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REVISED INDEPENDENT VERIFICATION SURVEY OF THE A AND B RADIOACTIVE WASTE TRANSFER LINES TRENCH BROOKHAVEN NATIONAL LABORATORY UPTON, NEW YORK

P. C. Weaver

Prepared for the
U.S. Department of Energy

ORISE
Oak Ridge Institute for Science and Education

The Oak Ridge Institute for Science and Education (ORISE) is a U.S. Department of Energy facility focusing on scientific initiatives to research health risks from occupational hazards, assess environmental cleanup, respond to radiation medical emergencies, support national security and emergency preparedness, and educate the next generation of scientists. ORISE is managed by Oak Ridge Associated Universities. Established in 1946, ORAU is a consortium of 97colleges and universities.

NOTICES

REVISED INDEPENDENT VERIFICATION SURVEY OF THE A AND B RADIOACTIVE WASTE TRANSFER LINES TRENCH BROOKHAVEN NATIONAL LABORATORY UPTON, NEW YORK

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REVISED
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OF THE
A AND B RADIOACTIVE WASTE TRANSFER LINES TRENCH
BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK

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ABBREVIATIONS AND ACRONYMS

AEC	Atomic Energy Commission
BAO	Brookhaven Area Office
BKG	background
BNL	Brookhaven National Laboratory
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm	centimeter
cm^2	square centimeter
cpm	counts per minute
Cs-137	cesium-137
DCGL	derived concentration guideline level
DOE	U.S. Department of Energy
EPA	Environmental Protection Agency
FIPS	Federal Information Processing Standard
FSP	Field Sampling Plan
g	gram
GPS	global positioning system
HFBR	High Flux Beam Reactor
IAG	interagency agreement
ISM	Integrated Safety Management
ITP	Intercomparison Testing Program
JHA	job hazard analysis
keV	kiloelectron volts
kg	kilogram
MAPEP	Mixed Analyte Performance Evaluation Program
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	minimum detectable concentration
NaI	sodium iodide
NIST	National Institute of Standards and Technology
NRIP	NIST Radiochemistry Intercomparison Program
NYSDEC	New York State Department of Environmental Conservation
ORAU	Oak Ridge Associated Universities
ORISE	Oak Ridge Institute for Science and Education
OU	Operable Unit
pCi/g	picocuries per gram
Ra-226	radium-226
RCRA	Resource Conservation and Recovery Act
ROD	record of decision
sec	second
SOR	sum-of-ratio
SPCS	State Plane Coordinate System
Sr-90	strontium-90
TAP	total absorption peak

REVISED INDEPENDENT VERIFICATION SURVEY OF THE A AND B RADIOACTIVE WASTE TRANSFER LINES TRENCH BROOKHAVEN NATIONAL LABORATORY UPTON, NEW YORK

INTRODUCTION

The Brookhaven Nation Laboratory (BNL) located in Upton, Suffolk County, New York conducts research and development for the Department of Energy (Figure A-1). BNL was originally occupied by the U.S. Army as Camp Upton during both World Wars I and II. In 1947, the site was transferred to the Atomic Energy Commission (AEC). The AEC was resolved into the Energy Research and Development Administration, and later into the Department of Energy (DOE). The DOE's Brookhaven Area Office (BAO) oversees the site.

Research operations and processes conducted at the site have produced a variety of radioactive and hazardous wastes. As a result, the BNL site was included on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priority List on December 21, 1989. In May 1992, the DOE entered into an interagency agreement (IAG) with the Environmental Protection Agency (EPA) and New York State Department of Environmental Conservation (NYSDEC) under CERCLA, section 120. The IAG established the framework and schedule for characterizing, assessing, and remediating the site in accordance with requirements of CERCLA and the Resource Conservation and Recovery Act (EPA 1997). In April 2009, the *Record of Decision – Area of Concern 31, High Flux Beam Reactor* (HFBR ROD), was finalized. The HFBR ROD includes the removal of the A &B waste transfer lines and associated contaminated soil (BNL 2009).

The A-waste line, B-waste line, original D-waste line, steam line, and Non-Acid Off-Gas Pipe were installed in 1949 in an underground concrete culvert. The A- and B-waste lines operated from 1952 until they were abandoned-in-place in 1961. The original 4 inch D-waste line operated briefly in 1952, but was abandoned-in-place after the pipe developed leaks. The steam line operated until it was abandoned in 2001.

The transfer lines carried radioactive liquid wastes to Building 811 from Building 801. BNL has recently performed remediation of a portion of the A and B Radioactive Waste Transfer Line

(A/B Trench) working from Building 811 towards Building 801. BNL divided work on the A&B Trench into four phases.

DOE-BAO is responsible for oversight of remedial actions that are conducted at the BNL. It is the policy of the DOE to perform independent (third party) verification of final status survey (FSS) activities (DOE 2006). The purpose of independent verification (IV) is to confirm that remedial actions have been effective in meeting established guidelines and that documentation accurately and adequately describes the final site conditions. At the request of the DOE-BAO, the Oak Ridge Institute for Science and Education (ORISE) performed IV of the A/B Trench. By using an independent third party, DOE can provide a level of assurance to the stakeholders that the as-left radiological concentration in the A/B Trench is accurately documented. This report has been revised to reflect additional surveys performed by ORISE at the southern end of the trench (Zone 1 and Zone 2) and report the results of soil samples that were collected during this activity.

