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March 30, 2006
BYR 2006-027

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555-001

References: (a) License No. DPR-3 (Docket No. 50-29)

(b) BYR 2004-133, Submittal of Revision 1 to the Yankee Nuclear Power Station's License Termination Plan

(c) Yankee Nuclear Power Station – Issuance of Amendment 158 Re: License Termination Plan

Subject: Submittal of YNPS-FSS-NOL01-00, Final Status Survey Report for Survey Area NOL-01

Dear Madam/Sir:

This letter submits YNPS-FSS-NOL01-00, Final Status Survey Report for NOL-01. YNPS-FSS-NOL01-00 was written in accordance with Section 5 of the YNPS License Termination Plan, "Final Status Survey Plan," and is consistent with the guidance provided in the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM).

We trust that this information is satisfactory; however if you should have any questions or require any additional information, please contact me at (301) 916-3995.

Very truly yours,

Alice C C

YANKEE ATOMIC ELECTRIC COMPANY

Alice C. Carson
Licensing Manager

Enclosure: YNPS-FSS-NOL01-00 (2 hard copies plus CD)

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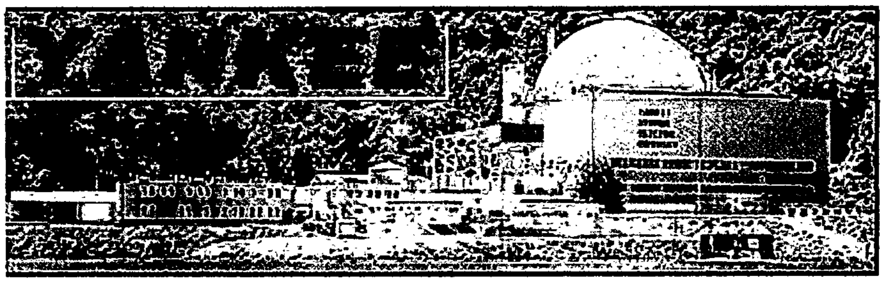
Yankee Nuclear Plant Station Final Status Survey Report For NOL-01



Yankee Atomic Electric Company

YANKEE NUCLEAR POWER STATION
FINAL STATUS SURVEY REPORT

REPORT NO.: YNPS-FSS-NOL01-00

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List of Abbreviations and Acronyms

ALARA .... As Low As Reasonably Achievable
DCGL .... Derived Concentration Guideline Level
$DCGL_{EMC}$ .... DCGL for small areas of elevated activity
$DCGL_{W}$ .... DCGL for average concentration over a wide area, used with statistical tests
DQO .... Data Quality Objectives
DPH .... Massachusetts Department of Public Health
EMC .... Elevated Measurement Comparison
ETD .... Easy-to-Detect
FSS .... Final Status Survey
FSSP .... Final Status Survey Plan
GPS .... Global Positioning System
H_o .... Null Hypothesis
HSA .... Historical Site Assessment
HTD .... Hard-to-Detect
ISOCS .... *In-situ* Object Counting System®
LBGR .... Lower Bound of the Grey Region
LTP .... License Termination Plan
MARSSIM .... Multi-Agency Radiation Survey and Site Investigation Manual
MDA .... Minimum Detectable Activity
MDC .... Minimum Detectable Concentration
PAB .... Primary Auxiliary Building
QAPP .... Quality Assurance Project Plan
QC .... Quality Control
RCA .... Radiological Controlled Area
RP .... Radiation Protection
RSS .... Reactor Support Structure
SFP .... Spent Fuel Pool
VC .... Vapor Container
YNPS .... Yankee Nuclear Power Station

1.0 EXECUTIVE SUMMARY

1.1 Identification of Survey Area and Units

A Final Status Survey (FSS) was performed of Survey Area NOL-01 in accordance with Yankee Nuclear Power Station's (YNPS) License Termination Plan (LTP).

NOL-01 is described in the LTP as the Eastern Lower RCA Yard. Decommissioning of the area resulted in the complete excavation of the land area and the encompassed structures. As a result, the boundaries of NOL-01 include the areas discussed below.

