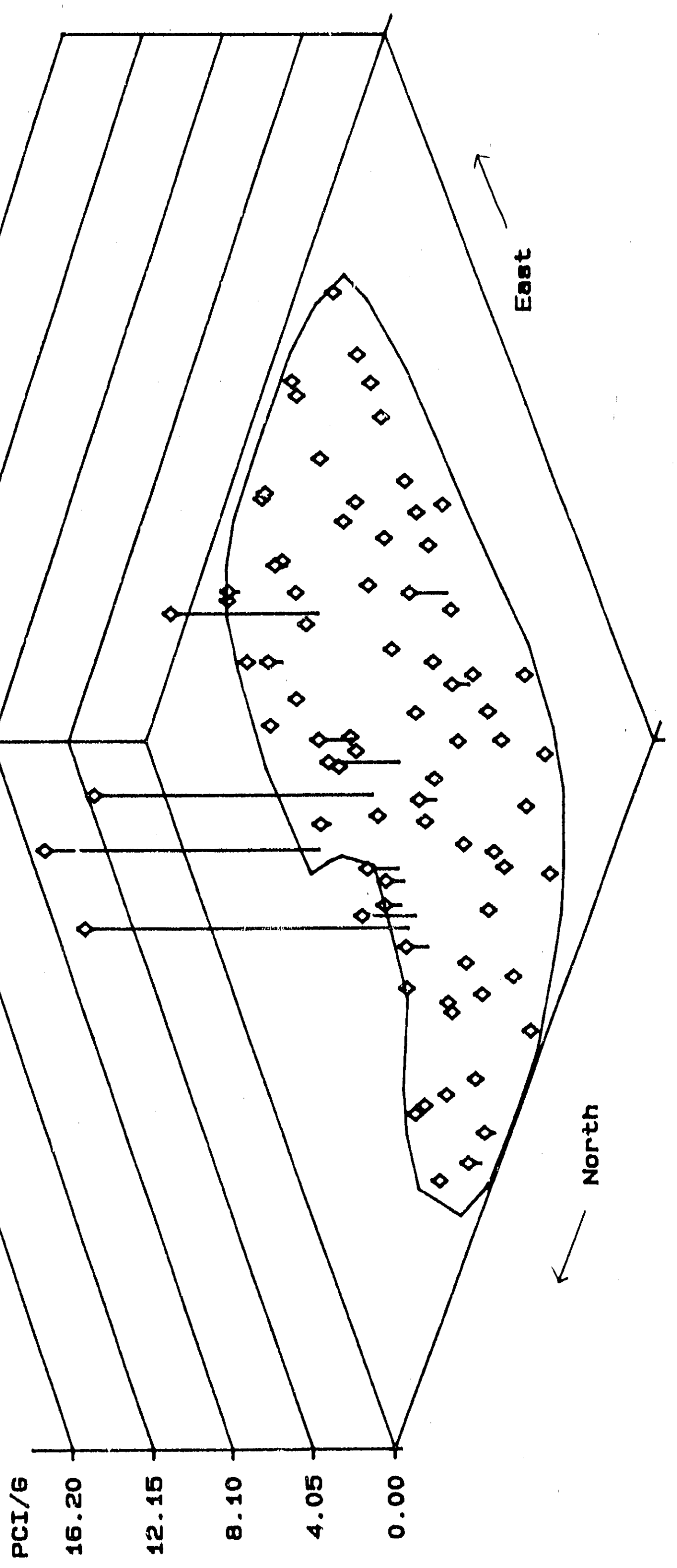


Pyramids − Nondetects
Diamonds − Positive Data

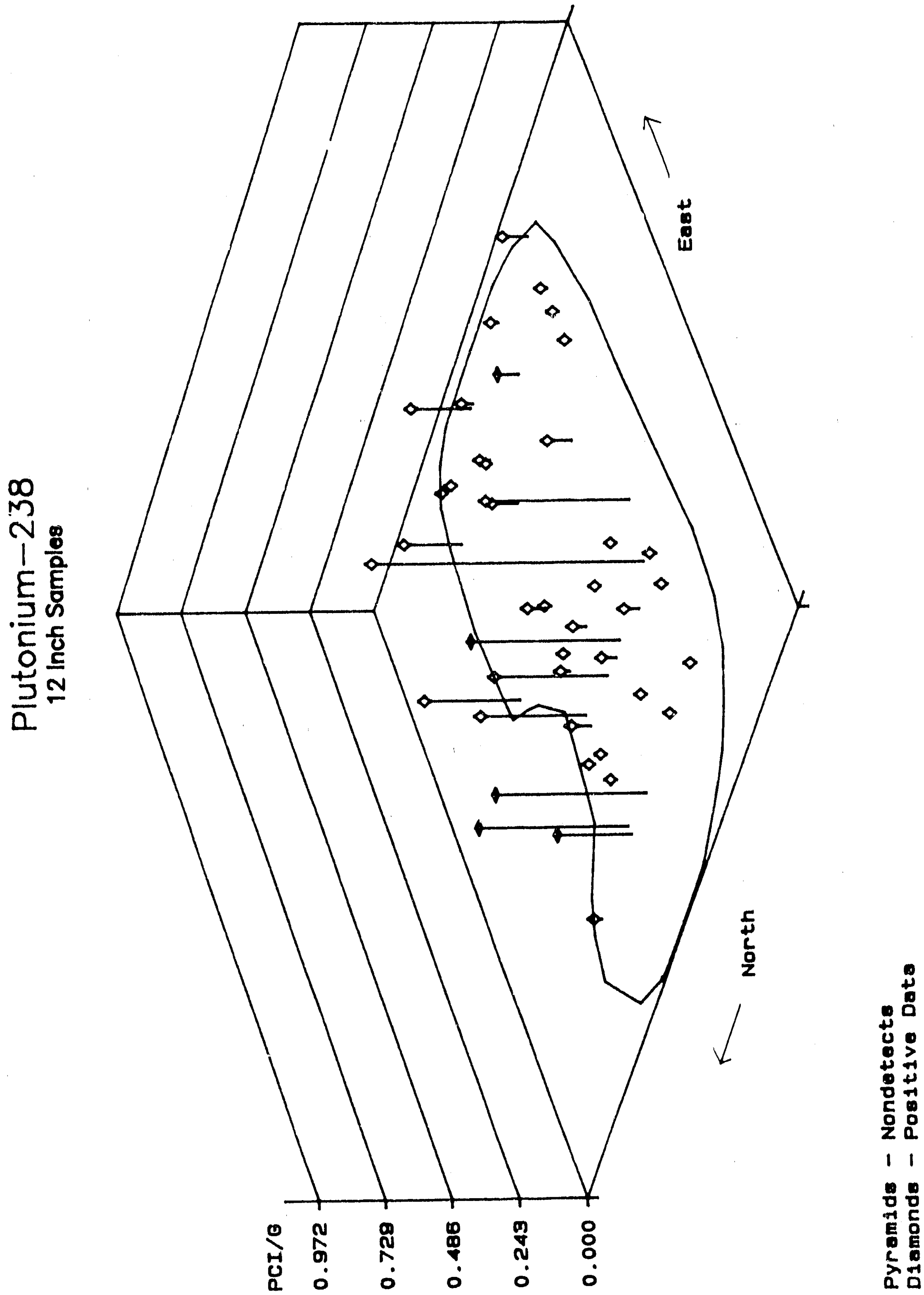
Neptunium-237
18 Inch Samples



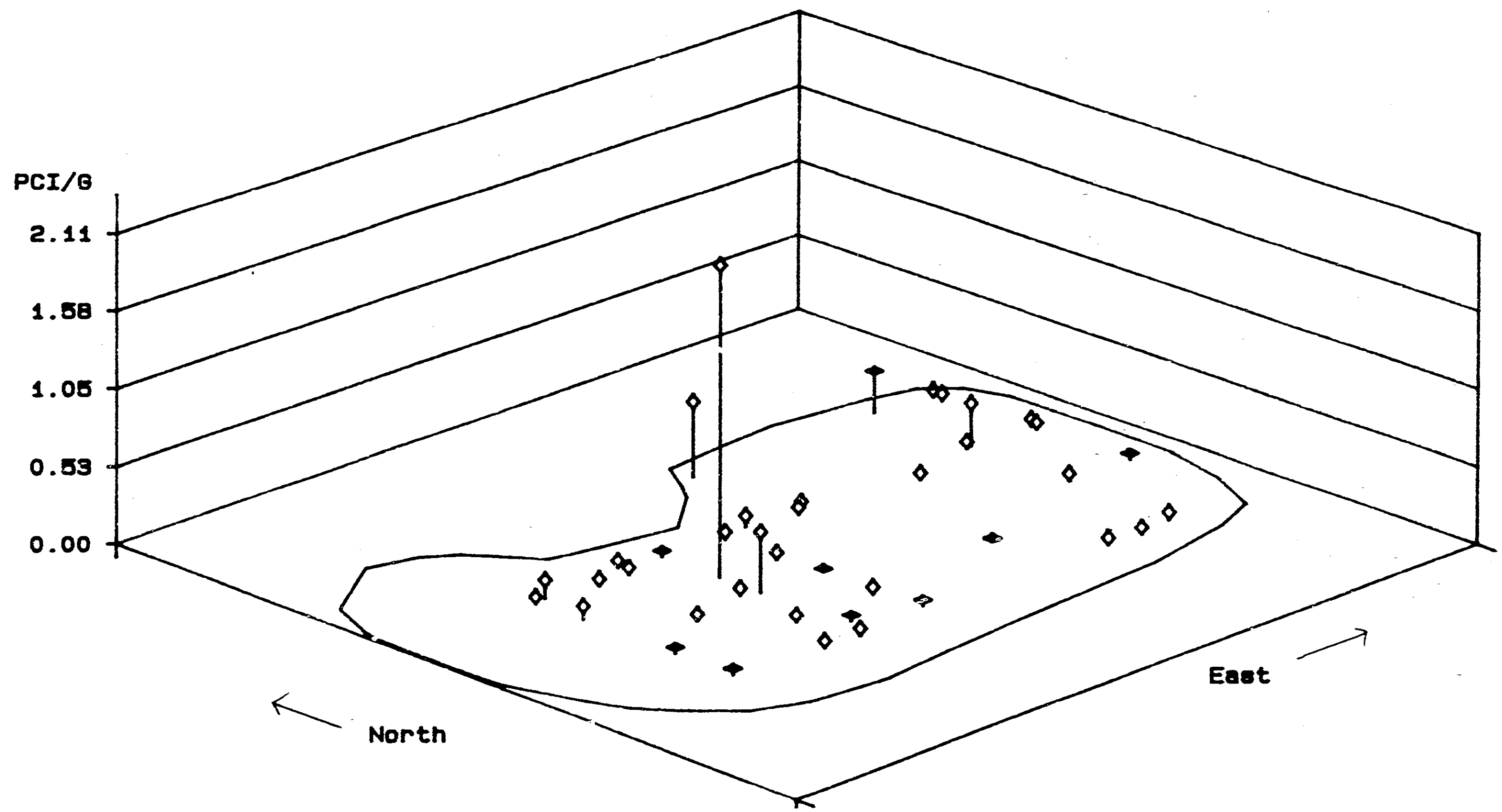
Plutonium—238
6 Inch Samples



Pyramids - Nondetects
Diamonds - Positive Data

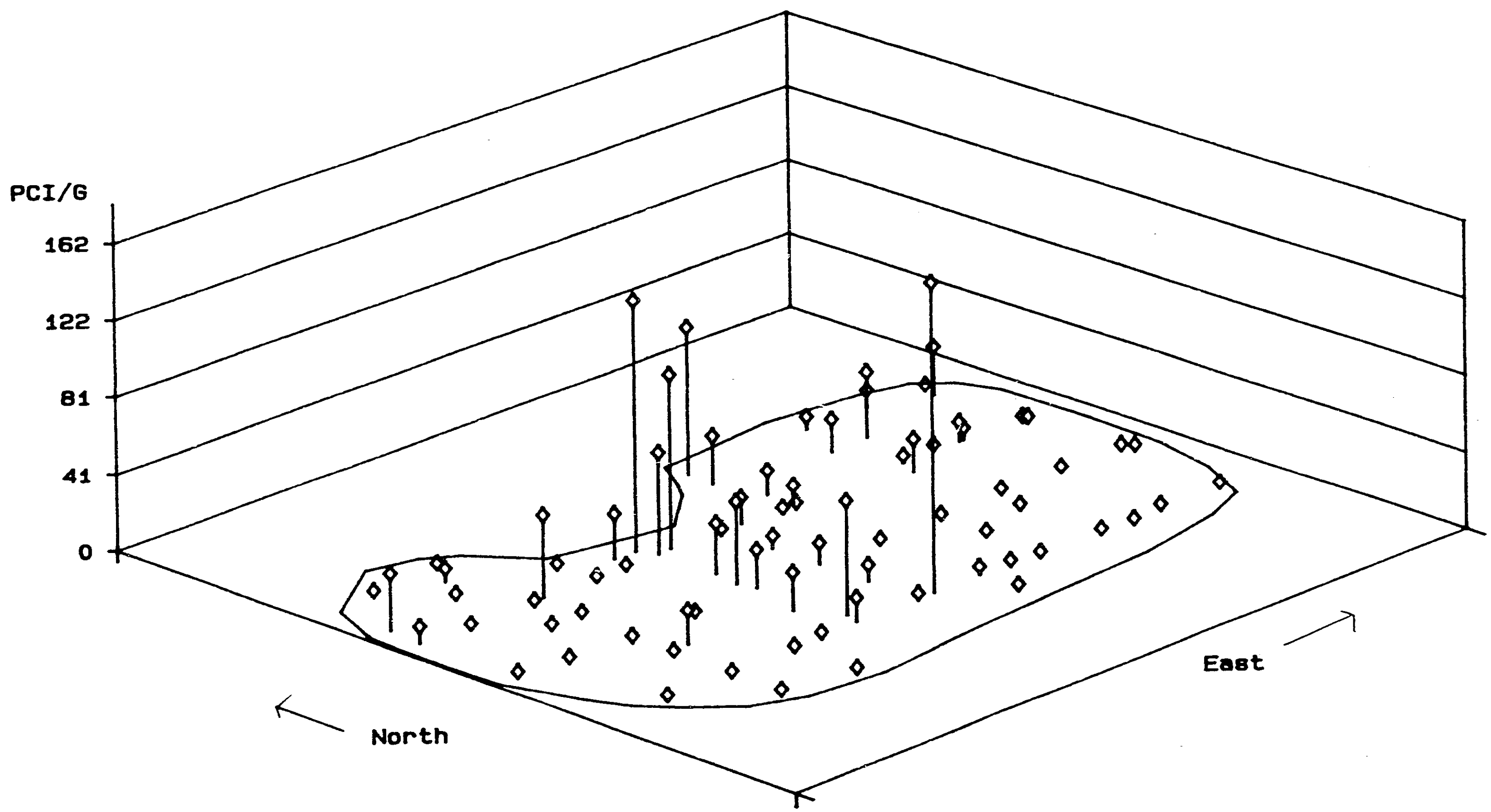

Plutonium-238
12 Inch Samples
PCI/G
0.972
0.729
0.486
0.243
0.000
East
North
Pyramids - Nondetects
Diamonds - Positive Data

Plutonium−238
18 Inch Samples

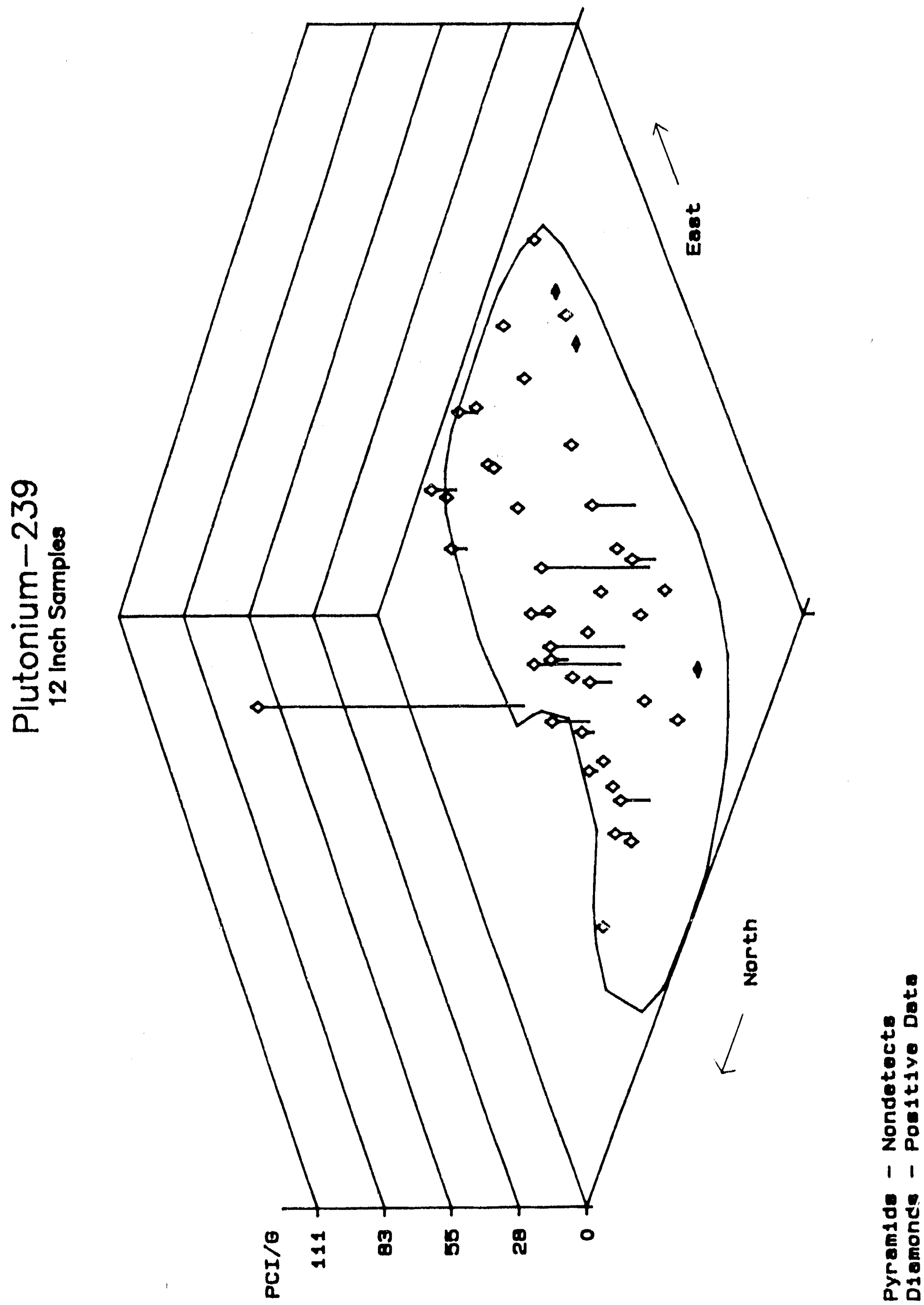


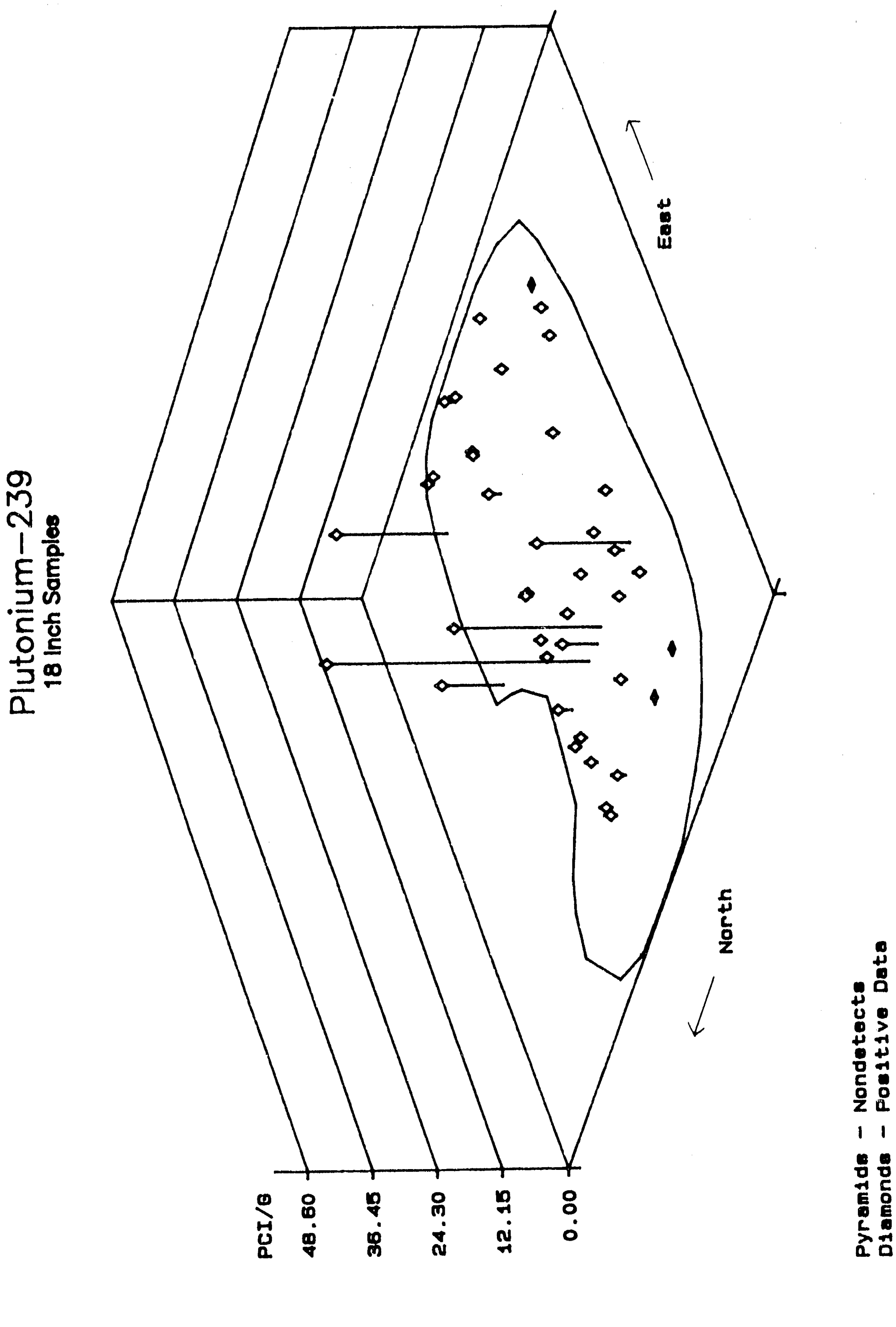
Pyramids − Nondetects
Diamonds − Positive Data

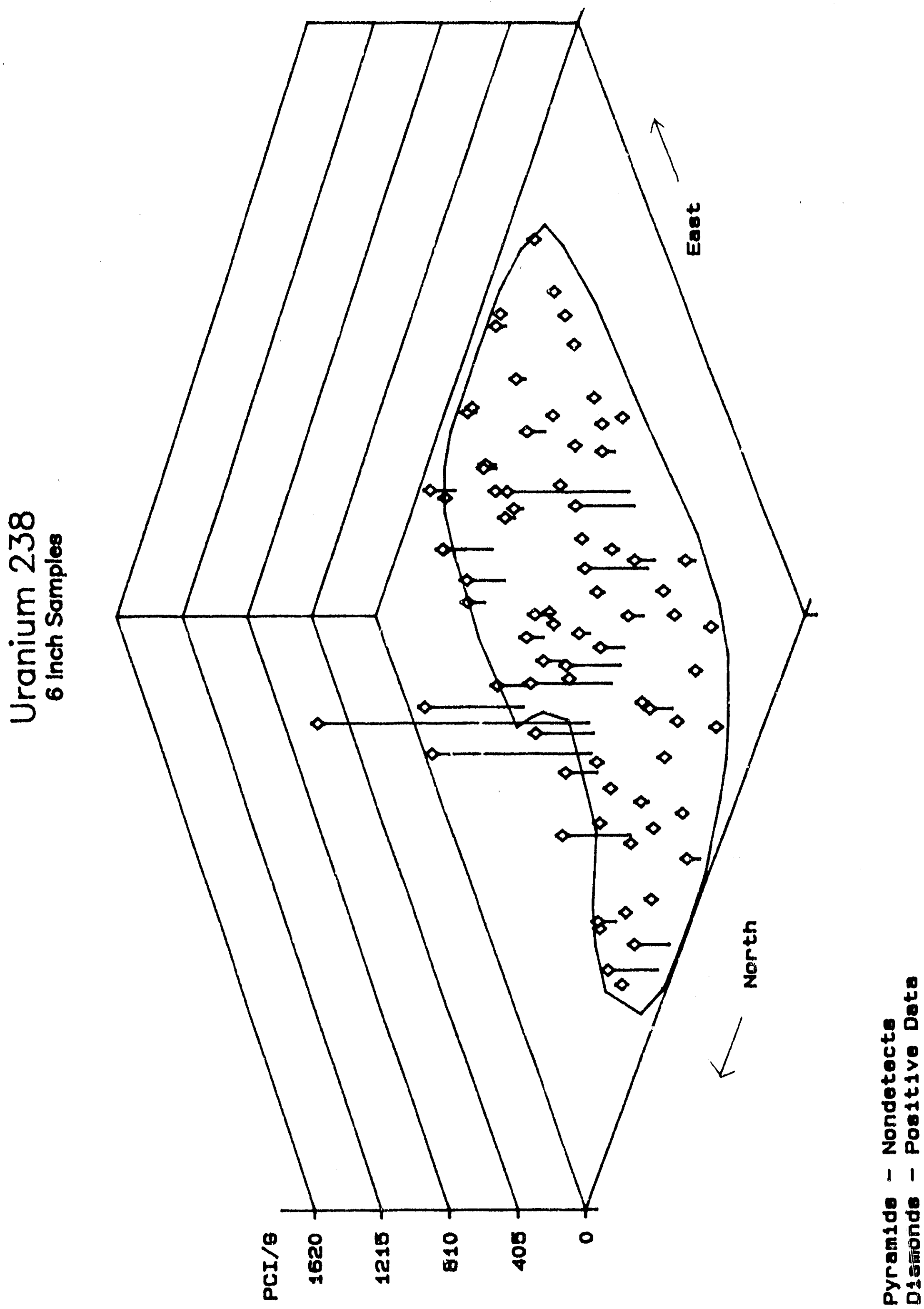
Plutonium-239
6 Inch Samples

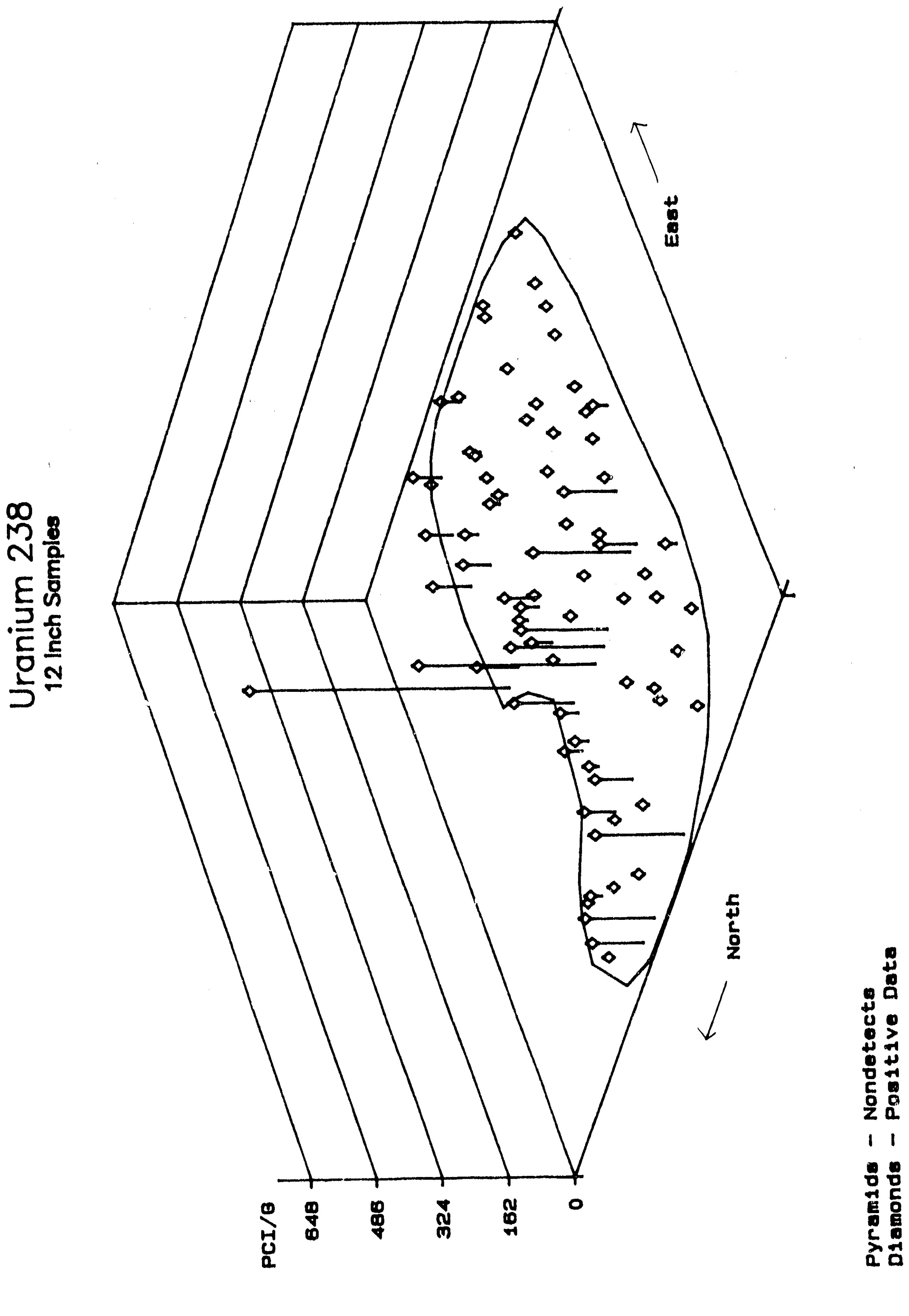


Pyramids - Nondetects
Diamonds - Positive Data

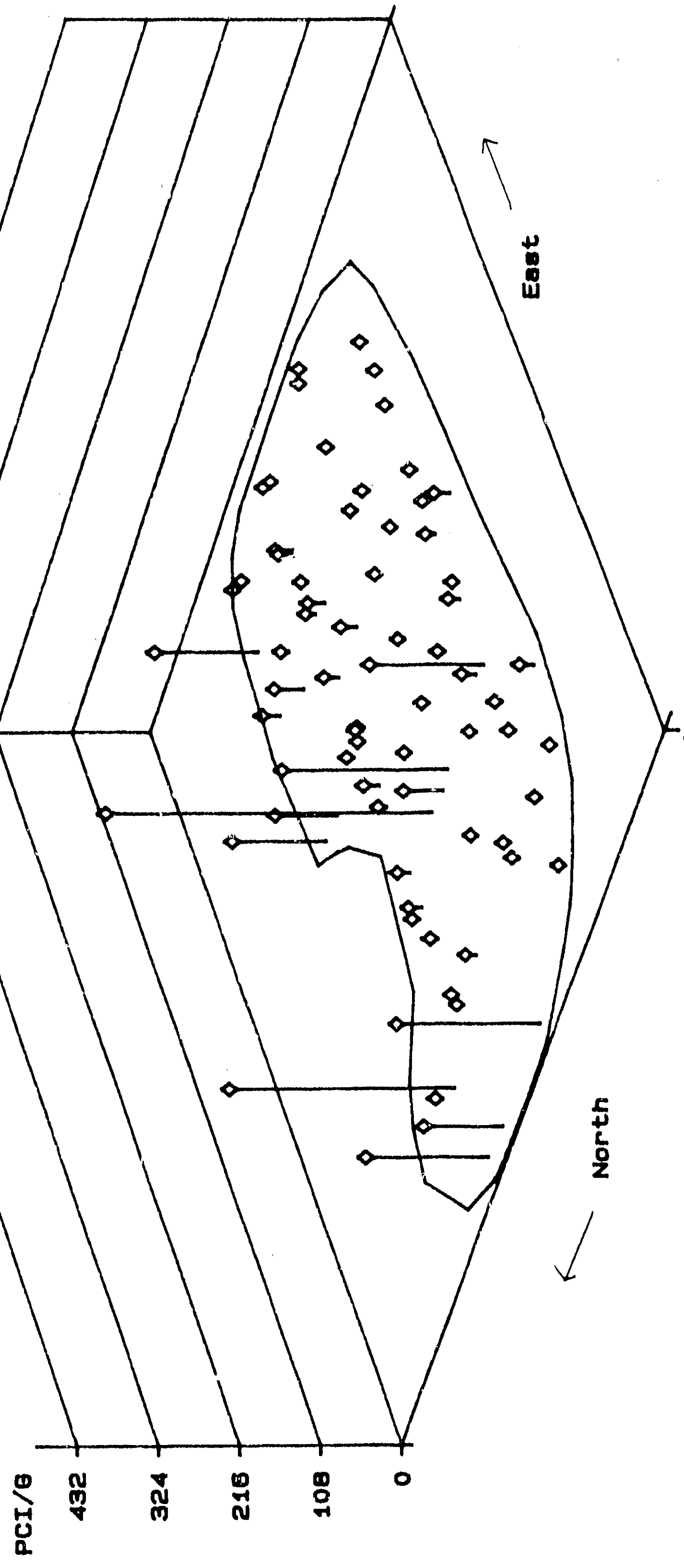

Plutonium-239
12 Inch Samples
PCI/G
111
83
55
28
0
East
North
Pyramids - Nondetects
Diamonds - Positive Data


Plutonium-239
18 Inch Samples
East
North
PCI/G
48.60
36.45
24.30
12.15
0.00
Pyramids - Nondetects
Diamonds - Positive Data

