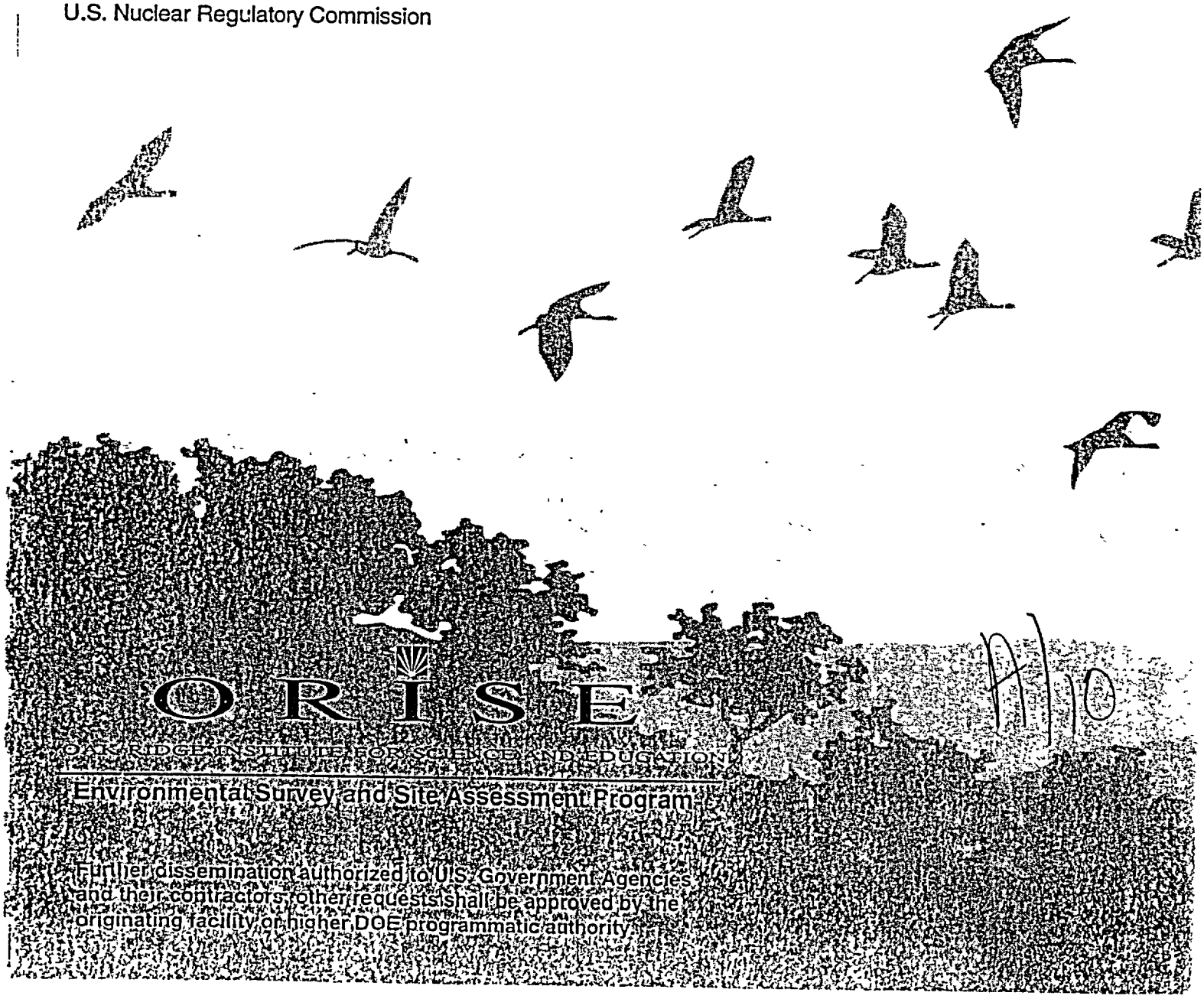
FINAL REPORT

CHARACTERIZATION SURVEY OF THE FORMER GAMMA INDUSTRIES SITE PORT NORRIS, NEW JERSEY

P. C. WEAVER

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



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CHARACTERIZATION SURVEY
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ABBREVIATIONS AND ACRONYMS

A	area
A'	elevated activity area
Δ/σ	relative shift
$\bar{X}$	mean
σ	standard deviation
cm	centimeter
cm^2	square centimeter
cpm	counts per minute
CRC	Cumberland Research Corporation
dpm	disintegrations per minute
dpm/100 cm^2	disintegrations per minute per 100 square centimeters
DCGL	derived concentration guideline level
$DCGL_{EMC}$	elevated measurement comparison
$DCGL_W$	Wilcoxon Rank Sum test
D&D	decontamination and decommissioning
DOE	Department of Energy
DQO	data quality objective
EML	Environmental Measurements Laboratory
ESSAP	Environmental Survey and Site Assessment Program
ft^2	square feet
FSS	final status survey
GI	Gamma Industries
GNI	The GNI Group
ha	hectare
ITP	Intercomparison Testing Program
kg	kilogram
L	grid spacing
LBGR	lower bound of the gray region
m	meter
m^2	square meter
mCi	millicuries
MAPEP	Mixed Analyte Performance Evaluation Program
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	minimum detectable concentration
MeV	megaelectron volts
n	number of data points
NaI	sodium iodide
NIST	National Institute of Standards and Technology
NRC	U.S. Nuclear Regulatory Commission
NRIP	NIST Radiochemistry Intercomparison Program
ORISE	Oak Ridge Institute for Science and Education
pCi/g	picocuries per gram
RESRAD	residual radiation computer code
SU	survey unit

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INTRODUCTION

The Gamma Industries site, located in Port Norris, New Jersey, was originally owned and operated by the Cumberland Research Corporation (CRC) for the manufacturing of cobalt-60 and iridium-192 radiography sources. CRC was purchased by General Nuclear in the late 1960's or early 1970's and operated under this ownership until 1972. After the change in ownership, iridium-192 operations ceased at the facility (GNI 1989).

In 1972, Gamma Industries (GI) purchased all nuclear related assets and business activities from General Nuclear. The facility's hot cell was then used to encapsulate Co-60 teletherapy sources. These hot cell operations ended in 1977 and most of the radioactive material was removed at that time. Although the hot cell equipment was left intact, the facility remained unoccupied for seven years.

In June of 1984, GIs' assets were purchased by Gulf Nuclear, which later became a subsidiary of The GNI Group (GNI). In September 1984, radioactive contamination within the facility and buried radioactive material on the adjacent property were identified. Site excavations identified 19 drums containing a total estimated Co-60 activity of 62 mCi. These drums were shipped off-site for disposal. In February 1985, additional decommissioning activities, including equipment removal, hot cell decontamination, and excavation of a holding tank, were completed. A final site survey was performed by the licensee in December 1985, the results of which were provided in a February 1989 report. The submittal was accompanied by a request for termination of U.S. Nuclear Regulatory Commission (NRC) License No. 17-16109-01 which authorized facility operations.

In April 1989, the NRC performed a closeout inspection of the facility and identified locations of residual contamination inside the building, particularly within the hot cell, that exceeded the NRC's acceptable residual contamination criteria. The survey of the exterior property showed three areas with gamma radiation in excess of background levels. A soil sample collected from one location had

a Co-60 concentration of approximately 1600 pCi/g. The depth of the contamination was not determined. Iridium-192 is not considered to be a contaminant of concern due to its half-life of only 74 days.

The Oak Ridge Institute for Science and Education's (ORISE), Environmental Survey and Site Assessment Program (ESSAP) conducted a radiological survey of the site in 1996. Background data and documentation, radiological data, and other relevant information forwarded to ESSAP by the NRC, was reviewed in preparation for the survey. The survey verified the presence of residual surface contamination on building surfaces and in soils, both beneath the building slab and in surface and subsurface locations on site grounds (ORISE 1996). GNI has since removed the building structure, including the concrete foundation, and backfilled the hot cell observation pit area.

To implement closure of the site, the NRC Region I office requested ESSAP to perform a characterization survey of the GI site. The survey was designed in such a manner that any significant remaining contamination would be identified, or alternatively, to satisfy final status survey requirements for those portions of the site where no residual contamination was identified. The survey was conducted to demonstrate that the site land areas comply with the NRC's unrestricted release criteria through application of the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) methodologies (NRC 1997).

SITE DESCRIPTION

Gamma Industries is located on a 1.3 hectare (3.1 acre) plot on Peace Avenue in Port Norris, New Jersey (Figures 1 and 2). The site is surrounded by undeveloped land to the north, south, and east, and a private residence, which fronts Peace Street, on the west. Access to the property is via a dirt drive which borders the south end of the property. The building was located in the approximate center of the property. A paved area adjoined the building on the south side.