NOL-01 consists of the designated open land areas and is the site of the former Spent Fuel Pool (SFP-01), Ion Exchange Pit (NSY-02), Vapor Container (VC) Elevator Foundation (NSY-09), the North and South Decontamination Pads and Fuel Transfer Enclosure (NSY-01). All structures have been demolished and removed from the survey area resulting in an open land FSS area survey. Figure 1 illustrates the relationship of the former structures to Survey Area NOL-01.

NOL-01 is located within the Radiologically Controlled Area (RCA), as delineated in years 2004-2005, and is classified as a MARSSIM Class 1 area. The survey area encompasses a land area of approximately 2,183 square meters and has been subdivided into four distinct Survey Units.

1.2 Dates(s) of Survey

The FSS of the NOL-01 survey units was performed during the following time periods:

NOL-01-01 – August 24 to September 8, 2005
NOL-01-02 – August 1 to 23, 2005
NOL-01-03 – August 1 to 23, 2005
NOL-01-04 – November 17 to November 29, 2005

1.3 Number and Types of Measurements Collected

Final Status Survey Plans (FSSPs) were developed for each survey unit in accordance with YNPS LTP and FSS procedures utilizing the MARSSIM protocol. The planning and design of the survey plans employed the Data Quality Objective (DQO) process, ensuring that the type, quantity and quality of data gathered was appropriate for the decision-making process and that the resultant decisions were technically sound and defensible. A total of 62 fixed-point soil samples were collected, providing data for the non-parametric testing of the survey area. In addition to the fixed-point samples, a total of 354 *In-Situ* Object Counting System (ISOCS) scans, supplemented by hand-held survey instrument scans, were performed to provide 100% coverage of the survey area. Eleven (11) biased soil samples and

103 investigative soil samples were collected in areas of concern identified as elevated by scan surveys.

1.4 Summary of Survey Results

Following the survey, the data were reviewed against the survey design to confirm completeness and consistency, to verify that the results were valid, to ensure that the survey plan objectives were met and to verify survey unit classification. The boundaries of areas of elevated activity were determined based upon the results of a 100% surface scan, and the average activity within each area was compared to the fractional elevated measurement comparison ($DCGL_{EMC}$) or the elevated area was remediated. The fractional sum of the $DCGL_{EMC}$ was also calculated for each survey unit and determined to be less than 1 by the unity rule. No significant anomalies were observed in the graphical representation of the data collected as depicted in Attachment B. Retrospective power curves were generated that demonstrated that adequate power was achieved. An evaluation of the fixed-point sample data shows that: (1) none of the LTP radionuclide values exceeded the $DCGL_W$ and (2) the sum-of-fractions for those nuclides is less than 1, per the unity rule for each of the survey units. Therefore, the null hypothesis (H_o) (that is, that the survey unit exceeds the release criteria) is rejected.

1.5 Conclusions

Based upon the evaluation of the data acquired for the FSS, NOL-01 meets the release requirements set forth in the YNPS LTP. The Total Effective Dose Equivalent (TEDE) to the average member of the critical group does not exceed 25 mrem/yr, and 10CFR20 Subpart E ALARA requirements have been met. This survey unit was evaluated against the site release criteria administrative level DCGLs that ensure that the 10 mrem/yr limit of the Massachusetts Department of Public Health (DPH) will be met.

2.0 FSS PROGRAM OVERVIEW

2.1 Survey Planning

The YNPS FSS Program employs a strategic planning approach for conducting final status surveys with the ultimate objective to demonstrate compliance with the DCGLs, in accordance with the YNPS LTP. The DQO process is used as a planning technique to ensure that the type, quantity, and quality of data gathered is appropriate for the decision-making process and that the resultant decisions are technically sound and defensible. Other key planning measures are the review of historical data for the survey unit and the use of a team for plan development.

2.2 Survey Design

In designing the FSS, the questions to be answered are: "Does the residual radioactivity, if present in the survey unit, exceed the LTP release criteria?" and "Is the potential dose from this radioactivity ALARA?" In order to answer these questions, the radionuclides present in the survey units must be identified, and the survey units classified. Survey units are classified with respect to the potential for contamination: the greater the potential for contamination, the more stringent the classification and the more rigorous the survey.