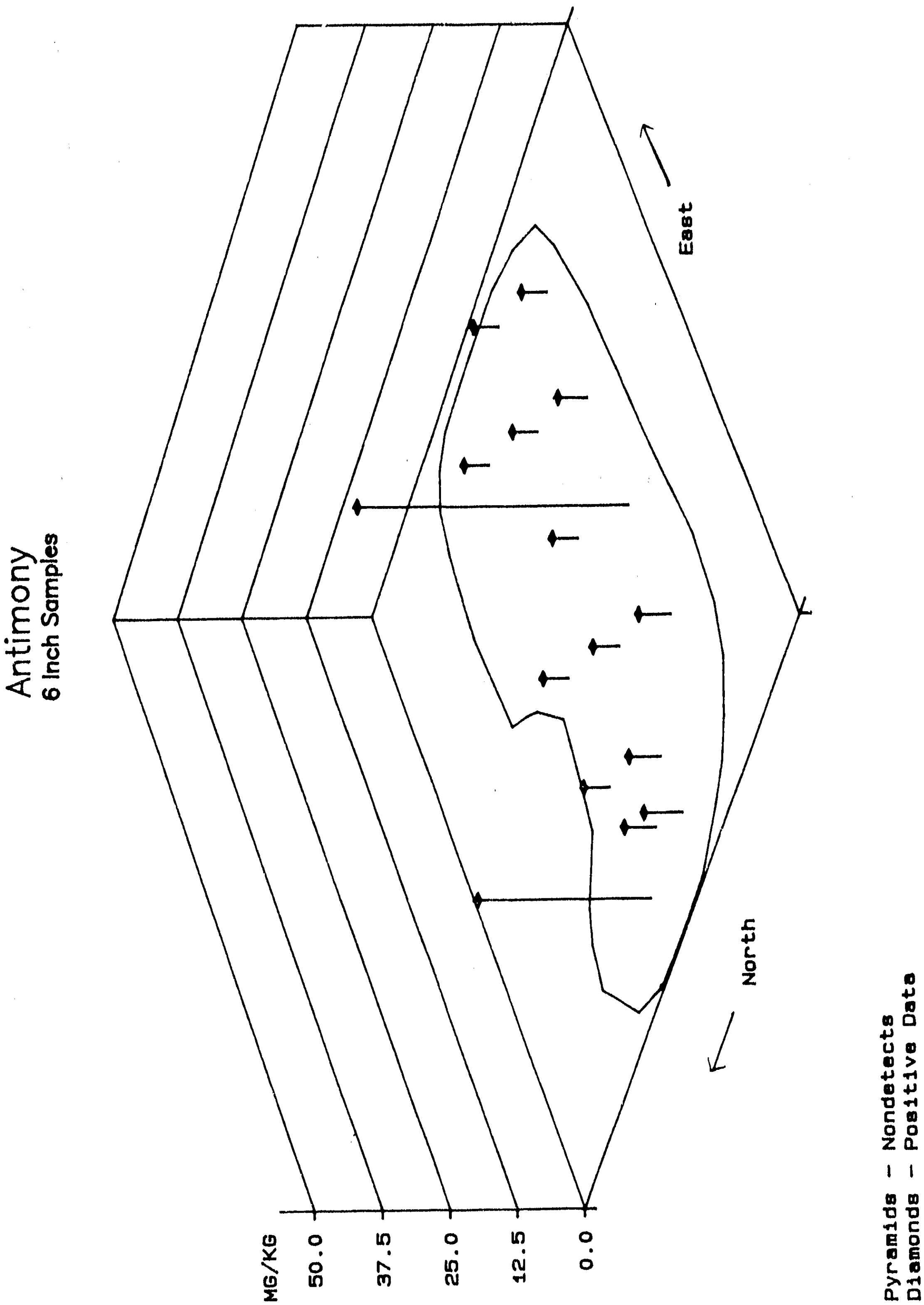

Uranium 238
6 Inch Samples
PCI/G
1620
1215
810
405
0
East
North
Pyramids - Nondetects
Diamonds - Positive Data


Uranium 238
12 Inch Samples
East
North
PCI/G
648
486
324
162
0
Pyramids - Nondetects
Diamonds - Positive Data

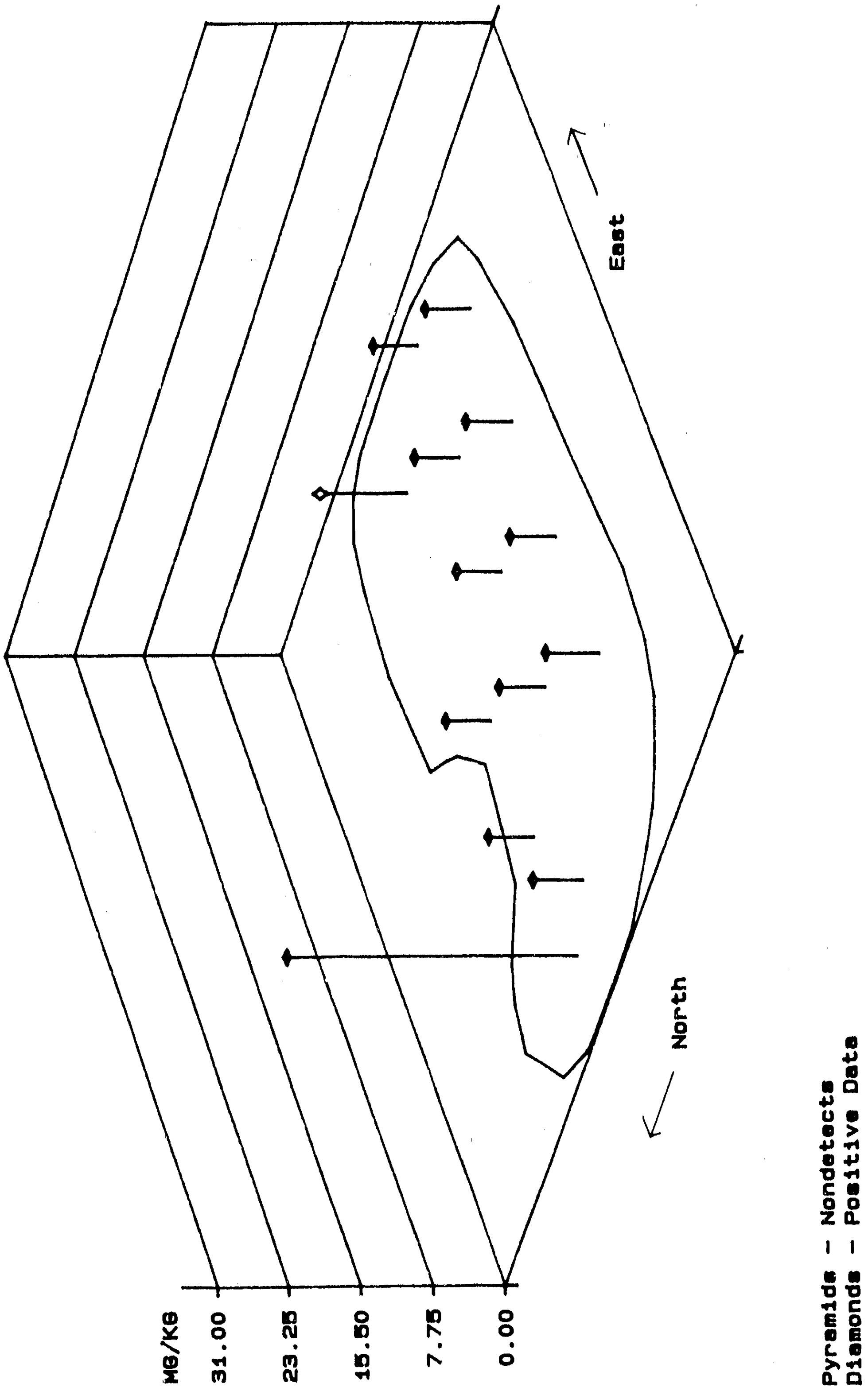
Uranium 238
18 Inch Samples

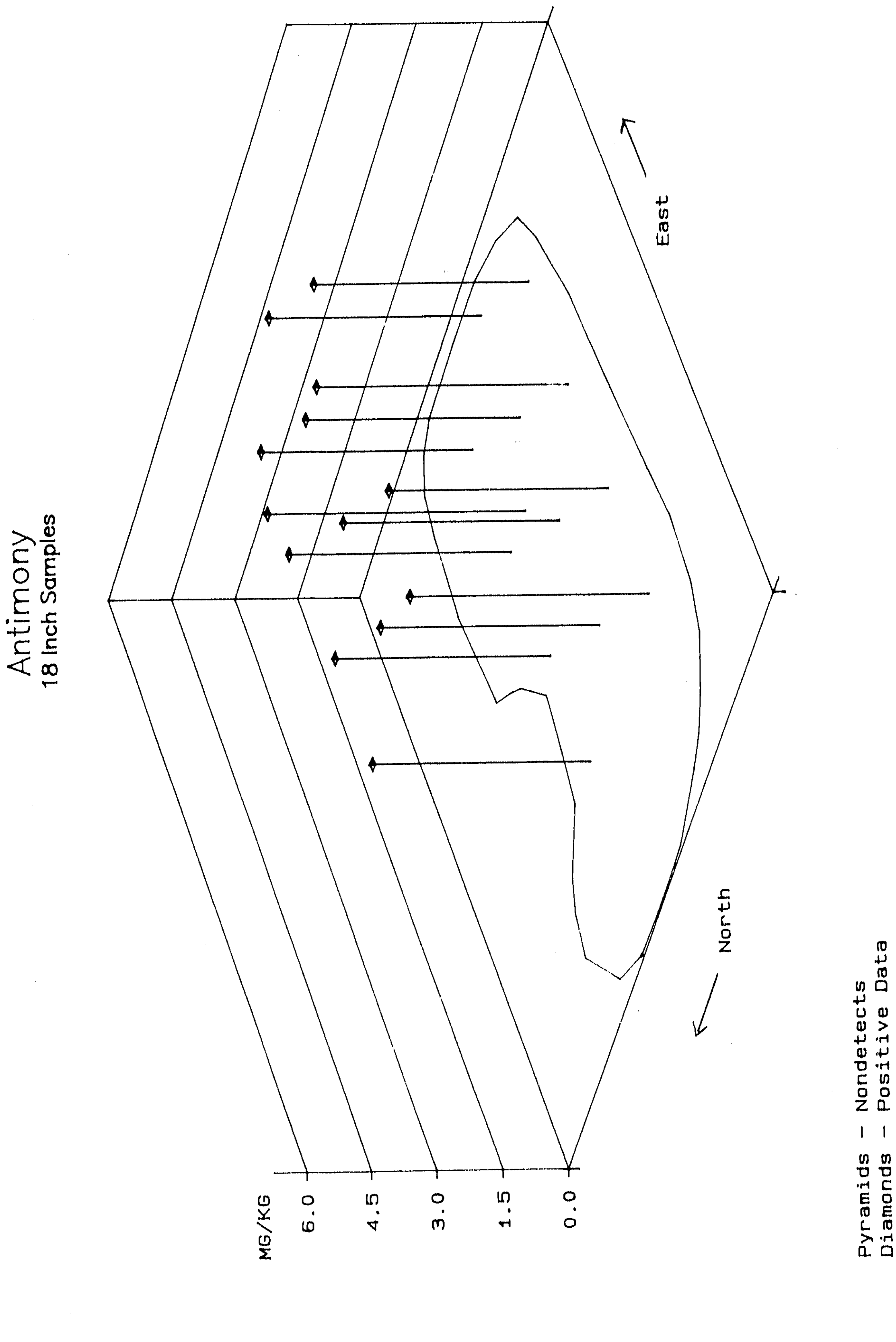


Pyramids – Nondetects
Diamonds – Positive Data


Antimony
6 Inch Samples
East
North
MG/KG
50.0
37.5
25.0
12.5
0.0
Pyramids - Nondetects
Diamonds - Positive Data

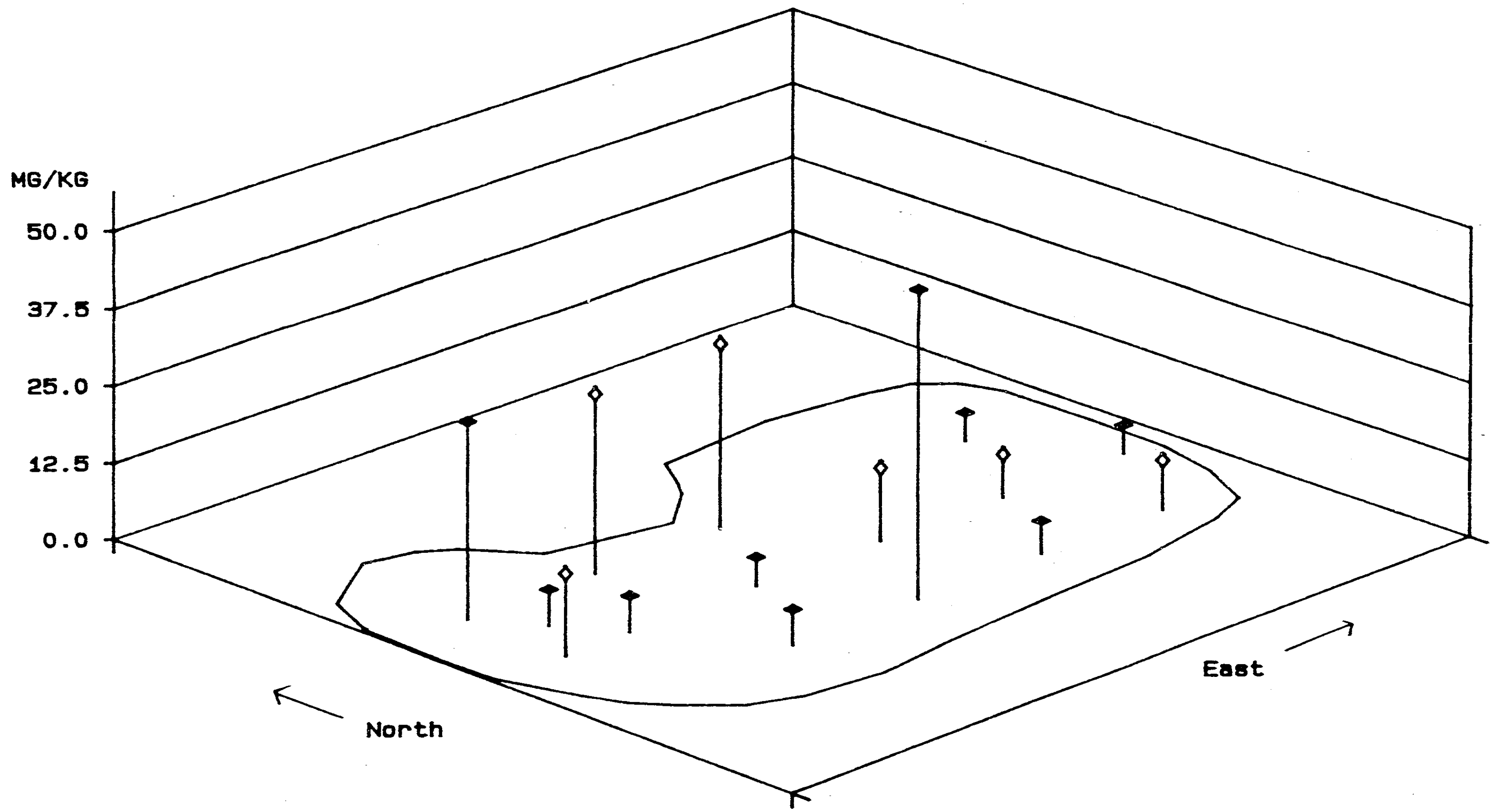
Antimony
12 Inch Samples





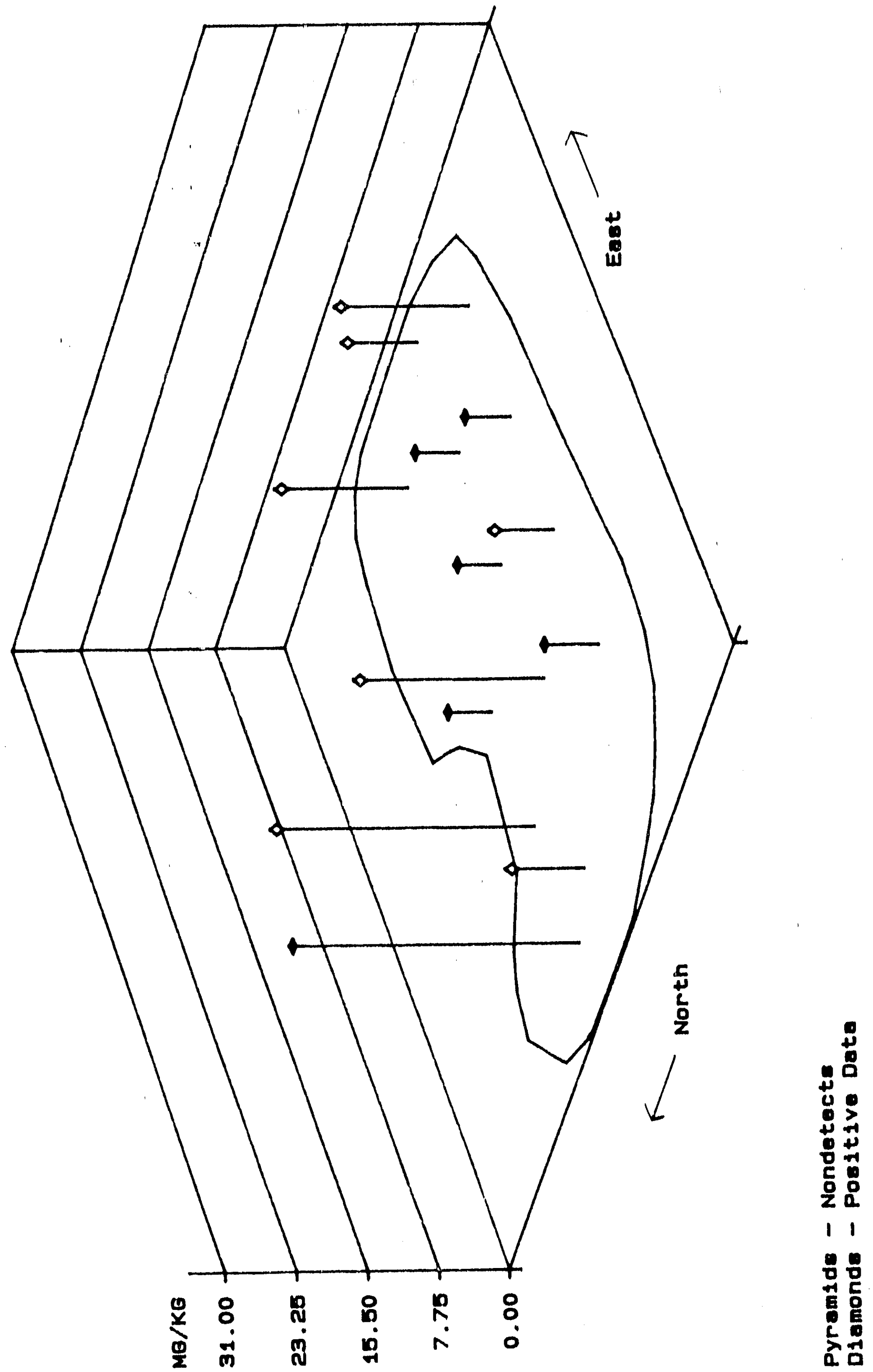
Antimony
18 Inch Samples
MG/KG
6.0
4.5
3.0
1.5
0.0
East
North
Pyramids - Nondetects
Diamonds - Positive Data

Arsenic
6 Inch Samples

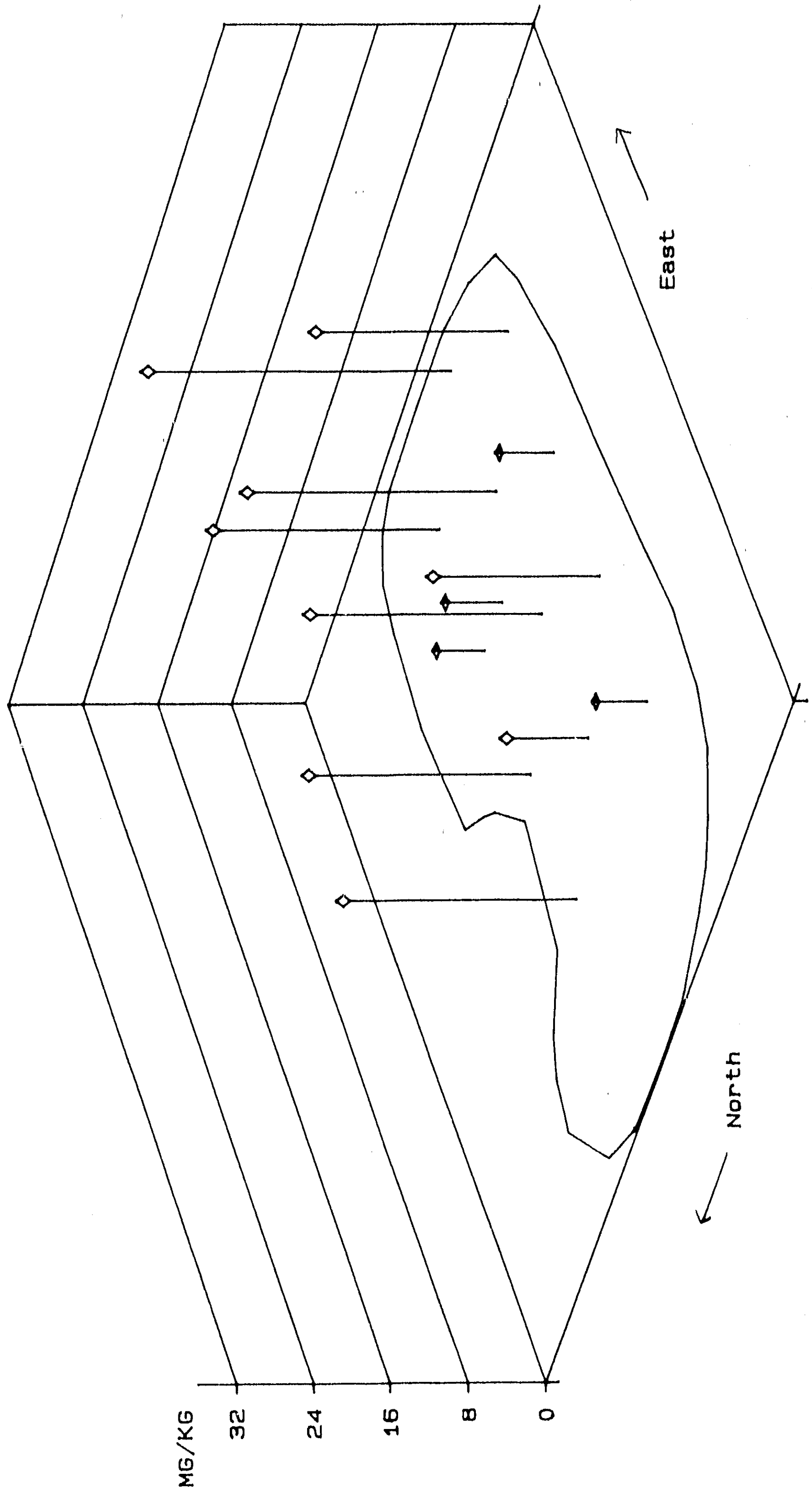


Pyramids - Nondetects
Diamonds - Positive Data

Arsenic
12 Inch Samples

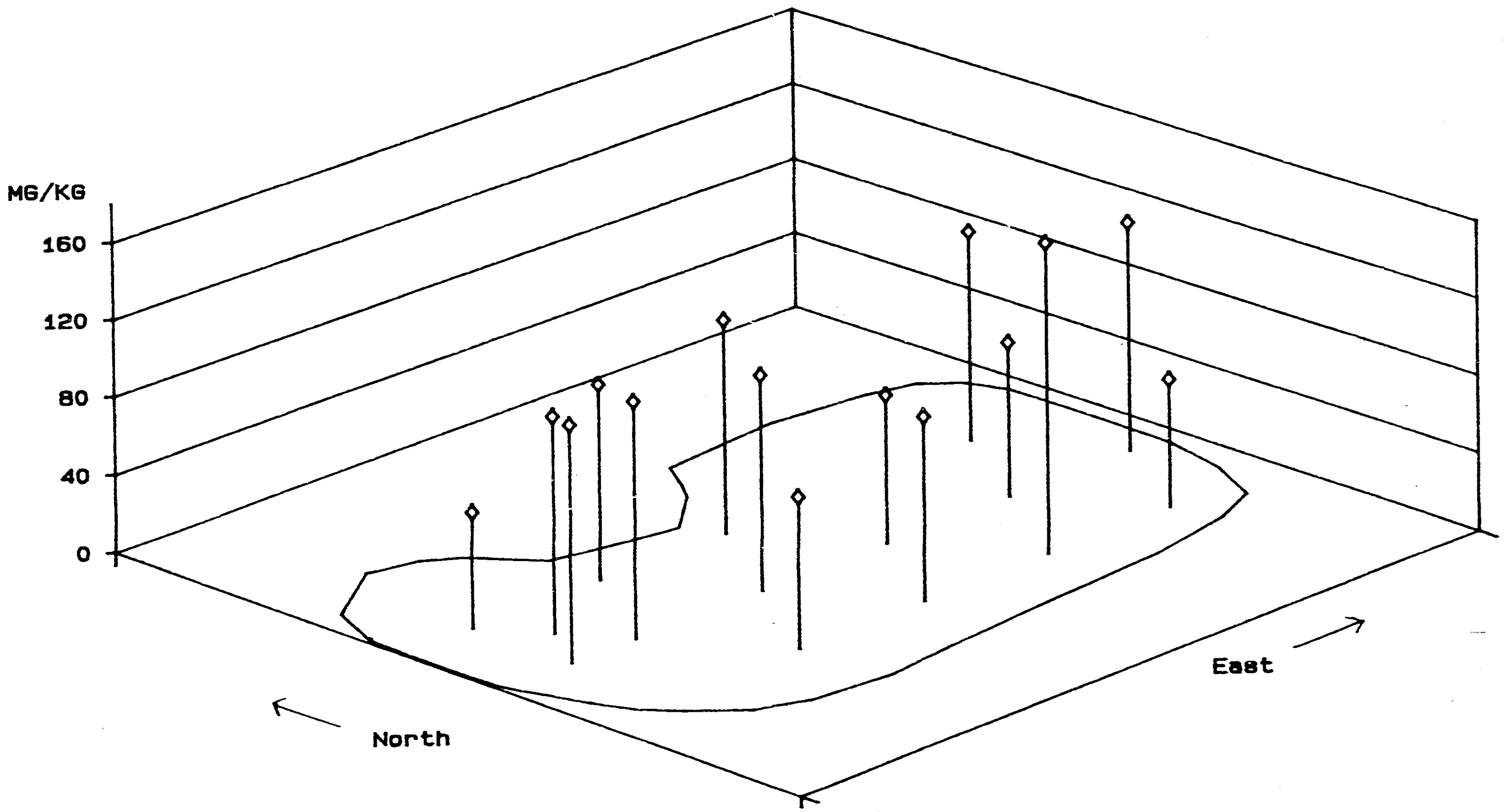


Arsenic
18 Inch Samples

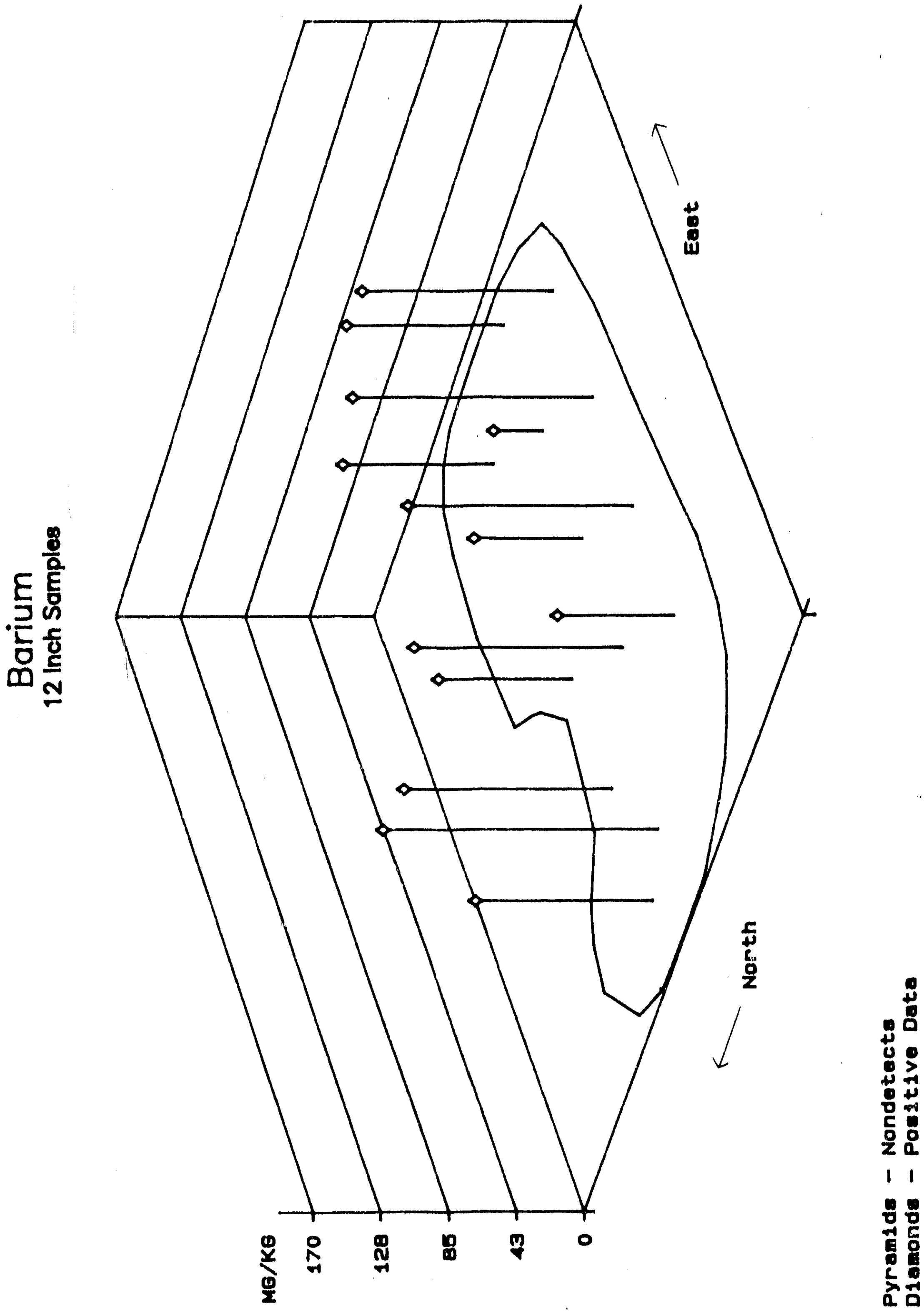


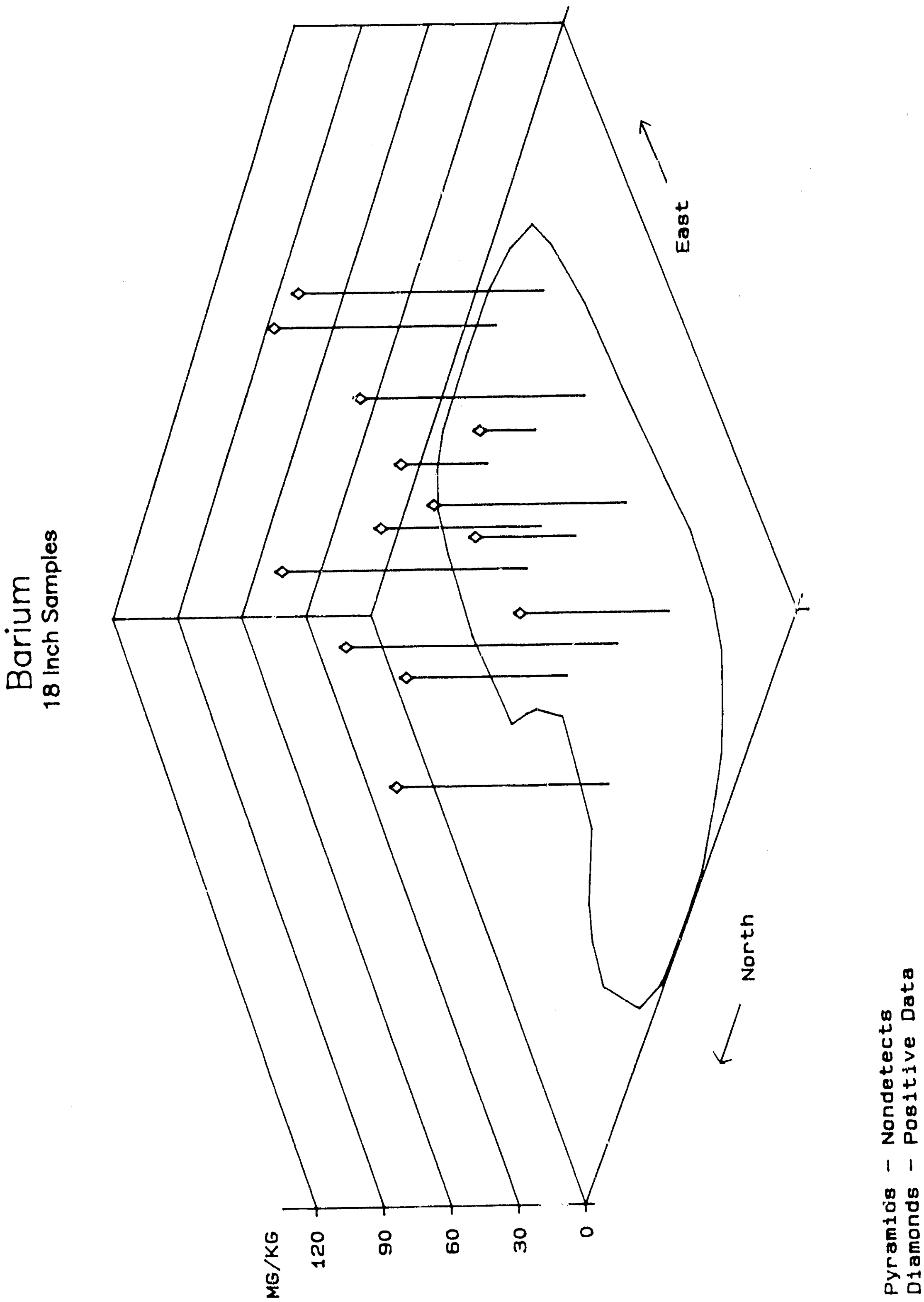
Pyramids - Nondetects
Diamonds - Positive Data