Since the 1996 survey, the building has been razed and any open pits were backfilled. Most of the overgrown vegetation had been removed from the area within the fence prior to conducting this survey. Vegetation growth on the property to the north, east, and west of the fenced area was extensive.

OBJECTIVES

The survey objectives were to design a survey to adequately characterize the site and to meet final status survey objectives. Survey results would be used by the NRC in their determination as to the site's radiological status relative to the unrestricted release criteria. The survey design was based on the MARSSIM approach which determined the required number of samples to statistically evaluate the survey results.

Additional judgmental samples were collected to supplement the information provided by the statically based survey design. These sets were 1) samples from locations of suspected elevated activity detected by surface scans and 2) subsurface samples from locations of suspected former burial areas.

DOCUMENT REVIEW

The documentation review consisted of the 1996 radiological survey report prepared by ESSAP for the NRC and additional background documentation, radiological data, and other relevant information forwarded to ESSAP by the NRC prior to the 1996 survey.

PROCEDURES

During the period October 30 through November 2, 2000 ESSAP performed a characterization survey of the GI site. The survey was in accordance with a plan dated September 13, 2000 submitted to and approved by the NRC Region I and the ORISE/ESSAP Survey Procedures and Quality Assurance Manuals (ORISE 2000a, b, and c). This report summarizes the procedures and results of the survey.

SURVEY DESIGN

The process for designing a survey using the MARSSIM approach depends upon the development of data quality objectives (DQOs). On the basis of these objectives, the known or anticipated radiological conditions of the site, and the number and locations of measurement and sampling points required to demonstrate compliance with the derived concentration guideline level (DCGL) were determined. The elements of this survey were selected to conform to the MARSSIM integrated survey approach, including the number and locations of measurement and sampling points, selection of appropriate survey techniques for adequate data development, and selection of appropriate survey instrumentation.

Application of Decommissioning Criteria

Stating the null and alternative hypotheses and identifying survey objectives are basic to the DQO process. The objectives of this characterization survey were to determine if there were any areas of residual radioactivity exceeding the release criterion and determine if those portions of the site where residual contamination was not identified satisfied final status survey (FSS) requirements. The null, $\mathbf{H_o}$, and alternative hypotheses, $\mathbf{H_a}$, were as follows: $\mathbf{H_o}$, that residual contamination exceeds the release criterion and the alternative hypothesis, $\mathbf{H_a}$, the residual contamination meets the release criterion.

Since Co-60 is not present in background soils, the Sign Test was selected to test the hypothesis. To determine data needs for this test, the acceptable probability of making a Type I and a Type II decision error was established. The acceptable default Type I error (α) was 0.05 and the Type II (β) decision error was set at 0.05.

Derived Concentration Guideline Levels (DCGLs)

Historical records and the results from previous surveys indicate that Co-60 was the only radionuclide present. The applicable NRC screening level DCGL for Co-60 concentrations in soil was 3.8 pCi/g (NRC 1999).

Classification of Areas/Survey Units

The GI site was divided into three categories based on the potential for contamination: Class 1, 2, or 3. A description of each is as follows:

Class 1: Areas that have a significant potential for radioactive contamination (based on site operating history) or known contamination (based on previous radiological surveys).

Class 2: Areas contiguous to Class 1 that have a potential for radioactive contamination or known contamination, but are expected to be at contamination levels significantly below those identified as Class 1.

Class 3: Areas that are not expected to contain any residual contamination based on site operating history or previous radiological surveys.

The site consists of 11,200 m^2 (120,500 ft^2) (Figure 3). The survey design determined that seven survey units were required for evaluating the site. The survey design included six Class 1 survey units and one Class 2 unit. Survey unit (SU) 1 consisted of 1800 m^2 and SU 2 consisted of 1400 m^2. These two SUs included that portion of the site within the fence and the former building location, and were designated as Class 1 areas. SU 3 had a total area of 2025 m^2 and was designated a Class 2 unit. SU 4 had a total area of 1575 m^2 and was designated as a Class 1 unit. SUs 3 and 4 included the area located to the west of the building/fenced area. Based on the historical site assessment, SUs 5, 6, and 7 were classified as Class 1 units. This area had at one time been host to a burial ground. Each of these SUs consisted of 2000 m^2 located to the east of the building/fenced area.

Statistical Tests

The following steps detail the procedure for determining the number of data points required to test H_o using the Sign test.

Calculate the Relative Shift

The relative shift (Δ/σ), is calculated to determine the sample size, where Δ is the $DCGL_w$ minus the lower bound of the gray region (LBGR). Therefore, calculating the relative shift requires the $DCGL_w$

value, LBGR, and the standard deviation (σ) of the contaminant in the survey area. An estimate of the mean ($\bar{X}$) and the standard deviation were calculated based on 10 samples collected during the ESSAP 1996 survey. Judgmental hot spot locations were excluded from the estimation. The estimate of the mean ($\bar{X}$) was determined to be 0.38 pCi/g and σ equaled 0.65 pCi/g.

The following data were used in the determination of the relative shift:

1) The $DCGL_W$ for Co-60 — 3.8 pCi/g in soil.

2) The σ of Co-60 in the SUs—0.65 pCi/g.

3) The LBGR was set at one-half of the DCGL for planning purposes at 1.9 pCi/g.

The calculated Δ/σ was—1.9/0.65 which is equal to 2.9.

Determine the Number of Data Points Assuming Uniform Distribution of Contamination

The calculated Δ/σ of 2.9 is not listed in the MARSSIM Table 5.5; therefore, the next lower value, 2.5 was used. The number of data points required for each survey unit was determined to be 15 based on a Δ/σ of 2.5 and Type I and Type II decision errors of 0.05. A random-start triangular pattern was determined for each of the SUs, to position survey data points (Figures 4 through 8). Table 1 provides the grid spacing (L) used for each SU. The number of data points (n) and the area (A), in meters, of the SU, were used to determine the grid spacing (L) for a triangular grid pattern as given by:

$$L = \sqrt{\frac{A}{0.866\ n}}$$

Table 1 also identifies the elevated activity area (A'), for a triangular grid pattern, which is given by:

$$A' = 0.866L^2$$

Data Points for Areas of Elevated Activity

Systematic soil sampling and surface scanning on a specified grid size, were used to obtain an adequate assurance level that locations of elevated radioactivity were identified.

Determining values for the $DCGL_{EMC}$ required modifying the $DCGL_W$ using a correction factor that accounted for the difference in area and the resulting change in dose or risk. The area factor is the magnitude by which the concentration within the small area of elevated activity can exceed the $DCGL_W$ while maintaining compliance with the release criterion. Outdoor area factors for Co-60, generated by the RESRAD version 5.95 dose modeling computer code, are listed in Table 2. An evaluation of the number of data points needed to ensure coverage of any area of elevated activity was required if the scan minimum detectable concentration (MDC) was greater than the $DCGL_W$. The maximum acceptable concentration $DCGL_{EMC}$ in the elevated activity area, A', was determined by:

$$DCGL_{EMC} = DCGL_W * Area\ Factor$$

The specific area factor for each of the SUs was interpolated from the values in Table 2. The area factor for determining the required scan MDC used in this assessment corresponded to the Class 1 SU with the largest area (133 m^2) and therefore the most conservative $DCGL_{EMC}$. The area factor for an area of 133 m^2 is 1.2. The upper limit for the $DCGL_{EMC}$ was determined to be 4.6 pCi/g.

The $DCGL_{EMC}$ was compared to the actual gamma scan MDC of 3.4 pCi/g for Co-60 that was obtained from Table 6.7 of MARSSIM for a SPA-3 NaI scintillation detector. The actual scan MDC for the selected scanning technique was compared to the required scan MDC (4.6 pCi/g). Since the actual scan MDC was less than the required scan MDC, no additional sampling points (above the number calculated previously) were necessary for assessing potentially elevated areas. Thus, the instrumentation selected exhibited adequate sensitivity to detect any elevated areas of concern.

Determining Survey Locations

A scale drawing of each SU was prepared along with the overlying planer reference coordinate system. Any location within the survey area was thus identifiable by a unique set of coordinates. The maximum length, X, and width, Y, dimensions of the SU were then determined. For the Class 1 areas, a triangular pattern, having the dimensions determined by spacing requirements described in the previous section, was installed in each SU by selecting a random starting point. The initial random start coordinate identified the initial row of data points parallel to the X axis, at intervals of L. A second row of data points was determined parallel to the first row, at a distance of 0.866*L from the first row. Survey points along the second row were midway (on the X-axis) between the points on the first row. This process was repeated to identify a pattern of data points throughout the affected SU. The grid patterns for each SU are shown separately in Figures 4 through 8. If identified points fell outside the SU or at locations which could not be surveyed, additional points were determined using the random process described above, until the desired total number of data points were identified.