The survey design additionally includes the number, type and locations of fixed measurements/samples (as well as any judgmental assessments required), scanning requirements, and instrumentation selection with the required sensitivities or detection levels. DCGLs are developed relative to the surface/material of the survey unit and guide the minimum sensitivity required for the survey. Determining the acceptable decision error rates, the lower bound of the gray region (LBGR), statistical test selection and the calculation of the standard deviation and relative shift allow the development of a prospective power curve plotting the probability of the survey unit passing FSS.

2.3 Survey Implementation

Once the planning and development has been completed, the implementation phase of the FSS program begins. Upon completion of remediation and final characterization activities, a final walk down of the survey unit is performed. If the unit is determined to be acceptable (i.e. physical condition of the unit is suitable for FSS), it is turned over to the FSS team, and FSS isolation and control measures are established. After the survey unit isolation and controls are in place, grid points are identified for the fixed measurements/samples, using Global Positioning System (GPS) coordinates consistent with the Massachusetts State Plane System, and the area scan grid is identified. Data is collected and any required investigations are performed.

2.4 Survey Data Assessment

The final stage of FSS involves assessment of the data collected to ensure the validity of the results, to demonstrate achievement of the survey plan objectives, and to validate survey unit classification. During this phase, the DQOs and survey design are reviewed for consistency between DQO output, sampling design and other data collection documents. A preliminary data review is conducted to include: checking for problems or anomalies, calculation of statistical quantities and preparation of graphical representations for data comparison. Statistical tests are performed, if required, and the assumptions for the tests are verified. Conclusions are then drawn from the data, and any deficiencies or recommendations for improvement are documented.

2.5 Quality Assurance and Quality Control Measures

YNPS FSS activities are implemented and performed under approved procedures, and the YNPS Quality Assurance Project Plan (QAPP) assures plans, procedures and instructions have been followed during the course of FSS, as well as providing guidance for implementing quality control measures specified in the YNPS LTP.

3.0 SURVEY AREA INFORMATION

3.1 Survey Area Descriptions and Historical Site Assessment (HSA) Information

Survey Area NOL-01 consists of land area containing approximately 2183 square meters of surface area. Since the beginning of plant operations, the area designated as NOL-01 has been posted and controlled as an RCA. Figure 2 depicts the boundaries of NOL-01 in relation to the site map. The LTP assumed that the Spent Fuel Pool and Fuel Transfer Chute system (SFP-01), VC elevator and stairway access (NSY-09), Fuel Transfer Enclosure and Vertical Concrete Cask transporter pad (NSY-01) and the Ion Exchanger Pit (NSY-02) structures, located within and adjacent to NOL-01, were to undergo FSS and remain onsite. However, subsequent management decisions resulted in the complete demolition and removal of these structures and the soil surface area of the former structures was incorporated into NOL-01.

3.2 History of Survey Area

NOL-01 is adjacent to the original Radiation Protection (RP) Control Point that was the normal access to the upper RCA, thus causing the potential for contamination migration from routine personnel and material traffic into and out of the RCA. In addition, unplanned operational events and activities led to the contamination of NOL-01, as listed in Table 1.

Table 1

Survey Area NOL-01 Events

Date	Event
September 18, 1963	Shield Tank Cavity Shield Water Spill
October 8, 1963	De-watering Pump Packing Leakage
October 3, 1964	Leakage from Ion Exchanger Pit
September 27, 1966	Spent Fuel Pit Water Spill
November 1, 1966	Hose Failure (Fuel Chute Pump-back System draining in progress)
July 16, 1975	Yard Area Contamination
May 15, 1981	Contamination of Yard during Reactor Head Removal

Date	Event
February 17 & 18, 1994	Leakage from Frozen Fuel Chute De-watering Line
February 23, 1994	Leakage from Frozen NST Telltale Lines

3.3 Division of NOL-01 into Survey Units

NOL-01 is subdivided into four distinct survey units: NOL-01-01, NOL-01-02, NOL-01-03 and NOL-01-04. Figure 3 depicts the survey units relative to the survey area.