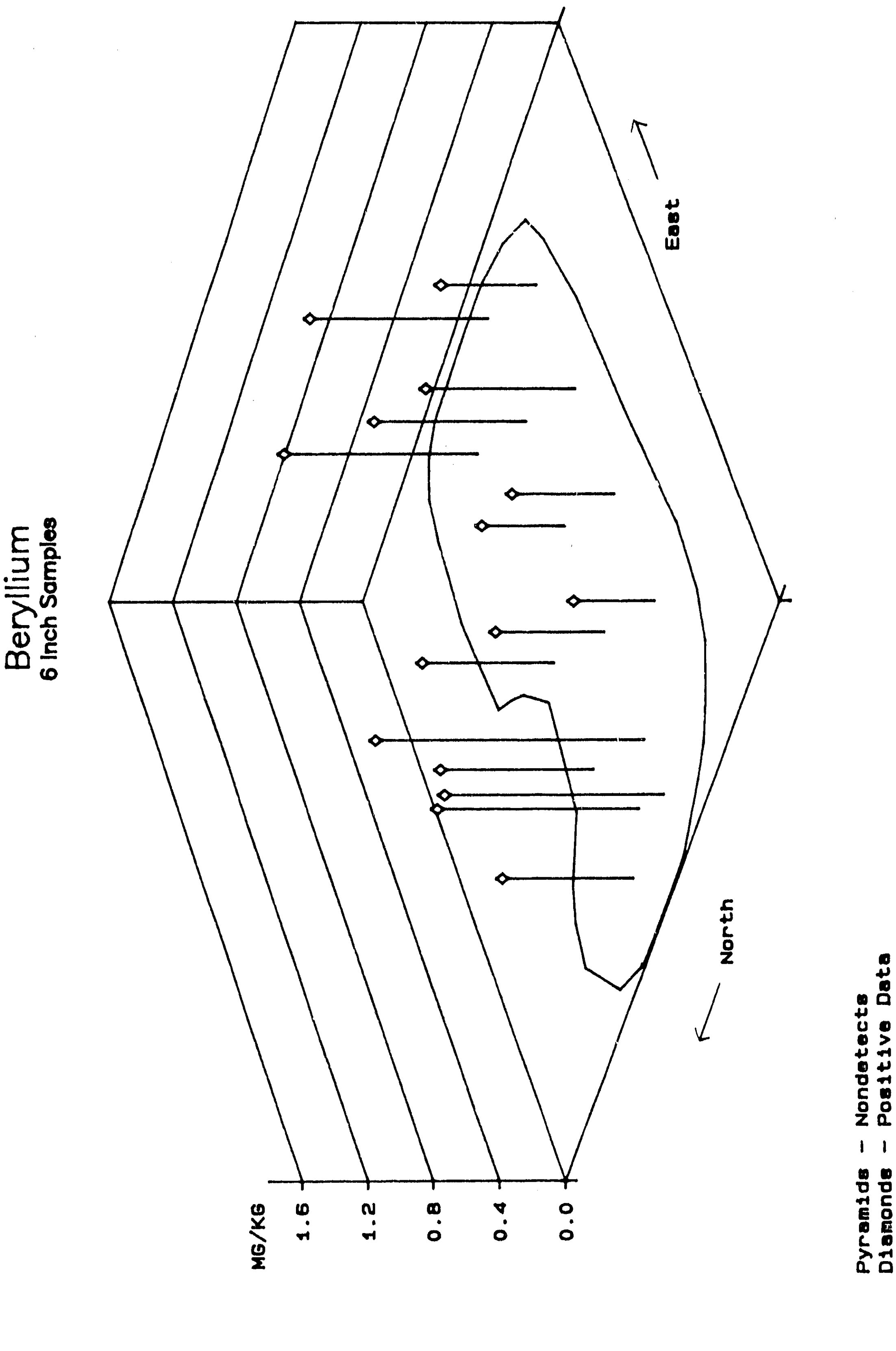
Barium
6 Inch Samples

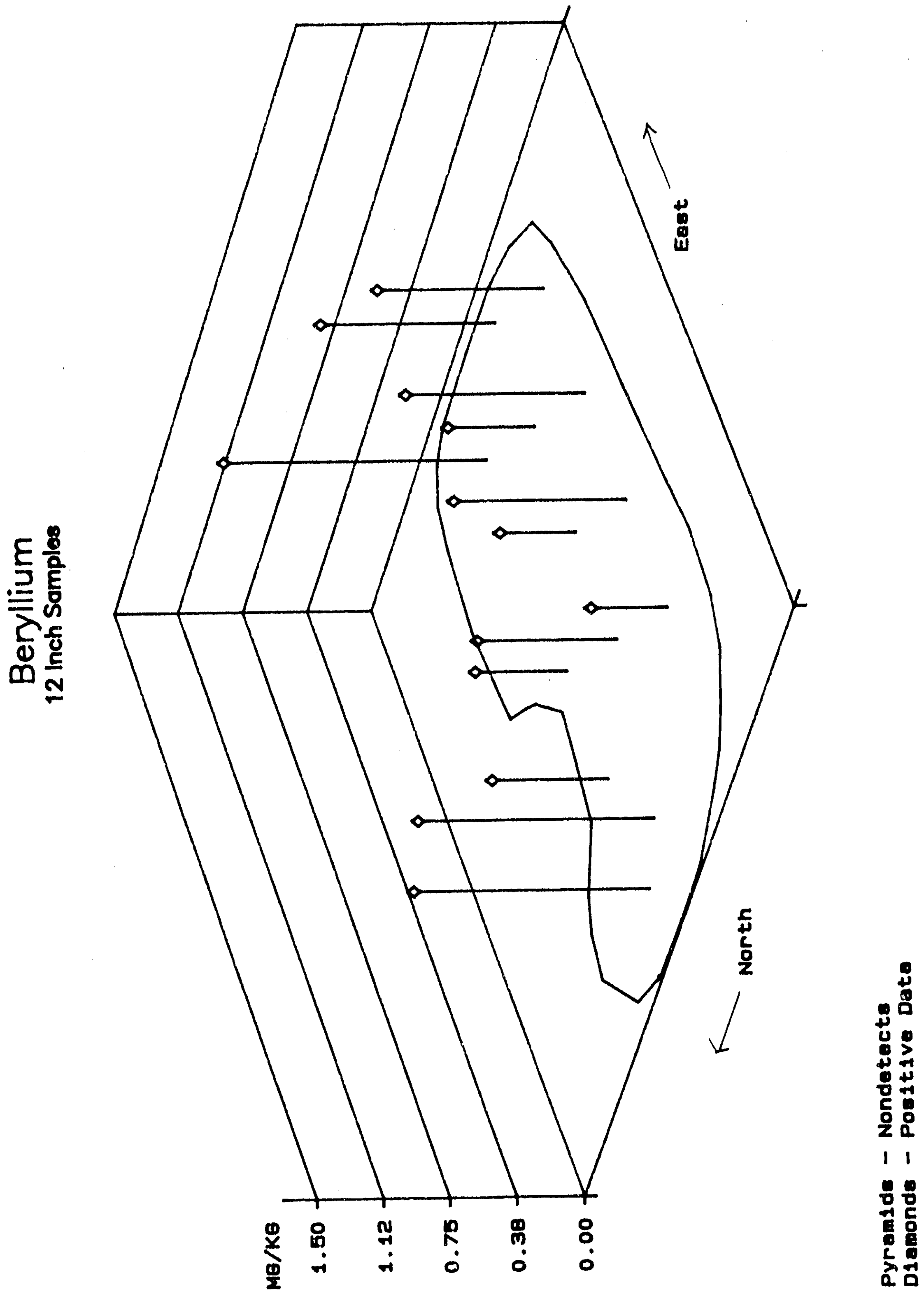


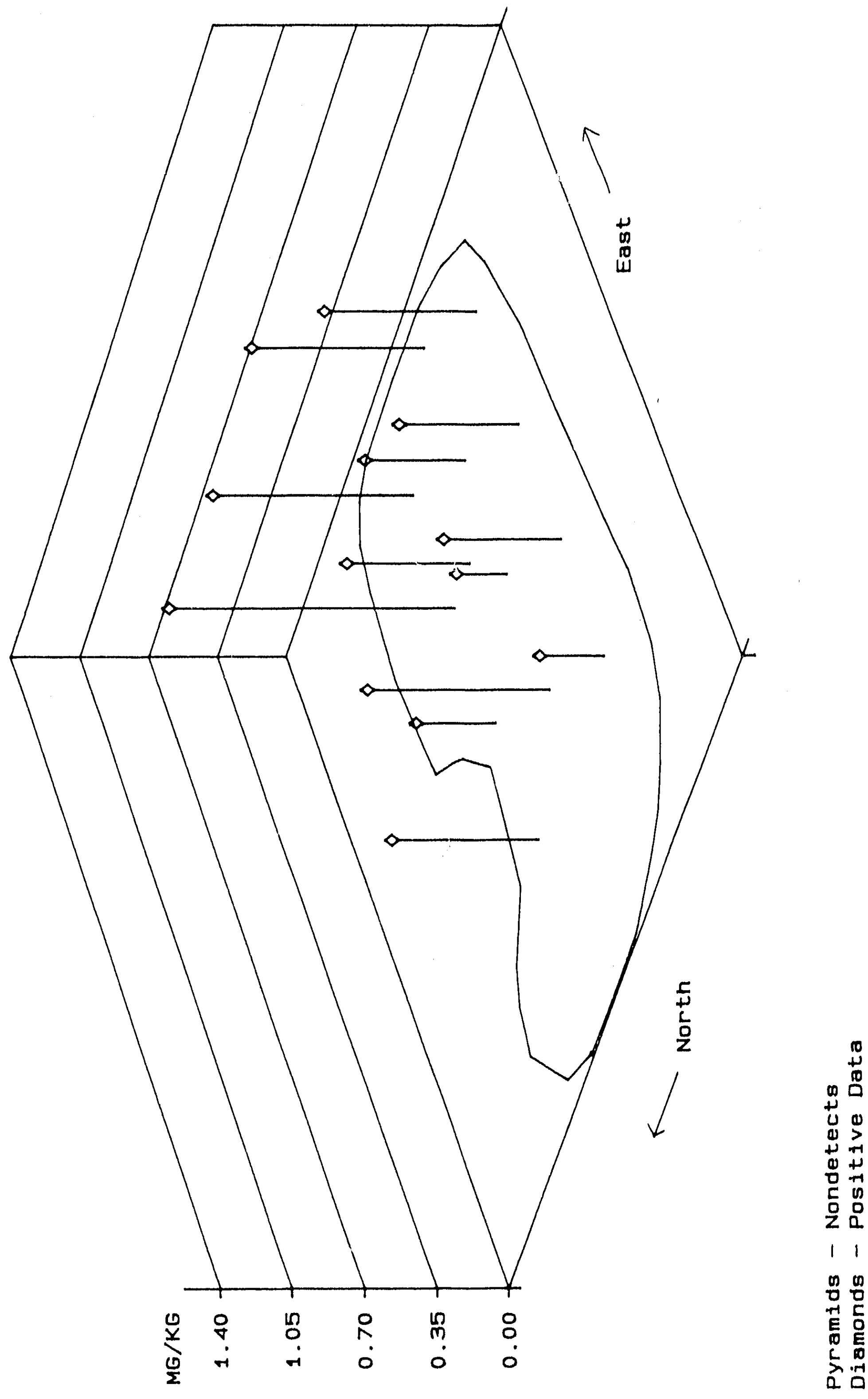
Pyramids - Nondetects
Diamonds - Positive Data


Barium
12 Inch Samples
MG/KG
170
128
85
43
0
East
North
Pyramids - Nondetects
Diamonds - Positive Data


Barium
18 Inch Samples
MG/KG
120
90
60
30
0
East
North
Pyramids - Nondetects
Diamonds - Positive Data

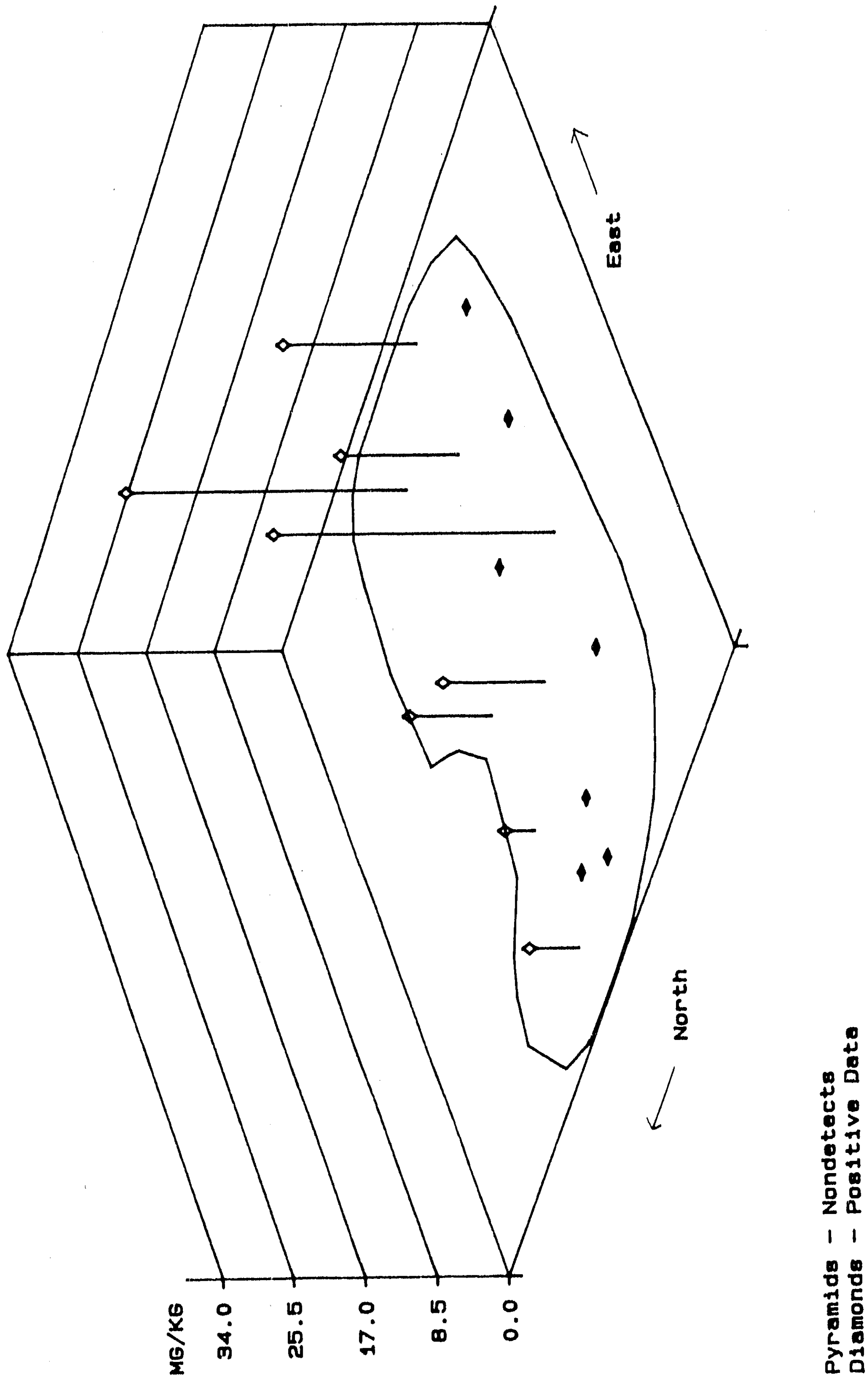

Beryllium
6 Inch Samples
MG/KG
1.6
1.2
0.8
0.4
0.0
East
North
Pyramids - Nondetects
Diamonds - Positive Data


Beryllium
12 Inch Samples
East
North
MG/KG
1.50
1.12
0.75
0.38
0.00
Pyramids - Nondetects
Diamonds - Positive Data