OBJECTIVES

The objective of the verification survey was to obtain evidence by means of measurements and sampling to confirm that the final radiological conditions were less than the established release criteria. This objective was achieved via multiple verification components including document reviews to determine the accuracy and adequacy of FSS documentation

PROCEDURES

ORISE personnel visited the BNL site September 28 and 29, 2009 and again on December 9 and 10, 2009 to perform visual inspections and independent measurements and sampling. The verification activities were conducted in accordance with the project-specific verification plan, the IEAV Survey Procedures, and Quality Program Manuals (ORISE 2009a and 2008, and ORAU 2009). The A/B Trench has been excavated from Building 811 to Building 801. The A/B Trench is a designated Class 1 survey unit due to its inherent operational purpose and the contaminants associated with the process activities.

REFERENCE SYSTEM

ORISE used a global positioning system (GPS) for documenting survey area boundaries and tracking data for accessible areas within the trench. The specific geological reference system used was the State Plane Coordinate System (SPCS) New York Long Island Federal Information Processing Standard (FIPS) 3104. Coordinate measurements collected using the GPS were accurate to within one meter.

SURFACE SCANS

High density scans for gamma radiation were performed within the accessible areas of the remediated A/B Trench (Figure A-2 and A-3). Surfaces scans were performed using NaI scintillation detectors coupled to ratemeters or ratemeter-scalers with audible indicators. Detectors were coupled to GPS systems that enable real-time gamma count rate and position data capture. Locations of elevated direct radiation, suggesting the presence of residual contamination, were marked for further investigation.

During the December verification effort of the trench excavation, the condition of most of the trench was such that it was considered a significant safety hazard for physical access. Therefore, in order to adequately verify the as-left condition of the trench, the team requested the excavation of soil along the bottom and sidewalls of the trench. This soil was laid down adjacent to the excavation, scanned, and then sampled. Scans were performed as previously detailed. Potential areas that may have required additional evaluation were re-excavated and scanned. Any contaminated soils identified would have been segregated for disposal.

SOIL SAMPLING

Surface soil samples were collected from judgmental locations based on surveyor observation of gamma radiation measurements and process knowledge. An additional six samples were collected for completion of Zone 1 and Zone 2 portions of the trench during the December survey effort, for a total of 10 judgmental samples (Figure A-4 and A-5).

SAMPLE ANALYSIS AND DATA INTERPRETATION

Samples and data were returned to the ORISE/IEAV laboratory in Oak Ridge, Tennessee for analysis and interpretation. Sample analyses were performed in accordance with the ORISE Laboratory Procedures Manual (ORISE 2009b). Soil samples were analyzed by gamma spectroscopy for Ra-226 and Cs-137. The spectra were reviewed for other identifiable photopeaks. Sr-90 was quantified by radiochemical separation and counted on a low background proportional counter. Soil sample results were reported in units of picocuries per gram (pCi/g).

APPLICABLE SITE GUIDELINES

The radiological contaminants of concern and the soil cleanup levels are shown in Table 1 and have been previously identified in the Operational Unit (OU) I ROD (BNL1999). Because multiple contaminants are present, application of the unity rule is involved requiring calculation of the sum-of-ratios (SORs) in accordance with the following equation:

$$\frac{Conc._{Ra-226}}{DCGL_{Ra-226}} + \frac{Conc._{Cs-137}}{DCGL_{Cs-137}} + \frac{Conc._{Sr-90}}{DCGL_{Sr-90}} + \leq 1$$

TABLE 1
RADIONUCLIDES OF CONCERN IN THE PERIMETER SOILS AREA AND A&B WASTE LINES INDUSTRIAL LAND USE CLEAN-UP GOALS BROOKHAVEN NATIONAL LABORATORY

Radionuclide	OU I ROD (pCi/g)
Cs-137	23
Sr-90	15
Ra-226	5

FINDINGS AND RESULTS

The results of the two verification surveys of the A/B Trench remediation activities are discussed below.

SURFACE SCANS

The background count rate averaged just slightly greater than 2,300 counts per minute (cpm) during the first verification survey and approximately 4,300 cpm during the second verification survey that were performed in order to complete the Zone 1 and 2 phases of the trench excavation. The difference in backgrounds between the two surveys is the result of using different sized NaI detectors. A 1.5 inch by 1.25 inch NaI detector was used initially and a 2 inch by 2 inch (SPA-3) was used for the final verification survey effort.