3.4 Survey Unit Description

NOL-01-01

NOL-01-01 consists of an open land area inside the Reactor Support Structure (RSS) footprint. NOL-01-01 extends south from the common boundary with Survey Unit NOL-06-01 (to the north) terminating at the face of the foundation of the former Primary Auxiliary Building (PAB), Survey Areas AUX-01 and AUX-02. A line tangent to the RSS support ring forms the eastern boundary. Survey Unit BRT-01 forms the western boundary. Originally, NOL-01-01 comprised a larger surface area; however, a portion of NOL-01-01 was transferred to NOL-01-02 and NOL-01-03 due to the SFP excavation. The resultant total area of NOL-01-01 is approximately 178 m^2.

NOL-01-02

Survey Unit NOL-01-02 is the previous site of the northern portion of the SFP and some surrounding land areas adjacent to the former RSS. Original demolition plans called for the SFP floor, foundations, and sub-grade structures to remain in place after demolition; however, most sub-surface structures were subsequently removed as part of the deconstruction process. Survey Unit NOL-01-02 is bounded by NOL-01-04 on the north, NOL-02-01 on the east, NOL-01-03 on the south, and NOL-01-01 on the west. NOL-01-02 has a total area of approximately 469 m^2.

NOL-01-03

Survey Unit NOL-01-03 is the previous site of the southern portion of the SFP, Ion Exchange (IX) Pit and Elevator Shaft and some surrounding land areas adjacent to the former RSS. The IX Pit was used for housing the reactor water cleanup ion exchangers and a portion of the structure was originally planned to remain after demolition. Subsequent management decisions resulted in the IX Pit structure and Elevator Shaft being demolished. Survey Unit NOL-01-03 is bounded by NOL-01-02 on the north, NOL-02-01 on the east, AUX-01 on the south, and NOL-01-01 on the west. NOL-01-03 has a total area of approximately 655 m^2.

NOL-01-04

Survey Unit NOL-01-04 consists of the excavated open land area in the section of the eastern lower RCA yard that abuts the Turbine Building and Service Building foundations and is referred to as the "alley way." Originally the Fuel Transfer Enclosure, Rad Lab Sump, North and South Decon Rooms and the Fuel Oil Transfer House structures were contained within the survey unit but have since been demolished and removed. The unit shares its west boundary with survey unit NOL-01-01, its south boundary with survey units NO-L01-02 and NOL-02-01, and its east boundary with survey area OOL-12. The NOL-01-04 footprint is approximately 881 m^2.

4.0 INDIVIDUAL SURVEY UNIT INFORMATION

4.1. Survey Unit NOL-01-01

4.1.1 Summary of Radiological Data Since HSA

4.1.1.1 Chronology and Description of Surveys Since HSA

A remediation/characterization effort was performed in Survey Unit NOL-01-01 from August 3 to 11, 2005, during which time 100 % of the unit was scanned using a SPA-3 (sodium iodide hand-held survey instrument) and remediation was performed as necessary. In addition to the scans, a total of 83 soil samples were taken. Of the 83 samples taken, 12 samples represented the "as left" condition of the survey unit at the time of turnover and were used to determine the statistical values for the DQOs (see Table 2).

Upon completion of the characterization effort, isolation and control measures were implemented for the FSS including ground and storm water controls. NOL-01-01 boundaries were marked with Survey Unit NOL-06-01 (to the north) terminating at the face of the foundation of the former PAB, Survey Areas AUX-01 and AUX-02 to the south. A line tangent to the RSS support ring formed the eastern boundary. Survey Unit BRT-01 formed the western boundary. The condition of NOL-01-01 at the time of FSS was an open land area consisting of soil and small rocks.

4.1.1.2 Radionuclide Selection and Basis

A large amount of the soil area in the RSS footprint was remediated for both radiological (elevated concentrations of Cs-137 and Co-60) and environmental (PCB-contamination) reasons. Characterization data (post-remediation soil samples) from areas NOL-01 and NOL-06 were used in the FSS planning for unit NOL-01-01. Cesium-137 and Co-60 were the only easy-to-detect (ETD) plant-related radionuclides identified in the characterization (post-remediation) surface soil samples. The average Cs-137 concentration was 0.17 pCi/g and the average Co-60 concentration was 0.064 pCi/g, and thus both average values were below the respective 10-mrem/yr DCGLs. The average Cs-137 concentration represented approximately 73% of the identified plant-related activity and the average Co-60 concentration represented approximately 27%.