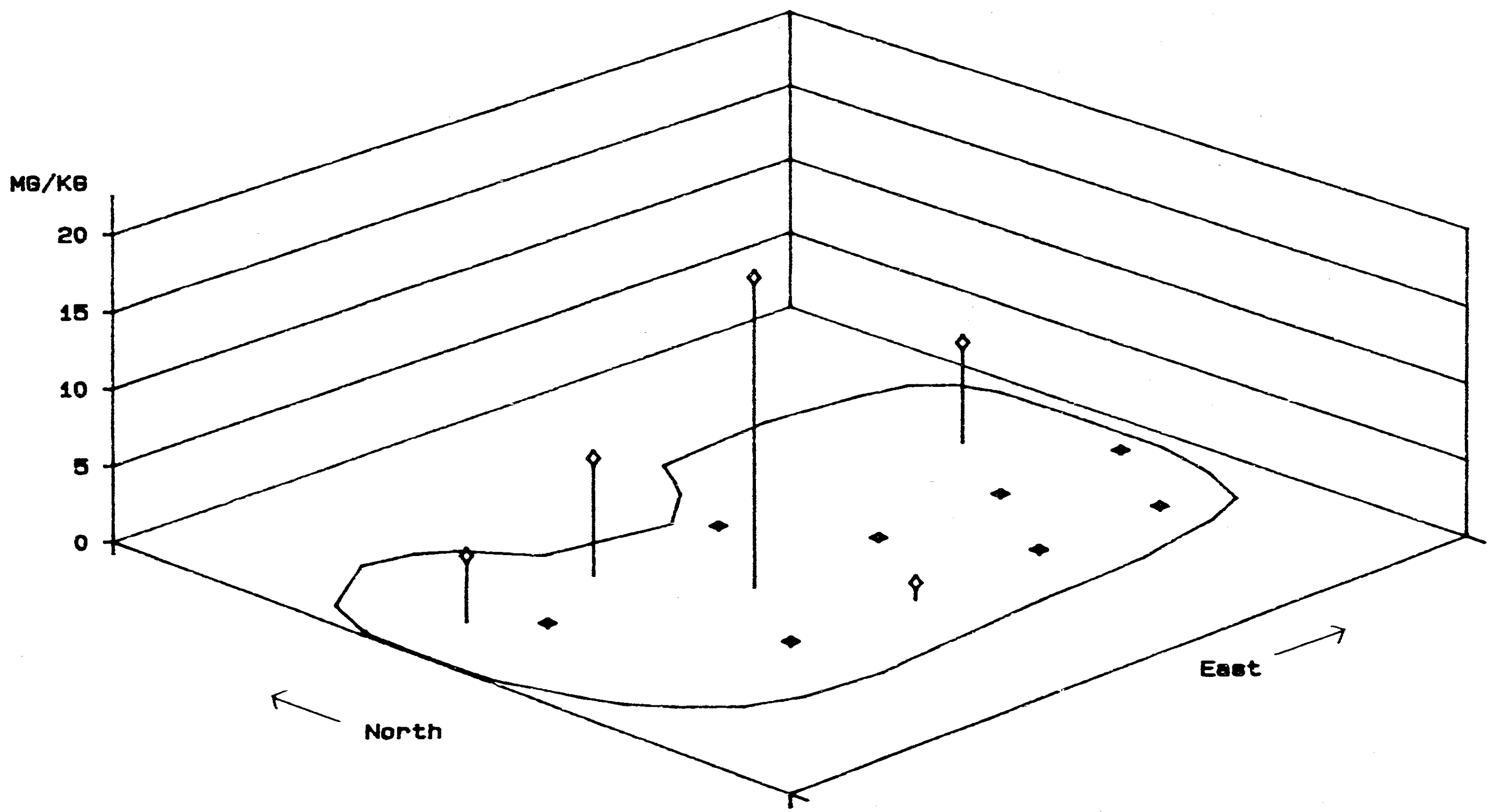


Beryllium
18 Inch Samples

Boron
6 Inch Samples

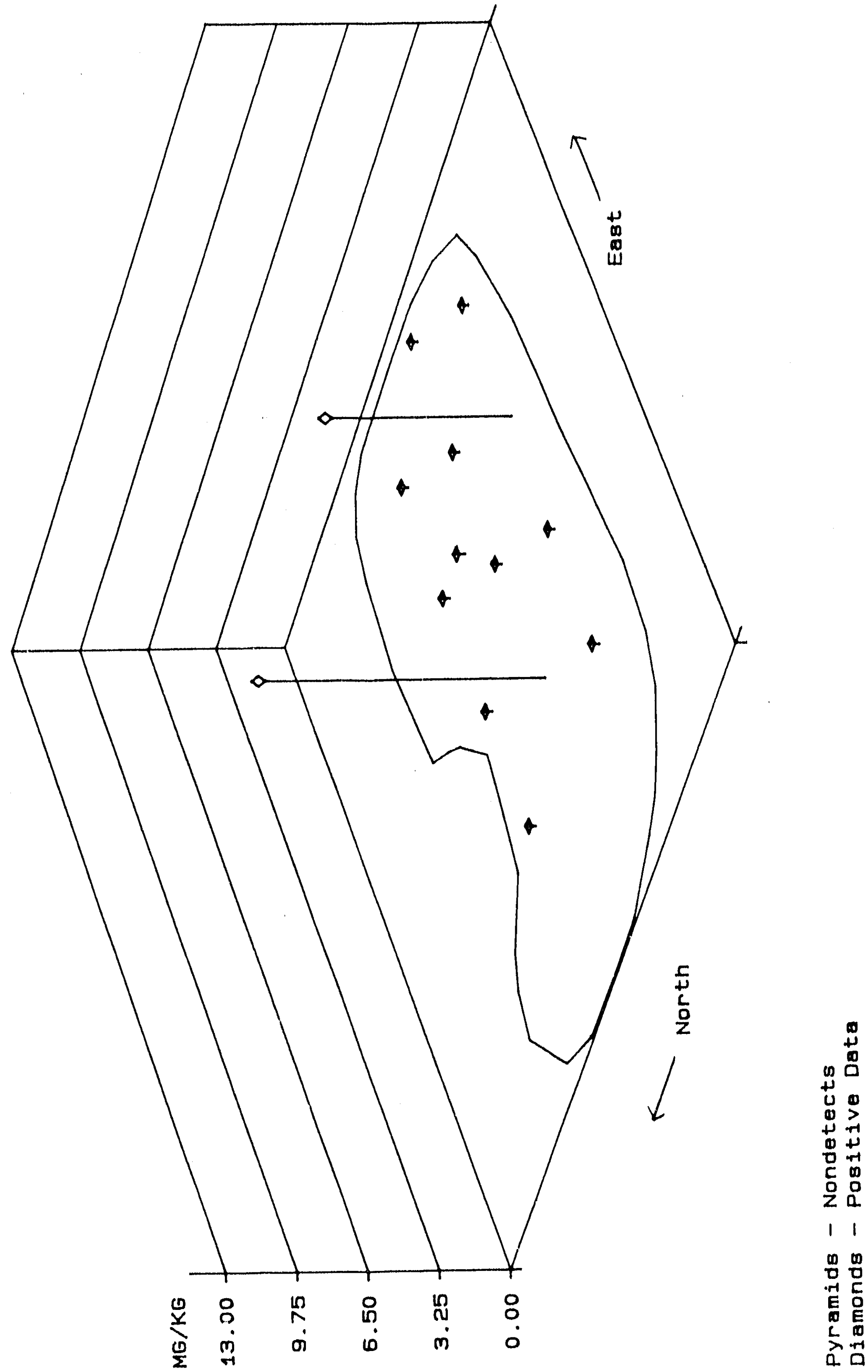


Boron
12 Inch Samples

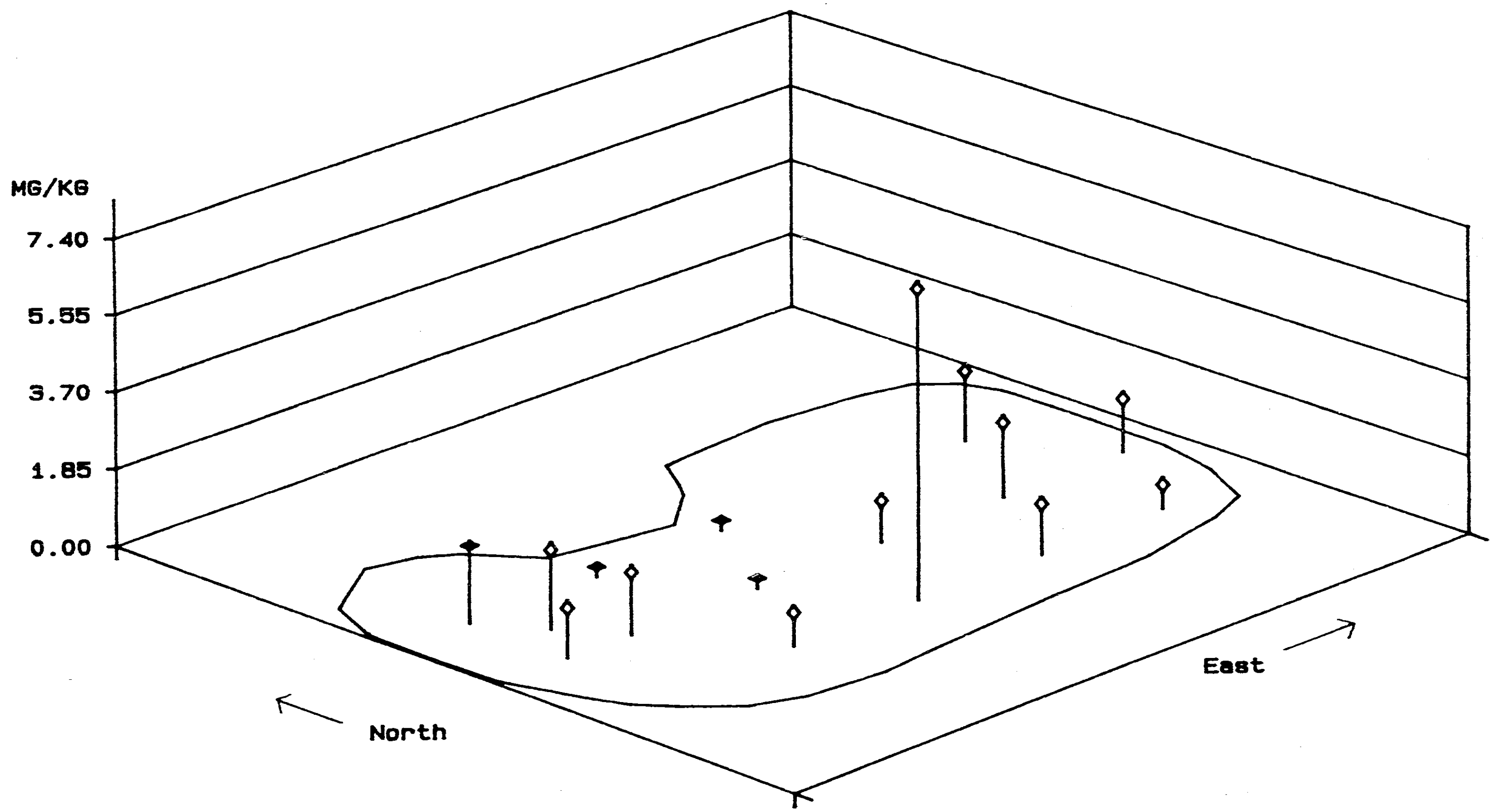


Pyramids - Nondetects
Diamonds - Positive Data

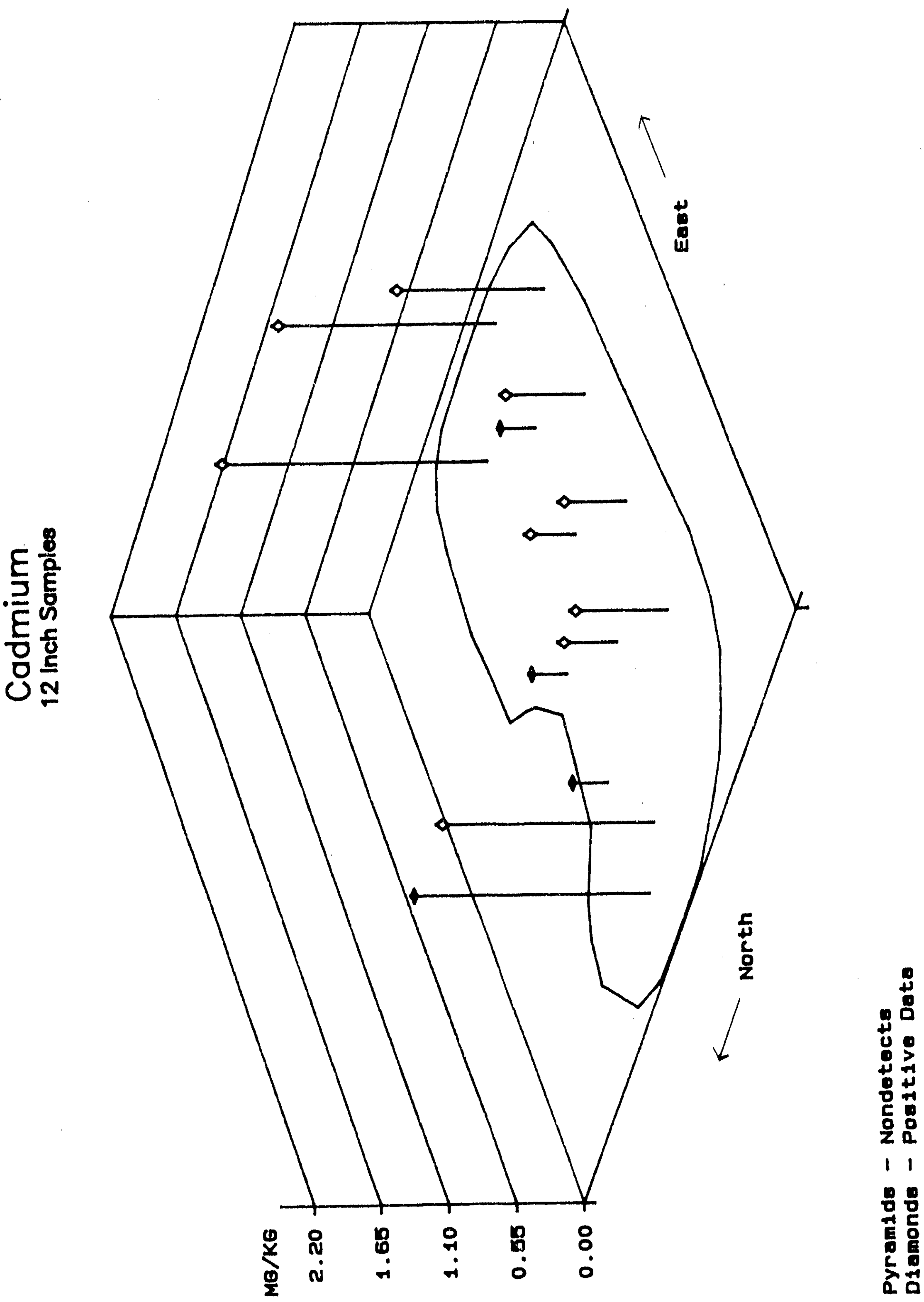
Boron
18 Inch Samples



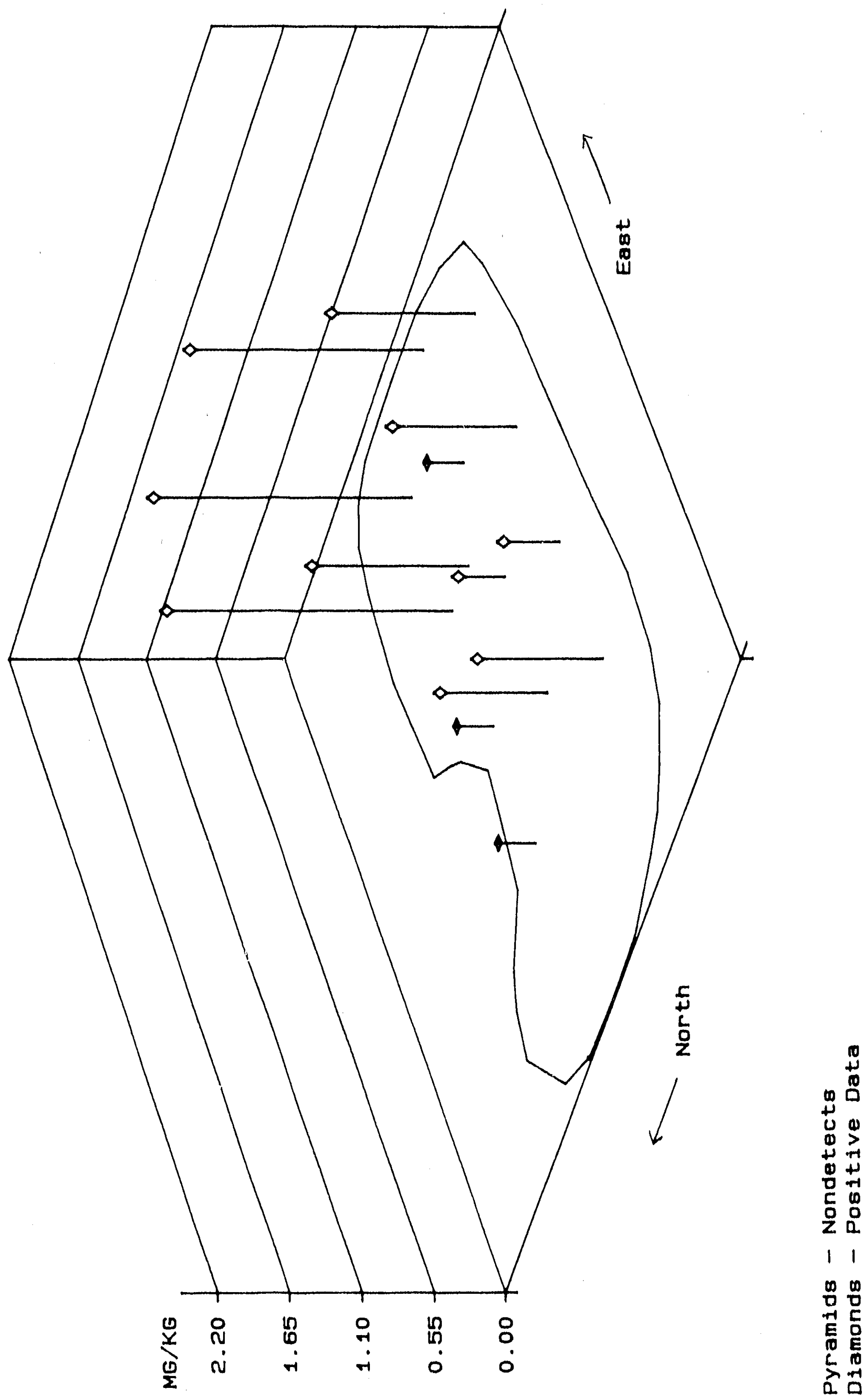
Cadmium
6 Inch Samples

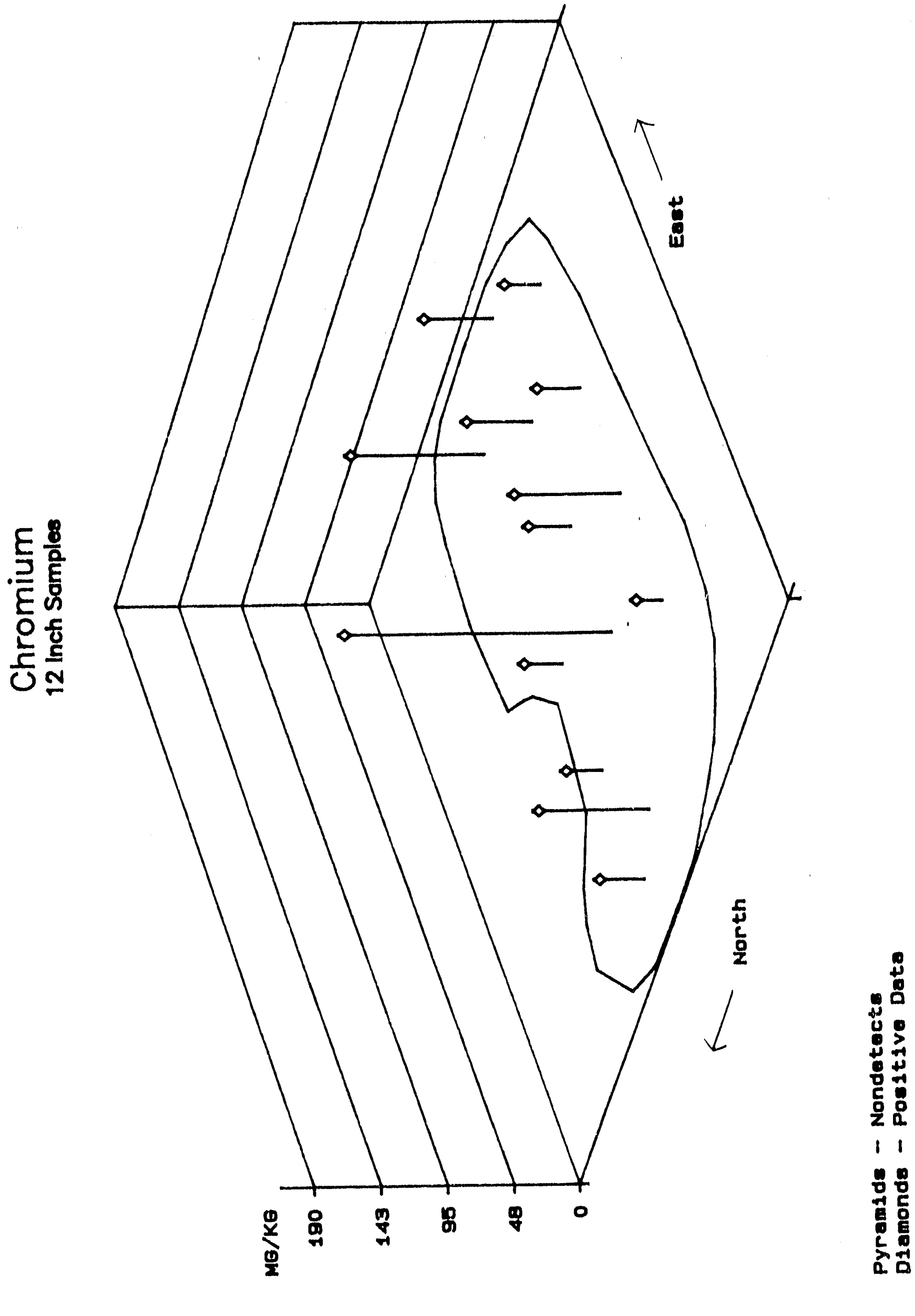


Pyramids – Nondetects
Diamonds – Positive Data

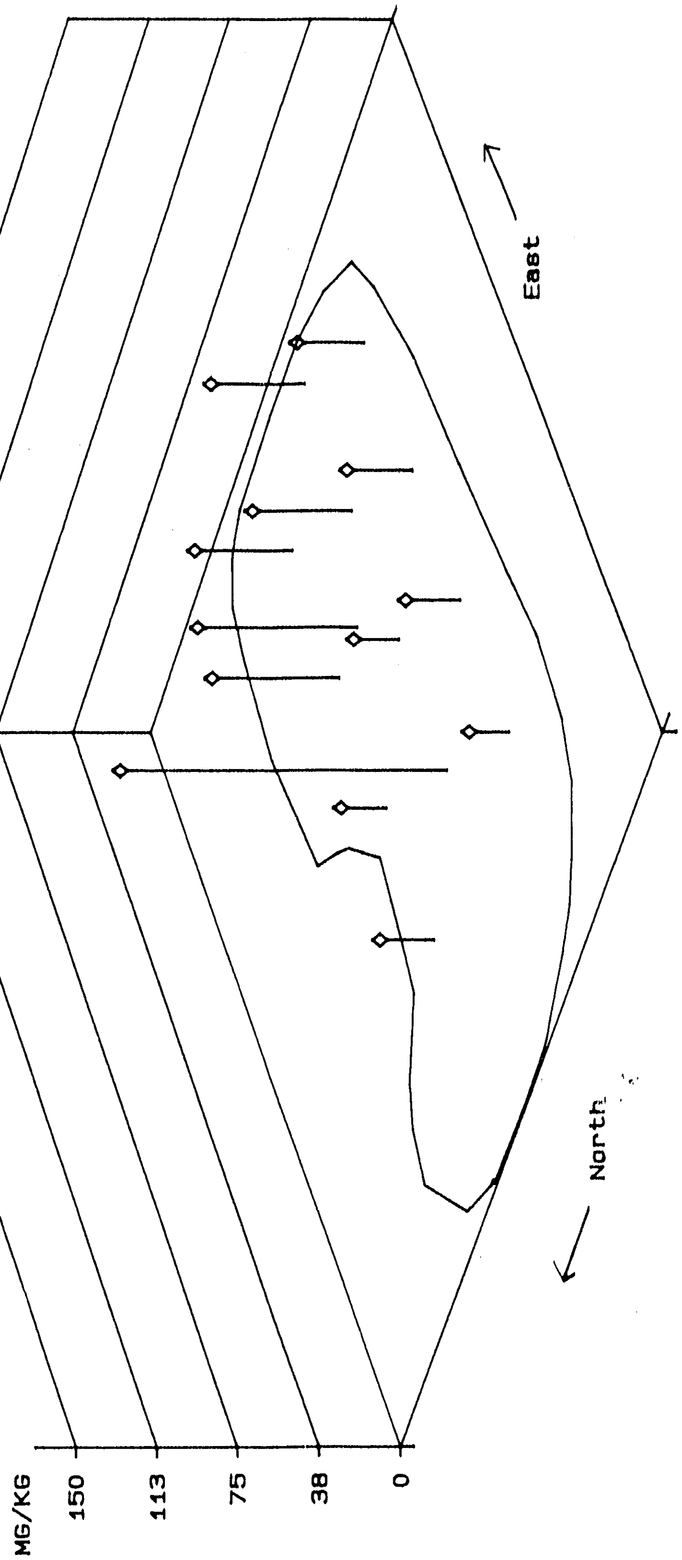

Cadmium
12 Inch Samples
MG/KG
2.20
1.65
1.10
0.55
0.00
East
North
Pyramids - Nondetects
Diamonds - Positive Data

Cadmium
18 Inch Samples



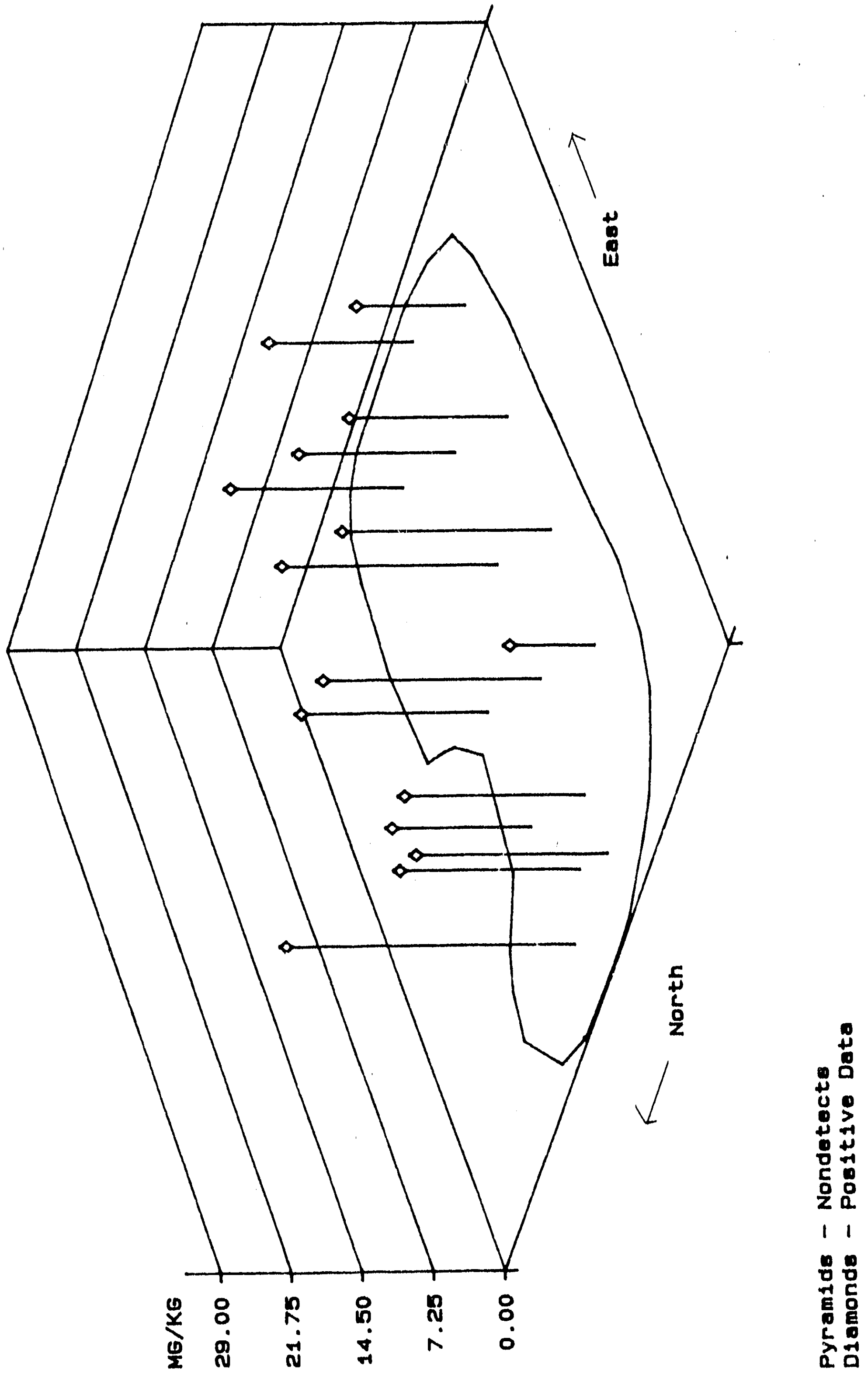

Chromium
12 Inch Samples
MG/KG
190
143
95
48
0
East
North
Pyramids -- Nondetects
Diamonds -- Positive Data

Chromium
18 Inch Samples

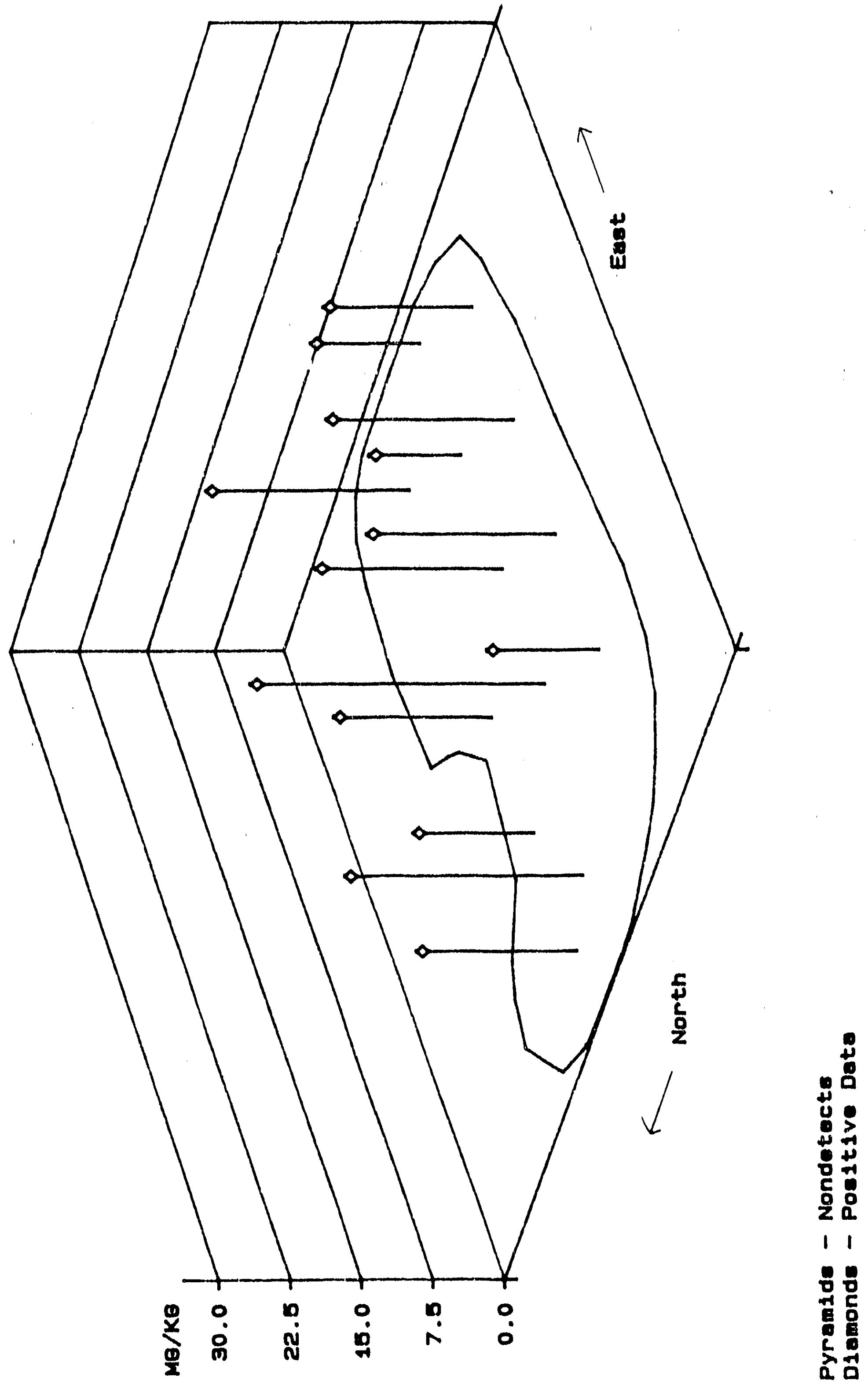


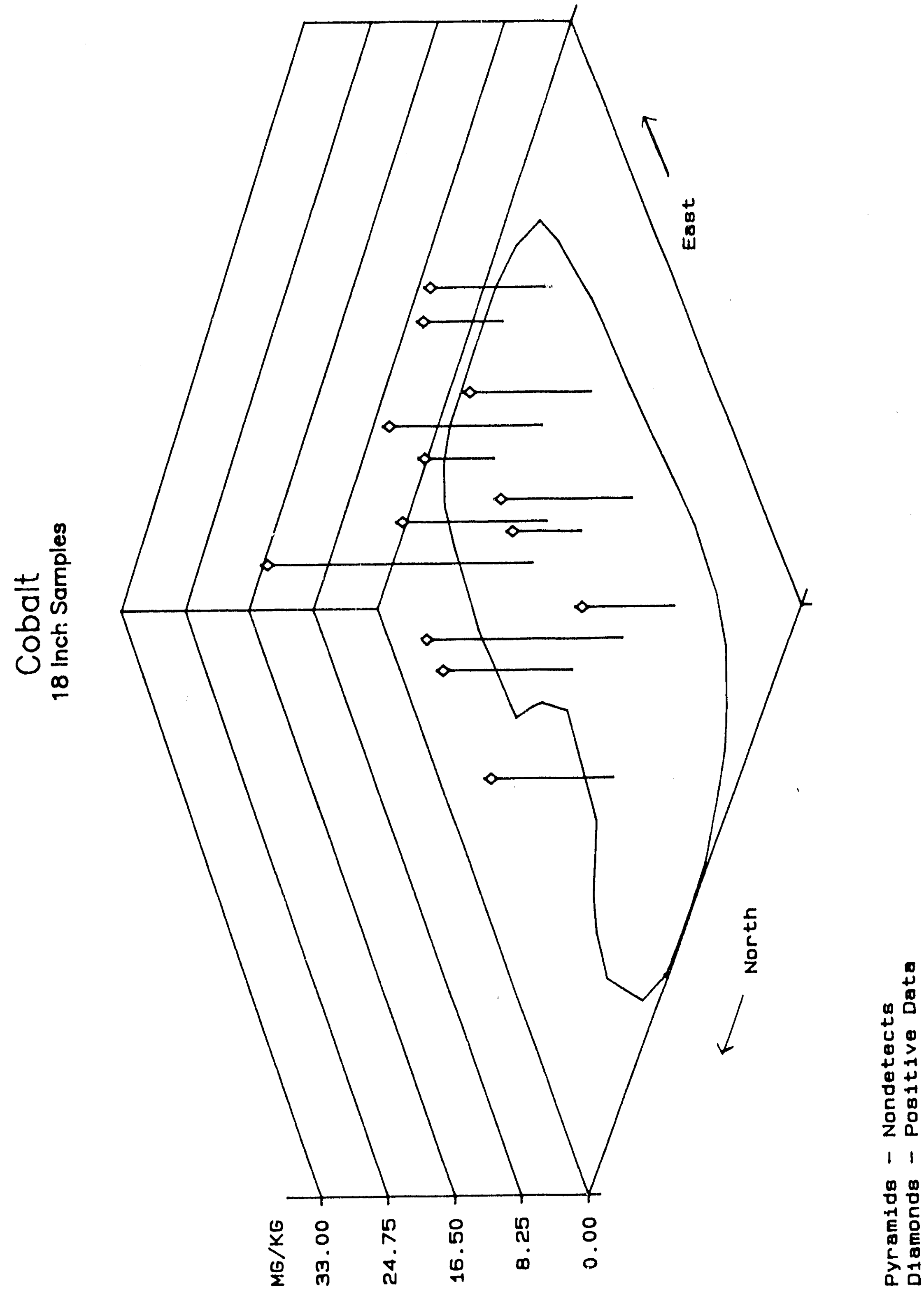
Pyramids - Nondetects
Diamonds - Positive Data

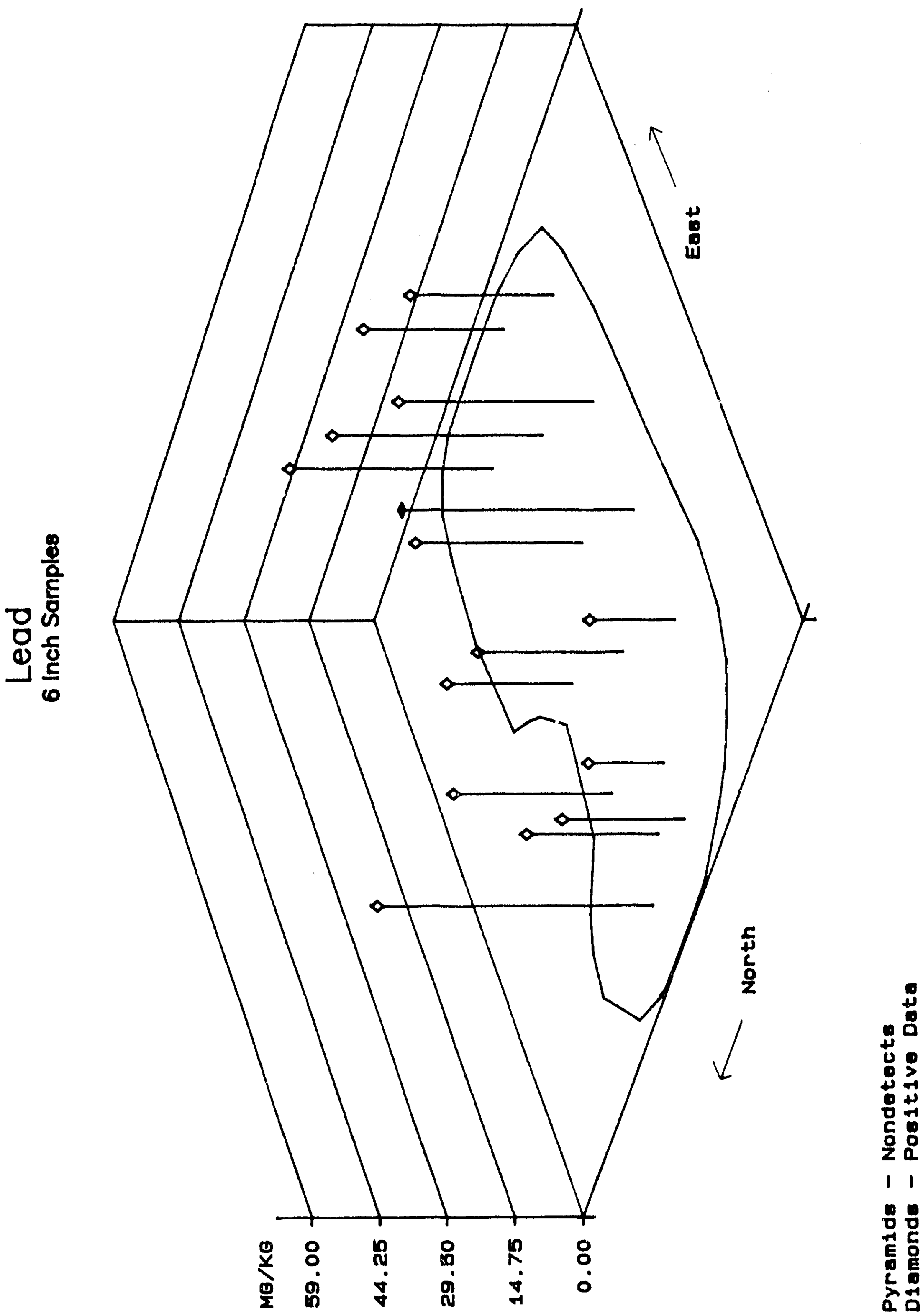
Cobalt
6 Inch Samples

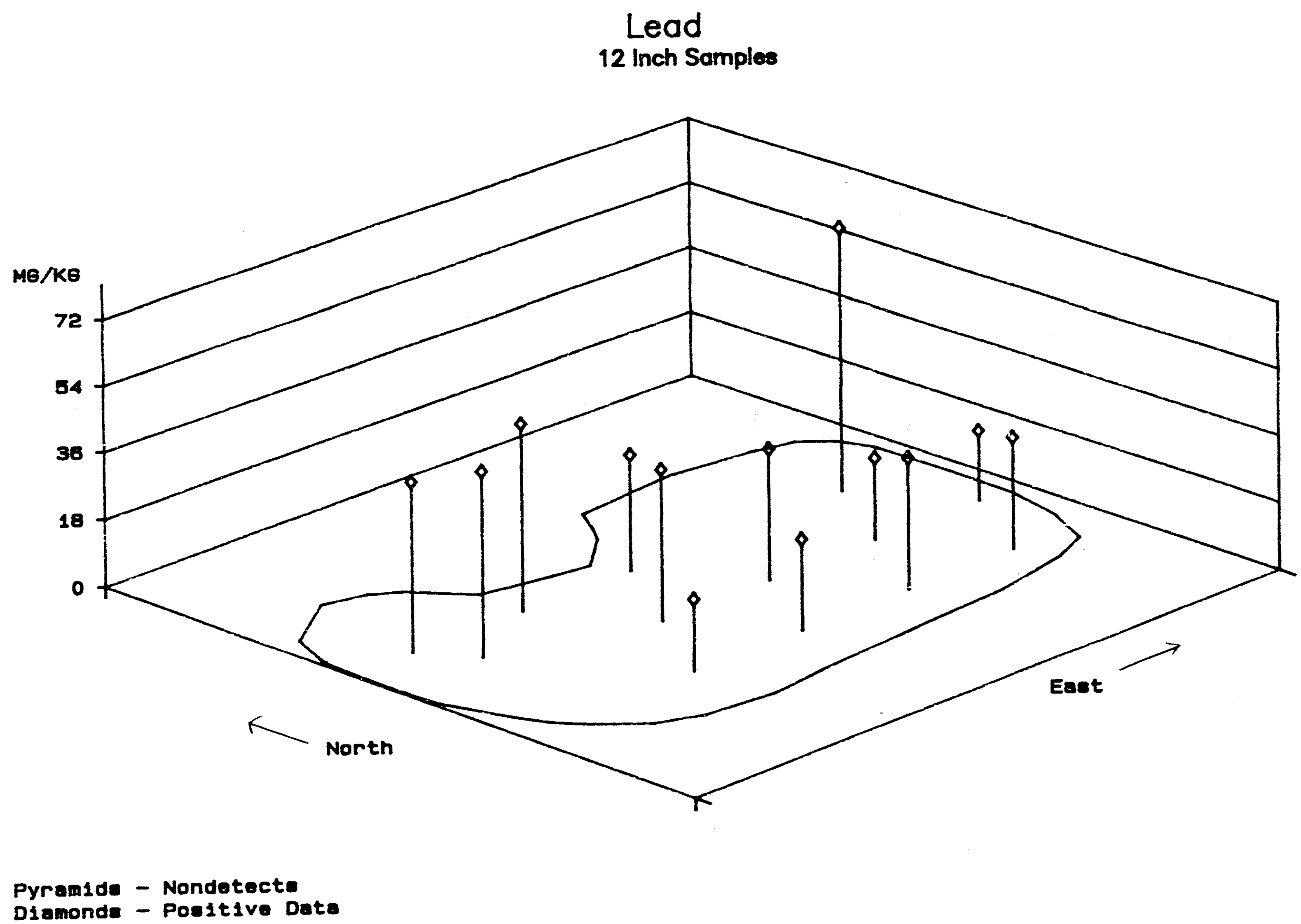


Cobalt
12 Inch Samples

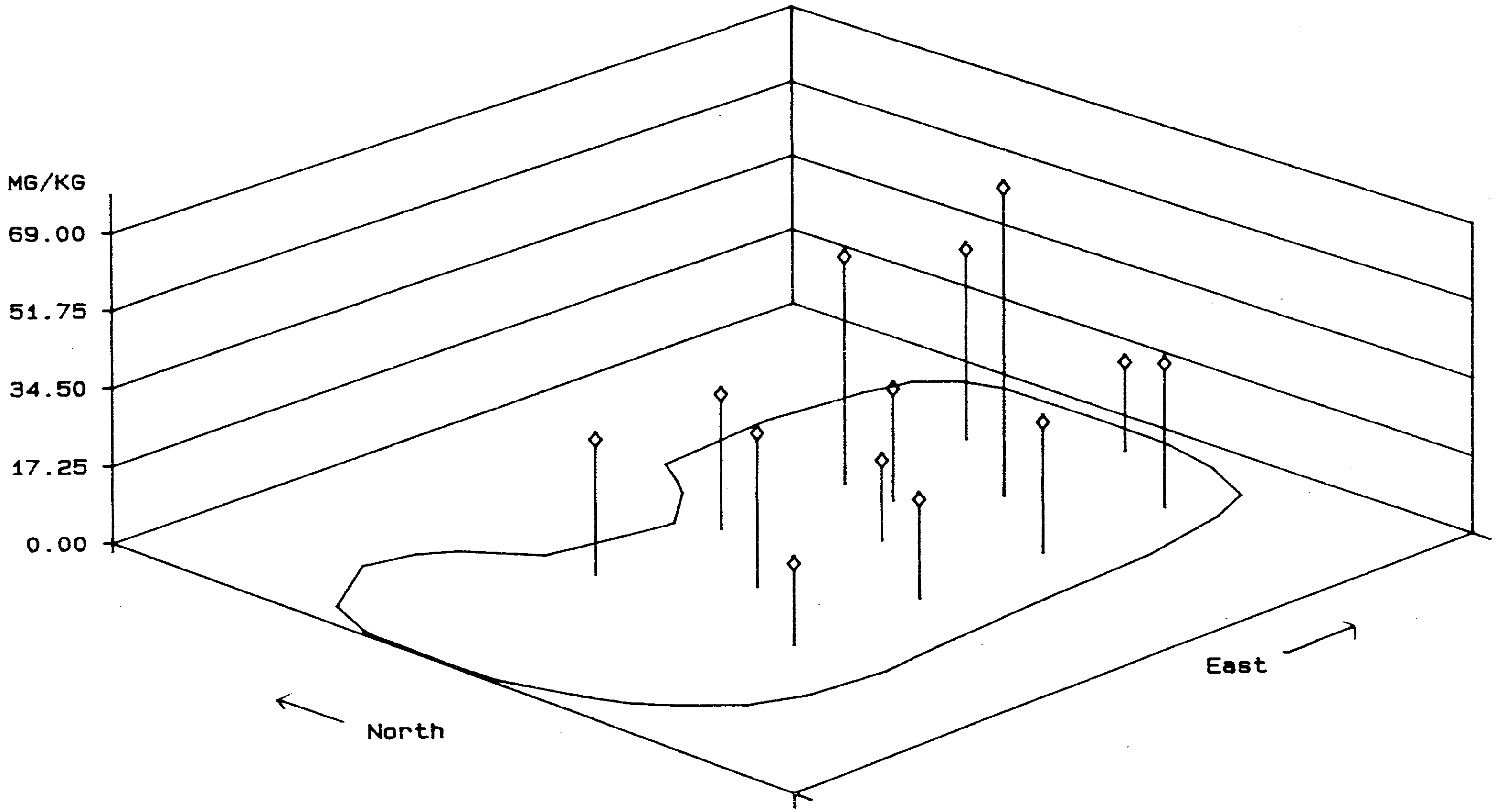



Cobalt
18 Inch Samples
MG/KG
33.00
24.75
16.50
8.25
0.00
East
North
Pyramids - Nondetects
Diamonds - Positive Data

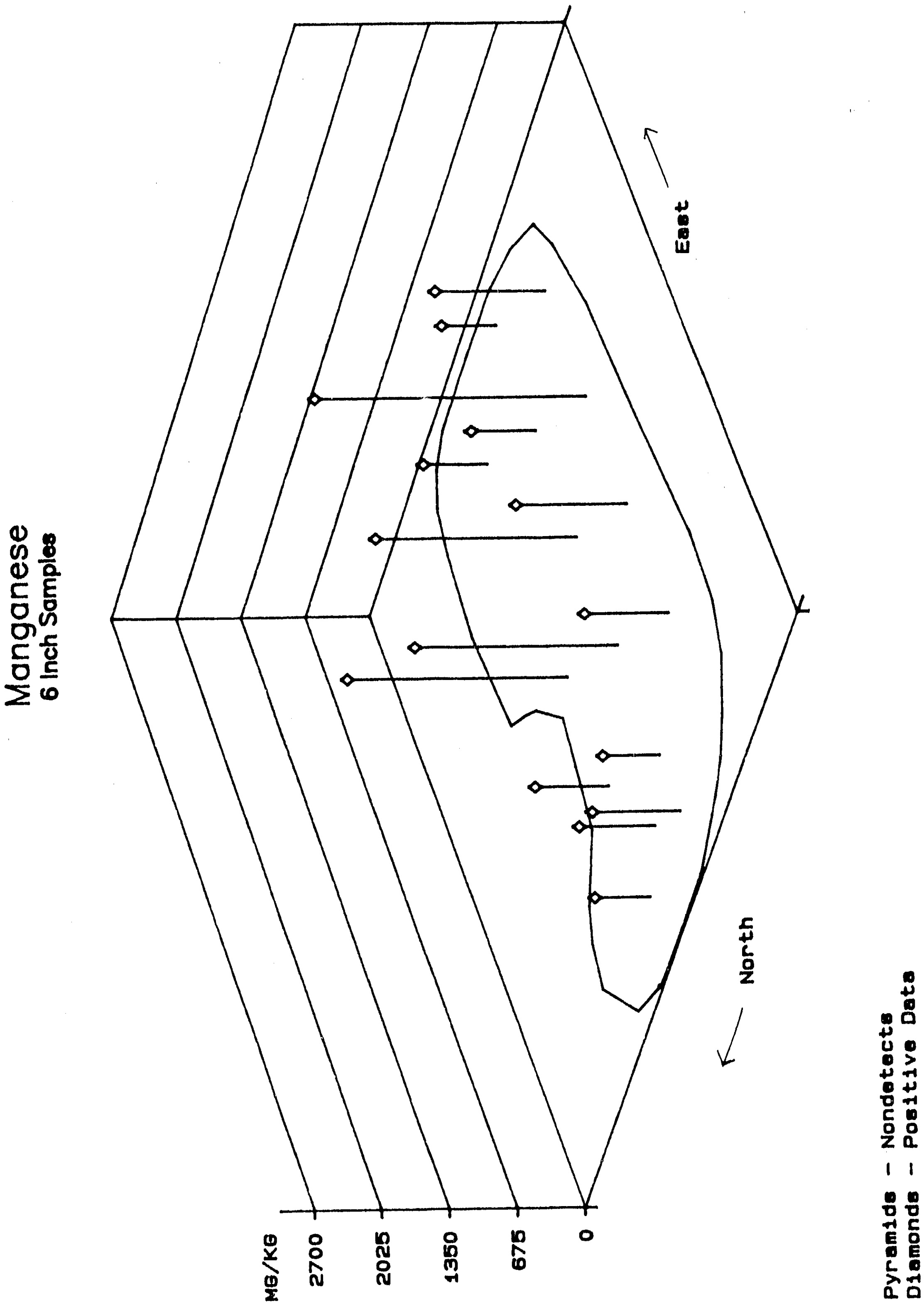

Lead
6 Inch Samples
MG/KG
59.00
44.25
29.50
14.75
0.00
East
North
Pyramids - Nondetects
Diamonds - Positive Data