Gamma area scan count rates during the initial survey generally ranged from 3,500 to approximately 7,300 cpm with a mean of 4,600 cpm. Gamma area scan count rates during the second verification survey effort generally ranged from 4,200 to approximately 72,000 cpm with a median of 8,300 cpm with the SPA-3. The count rate frequency distributions of the gamma scans are illustrated in Figures A-6 and A-7. Counts that were typically 30,000 cpm and greater were primarily detected when the detector was above the level of the trench as a result of the gamma radiation shine from a nearby building.

During the second verification survey effort of the trench, the ambient gamma radiation levels were higher in the area nearest to Building 801. The significant increase in activity was due to high activity sources inside Building 801. Once inside the trench, the radioactivity levels were significantly lower. No background reference area was defined by ORISE prior to the survey; therefore, measurement data provided in this report are the gross gamma count rate data.

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES

The summary radionuclide soil concentration data for the A/B Trench are presented in Table B-1. The data for the radionuclide concentrations in individual soil samples and the sum-of-ratios are provided in Table B-2. The concentration of Ra-226 ranged from 0.25 to 0.51 pCi/g, Cs-137 ranged from 0.00 to 0.18 pCi/g, and Sr-90 ranged from -0.24 to 0.27 pCi/g.

COMPARISON OF RESULTS WITH GUIDELINES

The final radionuclide concentration for the A/B Trench must meet the guidance per the BNL Field Sampling Plan (FSP) for each individual soil sample and the SOR for the average concentration of each radionuclide of interest must be less than one. The SOR for individual samples are included in Table B-2. All radionuclides were below the cleanup goals and the SOR limit.

SUMMARY

During the period between September 28 and 29, 2009 and December 9 and 10, 2009 an independent verification team with the Oak Ridge Institute for Science and Education conducted measurements and sampling of the A and B Radioactive Waste Transfer Line Trench at the Brookhaven National Laboratory site. Gamma walkover scans did not identify radiation levels that warranted additional investigation. ORISE collected ten judgmental soil samples. All individual samples and the corresponding mean concentration were determined to be below the established cleanup goals. Therefore, it is the opinion of ORISE that the remedial actions implemented by BNL sufficiently meet the established clean-up goals.