One pre-remediation soil sample was sent to an offsite laboratory for analyses of HTD nuclides. Several HTD radionuclides (i.e., C-14, Ni-63, and Sr-90) were identified in that sample at levels greater than the critical level but less than MDA. Post-remediation soil samples identified Cs-137 and Co-60 at concentrations that were acceptable for area turnover (i.e., concentrations below the respective DCGL values), but the post-remediation soil samples were not analyzed for HTD nuclides.

4.1.1.3 Summary of Scoping/Characterization Survey Data

Table 2 summarizes scoping, characterization, and remedial action surveys for Survey Area NOL-01-01.

Table 2
Summary of Results for
Survey Unit NOL-01-01 Characterization Data

Parameter	Remedial/Characterization 08/03/05-08/11/05
Number of samples Collected	12
Co^{60}: Mean Concentration Standard Deviation	0.06 pCi/g 0.11 pCi/g
Cs^{137}: Mean Concentration Standard Deviation	0.17 pCi/g 0.19 pCi/g

4.1.2 Basis for Classification

Based upon the historical use and radiological conditions associated with Survey Unit NOL-01-01, the unit was designated as MARSSIM Class 1. After review of data and information obtained during the course of demolition and interviews with personnel, it was determined that NOL-01-01 would remain a Class 1 unit.

4.1.3 Remedial Actions and Further Investigations

Survey Unit NOL-01-01 has passed FSS; therefore, no investigations into the reason for failure or potential impact are warranted.

4.1.4 Unique Features of Survey Unit

There are no unusually unique features in NOL-01-01

4.1.5 ALARA Practices and Evaluations

The generic ALARA evaluation for soils, as documented in Technical Report YA-REPT-00-003-05, "Generic ALARA Review for Final Status Survey of Soil at YNPS," (provided in Appendix A) concludes that no further remediation of soil below the 8.73 merm DCGL is warranted.

4.2. Survey Unit NOL-01-02

4.2.1 Summary of Radiological Data Since HSA

4.2.1.1 Chronology and Description of Surveys Since HSA

During the period of June 27 to July 25, 2005, an extensive remediation/characterization effort was performed within the SFP excavation, which included Survey Units NOL-01-02 and NOL-01-03. During this time, 100% of the excavation was scanned using a SPA-3 and remediation was performed as necessary. In addition to the scans, a total of 135 soil samples were taken. Of the 135 samples taken, 16 samples represented the "as left" condition of the survey unit at the time of turnover and were used to determine the statistical values for the DQOs (see Table 3).

Upon completion of the characterization effort, isolation and control measures were implemented for the FSS of the SFP excavation including ground and storm water controls. NOL-01-02 boundaries were marked with adjacent Survey Units BRT-01-01, NOL-01-03, NOL-01-04, and NOL-02-01 determining the western, southern, northern and eastern boundaries respectively. The condition of

NOL-01-02 at the time of FSS was an open excavation consisting of soil and small rocks sloping downward from the east and west directions.

4.2.1.2 Radionuclide Selection and Basis

During the initial DQO process, Co^{60}, Cs^{137} and Ag^{108m} were identified as the radiological nuclides of concern due to their presence in the characterization sample results. Tritium was added to the list of radionuclides of concern due to its presence in a nearby groundwater plume identified by well monitoring. The remaining LTP-required radionuclides were ruled out of the initial DQO process because of their absence in the characterization results.

Since multiple radionuclides were assumed to be present in the survey area, the unity rule (i.e. sum-of-fractions) is employed to show compliance with the release criteria.

4.2.1.3 Summary of Scoping/Characterization Survey Data

Table 3 summarizes scoping, characterization, and remedial action surveys for Survey Units NOL-01-02 and NOL-01-03.