A random-start systematic grid patten was also used to identify data point locations for the Class 2 area. The number of data points required for the statistical tests was used to determine the appropriate spacing, L.

In addition to the survey locations identified through statistical evaluations, judgmental locations were selected based on unusual appearance, location relative to contamination areas, high potential for residual activity, and scanning results. These data points were not included with those described above for statistical evaluations; instead they were compared individually to the established DCGL level and conditions.

SURVEY PROCEDURES

The total survey area consisted of the six Class 1 SUs and one Class 2 SU shown in Figure 3. The extent of survey coverage in each SU was based on the guidance contained in MARSSIM. ESSAP used the following procedures for the survey area.

Reference Grid

A 10 m × 10 m site reference grid system was established by ESSAP (Figure 3).

Surface and Subsurface Scans

Surface scans of soil, paved areas, and boreholes were performed using SPA-3 NaI scintillation detectors coupled to ratemeters with audible indicators. A 100 percent scan of the soil within the Class 1 SUs was performed. A 100 percent scan of the Class 2 area soil surfaces was also performed. Boreholes were scanned and logged typically at each 1 m depth interval.

Soil Sampling

Surface soil (0-15 cm) samples were collected from 15 systematically selected locations in each SU. Judgmental soil samples were collected at locations of elevated surface activity. Figures 4 through 8 show sampling locations.

Subsurface soil samples were also collected at 0.5 m intervals up to a depth of 2.6 m from 19 boreholes locations (Figures 5 and 9). Borehole locations were selected based on history of suspected elevated subsurface activity from the hot cell observation pit area, and from suspected burial areas.

SAMPLE ANALYSIS AND DATA INTERPRETATION

Samples and survey data were returned to ESSAP's Oak Ridge, TN laboratory for analyses and interpretation. Sample analyses were performed in accordance with the ORISE/ESSAP Laboratory Procedures Manual (ORISE 2000d). Soil samples were analyzed by solid-state gamma spectrometry. Spectra were reviewed for the radionuclide of interest, Co-60 and any other identifiable photopeaks. Soil sample results were reported in units of pCi/g. Individual measurements were directly compared to the DCGL for evidence of elevated areas.

Additional information concerning major instrumentation, sampling equipment, and analytical procedures is provided in Appendices A and B.

FINDINGS AND RESULTS

DOCUMENT REVIEW

The review of available site documentation provided in the GNI and ESSAP radiological survey reports, supplied the needed information for classifying site areas and preparing and planning the site survey (GNI 1989 and ORISE 1996).

SURVEY RESULTS

Surface Scans

Surface scans identified four locations of elevated direct radiation that were investigated in SUs 2, 4, and 5 (Figures 5, 7, and 8). A representative of The GNI Group excavated the soil from the elevated location in SU 2. Post-remedial action scans performed by ESSAP, indicated residual gamma activity was reduced to background levels. Ambient background levels for the site ranged from 3000 cpm to 6000 cpm.

Radionuclide Concentrations in Soils

The Co-60 concentrations in soil samples collected from systematic sampling locations are summarized in Table 3. Judgmental soil sample result are reported in Table 4.

Subsurface soil sample results collected from SUs 1, 2, 4, 5, and 6 are summarized in Table 5.

Survey Unit 1

The Co-60 concentration in systematic soil samples from SU 1 ranged from less than 0.02 to 0.14 pCi/g. Co-60 concentrations in subsurface samples were less than 0.04 pCi/g.

Survey Unit 2

Concentrations of Co-60 in systematic soil samples collected from SU 2 ranged from less than 0.02 to 0.32 pCi/g. The Co-60 concentration in judgmental soil samples ranged from less than 0.02 to 0.11 pCi/g. Gamma spectroscopy identified elevated Cs-137 concentrations in one of the samples collected from the elevated activity location detected in SU 2 (Figure 9). At a depth of 30 cm, the Cs-137 concentration was 104.5 pCi/g. After remediating to a depth of 0.5 m, the Cs-137 concentration level in the soil sample collected decreased to 1.3 pCi/g.

Subsurface soil concentrations of Co-60 ranged from less than 0.03 to 0.26 pCi/g.

Survey Unit 3

The Co-60 concentrations in SU 3 systematic samples were less than 0.04 pCi/g. No subsurface samples were collected from this SU.

Survey Unit 4

The Co-60 concentration in systematic and judgmental surface soils collected from SU 4 were less than 0.05 pCi/g. Four boreholes were drilled. The Co-60 concentration for subsurface samples ranged from less than 0.03 to 3.13 pCi/g.

Survey Unit 5

Systematic soil sample Co-60 concentrations in SU 5 ranged from less than 0.02 to 0.07 pCi/g and judgmental soil samples were less than 0.07 pCi/g. The subsurface soil sample concentration of Co-60 was less than 0.04 pCi/g.

Survey Unit 6

SU 6 Co-60 concentrations in systematic soil samples ranged from less than 0.02 to 0.08 pCi/g. Seven boreholes were drilled in SU 6. The Co-60 concentration in subsurface soil samples was less than 0.05 pCi/g.

Survey Unit 7

SU 7 Co-60 concentrations were less than 0.05 pCi/g. No subsurface soil samples were collected from this SU.

COMPARISON OF RESULTS WITH SITE SPECIFIC RELEASE CRITERIA

The interpretation of survey results was performed in accordance with MARSSIM (NRC 1997). Surface scans identified four locations of elevated activity. These locations were investigated by collecting surface (0-15 cm) soils and subsurface soils at depths ranging from 15-30 cm up to 0.5 m. Gamma spectroscopy analysis did not identify any activity above the $DCGL_W$ for Co-60. The maximum Co-60 concentration was determined to be 3.13 pCi/g and was identified in a sample collected from location 15N, 11W at a depth of 2.6 m. Because all individual sample results were less than the $DCGL_W$, the data did not require application of the Sign test to demonstrate compliance. Sample results indicate that the H_o is rejected and the alternative hypothesis, H_a, is accepted.

Laboratory analysis identified Cs-137 as the contaminant at the location of elevated activity found at 2.2N, 23E. Because the location was remediated, ESSAP collected additional measurements and

samples prior to leaving the site. The Cs-137 activity level was reduced from 104.5 pCi/g to 1.3 pCi/g. Surface measurements adjacent to this location were at background or slightly above. As a result of this discovery, all spectra were reviewed for Cs-137. Cesium concentrations ranged from less than 0.02 pCi/g to 1.3 pCi/g which is generally background range. The NRC DCGL for Cs-137 is 11 pCi/g. The scan MDC for the SPA-3 (2" × 2" detector) from NUREG 1507 for Cs-137 is 6.4 pCi/g. This provided sufficient capability for detecting the presence of any other Cs-137 activity.

The mean Co-60 concentrations in systematic surface soils are in Table 6. The median for all SUs was 0.03 pCi/g.

SUMMARY

During the period between October 30 and November 2, 2000, ESSAP performed a characterization survey of the former Gamma Industries site located on Peace Avenue in Port Norris, New Jersey. Survey activities included document reviews, surface scans, and soil sampling.

The results of the survey demonstrate that the site meets the Co-60 DCGL of 3.8 pCi/g. For the most part, the Co-60 concentrations in soil samples were less than the minimum detectable concentration (MDC) of the procedure. Of the 159 soil samples analyzed, sixteen were measurable above the MDC. Only one sample was shown to be near the DCGL at 3.13 pCi/g. This sample was collected from a borehole drilled in a suspected burial area.

The elevated surface activity detected in the initial samples collected from location 2.2N, 23E was identified as Cs-137 rather than Co-60. The source of the Cs-137 contamination is unknown as site history provided to ESSAP indicated licensing for only Ir-192 and Co-60. After remediation, an additional sample was collected. Analysis of this sample showed a significant decrease in Cs-137 activity. Co-60 activity in this sample was less than the MDC. It is ESSAP's opinion that the radiological conditions of the surveyed areas satisfy the NRC's Co-60 DCGL for release without radiological restrictions.