REFERENCES

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APPENDIX A

FIGURES

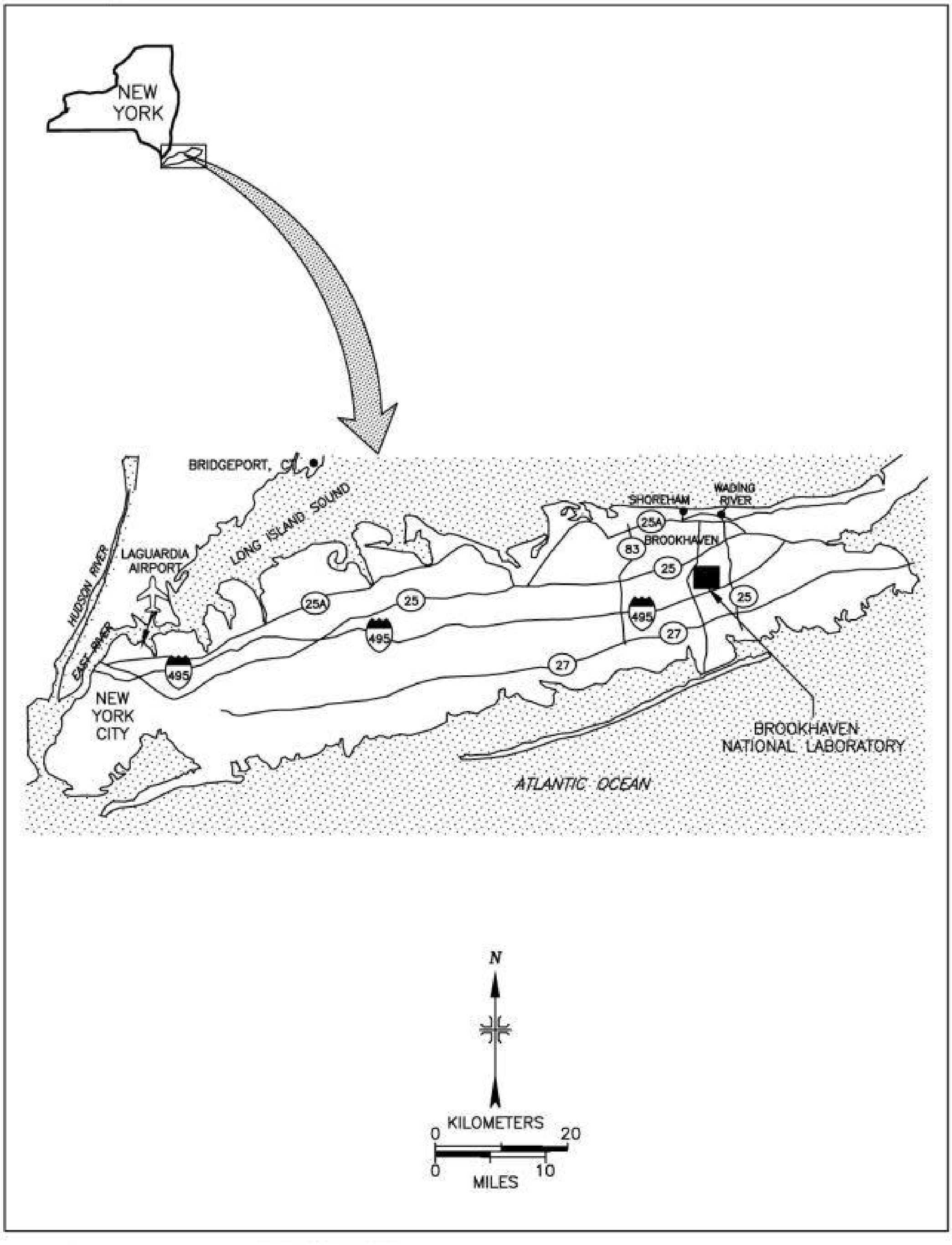

Figure A - 1: Location of Brookhaven National Laboratory, Upton, New York

Figure A - 2: A and B Radioactive Waste Line