Lead
12 Inch Samples
MG/KG
72
54
36
18
0
North
East
Pyramids – Nondetects
Diamonds – Positive Data

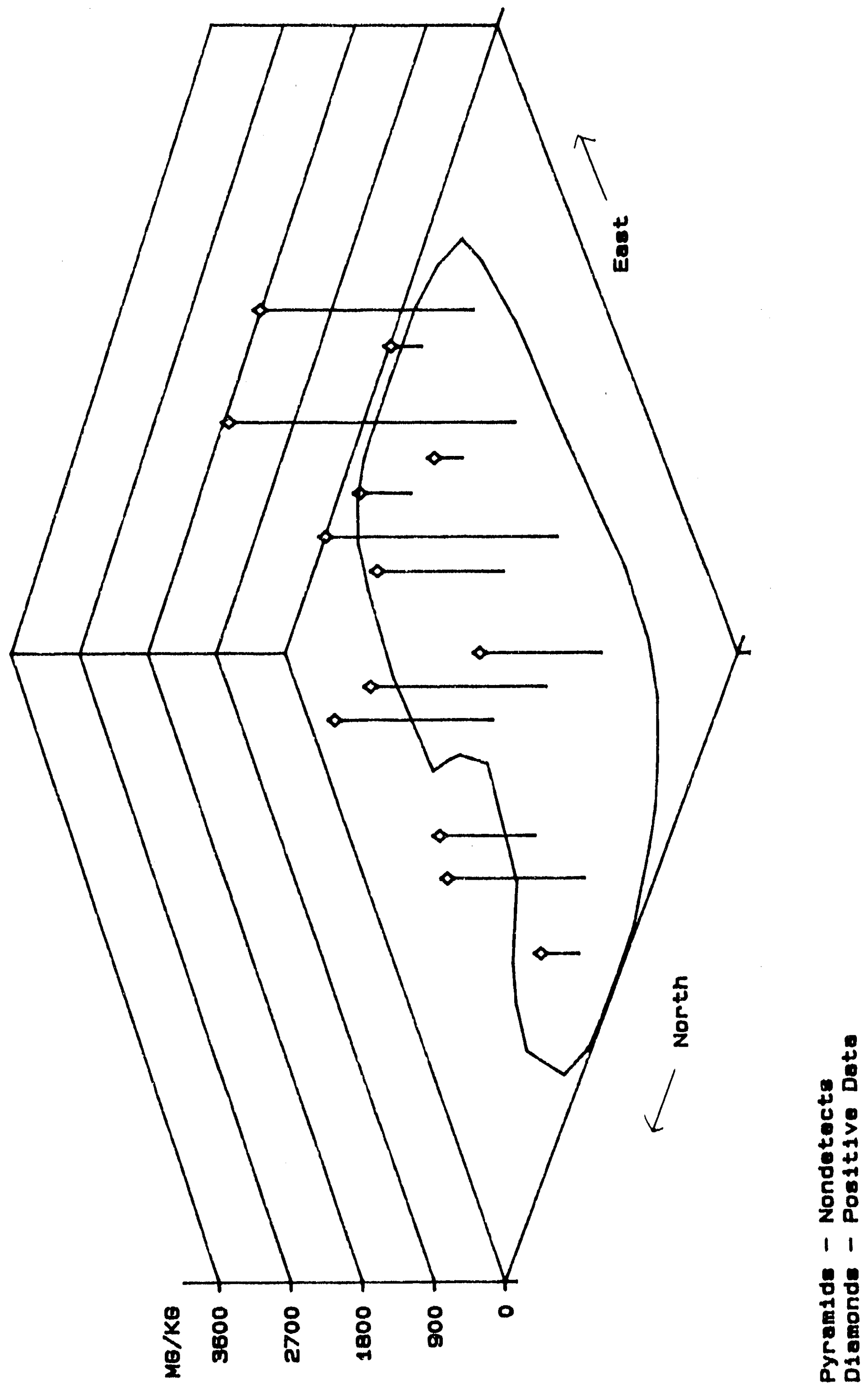
Lead
18 Inch Samples



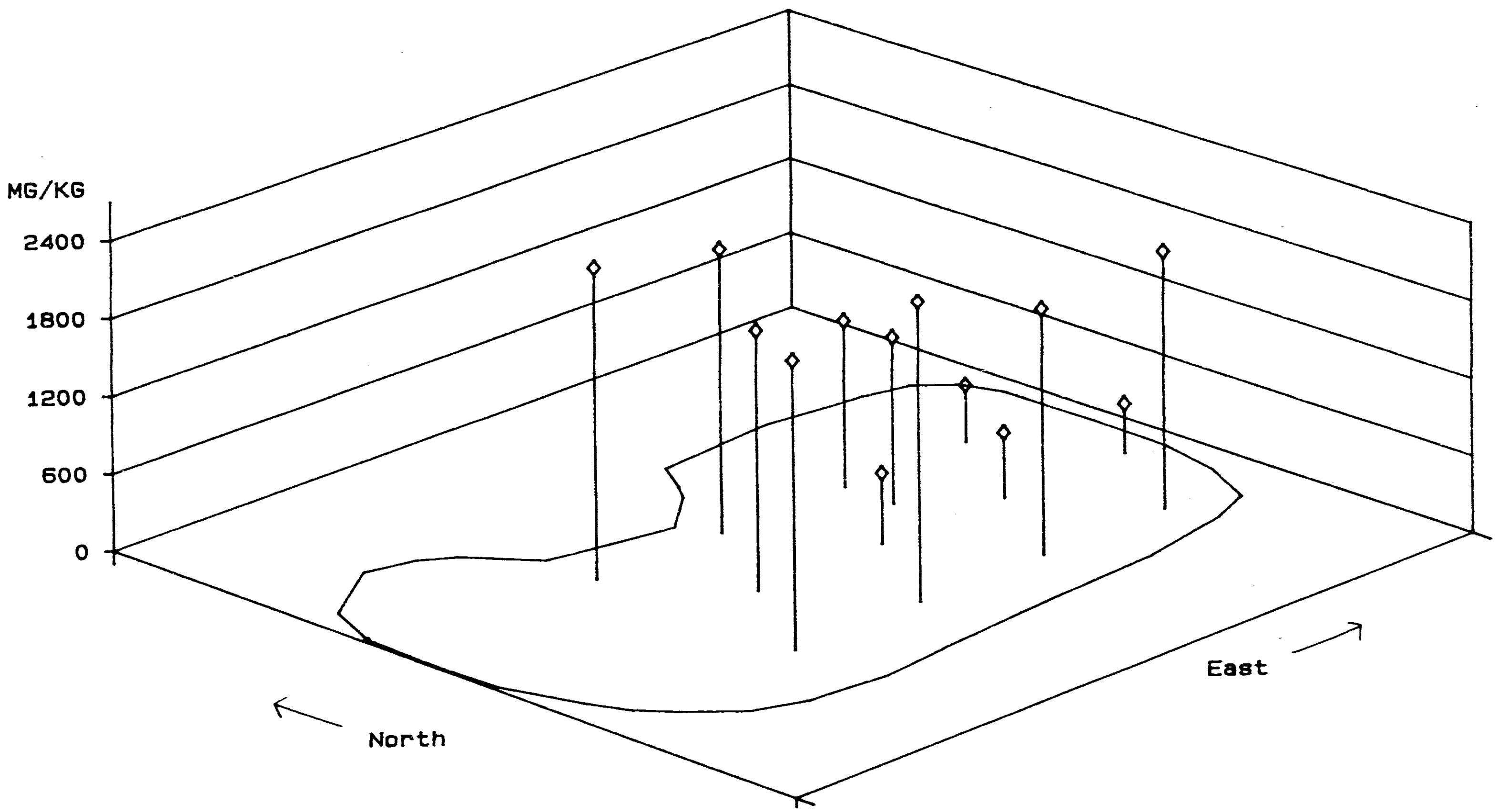
Pyramids - Nondetects
Diamonds - Positive Data


Manganese
6 Inch Samples
East
North
MG/KG
2700
2025
1350
675
0
Pyramids -- Nondetects
Diamonds -- Positive Data

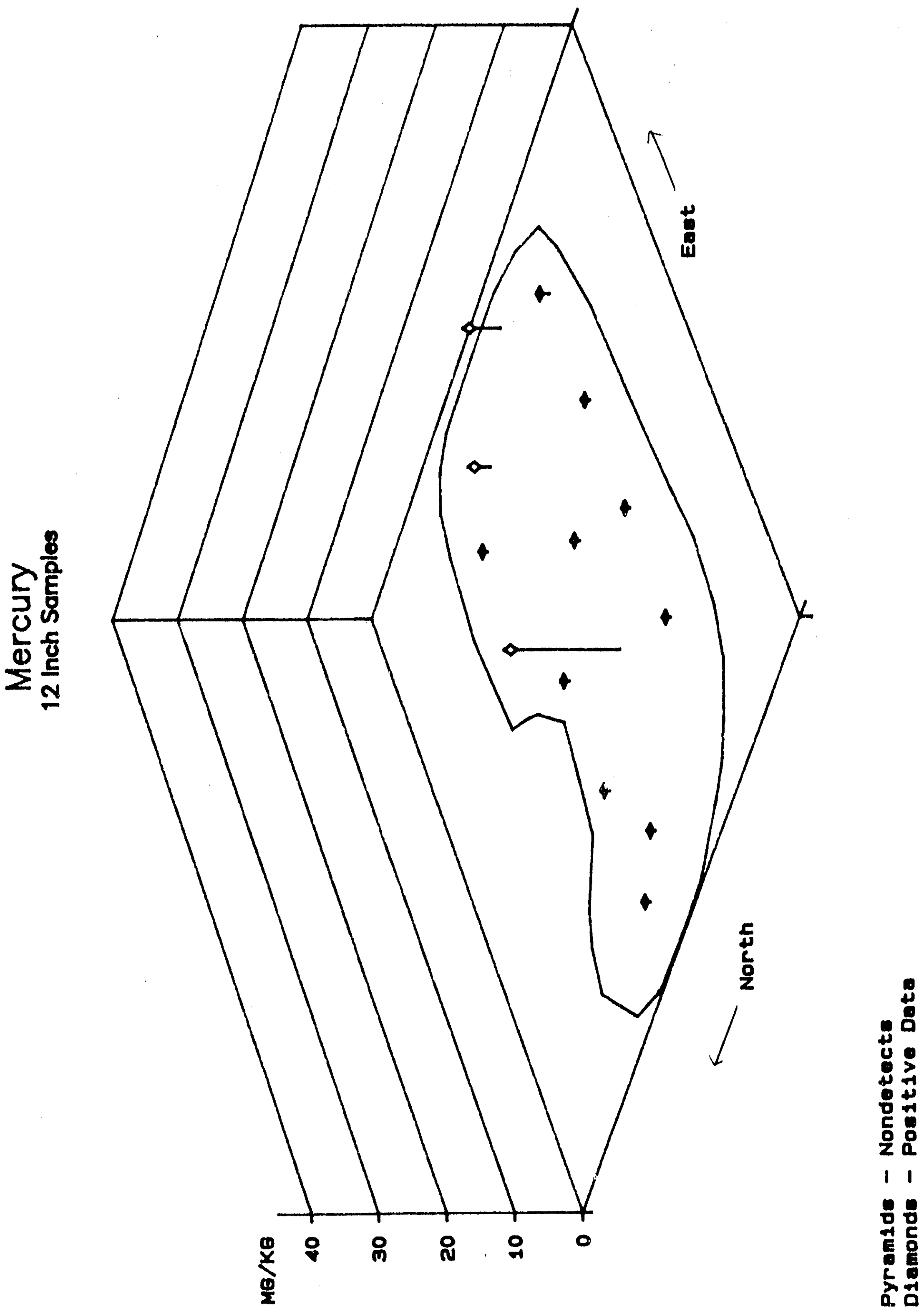
Manganese
12 Inch Samples



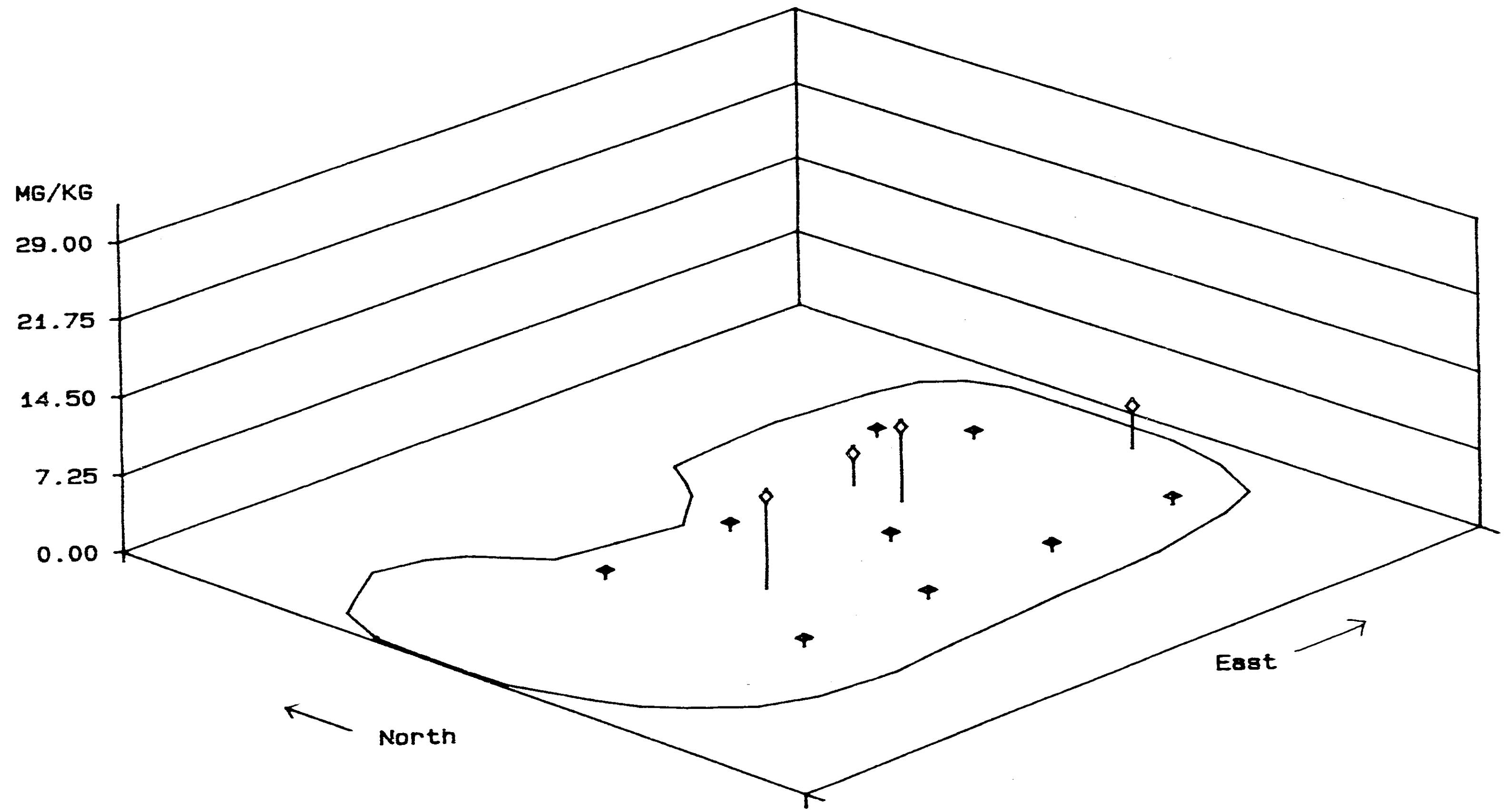
Manganese
18 Inch Samples



Pyramids – Nondetects
Diamonds – Positive Data

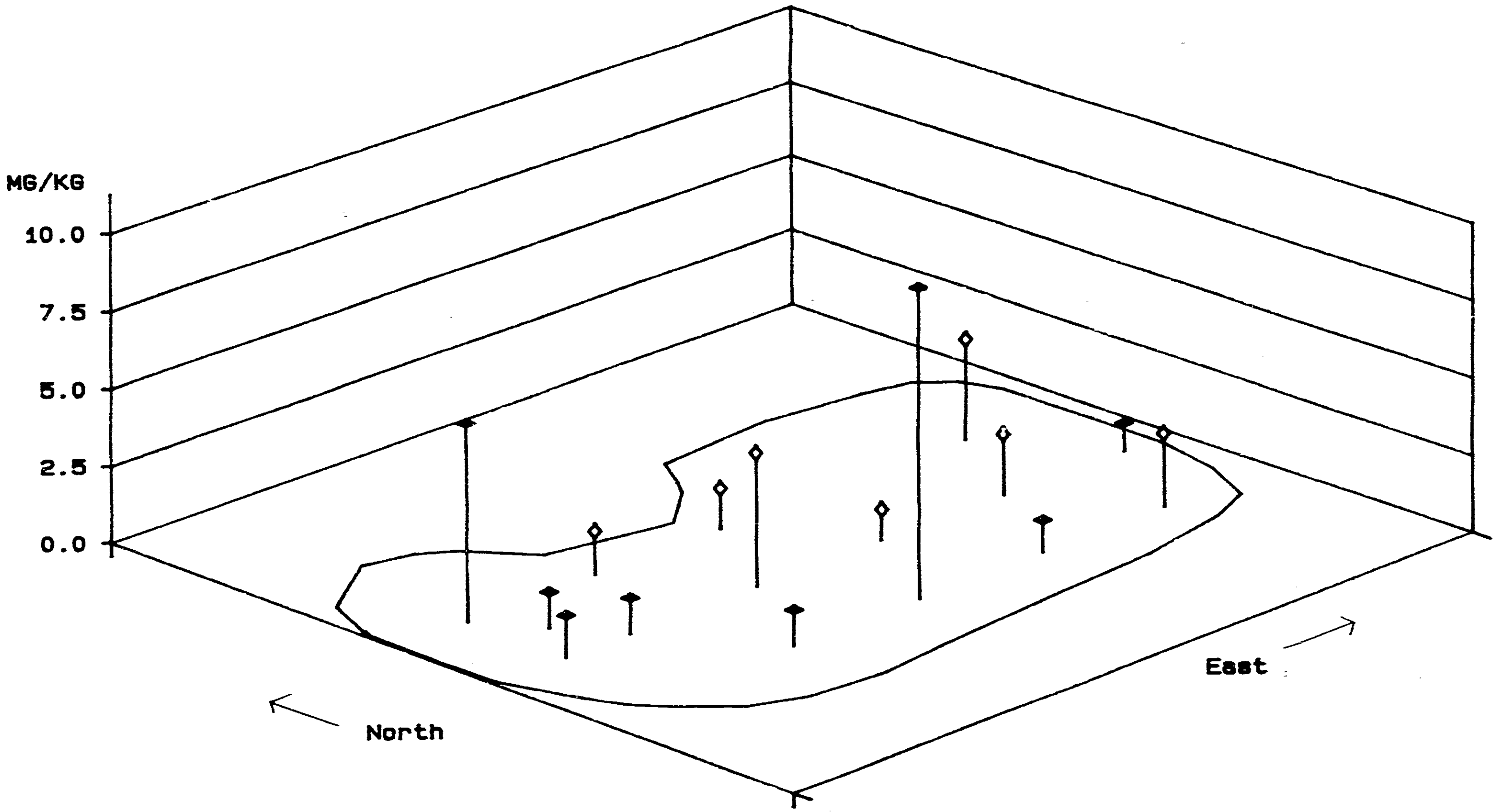

Mercury
12 Inch Samples
MG/KG
40
30
20
10
0
East
North
Pyramids - Nondetects
Diamonds - Positive Data

Mercury
18 Inch Samples



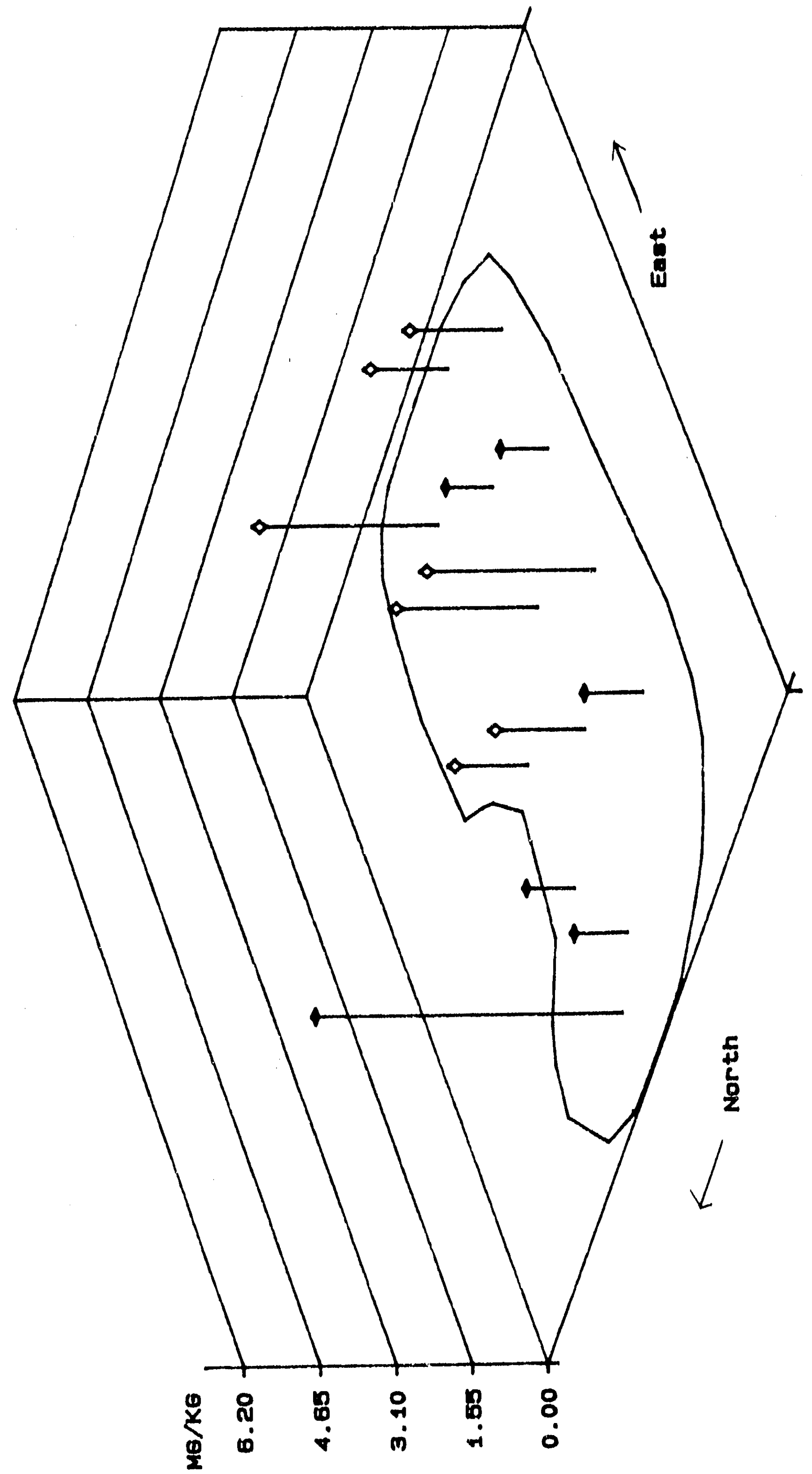
Pyramids – Nondetects
Diamonds – Positive Data

Molybdenum
6 Inch Samples



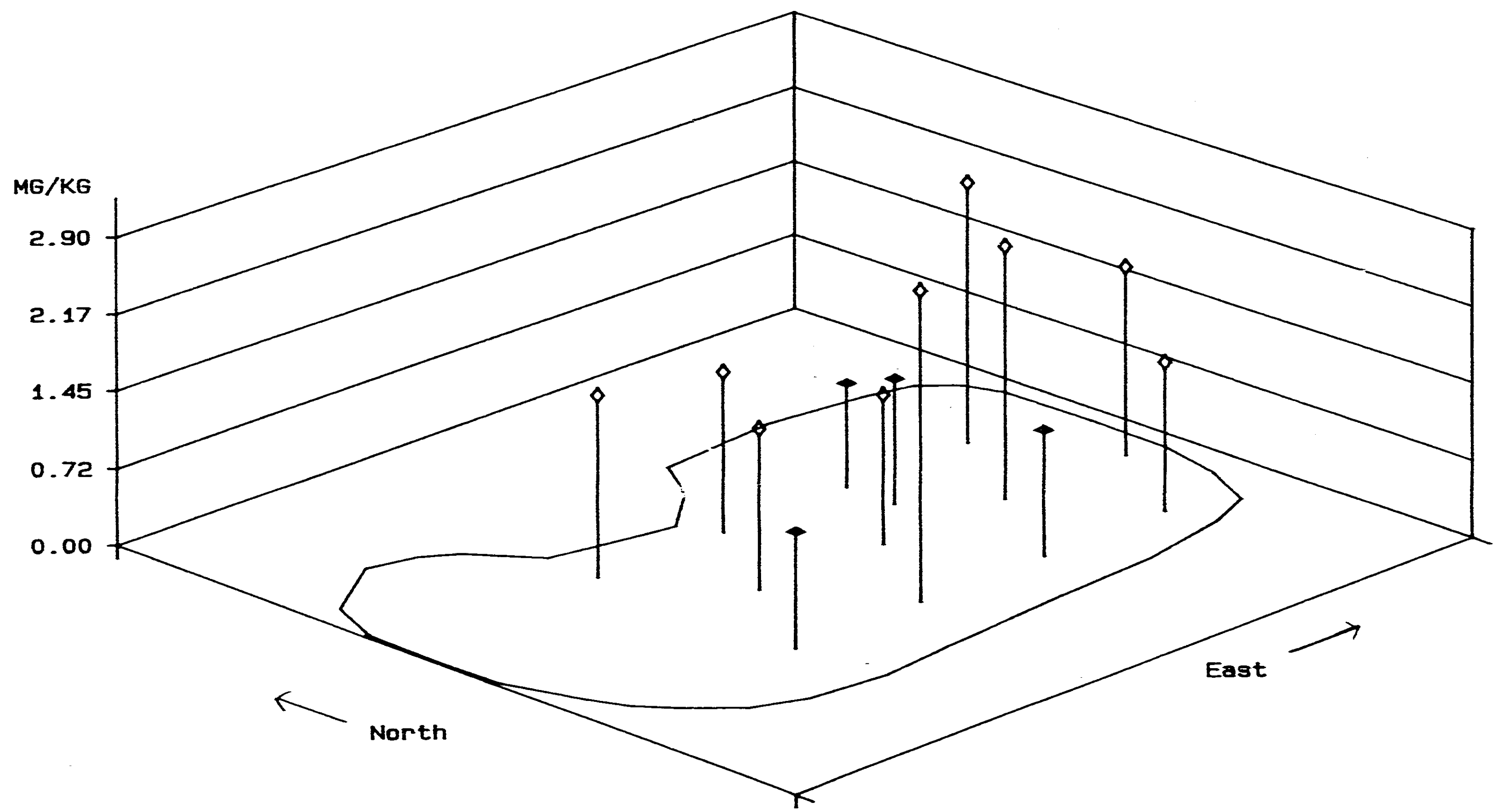
Pyramids – Nondetects
Diamonds – Positive Data

Molybdenum
12 Inch Samples



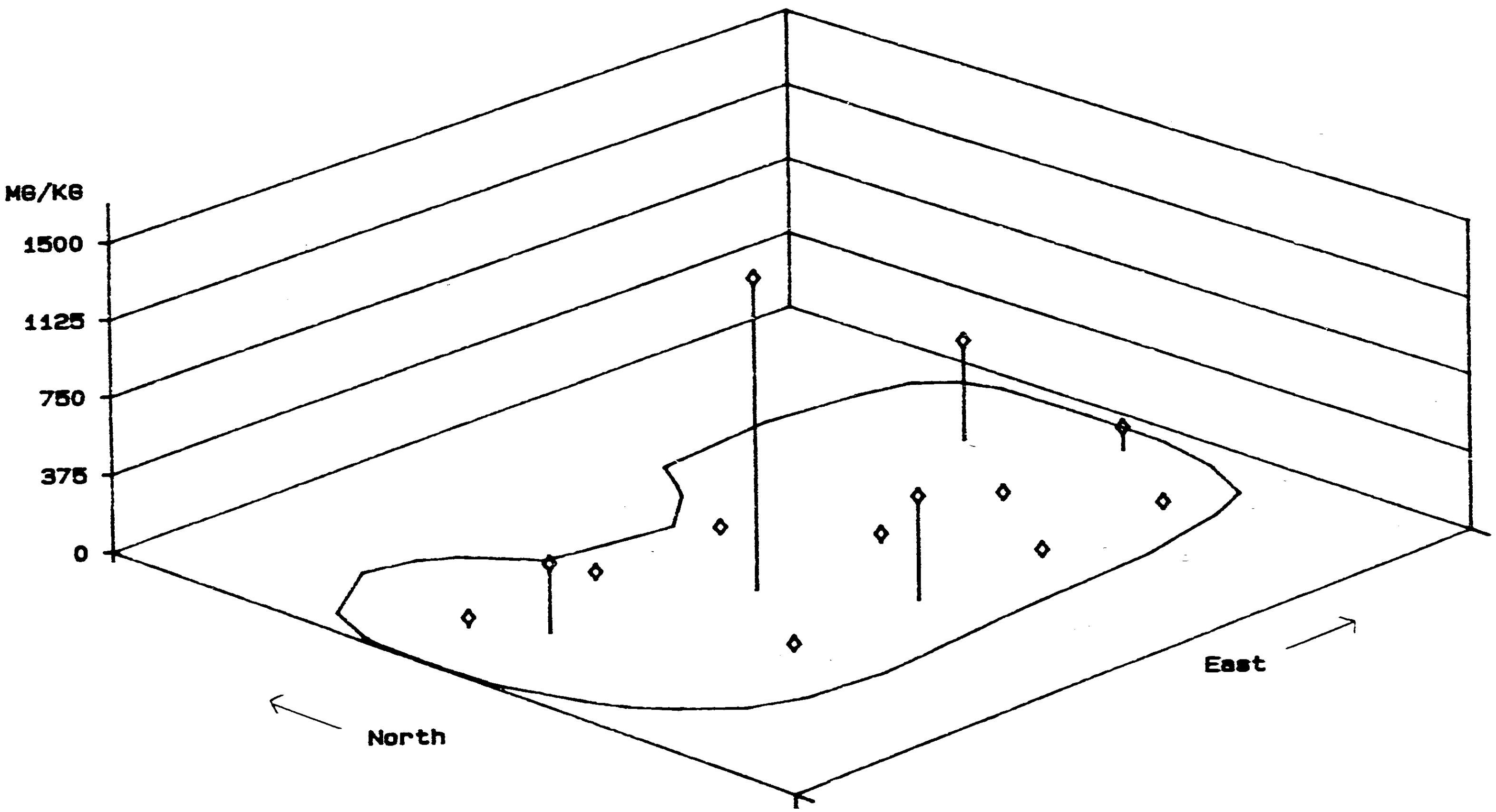
Pyramids - Nondetects
Diamonds - Positive Data