FIGURES

765-001 (2)

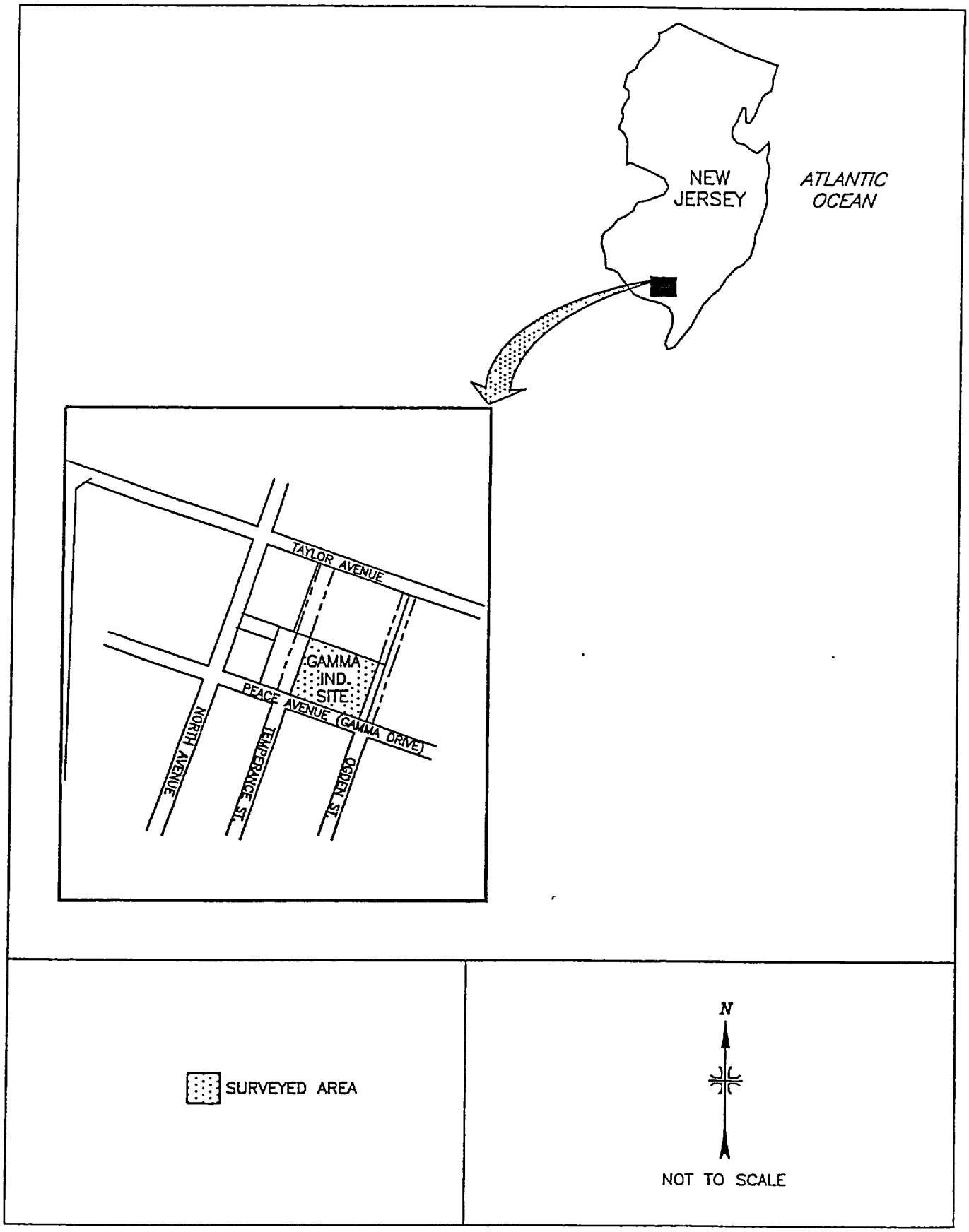

FIGURE 1: Location of the Former Gamma Industries Site – Port Norris, New Jersey

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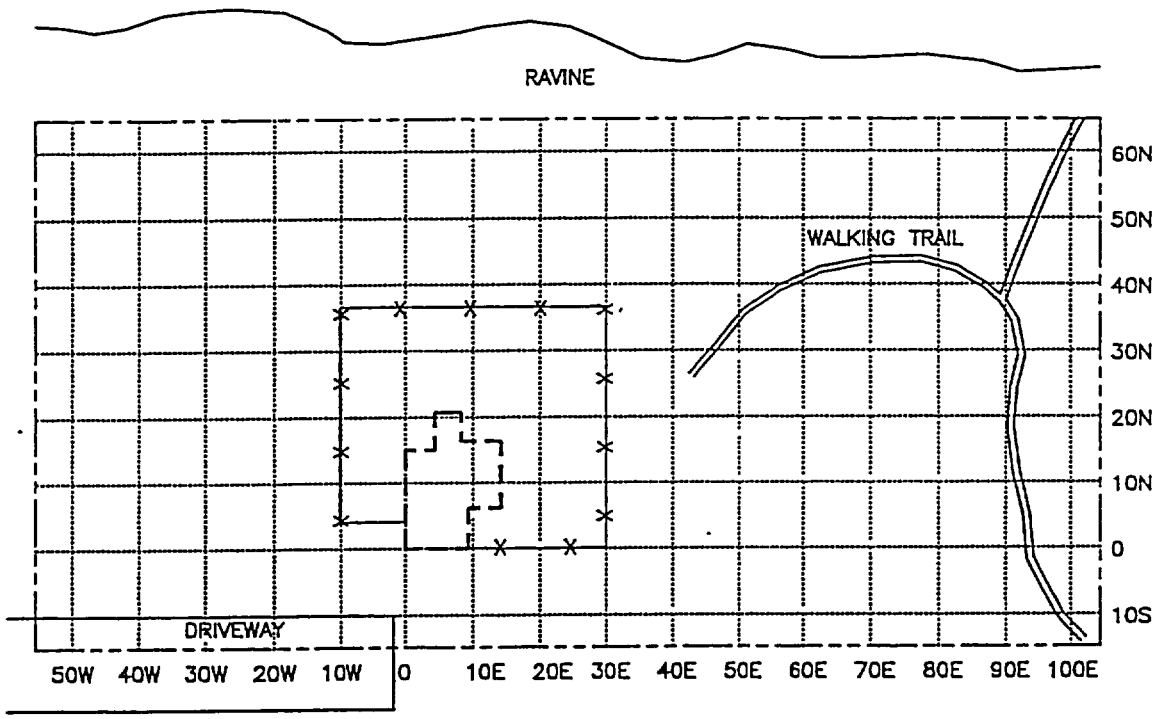

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OUTLINE OF FORMER BUILDING STRUCTURE

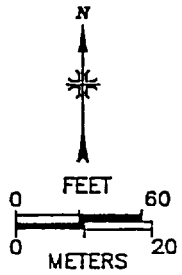
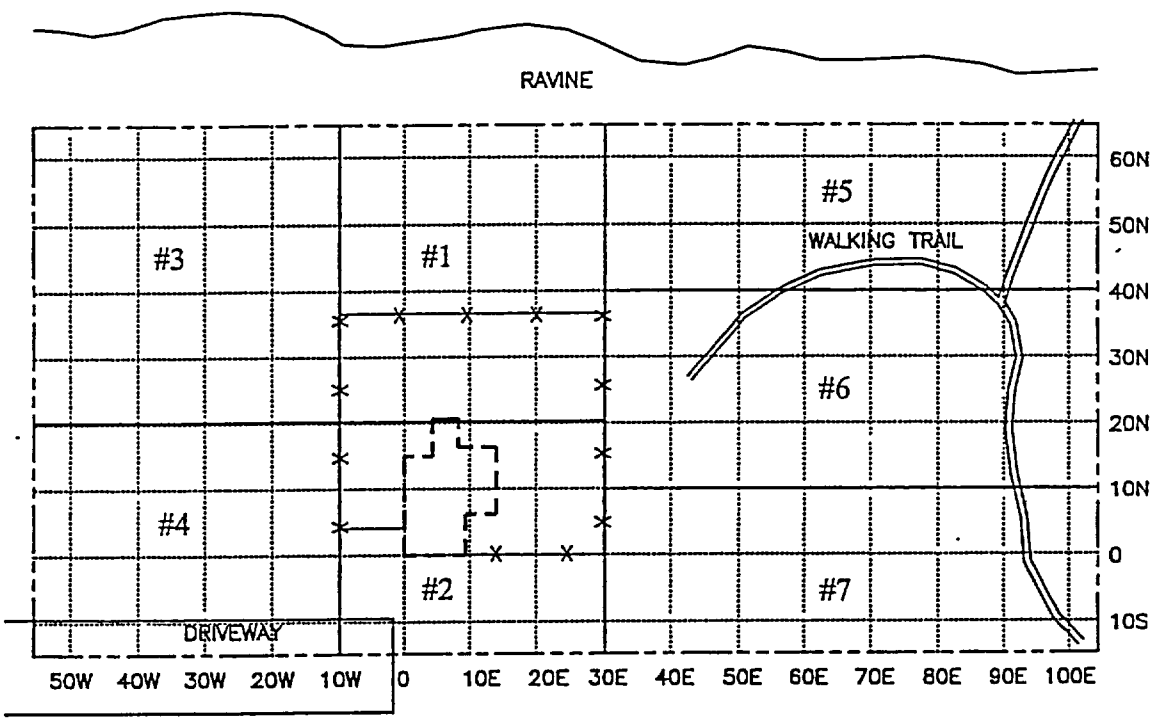