Trench Gamma Activity Scan Pattern

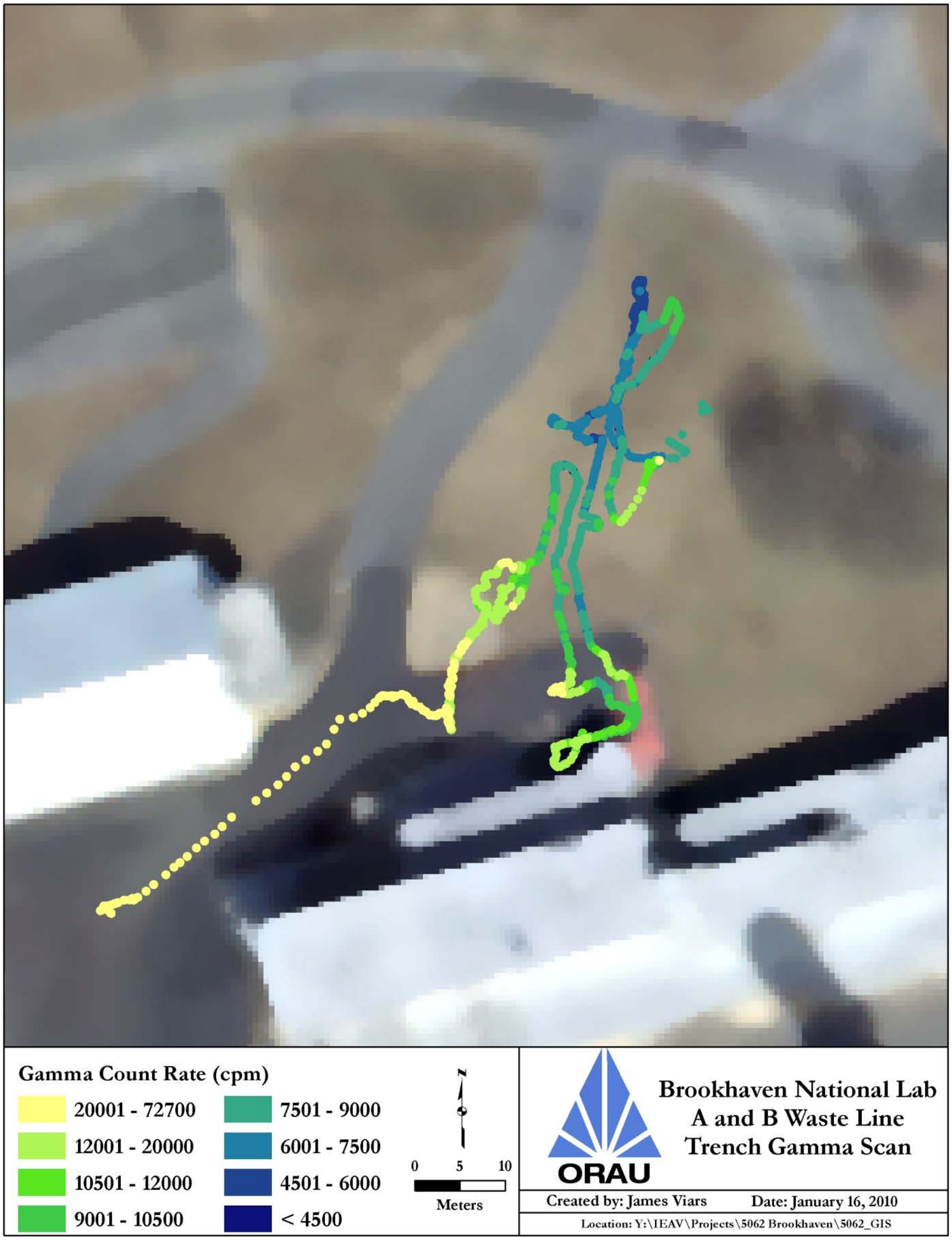

Figure A - 3: A and B Radioactive Waste Line Trench Gamma Activity Scan Pattern

Figure A - 4: A and B Radioactive Waste Line Trench (North) Sample Locations