Molybdenum
18 Inch Samples



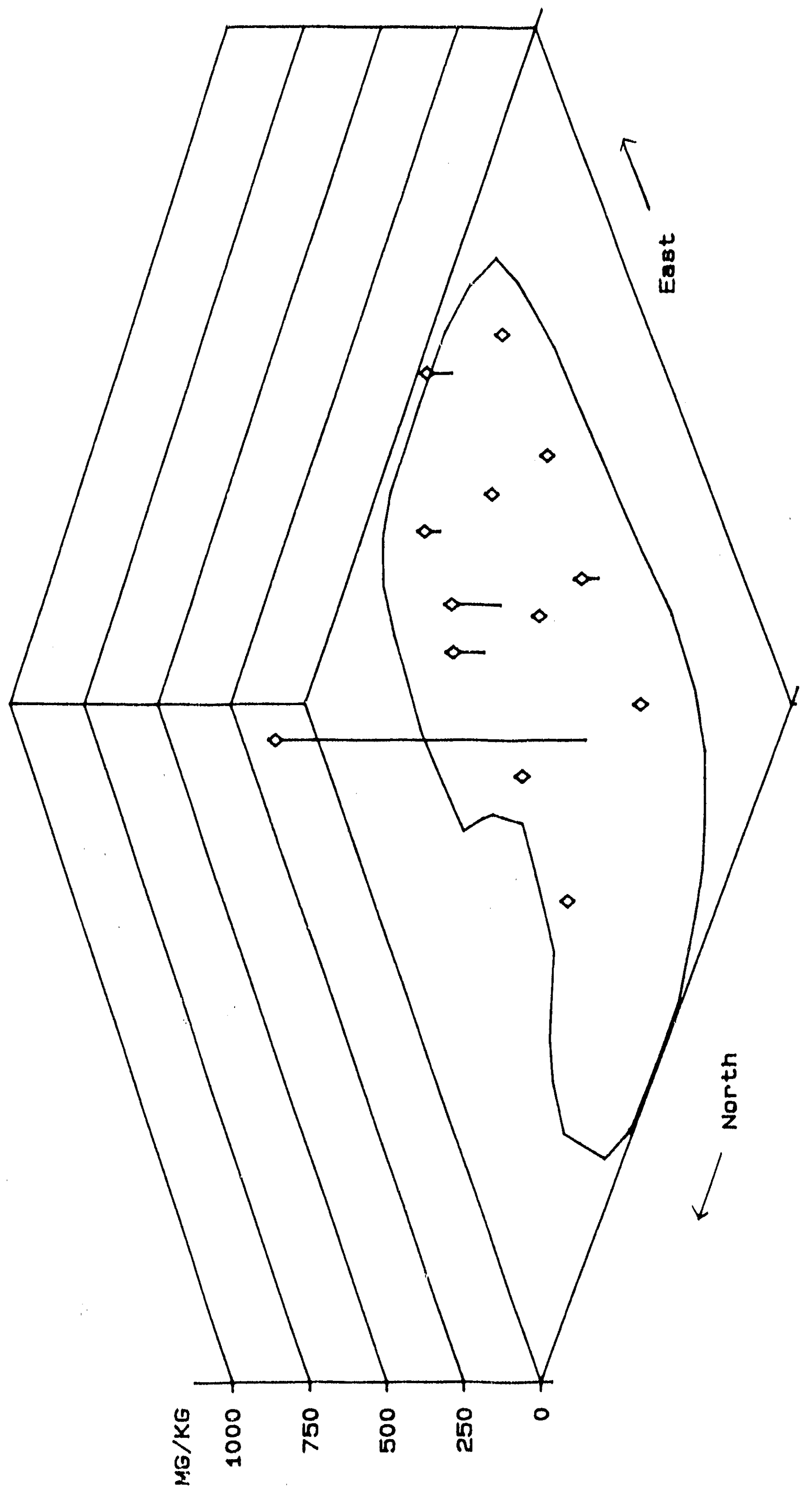
Pyramids – Nondetects
Diamonds – Positive Data

Nickel
12 Inch Samples



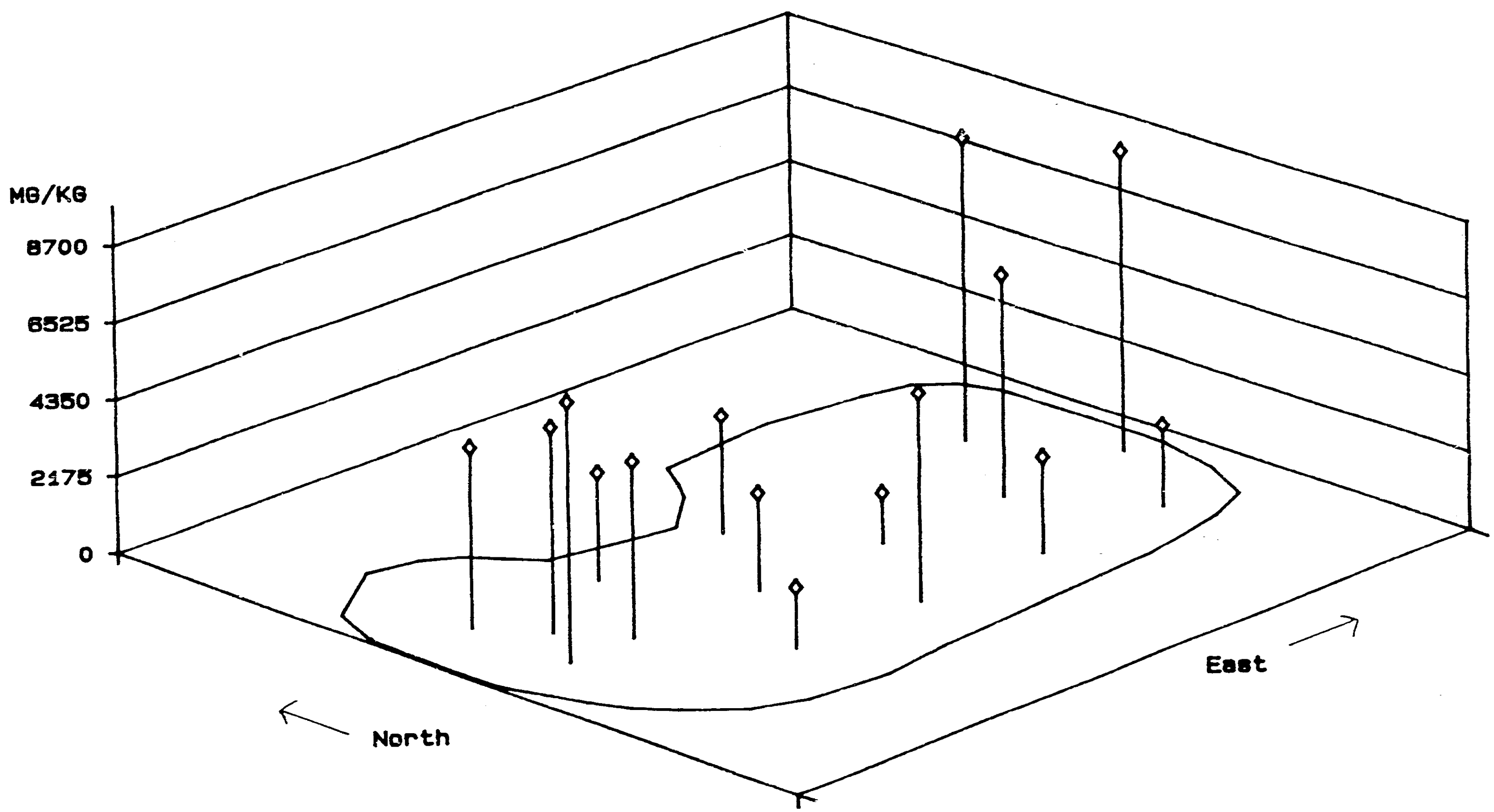
Pyramids – Nondetects
Diamonds – Positive Data

Nickel
18 Inch Samples



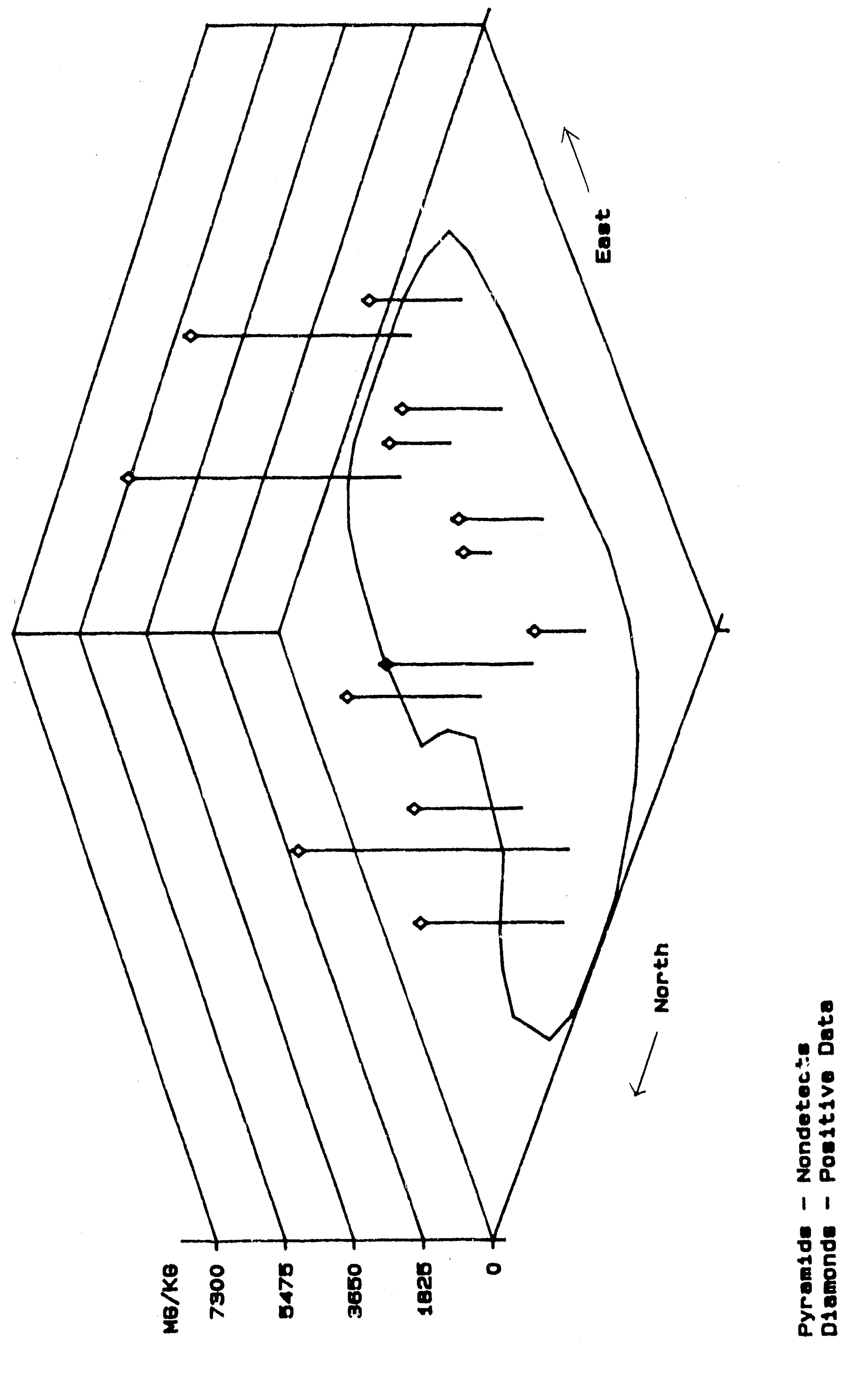
Pyramids - Nondetects
Diamonds - Positive Data

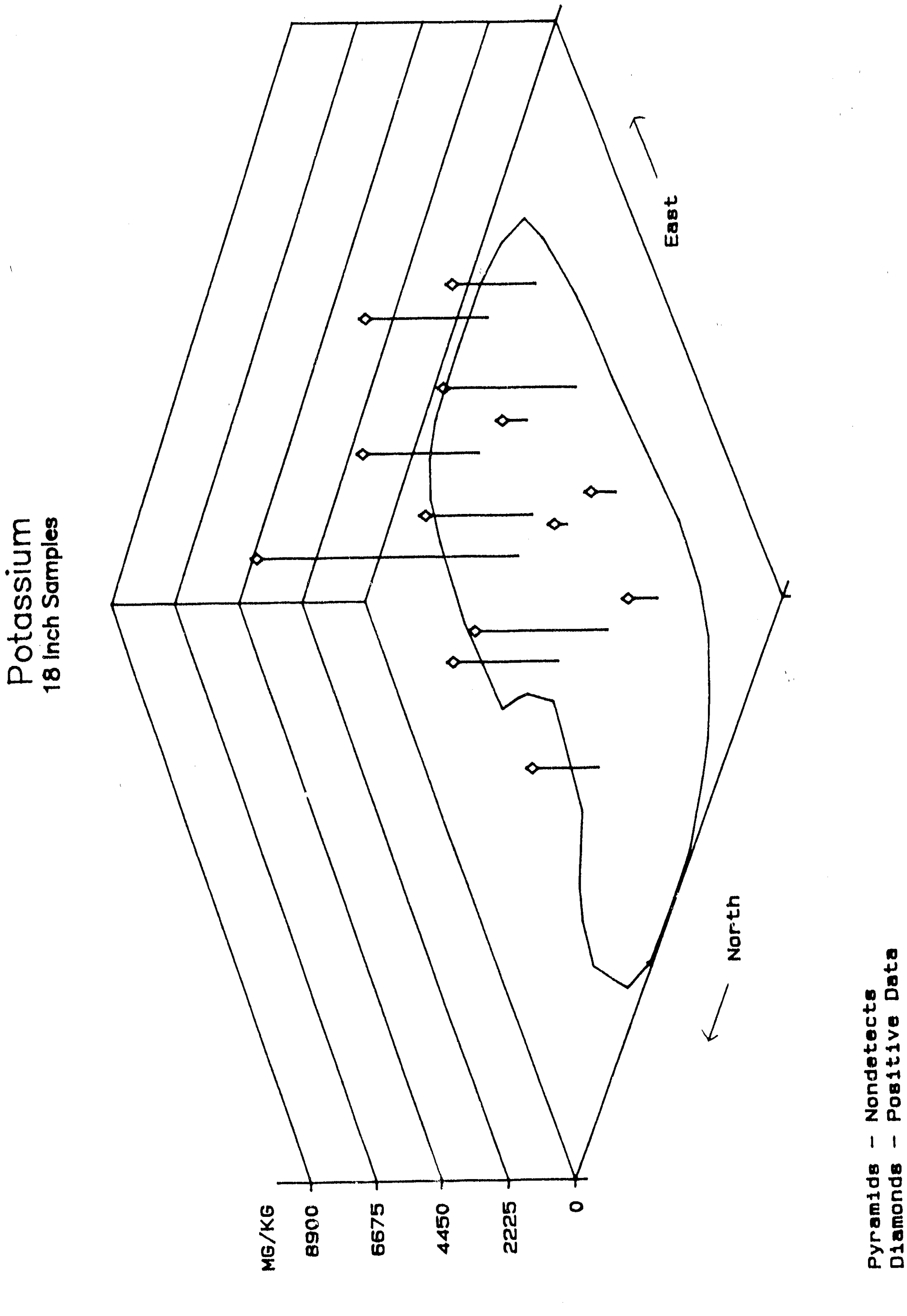
Potassium
6 Inch Samples



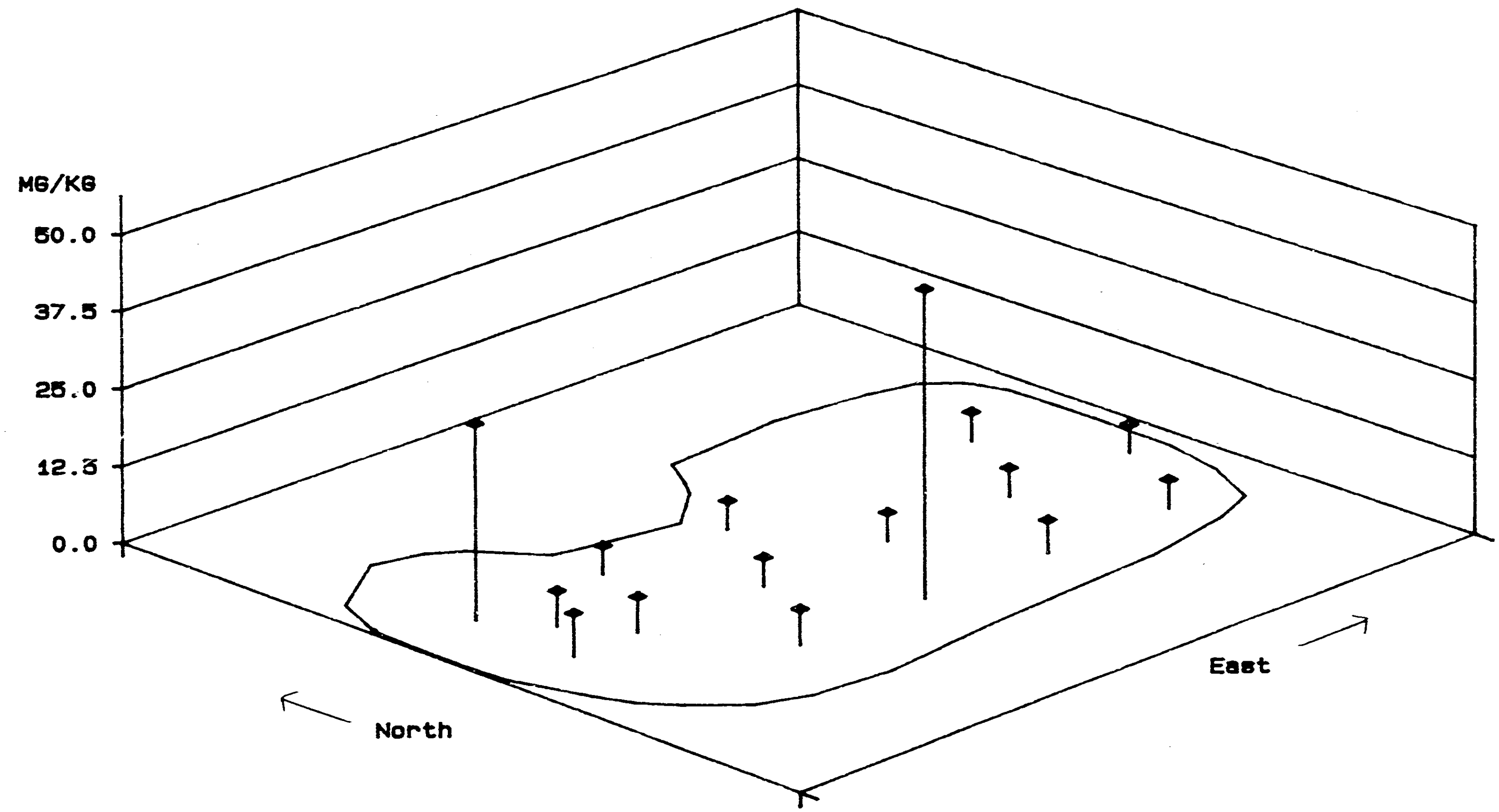
Pyramids – Nondetects
Diamonds – Positive Data

Potassium
12 Inch Samples

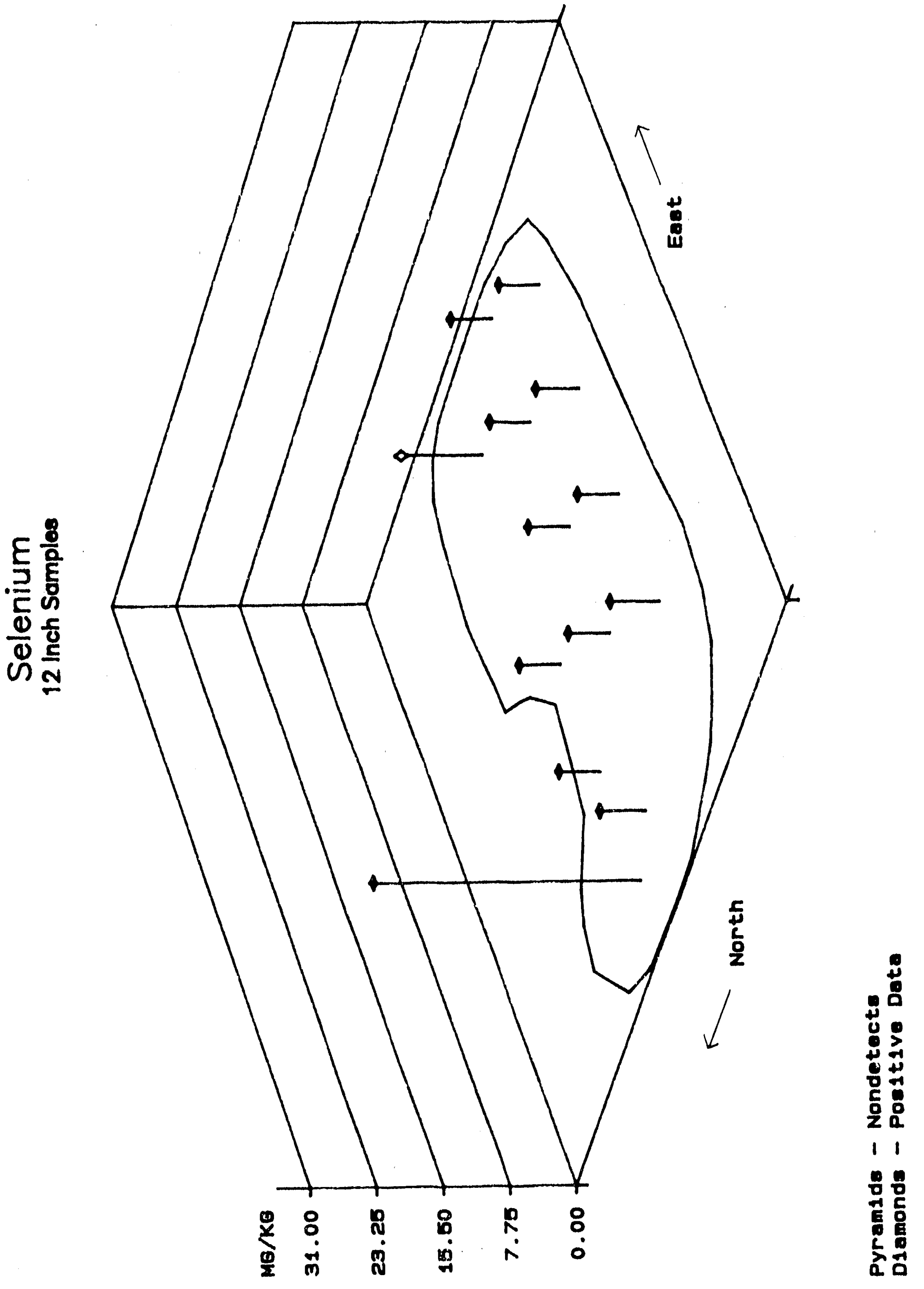


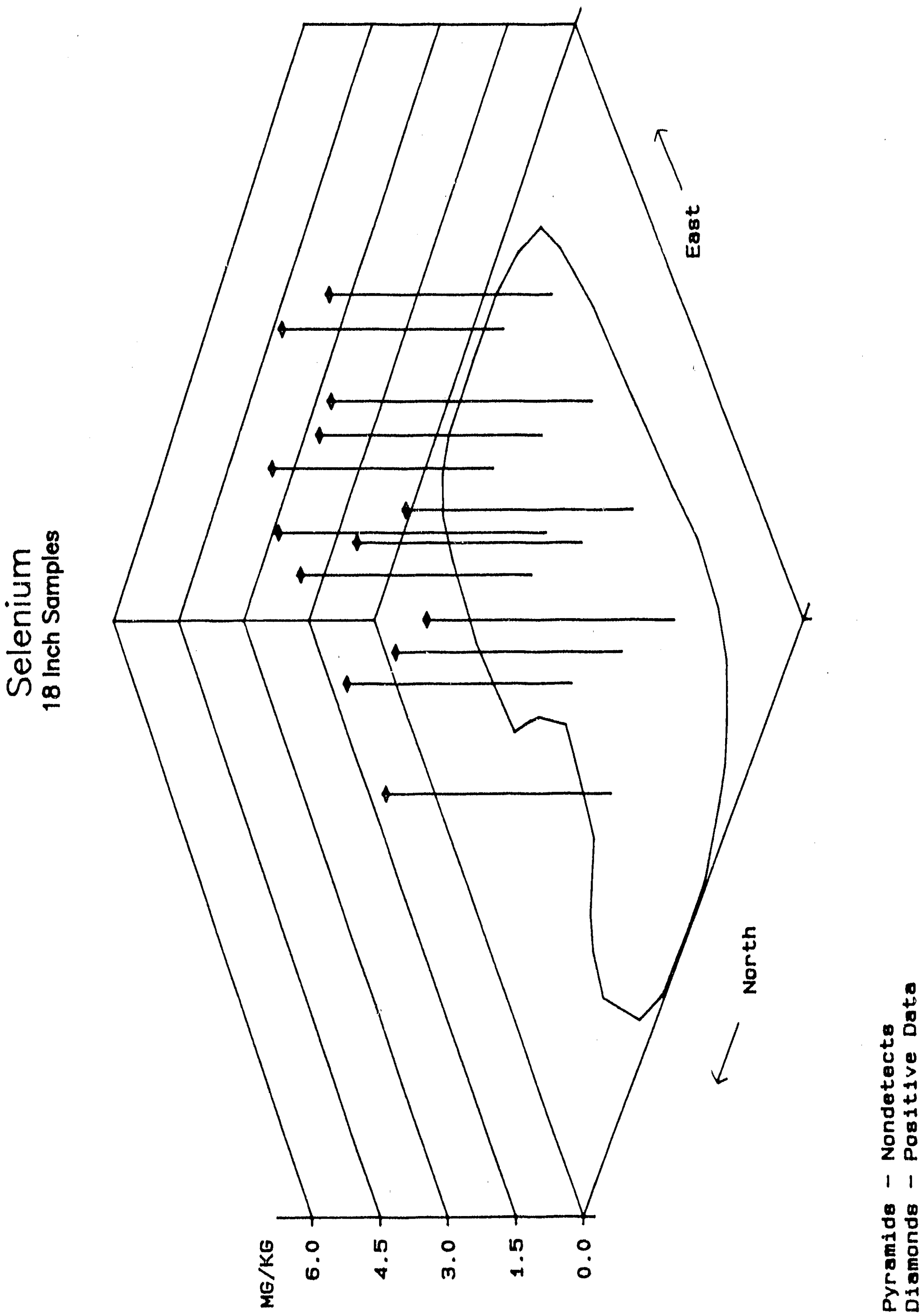

Potassium
18 Inch Samples
MG/KG
8900
6675
4450
2225
0
East
North
Pyramids - Nondetects
Diamonds - Positive Data

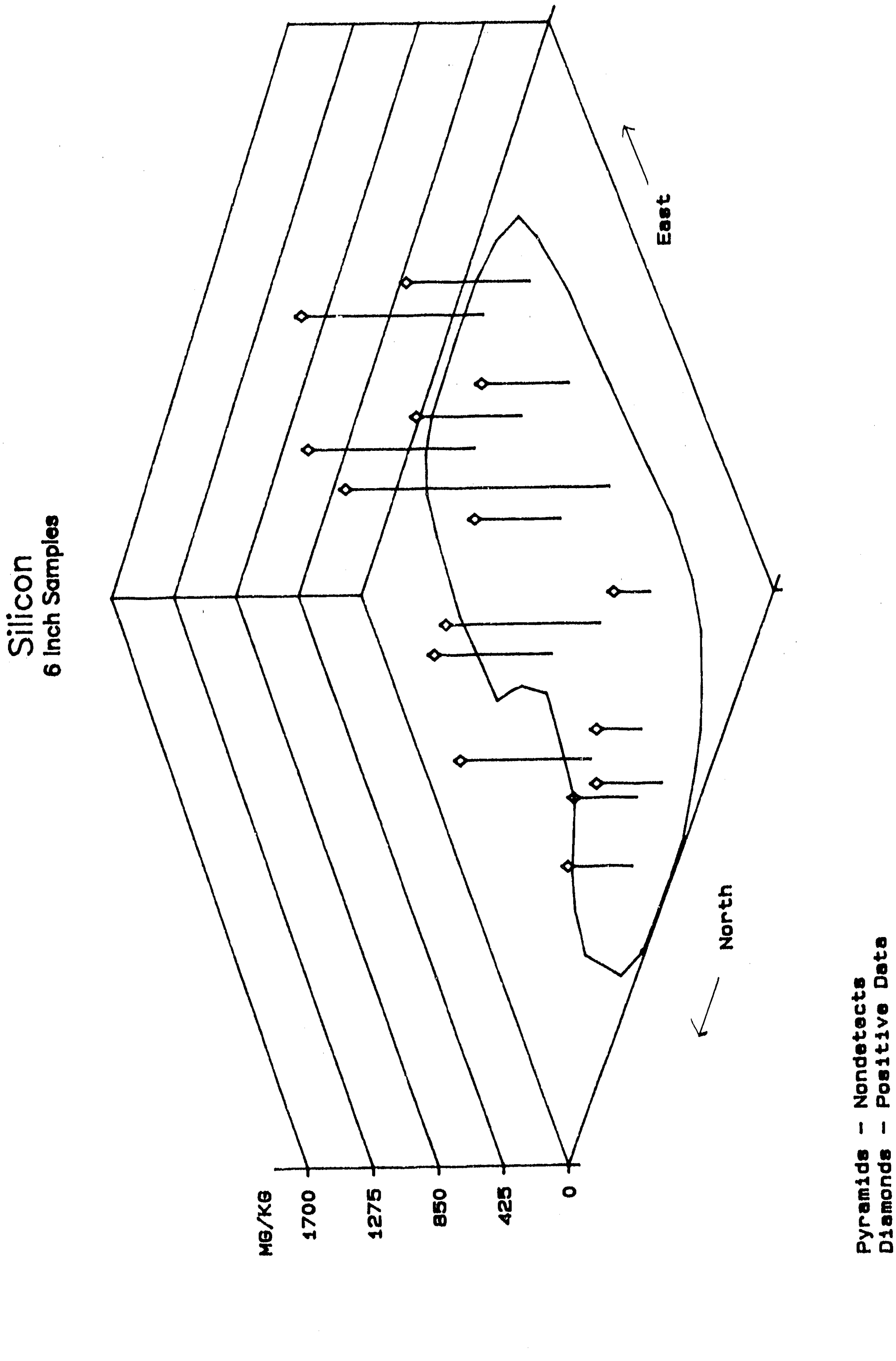
Selenium
6 Inch Samples



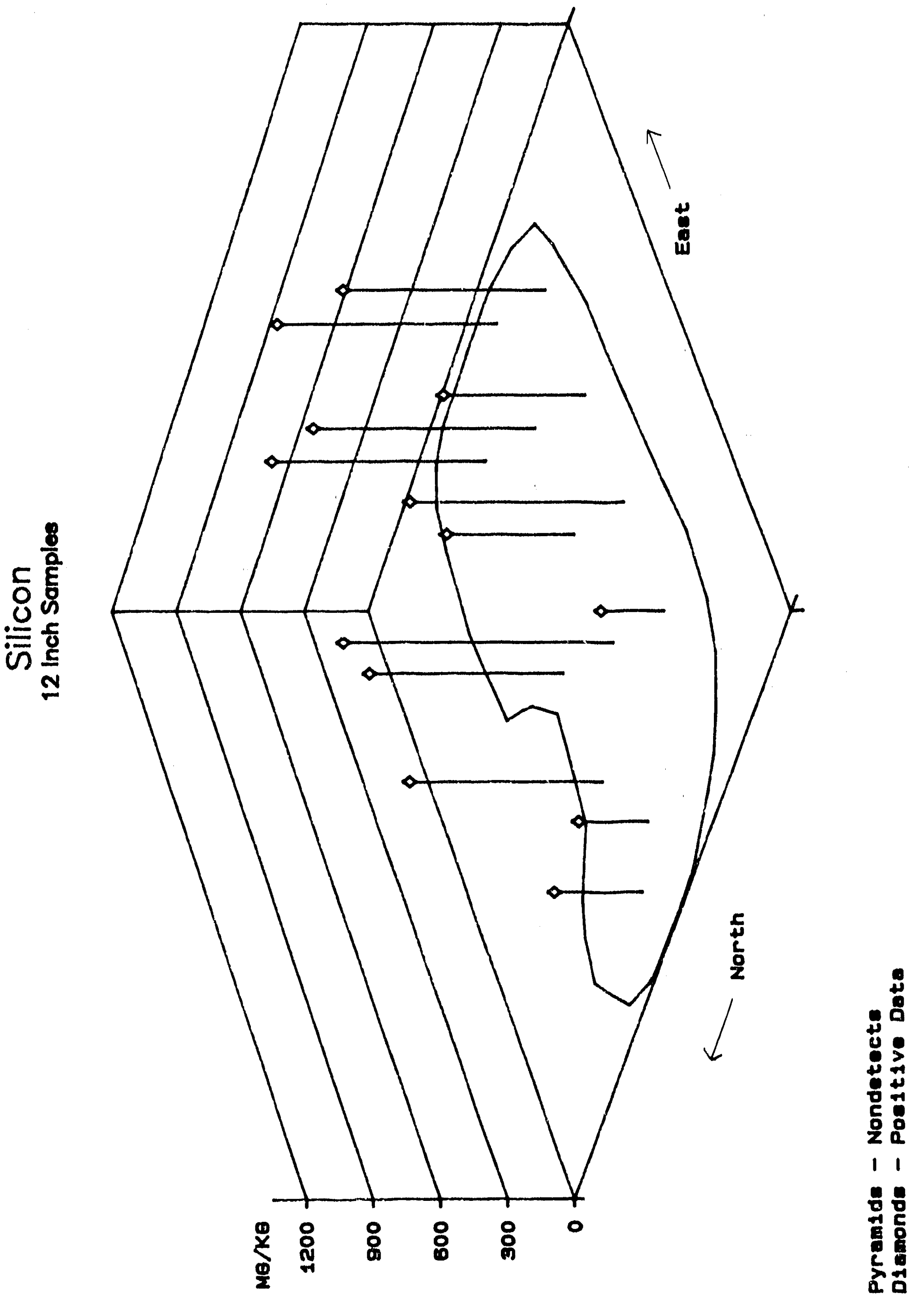
Pyramids - Nondetects
Diamonds - Positive Data


Selenium
12 Inch Samples
MG/KG
31.00
23.25
15.50
7.75
0.00
East
North
Pyramids -- Nondetects
Diamonds -- Positive Data