FIGURE 2: Former Gamma Industries Site – Plot Plan



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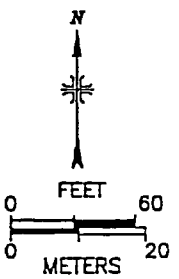


FIGURE 3: Former Gamma Industries Site – Survey Units

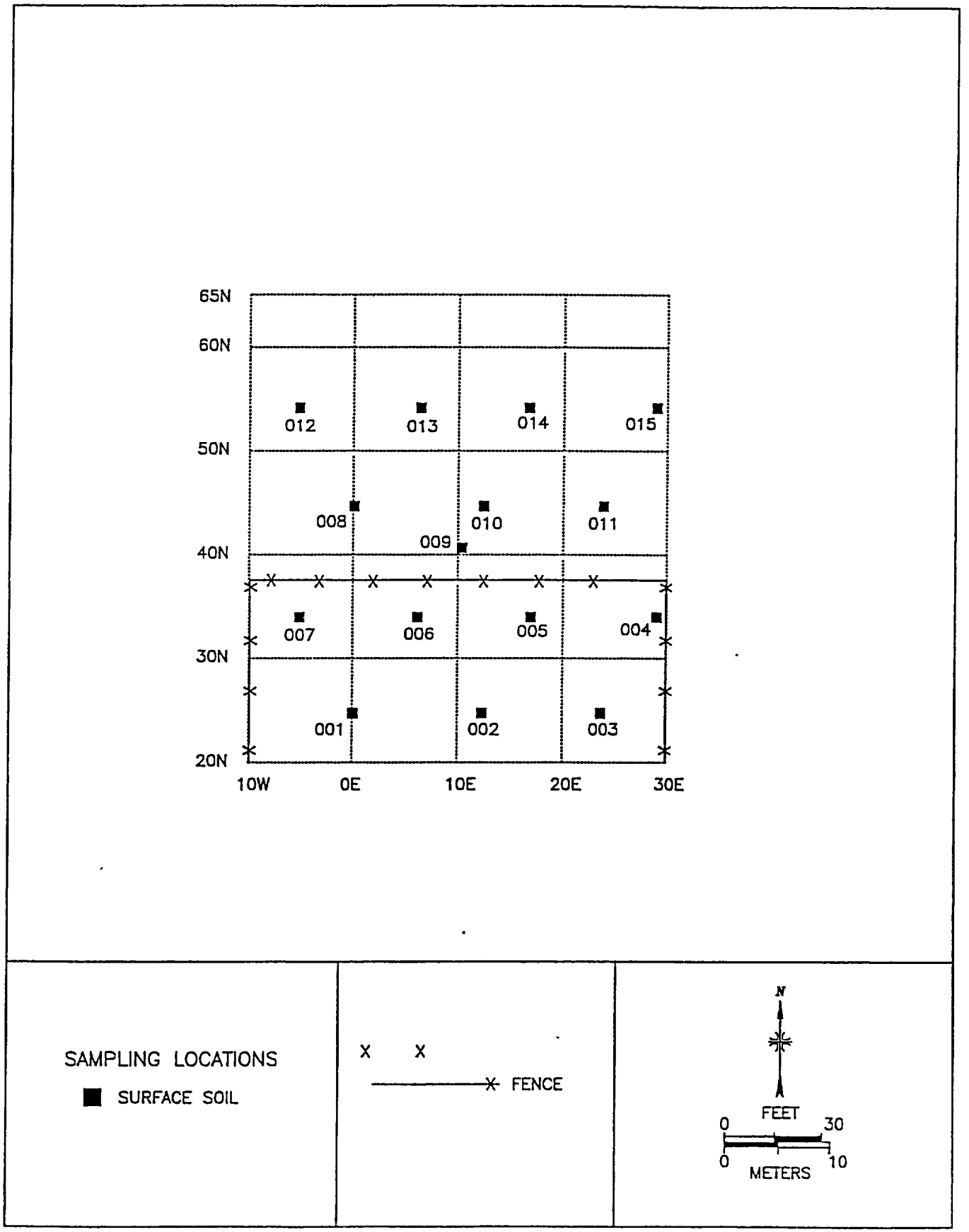


FIGURE 4: Survey Unit 1 – Sampling Locations

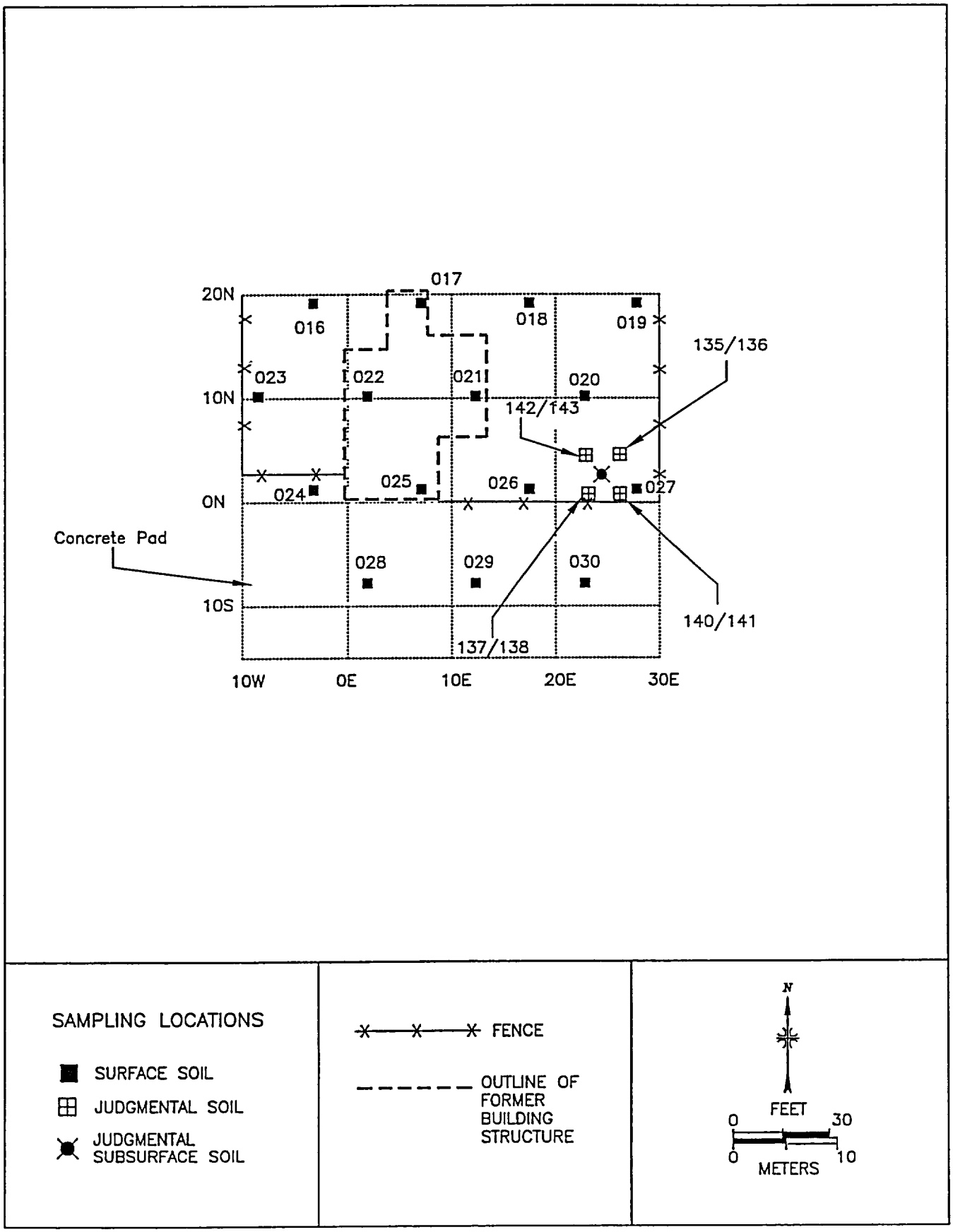
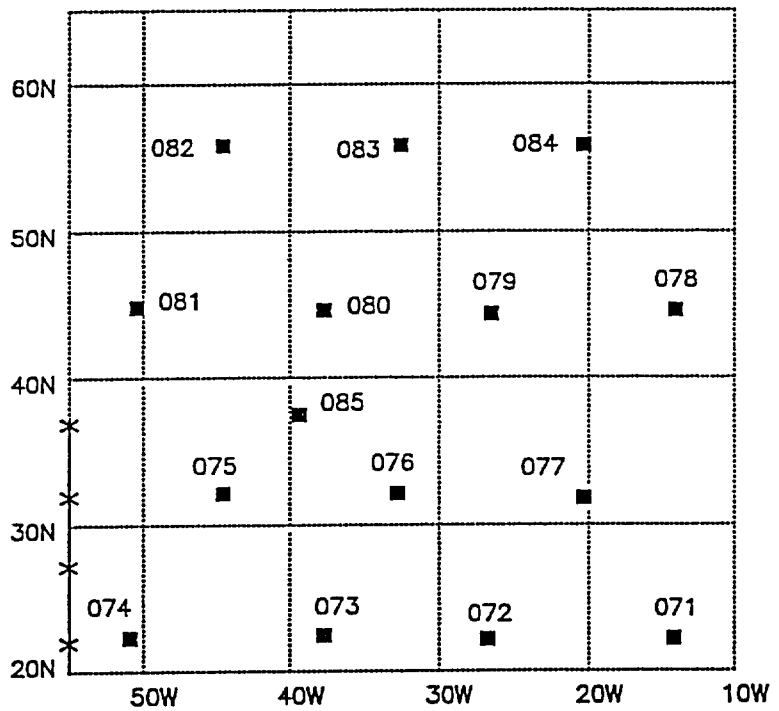