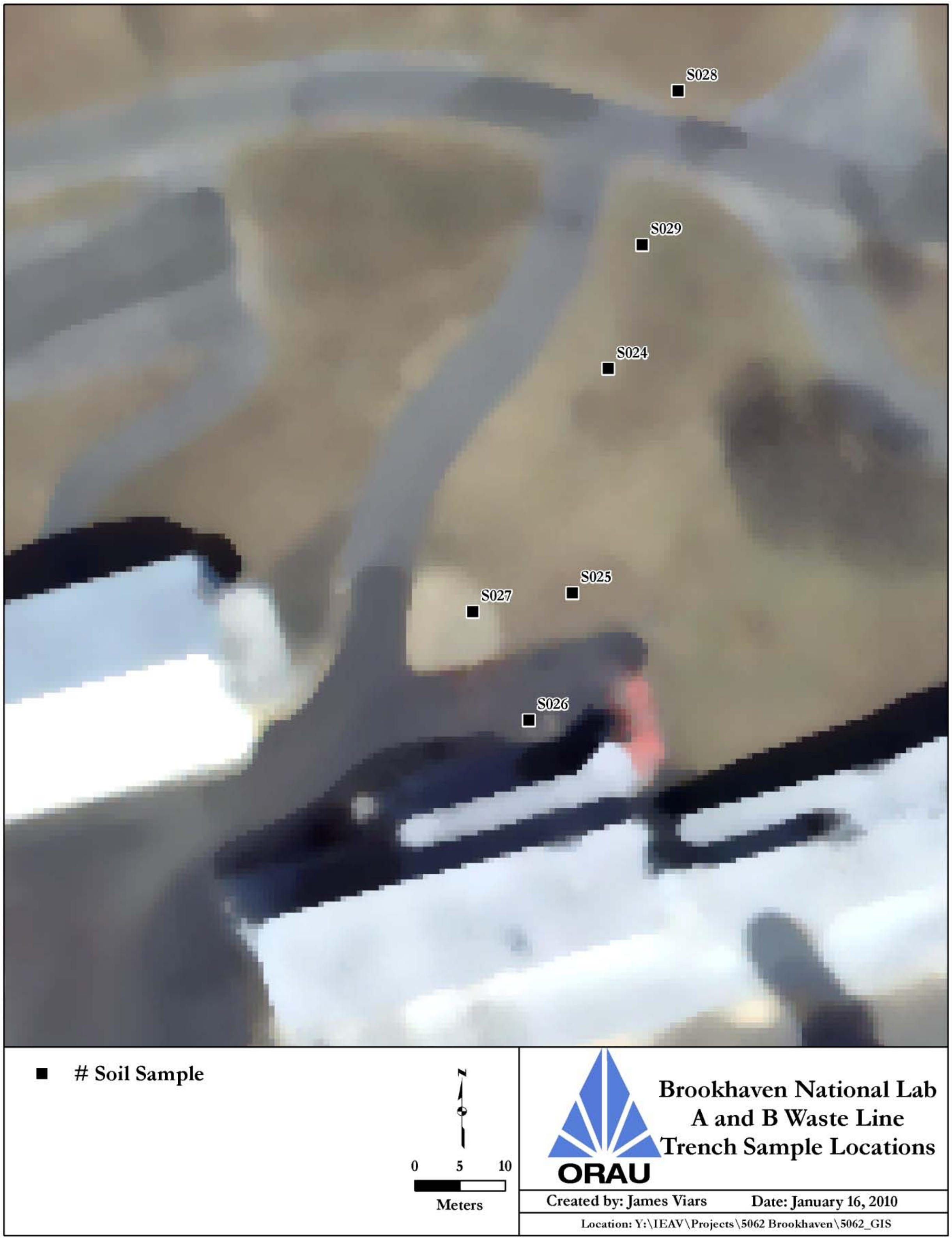

Figure A - 5: A and B Radioactive Waste Line Trench (South) Sample Locations

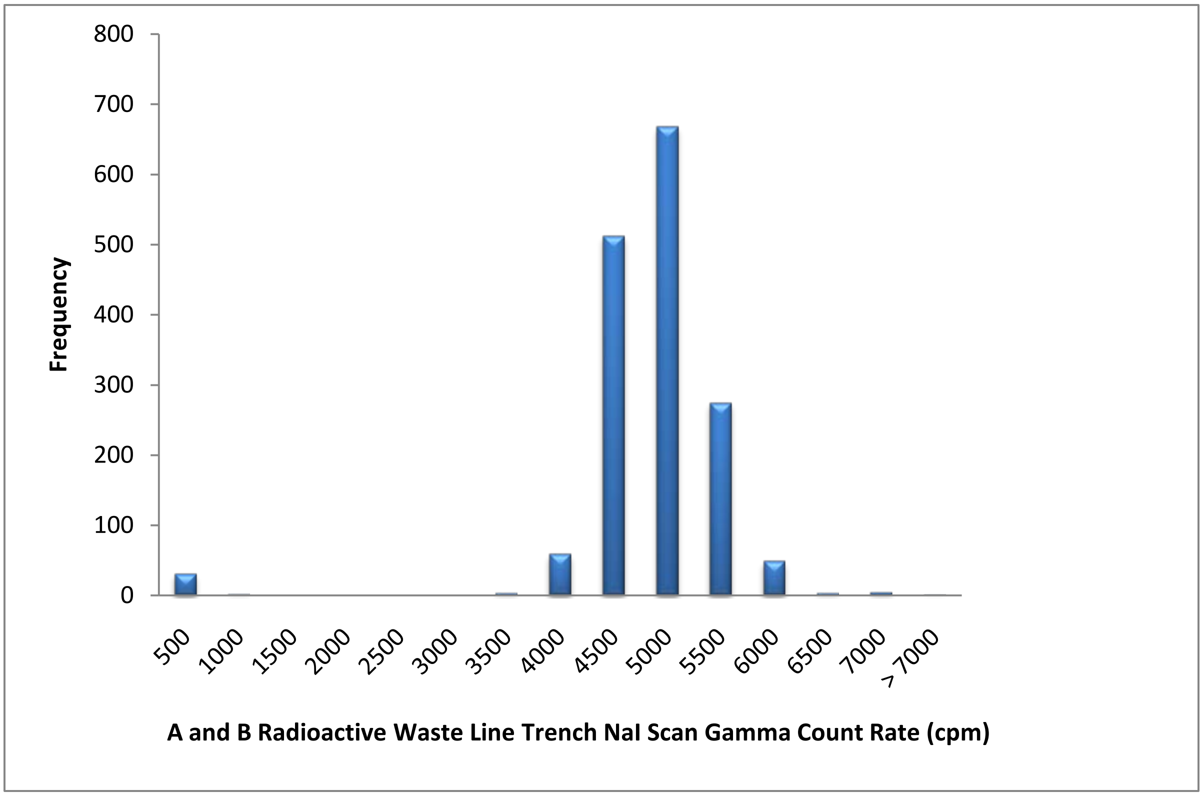

Figure A - 6: A and B Radioactive Waste Line Trench (North) Gamma Scan Count Rate Histogram