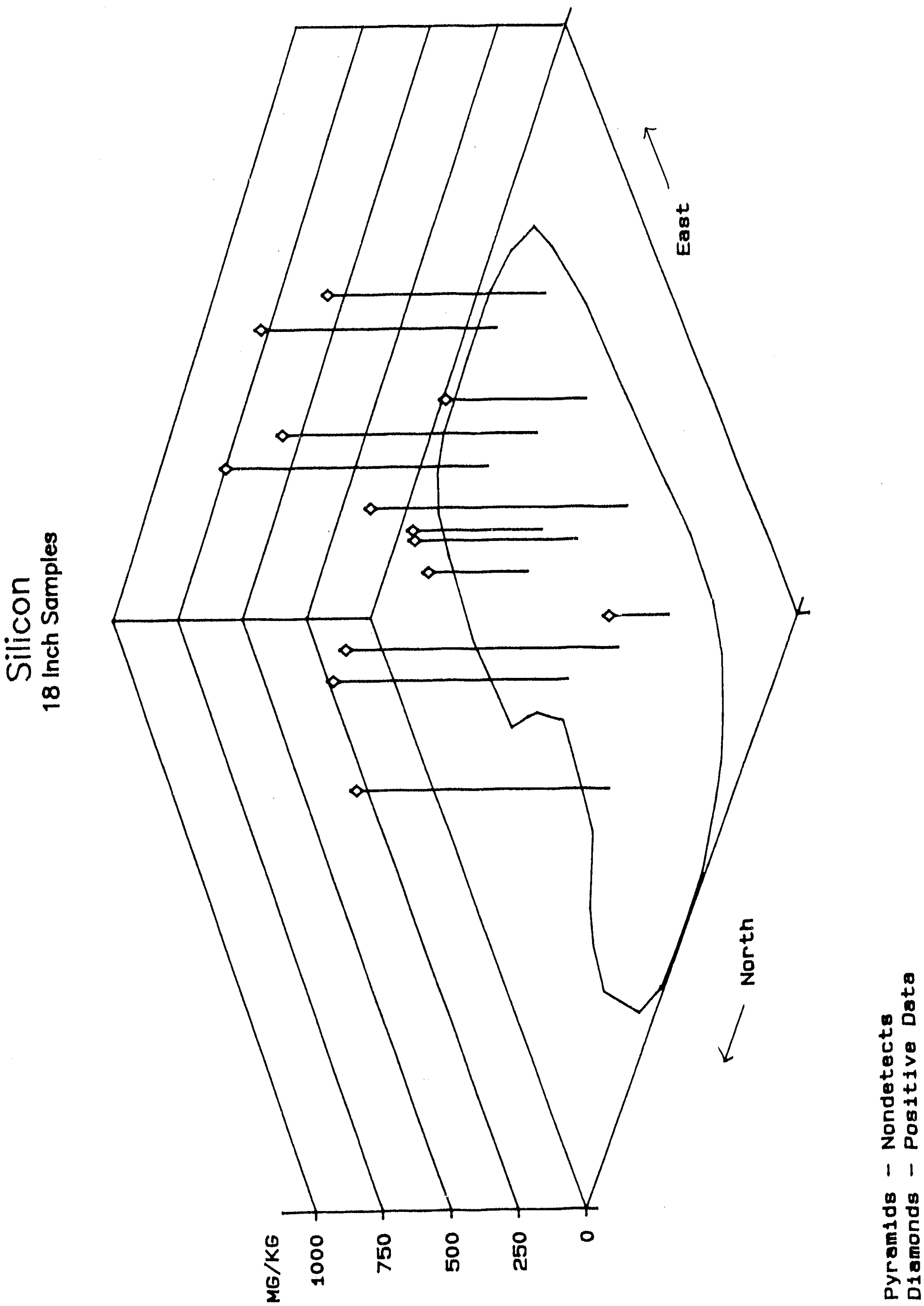

Selenium
18 Inch Samples
MG/KG
6.0
4.5
3.0
1.5
0.0
East
North
Pyramids - Nondetects
Diamonds - Positive Data



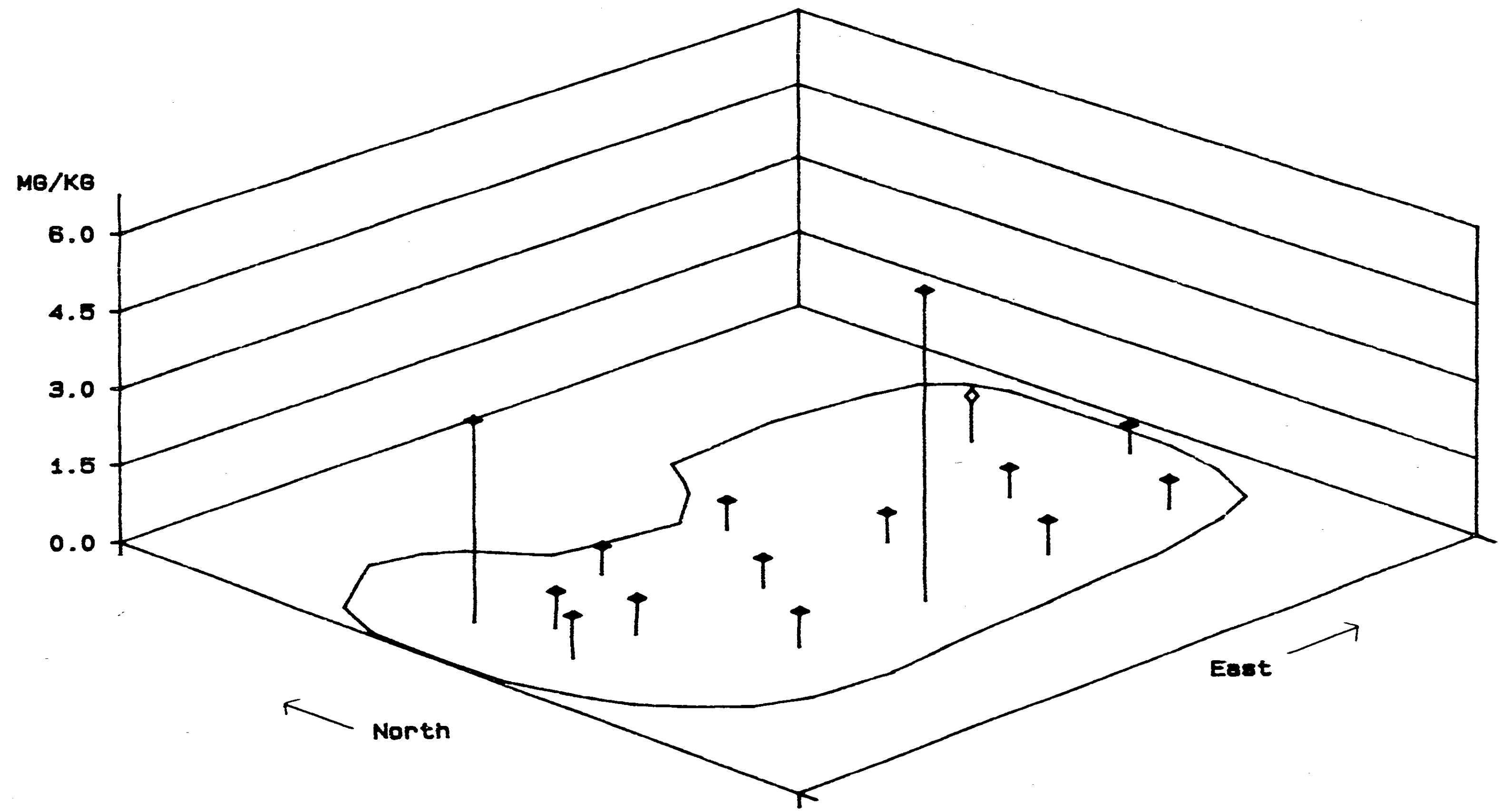
Silicon
6 Inch Samples
East
North
MG/KG
1700
1275
850
425
0
Pyramids - Nondetects
Diamonds - Positive Data



Silicon
12 Inch Samples
MG/KG
1200
900
600
300
0
East
North
Pyramids - Nondetects
Diamonds - Positive Data

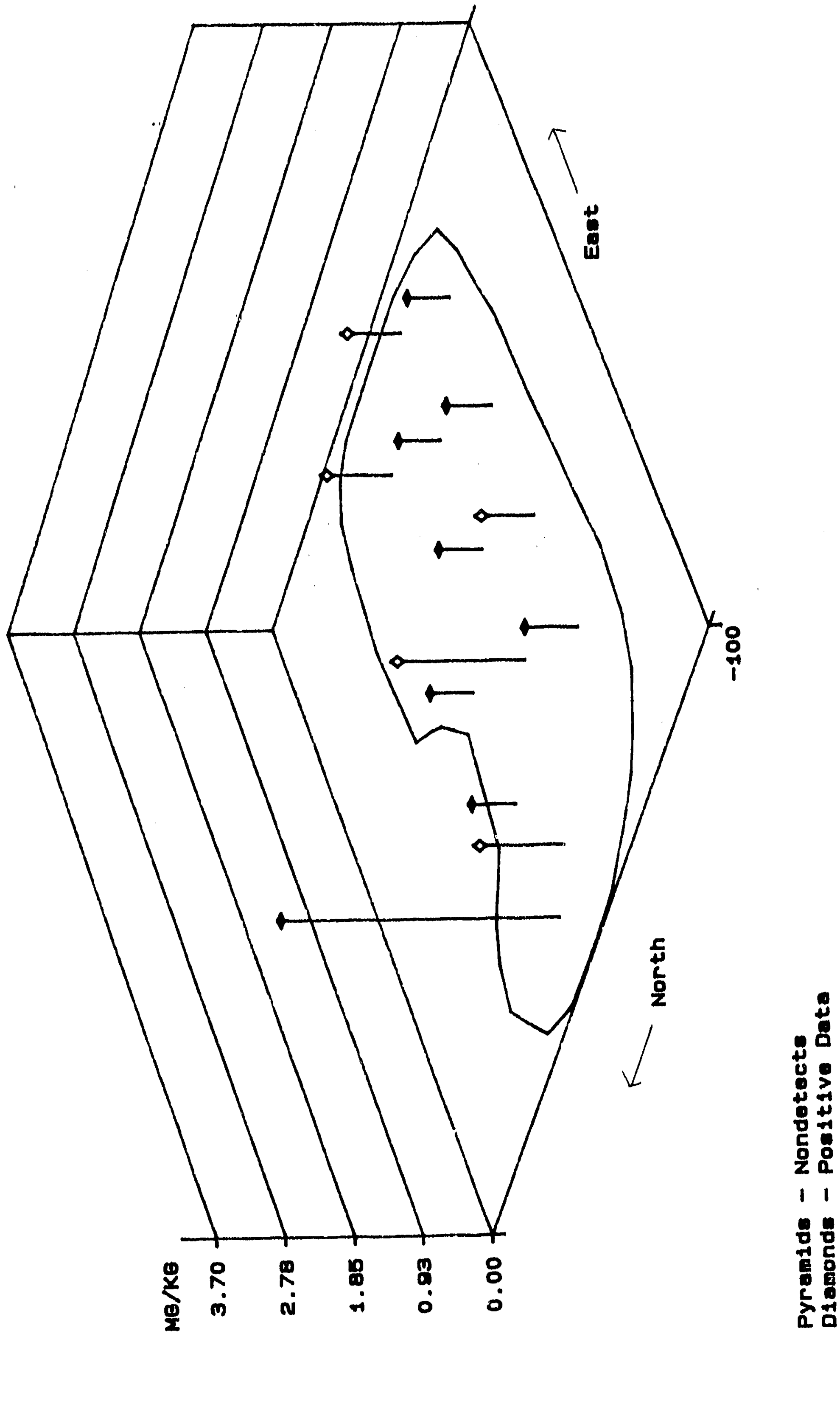

Silicon
18 Inch Samples
East
North
MG/KG
1000
750
500
250
0
Pyramids - Nondetects
Diamonds - Positive Data

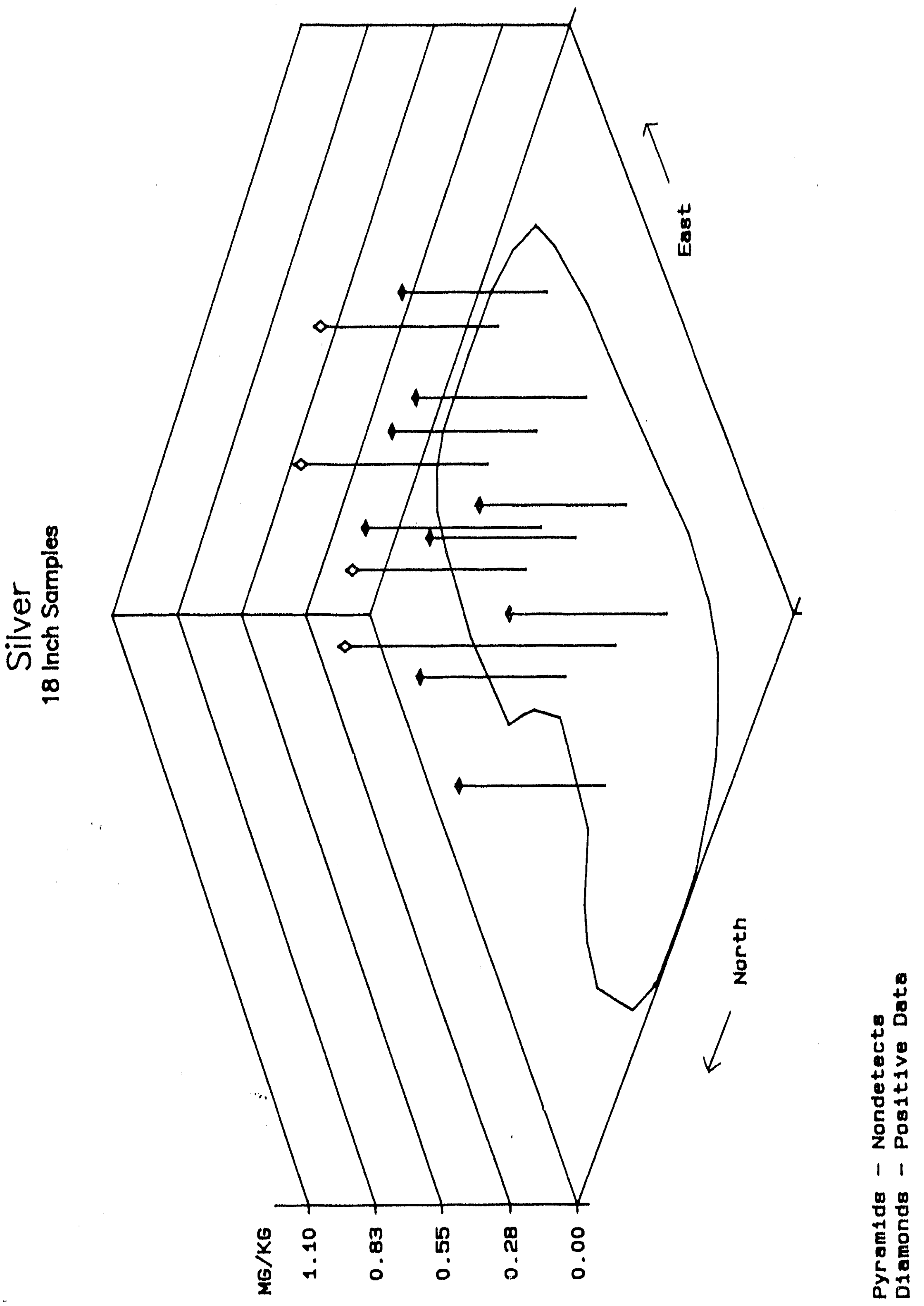
Silver
6 Inch Samples



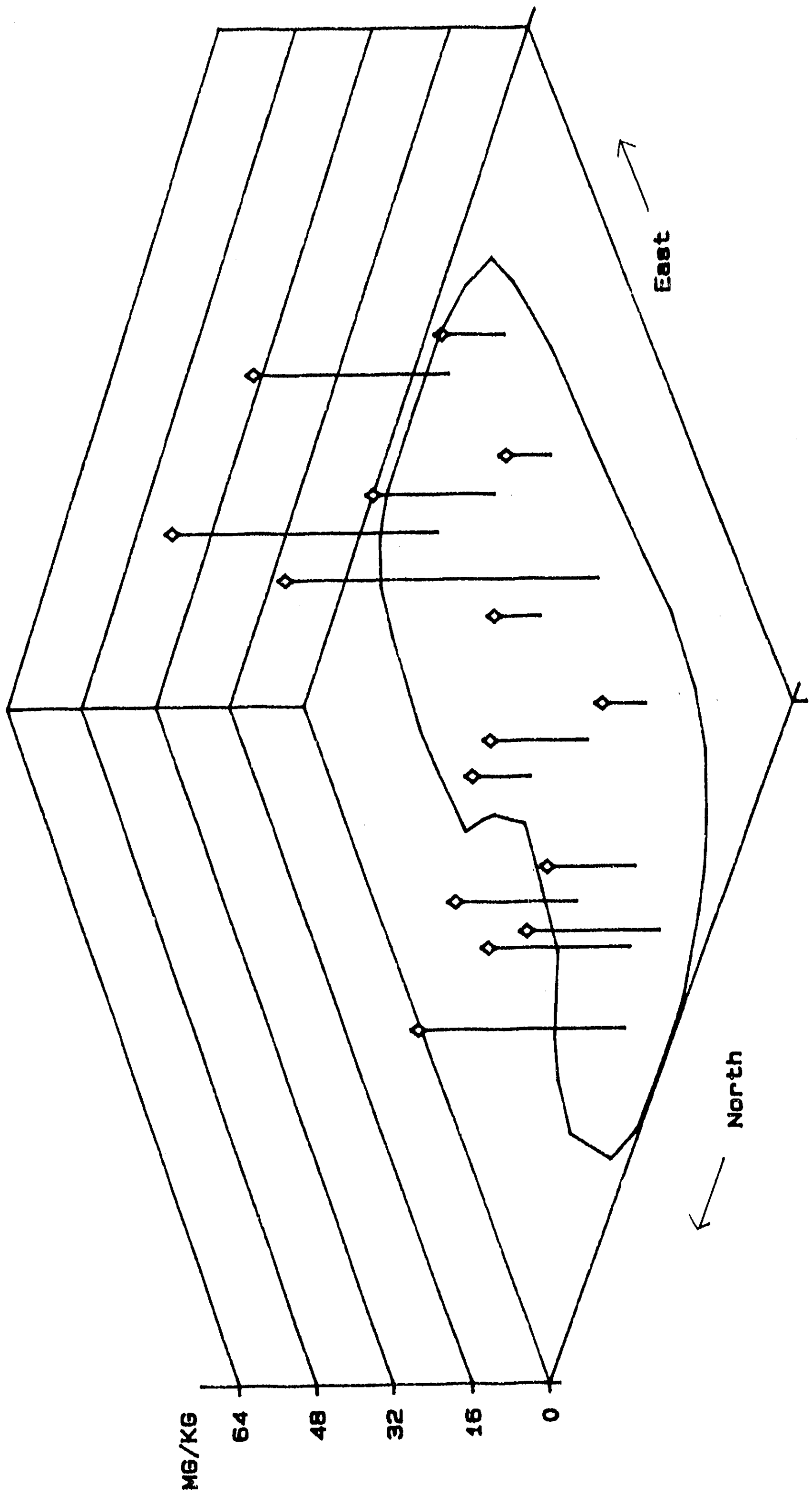
Pyramids - Nondetects
Diamonds - Positive Data

Silver
12 Inch Samples

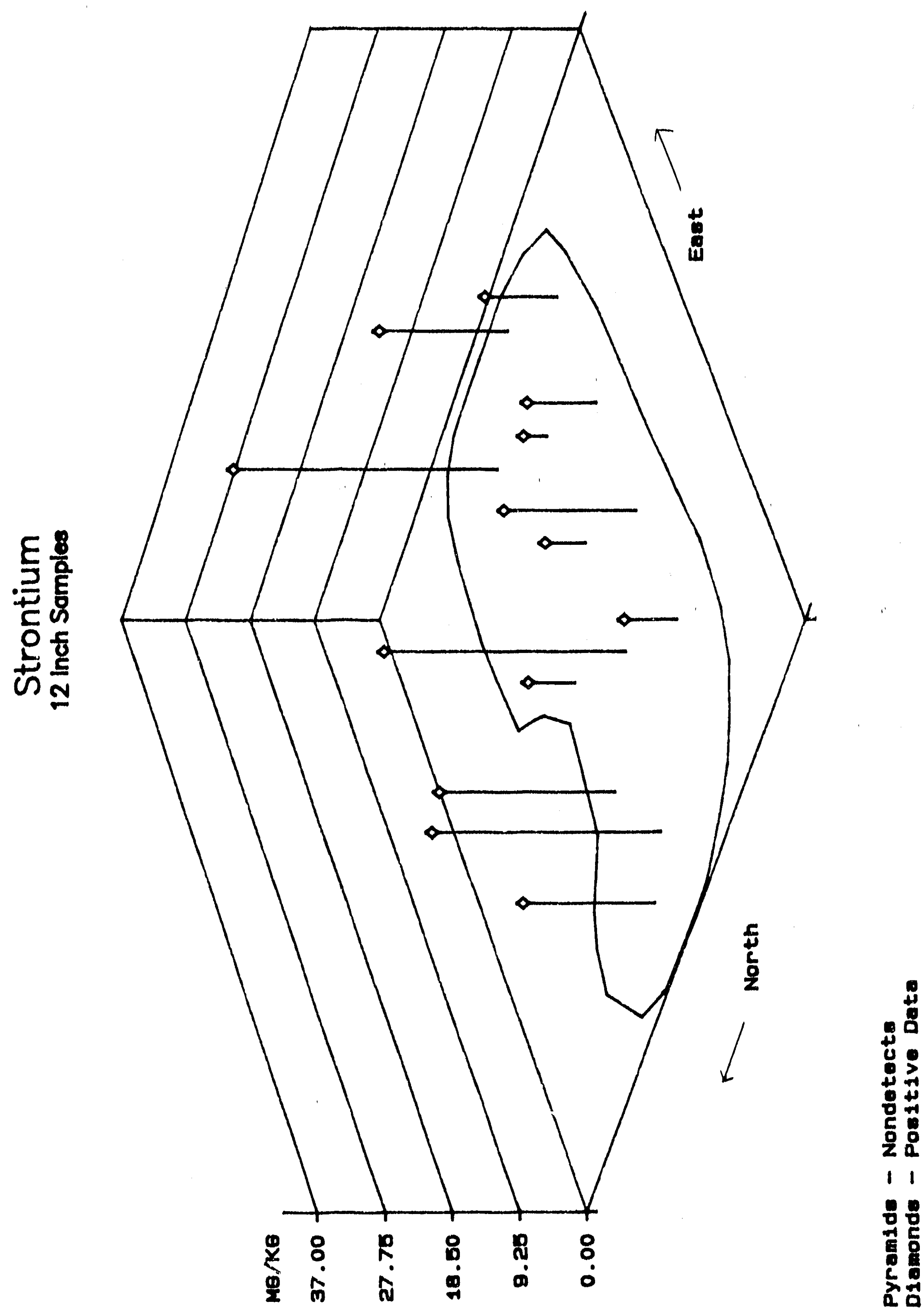



Silver
18 Inch Samples
MG/KG
1.10
0.83
0.55
0.28
0.00
East
North
Pyramids - Nondetects
Diamonds - Positive Data

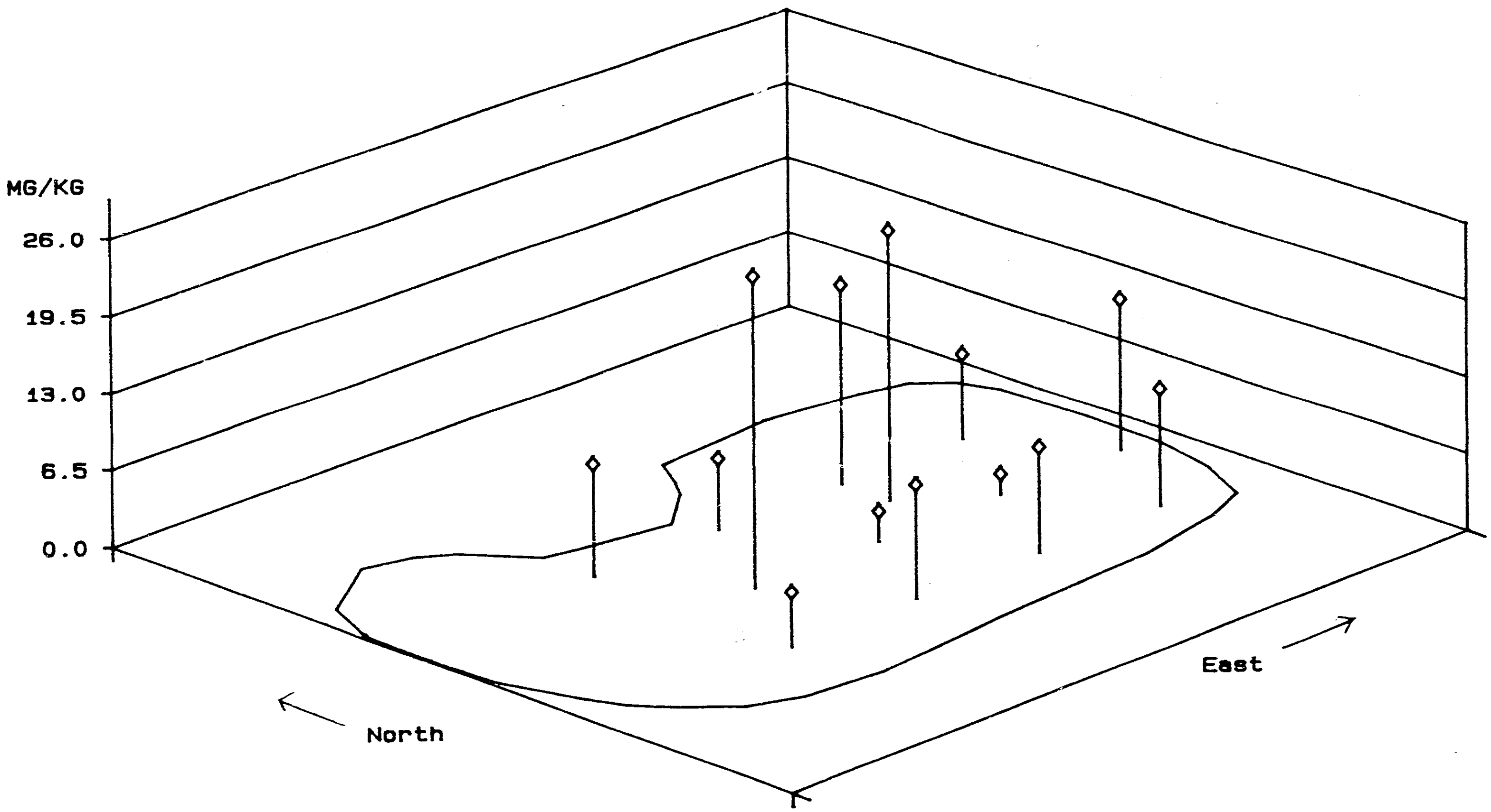
Strontium
6 Inch Samples



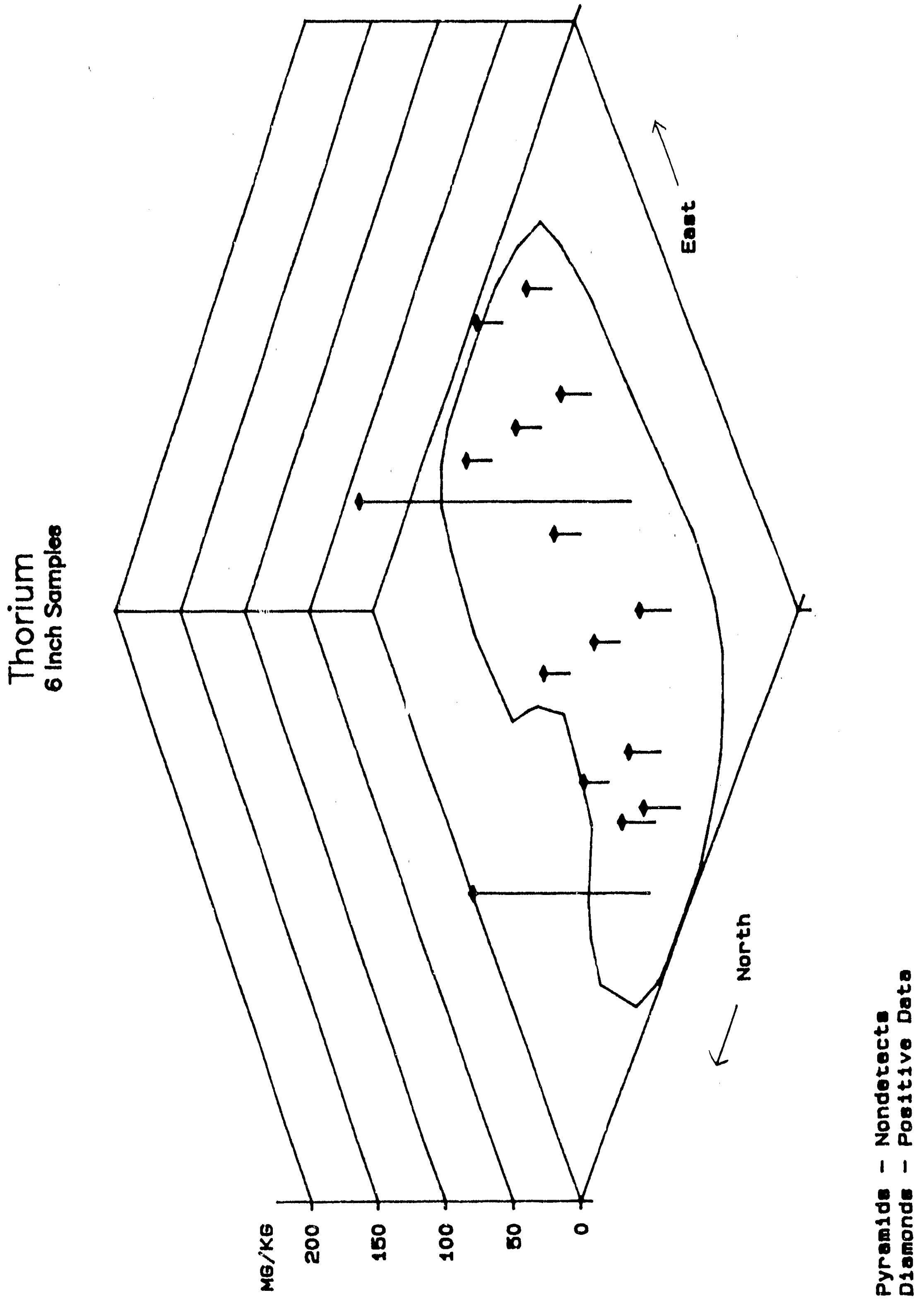
Pyramids - Nondetects
Diamonds - Positive Data


Strontium
12 Inch Samples
MG/KG
37.00
27.75
18.50
9.25
0.00
East
North
Pyramids - Nondetects
Diamonds - Positive Data

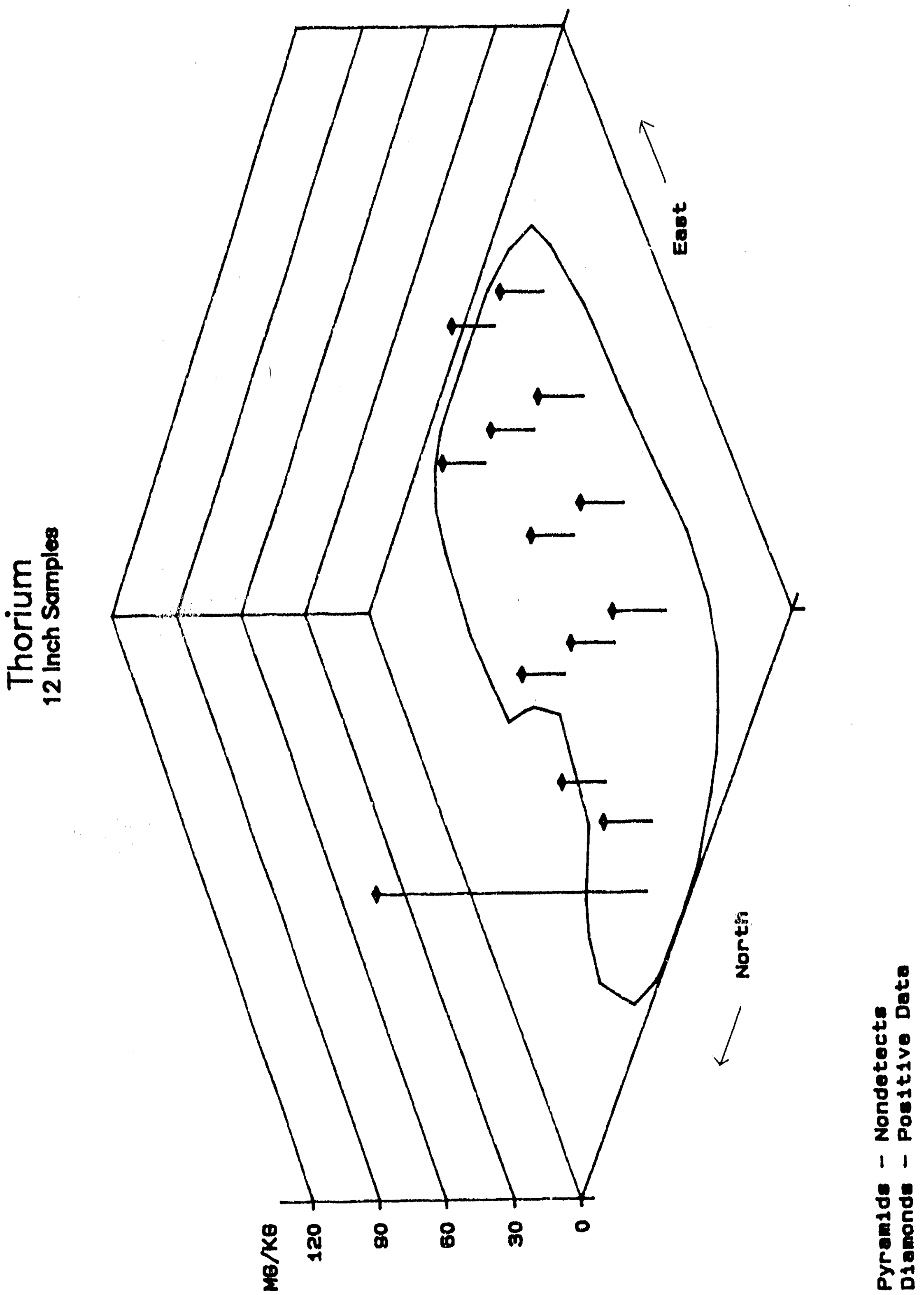
Strontium
18 Inch Samples



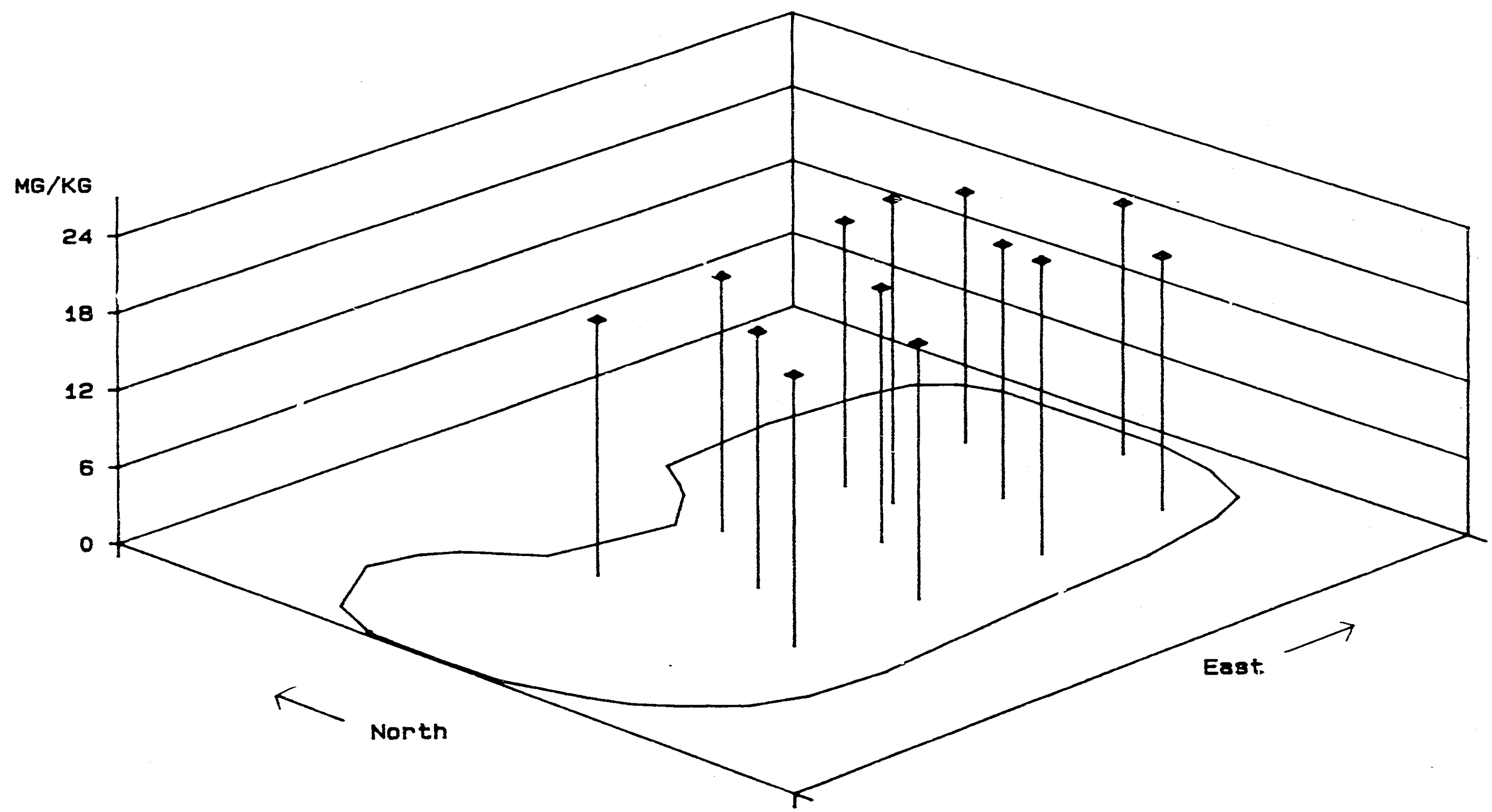
Pyramids – [illegible]detects
Diamonds – Positive Data