FIGURE 5: Survey Unit 2 – Sampling Locations



SAMPLING LOCATIONS

SURFACE SOIL

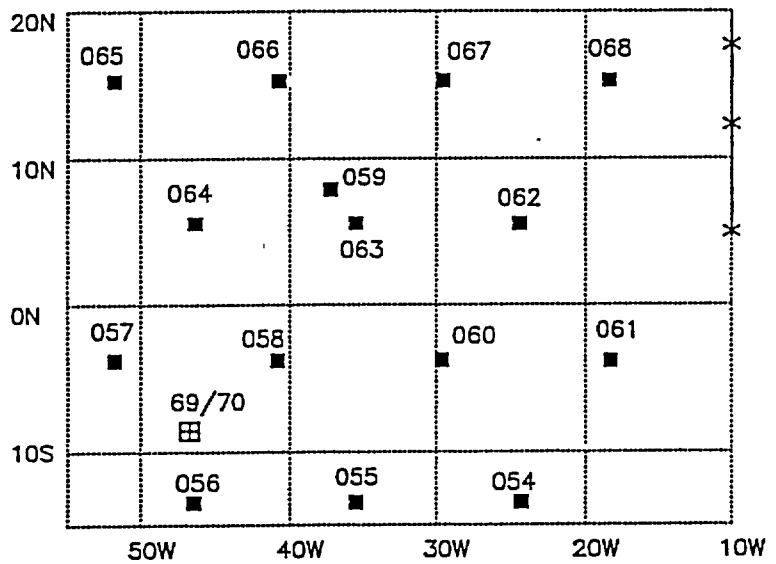
FENCE

N

FEET 0 30

METERS 0 10

FIGURE 6: Survey Unit 3 – Sampling Locations



SAMPLING LOCATIONS

SURFACE SOIL

JUDGMENTAL SOIL

FENCE

N

FEET 0 30

METERS 0 10

FIGURE 7: Survey Unit 4 – Sampling Locations

765–008 (5)

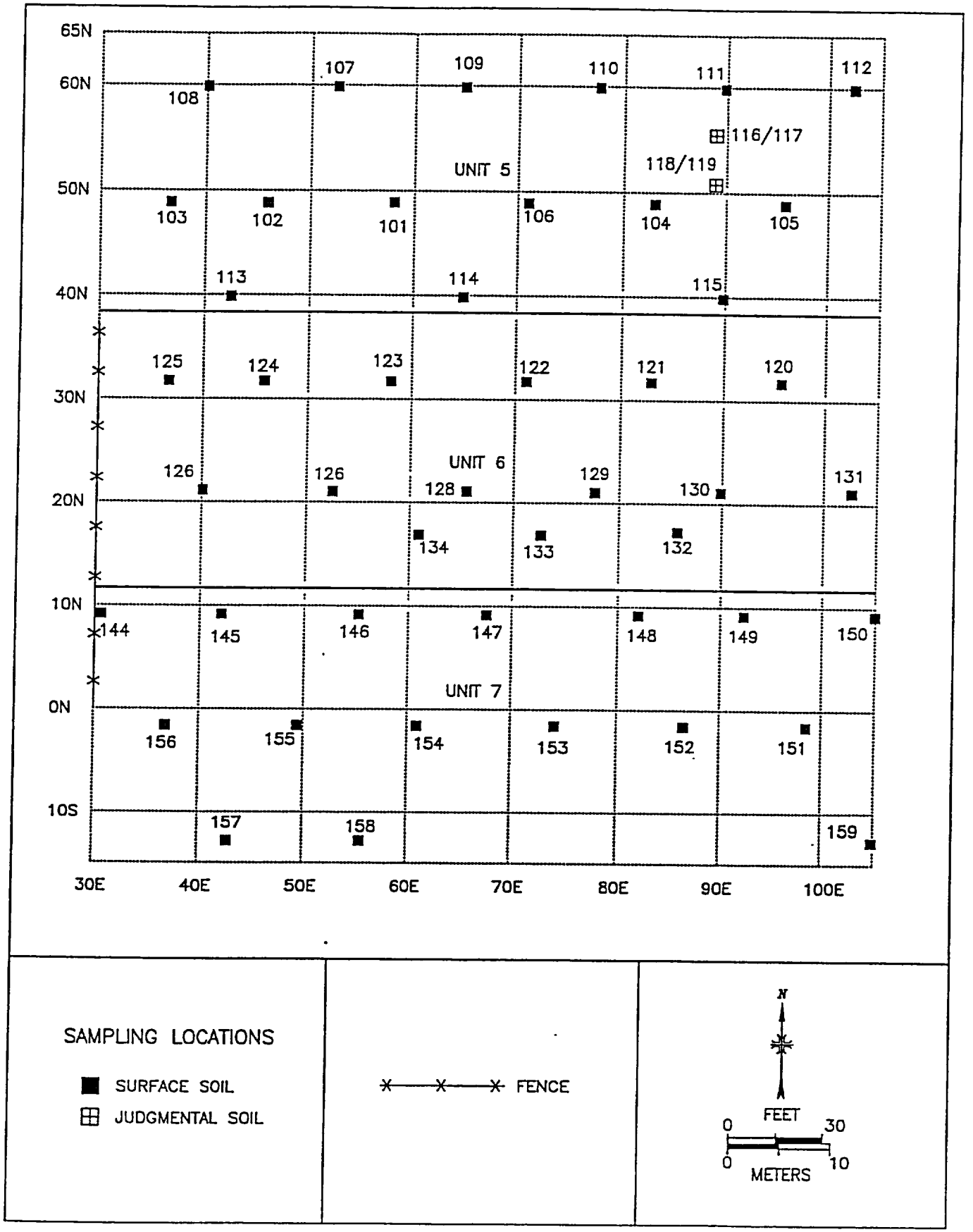
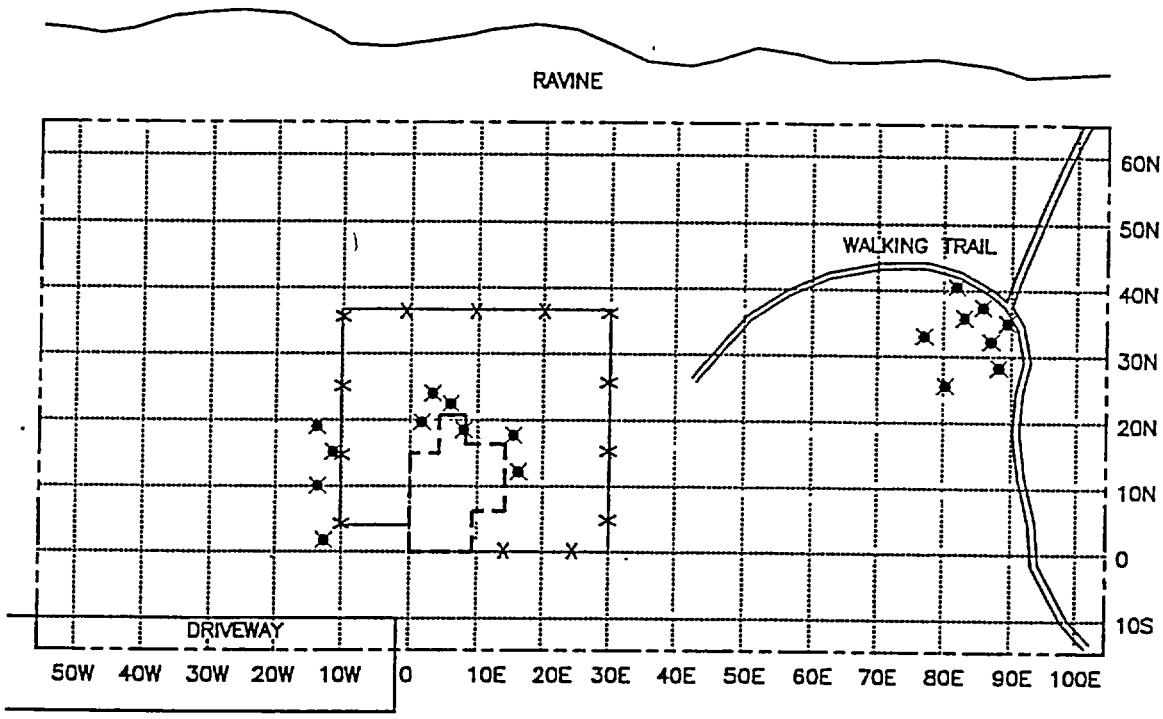