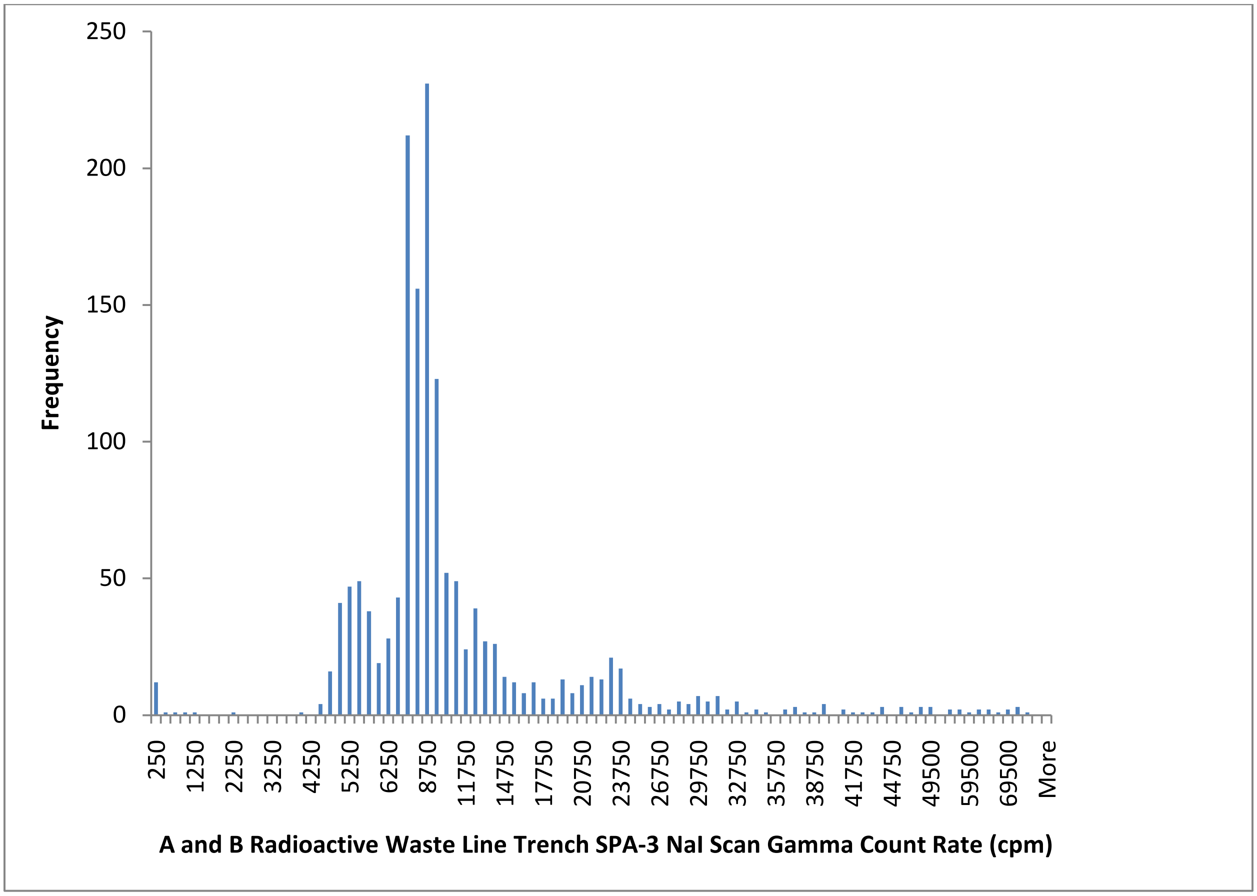

Figure A - 7: A and B Radioactive Waste Line Trench (North) Gamma Scan Count Rate Histogram

APPENDIX B

TABLES

TABLE B-1 RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES A & B RADIOACTIVE WASTE LINE TRENCH SUMMARY SAMPLE RANGE AND MEAN CONCENTRATION BROOKHAVEN NATIONAL LABORATORY UPTON, NY			
Survey Unit	**Ra-226 (pCi/g)**	**Cs-137 (pCi/g)**	**Sr-90 (pCi/g)**
North A/B Waste Line[a]	0.25 to 0.41	0.03 to 0.18	-0.10 to 0.12
Mean Concentration	*0.33*	*0.09*	*-0.01*
South A/B Waste Line[b]	0.25 to 0.51	0.00 to 0.14	-0.24 to 0.27
Mean Concentration	*0.35*	*0.05*	*-0.12*

[a]Samples 20-23 collected during the September verification effort.

[b]Samples 24- 29 collected during the December verification effort.

TABLE B-2 RADIONUCLIDE CONCENTRATIONS IN SOIL A & B RADIOACTIVE WASTE LINE TRENCH FORMER HAZARDOUS WASTE MANAGEMENT FACILITY BROOKHAVEN NATIONAL LABORATORY UPTON, NY				
Sample ID/Location[a]	**Radionuclide Concentration (pCi/g)**			
	Cs-137	**Sr-90**	**Ra-226**	**SOR**[b]
S020	0.18 ± 0.03[c]	-0.09 ± 0.22	0.41 ± 0.04	0.08
S021	0.03 ± 0.01	-0.10 ± 0.25	0.3 ± 0.04	0.05
S022	0.06 ± 0.02	0.12 ± 0.21	0.36 ±0.05	0.08
S023	0.10 ± 0.02	0.01 ± 0.20	0.25 ± 0.03	0.06
S024	0.02 ± 0.01	-0.23 ± 0.23	0.25 ± 0.04	0.04
S025	0.06 ± 0.02	-0.18 ± 0.23	0.35 ± 0.04	0.06
S026	0.07 ± 0.01	-0.18 ± 0.25	0.30 ± 0.03	0.05
S027	0.02 ± 0.01	-0.24 ± 0.23	0.43 ± 0.05	0.07
S028	0.14 ± 0.03	0.27 ± 0.26	0.51 ± 0.06	0.13
S029	0.00[d] ± 0.03	-0.19 ± 0.25	0.26 ± 0.04	0.04

[a]Refer to Figures A-4 and A-5.
[b]Sum of the ratios.
[c]Uncertainties are at the 95% confidence level based on total propagated uncertainties.
[d]"Zero" reported due to rounding.

APPENDIX C

MAJOR INSTRUMENTATION

APPENDIX C

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 her employer.

SCANNING INSTRUMENT/DETECTOR COMBINATIONS

Ludlum NaI Scintillation Detector Model SPA-3, Crystal: 2 inch x 2 inch
(Ludlum Measurements, Inc., Sweetwater, TX)
Coupled to
Ludlum Ratemeter-Scaler Model 2221
Coupled to
Trimble GeoXH Receiver and Data Logger (Trimble Navigation Limited, Sunnyvale, CA)

Fluke NaI Scintillation Detector Model 489-55, Crystal: 1.5 inch x 1.25 inch
(Fluke, Cleveland, OH)
Coupled to
Ludlum Ratemeter-Scaler Model 2221
Coupled to
Trimble GeoXH Receiver and Data Logger (Trimble Navigation Limited, Sunnyvale, CA)

LABORATORY ANALYTICAL INSTRUMENTATION

High Purity Extended Range Intrinsic Detector
CANBERRA/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
Dell Workstation and Canberra's Apex
Gamma Software
(Canberra, Meriden, CT)

High Purity Extended Range Intrinsic Detector
Model No. GMX-45200-5
(AMETEK/ORTEC, Oak Ridge, TN)
used in conjunction with:
Lead Shield Model SPG-16-K8
(Nuclear Data)
Multichannel Analyzer
Dell Workstation and Canberra's Apex
Gamma Software(Canberra, Meriden, CT)