Thorium
6 Inch Samples
MG/KG
200
150
100
50
0
East
North
Pyramids - Nondetects
Diamonds - Positive Data

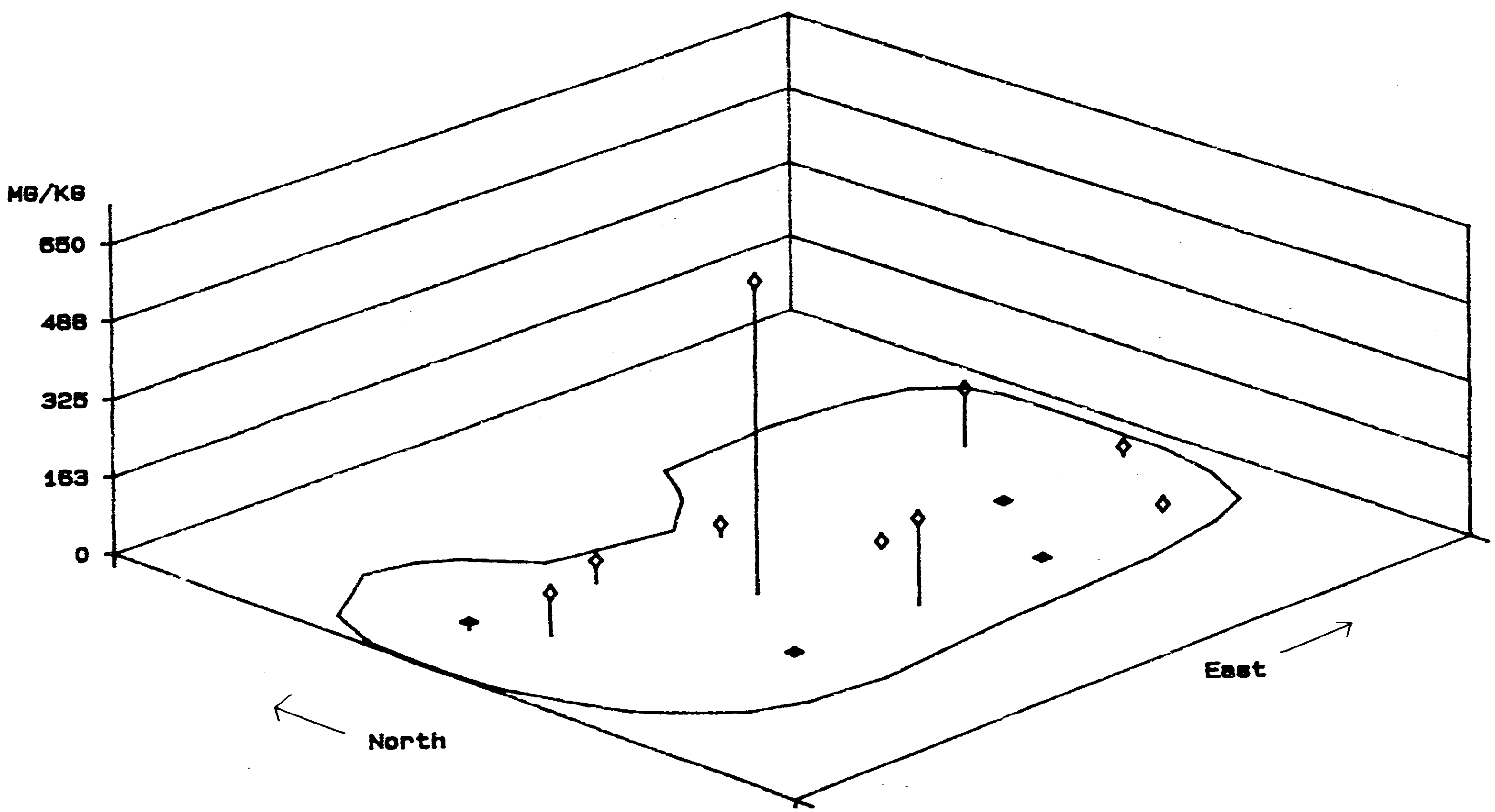

Thorium
12 Inch Samples
MG/KG
120
90
60
30
0
East
North
Pyramids - Nondetects
Diamonds - Positive Data

Thorium
18 Inch Samples



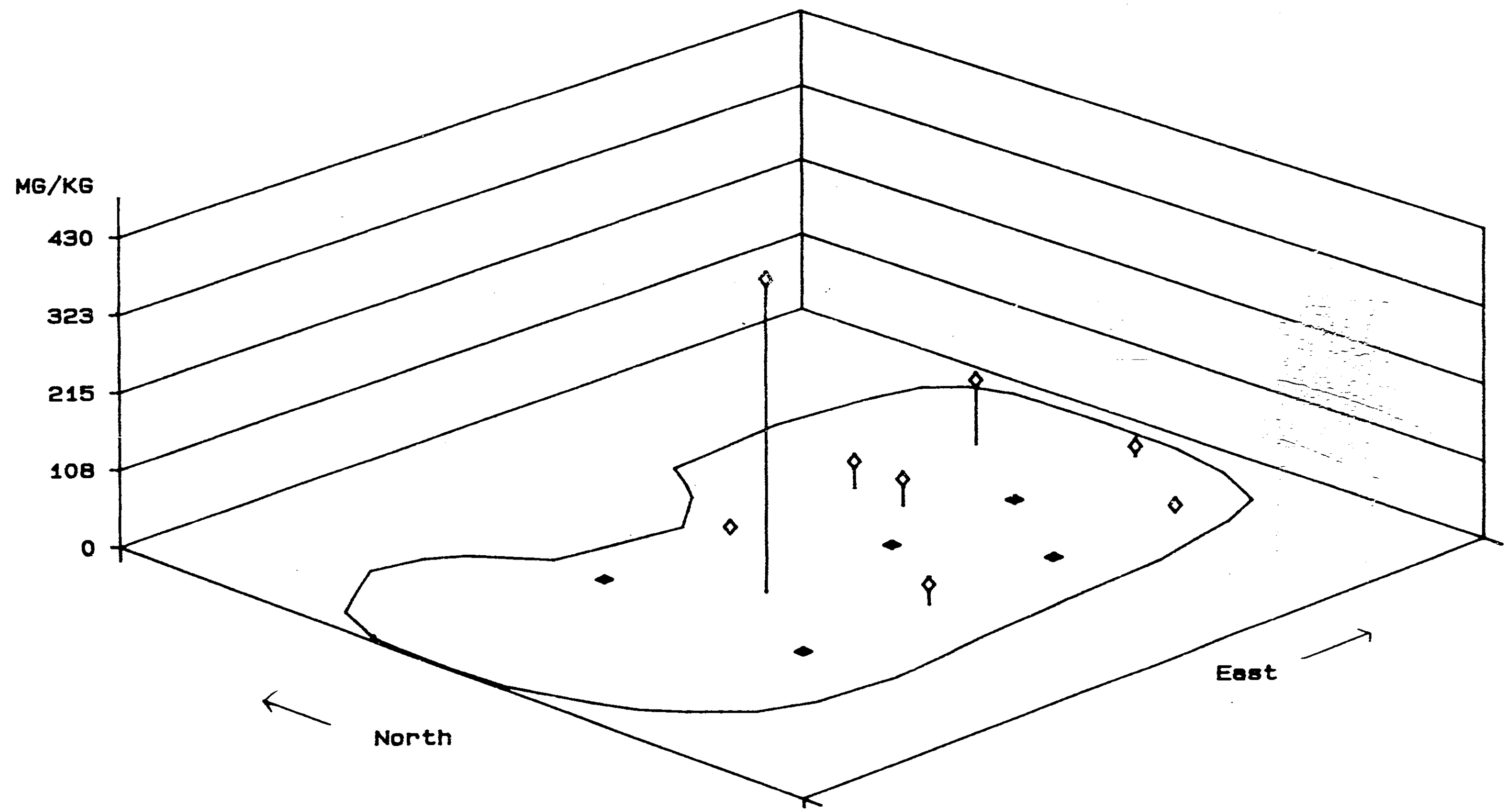
Pyramids – Nondetects
Diamonds – Positive Data

Uranium — Total
12 Inch Samples



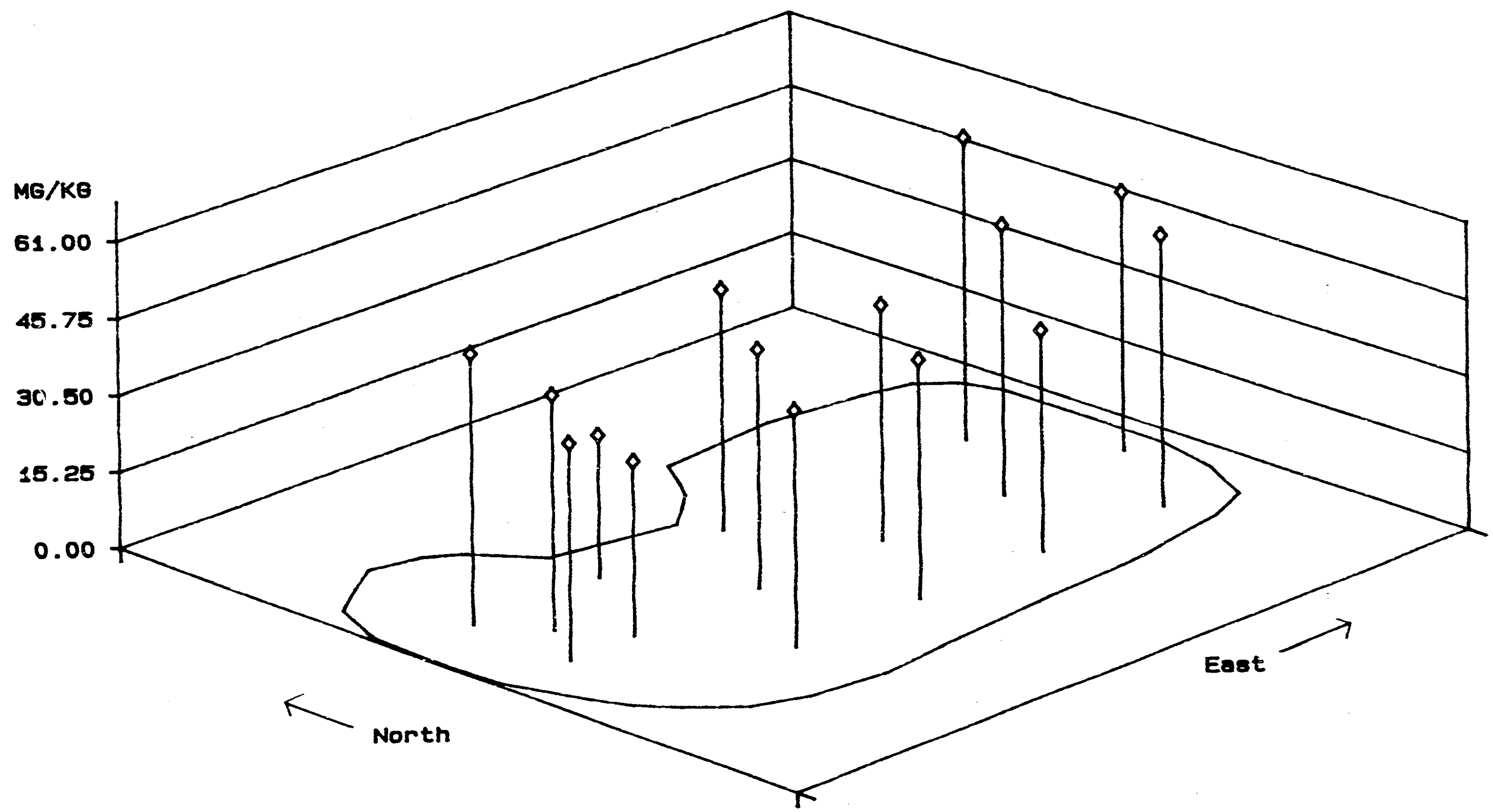
Pyramids - Nondetects
Diamonds - Positive Data

Uranium — Total
18 Inch Samples



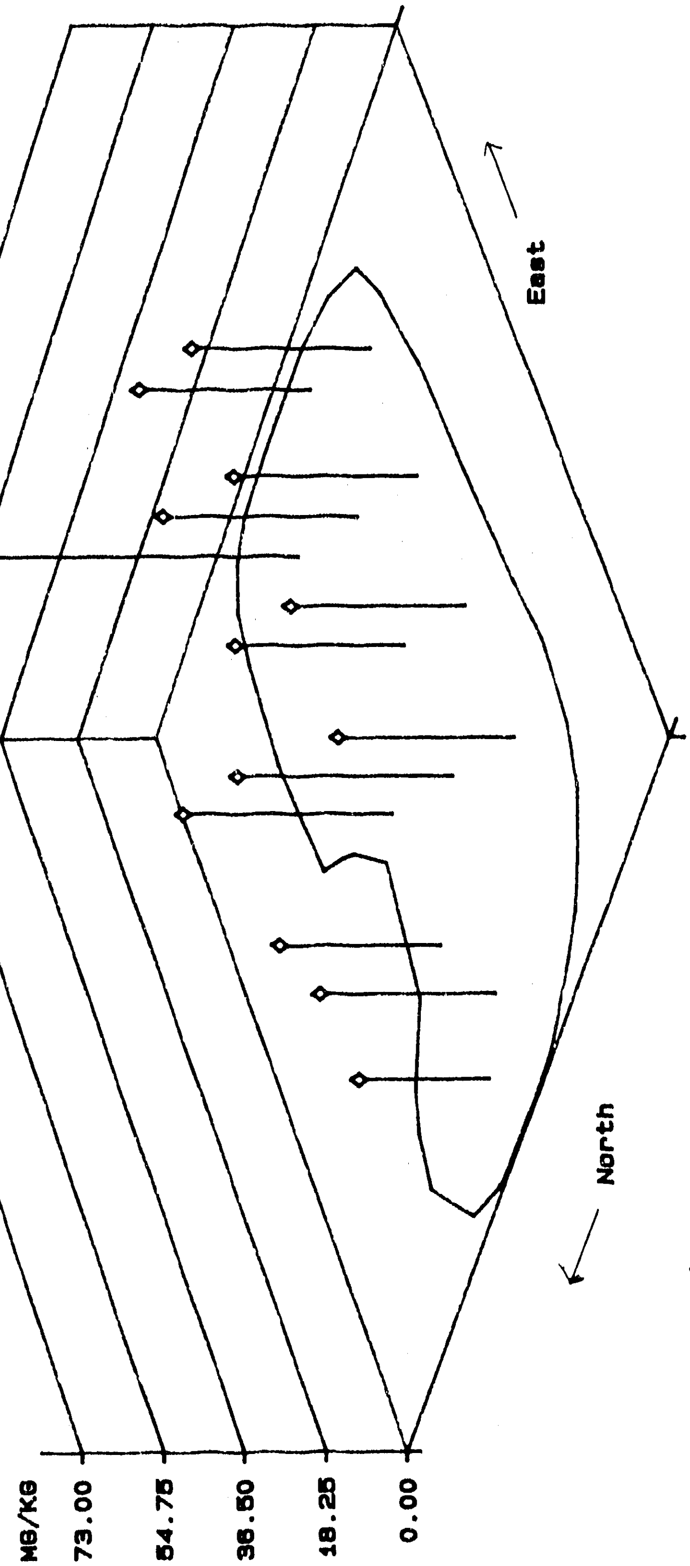
Pyramids – Nondetects
Diamonds – Positive Data

Vanadium
6 Inch Samples

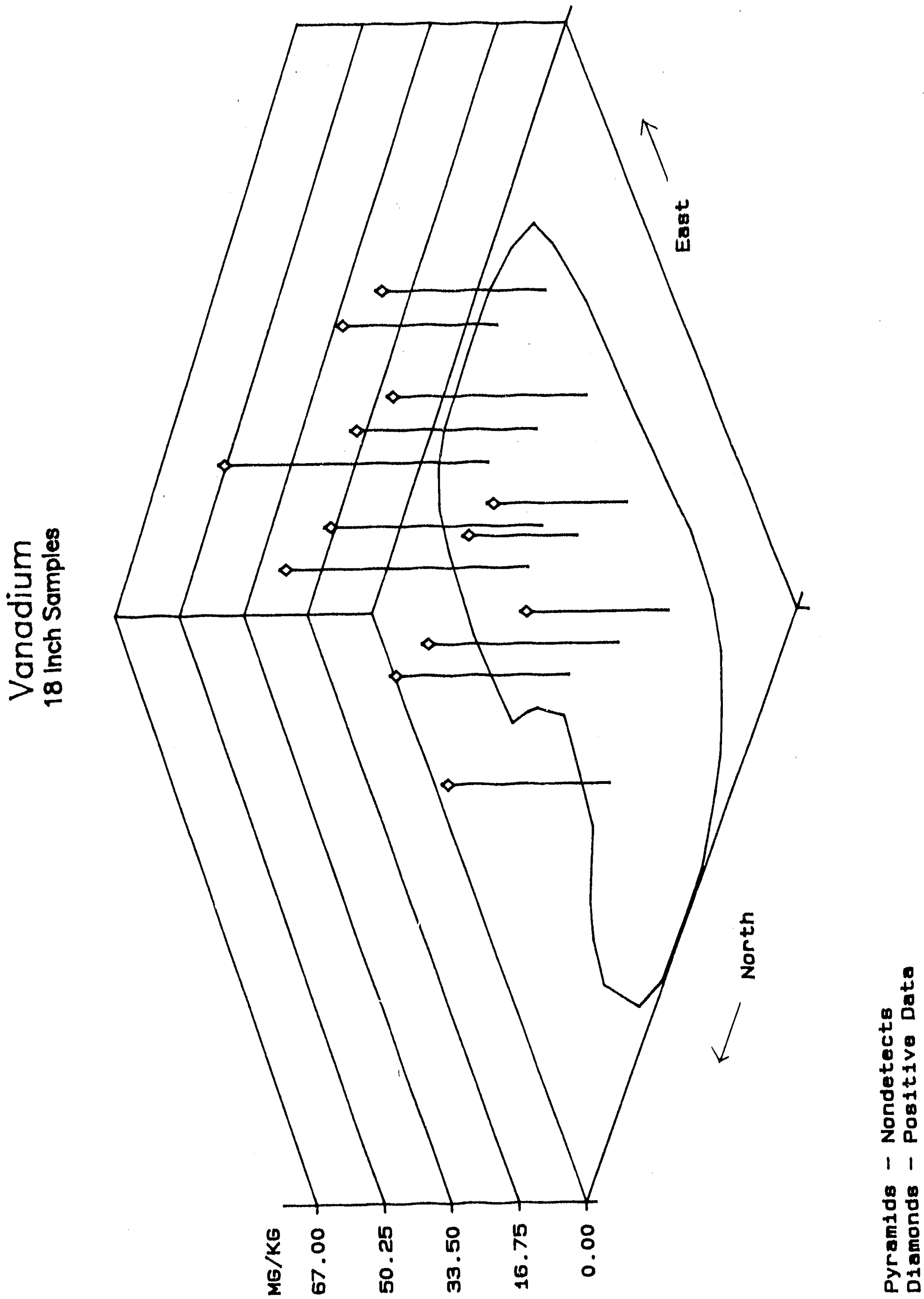


Pyramids - Nondetects
Diamonds - Positive Data

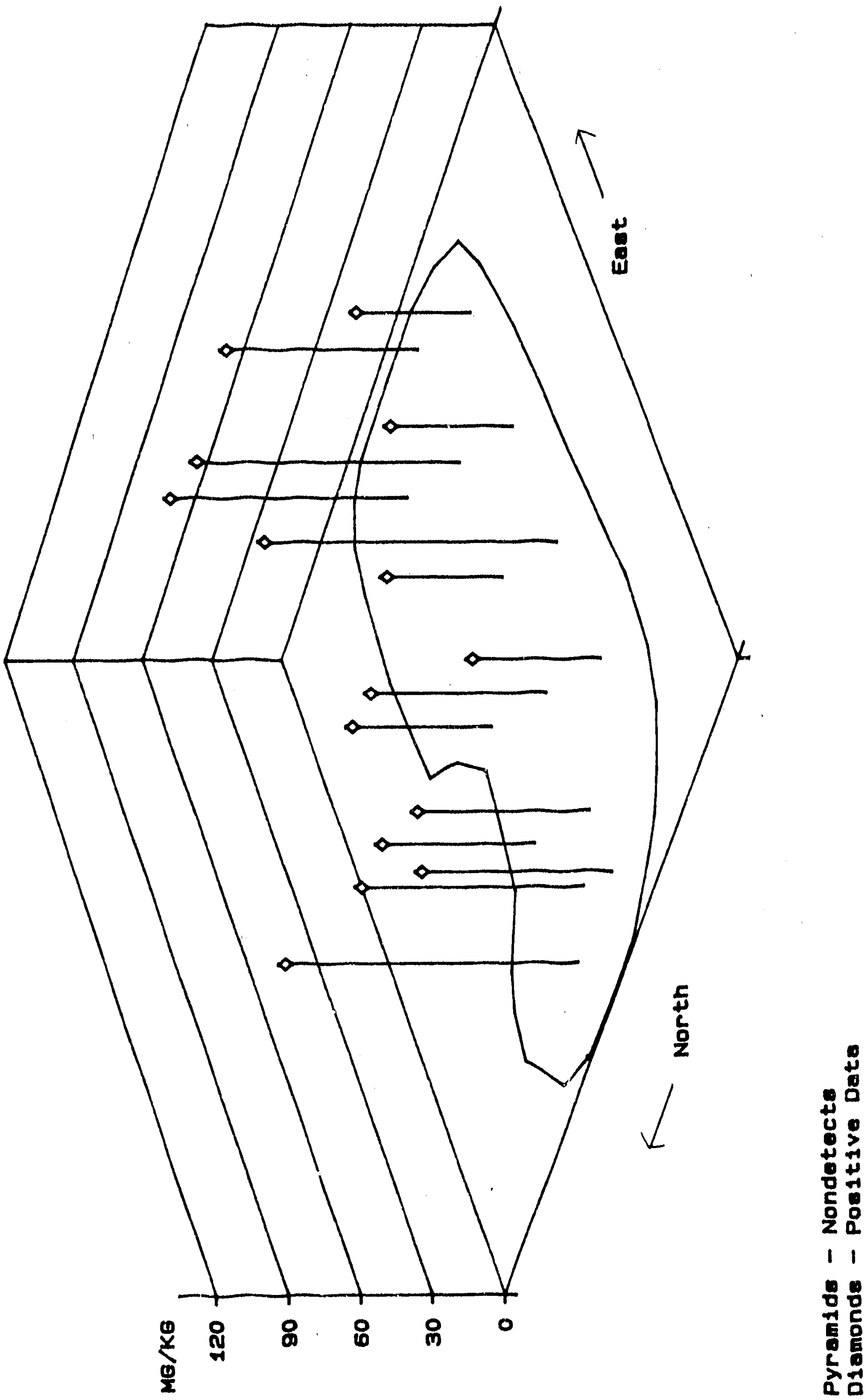
Vanadium
12 Inch Samples



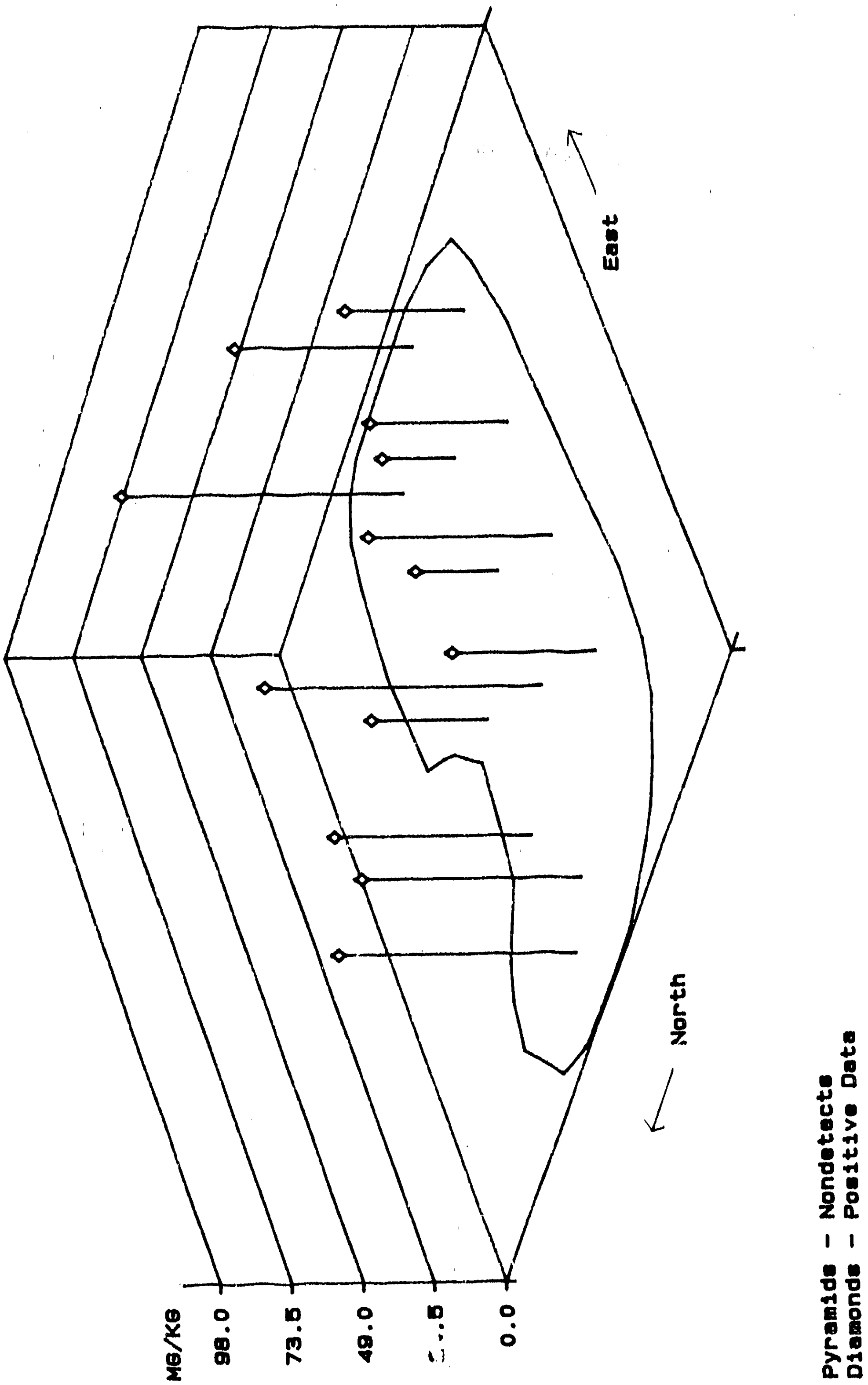
Pyramids - Nondetects
Diamonds - Positive Data


Vanadium
18 Inch Samples
East
North
MG/KG
67.00
50.25
33.50
16.75
0.00
Pyramids - Nondetects
Diamonds - Positive Data

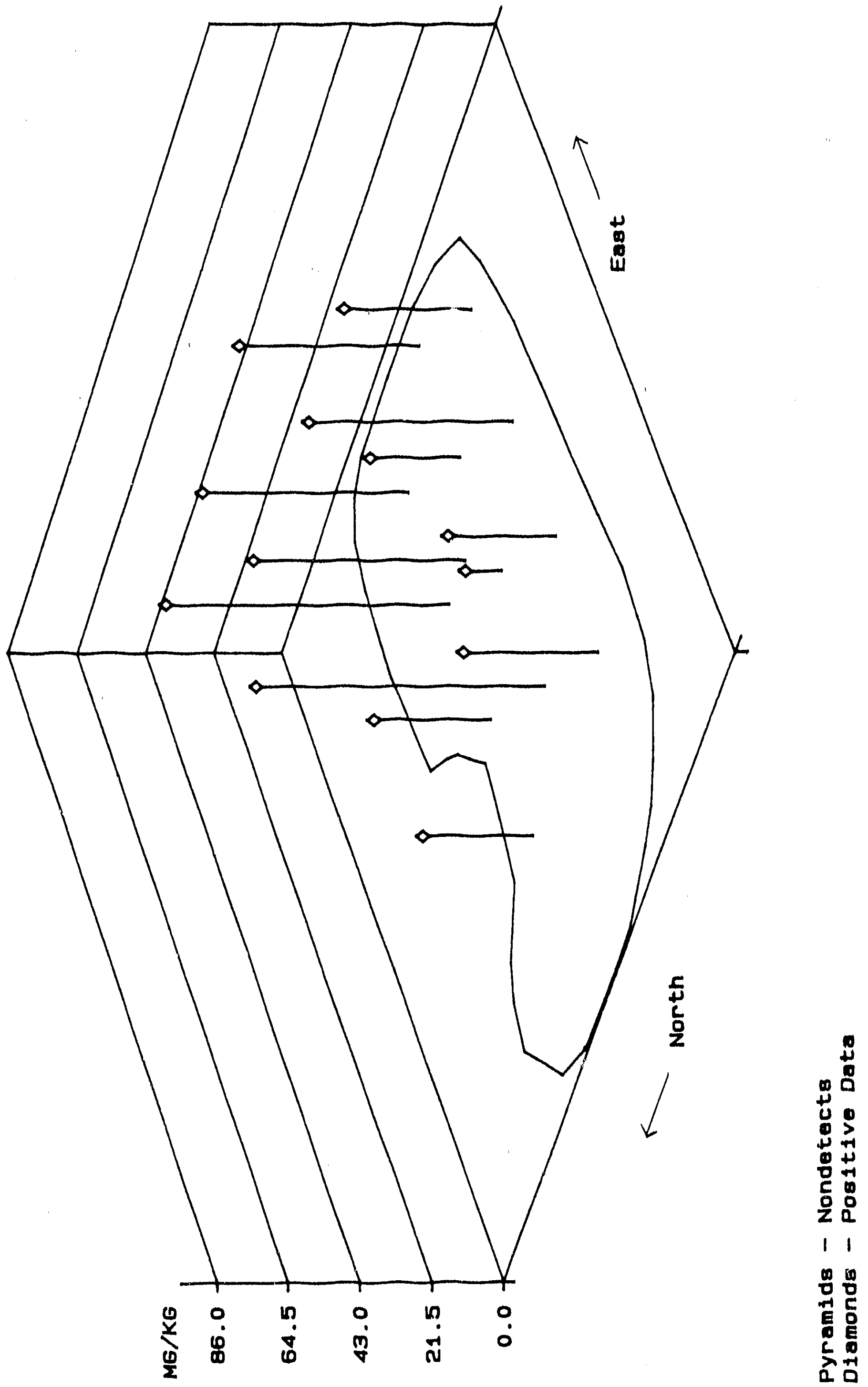
Zinc
6 Inch Samples



Zinc
12 Inch Samples



Zinc
18 Inch Samples



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