FIGURE 8: Survey Units 5, 6 and 7 – Sampling Locations



SAMPLING LOCATIONS

BOREHOLE

FENCE

OUTLINE OF FORMER BUILDING STRUCTURE

N

FEET 0 60

METERS 0 20

FIGURE 9: Former Gamma Industries Site – Borehole Sampling Locations

TABLES

TABLE 1

SURVEY UNIT AREA AND GRID SPACING

Unit	A (m^2)	L	A' (m^2)
Class 1 Units			
#1	1800	11.8	120
#2	1400	10.4	94
#4	1575	11.0	105
#5	2000	12.4	133
#6	2000	12.4	133
#7	2000	12.4	133
Class 2 Units			
#3	2025	12.5	135

TABLE 2

OUTDOOR AREA FACTORS

1 m^2	3 m^2	10 m^2	30 m^2	100 m^2	300 m^2	1000 m^2	2000 m^2	3000 m^2	10000 m^2
Area Factor									
9.8	4.4	2.12	1.52	1.23	1.13	1.06	1.05	1.04	1

TABLE 3

Co-60 CONCENTRATIONS IN SYSTEMATIC SOILS
GAMMA INDUSTRIES
PORT NORRIS, NEW JERSEY

Survey Unit	Sample ID[a]	Radionuclide Concentration (pCi/g)
		Co-60
Unit 1	001	<0.03
	002	0.14 ± 0.03[b]
	003	<0.03
	004	<0.03
	005	<0.03
	006	<0.02
	007	<0.03
	008	<0.04
	009	<0.03
	010	<0.03
	011	<0.06
	012	<0.04
	013	<0.03
	014	<0.04
	015	<0.03
Unit 2	016	<0.02
	017	0.32 ± 0.05
	018	<0.02
	019	<0.03
	020	<0.04

TABLE 3 (continued)

Co-60 CONCENTRATIONS IN SYSTEMATIC SOILS
GAMMA INDUSTRIES
PORT NORRIS, NEW JERSEY

Survey Unit	Sample ID[a]	Radionuclide Concentration (pCi/g)
		Co-60
Unit 2 (con't)	021	0.04 ± 0.02
	022	0.10 ± 0.03
	023	<0.02
	024	<0.03
	025	<0.02
	026	0.19 ± 0.04
	027	<0.02
	028	<0.02
	029	0.04 ± 0.02
	030	<0.03
Unit 3	071	<0.03
	072	<0.03
	073	<0.02
	074	<0.04
	075	<0.03
	076	<0.04
	077	<0.02
	078	<0.03
	079	<0.02
	080	<0.03
	081	<0.02
	082	<0.04

TABLE 3 (continued)

Co-60 CONCENTRATIONS IN SYSTEMATIC SOILS
GAMMA INDUSTRIES
PORT NORRIS, NEW JERSEY

Survey Unit	Sample ID[a]	Radionuclide Concentration (pCi/g)
		Co-60
Unit 3 (con't)	083	<0.02
	084	<0.03
	085	<0.02
Unit 4	054	<0.03
	055	<0.04
	056	<0.02
	057	<0.03
	058	<0.04
	059	<0.04
	060	<0.03
	061	<0.03
	062	<0.03
	063	<0.03
	064	<0.03
	065	<0.03
	066	<0.03
	067	<0.03
	068	<0.02
Unit 5	101	<0.04
	102	<0.02
	103	<0.02
	104	<0.03

TABLE 3 (continued)

Co-60 CONCENTRATIONS IN SYSTEMATIC SOILS
GAMMA INDUSTRIES
PORT NORRIS, NEW JERSEY

Survey Unit	Sample ID[a]	Radionuclide Concentration (pCi/g)
		Co-60
Unit 5 (con't)	105	<0.04
	106	<0.02
	107	<0.04
	108	<0.02
	109	<0.03
	110	<0.03
	111	<0.04
	112	<0.04
	113	<0.03
	114	<0.04
	115	0.07 ± 0.03
Unit 6	120	0.08 ± 0.04
	121	<0.03
	122	<0.03
	123	<0.04
	124	<0.03
	125	<0.02
	126	<0.04
	127	<0.02
	128	<0.02
	129	<0.04

TABLE 3 (continued)

Co-60 CONCENTRATIONS IN SYSTEMATIC SOILS
GAMMA INDUSTRIES
PORT NORRIS, NEW JERSEY

Survey Unit	Sample ID[a]	Radionuclide Concentration (pCi/g)
		Co-60
Unit 6 (con't)	130	<0.02
	131	<0.02
	132	<0.04
	133	<0.04
	134	0.02 ± 0.03
Unit 7	144	<0.02
	145	<0.03
	146	<0.03
	147	<0.04
	148	<0.03
	149	<0.02
	150	<0.03
	151	<0.04
	152	<0.03
	153	<0.03
	154	<0.03
	155	<0.04
	156	<0.02
	157	<0.05
	158	<0.03
	159	<0.03

[a]Refer to Figures 4 through 8
[b]Uncertainties represent the 95% confidence level based on total propagated uncertainties

TABLE 4

RADIONUCLIDE CONCENTRATIONS IN JUDGMENTAL SOILS
GAMMA INDUSTRIES
PORT NORRIS, NEW JERSEY

Survey Unit	Sample[a] Location	Sample ID	Depth (cm)	Radionuclide Concentration (pCi/g)	
				Co - 60	Cs-137
Unit 2	2.7N, 23E	135	0-15	<0.03	-
	2.7N, 23E	136	15-30	<0.03	-
	1.7N, 23E	137	0-15	0.08 ± 0.02[b]	-
	1.7N, 23E	138	15-30	<0.04	-
	2.2N, 23E	139	30-500	<0.03	
	2.2N, 23E	052	0-15	0.08 ± 0.02	1.75 ± 0.10
	2.2N, 23E	053	15-30	0.11 ± 0.03	104.50 ± 4.70
	2.2N, 23.5E	140	0-15	0.5 ± 0.02	-
	2.2N, 23.5E	141	15-30	<0.03	-
	2.2N, 22.5E	142	0-15	<0.02	-
	2.2N, 22.5E	143	15-30	<0.03	-
Unit 4	8.75, 48.8W	069	0-15	<0.04	-
	8.75, 48.8W	070	15-30	<0.05	-
Unit 5	55.5N, 89E	116	0-15	<0.04	-
	55.5N, 89E	117	15-30	<0.07	-
	50.3N, 88.5E	118	0-15	<0.04	-
	50.3N, 88.5E	119	15-30	<0.03	-

[a]Refer to Figures 5, 7, and 8
[b]Uncertainties represent the 95% confidence level, based on total propagated uncertainties