High-Purity Germanium Detector
Model GMX-30-P4, 30% Eff.
(AMETEK/ORTEC, Oak Ridge, TN)
Used in conjunction with:
Lead Shield Model G-16
(Gamma Products, Palos Hills, IL) and
Multichannel Analyzer
Dell Workstation and Canberra's Apex
Gamma Software
(Canberra, Meriden, CT)

Low background alpha/beta counting system
Canberra/Tennelec LB5100W
Eclipse Software
(Canberra, Inc., Meriden, CT)

APPENDIX D

SURVEY AND ANALYTICAL PROCEDURES

APPENDIX D

SURVEY AND ANALYTICAL PROCEDURES

PROJECT HEALTH AND SAFETY

The survey and sampling procedures were evaluated to ensure that any hazards inherent to the procedures themselves were addressed in current job hazard analyses (JHAs). All survey and laboratory activities were conducted in accordance with ORISE health and safety and radiation protection procedures.

Pre-survey activities included an overview of potential health and safety issues. Representatives with the Brookhaven National Laboratory provided site-specific safety awareness training for each individual ORISE survey effort. In-process and verification surveys were performed according to the ORISE generic health and safety plan, site-specific integrated safety management (ISM) pre-job hazard checklist, and safety procedures discussed during the on-site training.

QUALITY ASSURANCE

Analytical and field survey activities were conducted in accordance with procedures from the following Oak Ridge Associated Universities (ORAU) and ORISE documents:

- Survey Procedures Manual
- Laboratory Procedures Manual
- Quality Program Manual

The procedures contained in these manuals were developed to meet the requirements of 10 CFR 830 Subpart A, *Quality Assurance Requirements*, Department of Energy Order 414.1C *Quality Assurance*, and the U.S. Nuclear Regulatory Commission *Quality Assurance Manual for the Office of Nuclear Material Safety and Safeguards* 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, and ITP Laboratory Quality Assurance Programs.
- Training and certification of all individuals performing procedures.
- Periodic internal and external audits.

CALIBRATION

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

SURVEY PROCEDURES

Surface Scans

Scans for elevated gamma radiation were performed by passing the detector slowly over the surface. The distance between the detector and surface was maintained at a nominal distance of about 1 to 5 cm. NaI scintillation detectors were coupled to GPS units that enabled real-time recording of position in one-second intervals. Identification of elevated radiation levels was based on increases in the audible signal from the instrument. Positioning data files were downloaded from field data loggers for plotting using commercially available software (http://trl.trimble.com/docushare/dsweb/Get/Document-261826/GeoExpl2005_100A_GSG_ENG.pdf).

The scan minimum detectable concentrations (MDCs) for the NaI scintillation detector for the contaminants of concern in surface soil were obtained directly from NUREG-1507 when available or estimated using the calculational approach described in NUREG-1507[1]. A typical NaI 2 inch by 2 inch detector MDC for Cs-137 is 6.4 pCi/g. An audible increase in the activity rate was investigated by ORISE. It is standard procedure for the ORISE staff to pause and investigate any locations where gamma radiation is distinguishable from background levels.

Soil Sampling

Approximately 0.5 to 1 kg of soil was collected at each sample location. Collected samples were placed in plastic bags, sealed, and labeled in accordance with ORISE survey procedures.

RADIOLOGICAL ANALYSIS

Detection Levels

Detection limits, referred to as MDC, were based on 3 plus 4.65 times the standard deviation of the background count $[3 + (4.65 (BKG)^{1/2})]$. Because of variations in background levels, measurement efficiencies, and contributions from other radionuclides in samples, the detection limits differ from sample to sample and instrument to instrument.

Strontium Analysis

Soil samples were dissolved by a combination of potassium hydrogen fluoride and pyrosulfate fusions. The fusion cake was dissolved and strontium was coprecipitated on lead sulfate. The strontium was separated from residual calcium and lead by reprecipitating strontium sulfate from EDTA at a pH of 4.0. Strontium was separated from barium by complexing the strontium in DTPA while precipitating barium as barium chromate. The strontium was ultimately converted to strontium carbonate and counted on a low-background gas proportional counter. The typical MDC of the procedure is 0.4 pCi/g for a one hour count time.

Gamma Spectroscopy

Samples of soil 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

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

chosen to reproduce the calibrated counting geometry. Net material weights were determined and the samples counted using intrinsic germanium detectors coupled to a pulse height analyzer system. Background and Compton stripping, peak search, peak identification, and concentration calculations were performed using the computer capabilities inherent in the analyzer system. All total absorption peaks (TAP) associated with the radionuclides of concern were reviewed for consistency of activity. Total absorption peaks used for determining the activities of radionuclides of concern and the typical associated MDCs for a one-hour count time were:

Radionuclide	TAP (MeV)	MDC (pCi/g)
Cs-137	0.662	0.05
Ra-226 (from Pb-214)	0.351	0.08

Spectra were also reviewed for other identifiable TAPs.

<u>Uncertainties</u>

The uncertainties associated with the analytical data presented in the tables of this report represent the total propagated uncertainties for those data. These uncertainties were calculated based on both the gross sample count levels and the associated background count level.