TABLE 5

Co-60 CONCENTRATIONS IN SUBSURFACE SOILS
GAMMA INDUSTRIES
PORT NORRIS, NEW JERSEY

Survey Unit	Subsurface[a] Location	Sample ID	Depth (m)	Radionuclide Concentration (pCi/g)
Unit 1	20.5N, 8.8E	037	1.8	0.03 ± 0.02[b]
	20.5N, 8.8E	038	1.0	<0.03
	22.5N, 2E	041	1.5	<0.03
	22.5N, 2E	042	1.0	<0.04
Unit 2	11.3N, 15.1E	035	1.8	<0.03
	11.3N, 15.1E	036	1.0	<0.04
	20N, 1E	039	1.8	<0.03
	20N, 1E	040	1.0	<0.03
	18N, 9E	031	1.5	0.26 ± 0.03
	18N, 9E	032	1.0	<0.03
	18N, 15.5E	033	1.8	<0.03
	18N, 15.5E	034	1.0	<0.03
Unit 4	4N, 12.3W	043	1.5	<0.04
	4N, 12.3W	044	1.0	<0.05
	10N, 13W	045	1.8	<0.03
	10N, 13W	046	1.0	<0.04
	15N, 11W	047	2.0	0.16 ± 0.03
	15N, 11W	048	2.6	3.13 ± 0.14
	15N, 11W	049	1.0	0.10 ± 0.04

TABLE 5 (continued)

Co-60 CONCENTRATIONS IN SUBSURFACE SOILS
GAMMA INDUSTRIES
PORT NORRIS, NEW JERSEY

Survey Unit	Subsurface[a] Location	Sample ID	Depth (m)	Radionuclide Concentration (pCi/g)
Unit 4 (con't)	19N, 13W	050	1.9	<0.04
	19N, 13W	051	1.0	<0.03
Unit 5	40.3N, 81E	092	1.9	<0.04
	40.3N, 81E	093	1.0	<0.02
Unit 6	26N, 80E	086	1.9	<0.03
	26N, 80E	087	1.0	<0.03
	32.8N, 79.5E	088	1.9	<0.05
	32.8N, 79.5E	089	1.0	<0.03
	36.2N, 82.2E	090	1.5	<0.04
	36.2N, 82.2E	091	1.0	<0.03
	37.2N, 84E	094	1.0	<0.03
	33.5N, 86.3E	095	1.5	<0.02
	33.5N, 86.3E	096	1.0	<0.05
	35.5N, 90E	097	1.5	<0.02
	35.5N, 90E	098	1.0	<0.04
	29N, 89.8E	099	1.5	<0.03
	29N, 89.8E	100	1.0	<0.02

[a]Refer to Figures 5 and 9
[b]Uncertainties represent the 95% confidence level, based on total propogated uncertainties

TABLE 6

MEAN Co-60 CONCENTRATION IN SYSTEMATIC SOILS
GAMMA INDUSTRIES
PORT NORRIS, NEW JERSEY

Survey Unit	Mean Co-60 Concentration
1	<0.04 ± 0.03
2	<0.06 ± 0.08
3	<0.03 ± 0.01
4	<0.03 ± 0.01
5	<0.04 ± 0.01
6	<0.03 ± 0.02
7	<0.03 ± 0.01

REFERENCES

The GNI Group (GNI). Gamma Industries Facility Decontamination and Radiological Survey Prior to Release for Unrestricted Use. Houston, TX; February 1989.

Oak Ridge Institute for Science and Education (ORISE). Radiological Survey of the Former Gamma Industries Facility, Port Norris, New Jersey. Oak Ridge, TN; September 10, 1996.

Oak Ridge Institute for Science and Education. Characterization Survey Plan for the Former Gamma Industries Site. Oak Ridge, Tennessee; September 13, 2000a.

Oak Ridge Institute for Science and Education. Survey Procedures Manual for the Environmental Survey and Site Assessment Program, 10. Oak Ridge, Tennessee, September 28, 2000b.

Oak Ridge Institute for Science and Education. Quality Assurance Manual for the Environmental Survey and Site Assessment Program, 9. Oak Ridge, Tennessee; August 8, 2000c.

Oak Ridge Institute for Science and Education. Laboratory Procedures Manual for the Environmental Survey and Site Assessment Program, 14. Oak Ridge, Tennessee; May 10, 2000d.

U.S. Nuclear Regulatory Commission (NRC). Multiagency Radiation Survey and Site Investigation Manual (MARSSIM). Washington D.C.; NUREG-1575; December 1997.

U.S. Nuclear Regulatory Commission. NUREG-1507, Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions. Washington, D.C.; NRC; June 1998.

U.S. Nuclear Regulatory Commission. Supplemental Information on the Implementation of the Final Rule on Radiological Criteria for License Termination. Federal Register, Volume 64, Page 68395 (64 FR 68395), December 7, 1999.

APPENDIX A

MAJOR INSTRUMENTATION

APPENDIX A
MAJOR INSTRUMENTATION

The display of a specific product is not to be construed as an endorsement of the product or its manufacturer by the author or the author's employer.

DIRECT RADIATION MEASUREMENT

Instruments

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

Detectors

Eberline NaI Scintillation Detector
Model SPA-3
2 in x 2 in Crystal
(Eberline, Santa Fe, NM)

LABORATORY ANALYTICAL INSTRUMENTATION

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

High Purity Extended Range Intrinsic Detector
Model No. GMX-45200-5
(EG&g ORTEC, OAK RIDGE, TN)
used in conjuction with:
Lead Shield Model SPG-16-K8
(Nuclear Data)
Multichannel Analyzer
DEC ALPHA Workstation
(Canberra, Meriden, CT)

High-Purity Germanium Detector
Model GMX-23195-S, 23% Eff.
(EG&G ORTEC, Oak Ridge, TN)
Used in conjunction with:
Lead Shield Model G-16
(Gamma Products, Palos Hills, IL) and
Multichannel Analyzer
DEC ALPHA Workstation
(Canberra, Meriden, CT)

APPENDIX B

SURVEY AND ANALYTICAL PROCEDURES

APPENDIX B
SURVEY AND ANALYTICAL PROCEDURES

PROJECT HEALTH AND SAFETY

All survey and laboratory activities were conducted in accordance with ORISE health and safety and radiation protection programs.

CALIBRATION AND QUALITY ASSURANCE

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

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

- Survey Procedures Manual (September 2000)
- Laboratory Procedures Manual (May 2000)
- Quality Assurance Manual (March 2000)

The procedures contained in these manuals were developed to meet the requirements of Department of Energy (DOE) Order 414.1A and ASME NQA-1 for Quality Assurance and contain measures to assess processes during their performance.

Quality control procedures include:

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

SURVEY PROCEDURES

Surface Scans

Surface scans were performed by passing the detectors slowly over the surface; the distance between the detectors and the surface was maintained at a minimum—nominally 2 to 4 cm. Identification of elevated levels was based on increases in the audible signal from the recording and/or indicating instrument. Combinations of detectors and instruments used for the scans were:

Gamma - NaI scintillation detector with ratemeter

The scan MDC for the NaI scintillation detector Model SPA-3 for Co-60 was 3.4 pCi/g obtained from NUREG-1507.[1] The parameters applied in the field were the same as those relative to assumptions used to develop the scan MDC of 3.4 pCi/g. The observation interval was nominally one second, the level of performance was assigned a d′ of 1.38, surveyor efficiency remained conservatively estimated at 0.5, and the source to detector distance improved over that which was modeled.

Soil Sampling

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

ANALYTICAL PROCEDURES

Gamma Spectrometry

Soil samples were dried, mixed, crushed, and/or homogenized as necessary, and a portion sealed in a 0.5-liter Marinelli beaker or other appropriate container. The quantity placed in the beaker was chosen to reproduce the calibrated counting geometry. Net material weights were determined and samples counted using intrinsic germanium detectors coupled to a pulse height analyzer system.

[1]NUREG-1507. Minimum Detectable Concentrations With Typical Radiation Survey Instruments for Various Contaminants and Field Conditions. US Nuclear Regulatory Commission. Washington, DC, June 1998

Background and Compton stripping, peak search, peak identification, and concentration calculations were performed using the computer capabilities inherent in the analyzer system. All photopeaks associated with the radionuclides of concern were reviewed for consistency of activity.

Energy peaks used for determining the activities of radionuclides of concern were:

Radionuclide	Photopeak	MDC (pCi/g)
Co-60	1.173 MeV	0.05
Cs-137	0.662 MeV	0.05

Spectra were also reviewed for other identifiable photopeaks.