Table 3

Survey Units NOL-01-02 and NOL-01-03 Surveys

Parameter	Remedial 09/28/92-10/27/92	Scoping 05/21/93-11/17/98	Characterization 07/16/05-07/23/05
Number of samples Collected	19	56	16
Co^{60}: Mean Concentration	0.94 pCi/g	0.77 pCi/g	0.05 pCi/g
Standard Deviation	1.23 pCi/g	0.56 pCi/g	0.07 pCi/g
Minimum Concentration	0.05 pCi/g	0.06 pCi/g	-0.02 pCi/g
Maximum Concentration	3.87 pCi/g	1.77 pCi/g	0.24 pCi/g
Cs^{137}: Mean Concentration	10.31 pCi/g	0.53 pCi/g	0.19 pCi/g
Standard Deviation	32.86 pCi/g	0.58 pCi/g	0.23 pCi/g
Minimum Concentration	0.07 pCi/g	0.05 pCi/g	0.002 pCi/g
Maximum Concentration	160 pCi/g	1.80 pCi/g	0.62 pCi/g

4.2.2 Basis for Classification

Based upon the historical use and radiological conditions associated with Survey Unit NOL-01-02, the unit was designated as MARSSIM Class 1. After review of data and information obtained during the course of demolition and interviews with personnel, it was determined that NOL-01-02 would remain a Class 1 unit.

4.2.3 Remedial Actions and Further Investigations

Survey Unit NOL-01-02 has passed FSS; therefore, no investigations into the reason for failure or potential impact are warranted.

4.2.4 Unique Features of Survey Unit

A unique feature associated with NOL-01-02 is a depression in the central portion of the survey unit, which was the location of the former Spent Fuel Follower Tube.

4.2.5 ALARA Practices and Evaluations

Soil remediation activities were performed in NOL-01 during the construction of the security shield wall around the SFP in 1992 (see Table 2 for related data). Additional remediation was performed in conjunction with the characterization effort to lower the levels of residual activity ALARA (i.e. reduction of activity levels below the $DCGL_W$).

The generic ALARA evaluation for soils, as documented in Technical Report YA-REPT-00-003-05, "Generic ALARA Review for Final Status Survey of Soil at YNPS," (provided in Appendix A) concludes that no further remediation of soil below the 8.73 mrem DCGL is warranted.

4.3. Survey Unit NOL-01-03

4.3.1 Summary of Radiological Data Since HSA

4.3.1.1 Chronology and Description of Surveys Since HSA

During the period of June 27 to July 25, 2005, an extensive remediation/characterization effort was performed within the SFP excavation, which included Survey Units NOL-01-02 and NOL-01-03. During this time, 100% of the excavation was scanned using a SPA-3 (sodium iodide hand-held survey instrument) and remediation was performed as necessary. In addition to the scans, a total of 135 soil samples were taken. Of the 135 samples taken, 16 samples represented the "as left" condition of the survey unit at the time of turnover and were used to determine the statistical values for the DQOs (see Table 3).

Upon completion of the characterization effort, isolation and control measures were implemented for the FSS of the SFP excavation including ground and storm water controls. NOL-01-03 boundaries were marked with adjacent Survey Units AUX-01-01, NOL-01-01, NOL-01-02, andNOL-02-01, delineating the southern, western, northern and eastern boundaries respectively. The condition of NOL-01-03 at the time of FSS was an open excavation consisting of soil and small rocks sloping downward from the south, east and west directions.

4.3.1.2 Radionuclide Selection and Basis

During the initial DQO process, Co^{60}, Cs^{137} and Ag^{108m} were identified as the radiological nuclides of concern due to their presence in the characterization sample results. The remaining LTP-required radionuclides were ruled out of the initial DQO process because of their absence in the characterization results.

Since multiple radionuclides were assumed to be present in the survey area, the unity rule (i.e. sum-of-fractions) is employed to show compliance with the release criteria.

4.3.1.3 Summary of Scoping/Characterization Survey Data

Table 3 summarizes scoping, characterization, and remedial action surveys for Survey Unit NOL-01-03.

4.3.2 Basis for Classification

Based upon the historical use and radiological conditions associated with Survey Unit NOL-01-03, the unit was designated as MARSSIM Class 1. After review of data and information obtained during the course of demolition and interviews with personnel, it was determined that NOL-01-03 would remain a Class 1 unit.

4.3.3 Remedial Actions and Further Investigations

Survey Unit NOL-01-03 has passed FSS; therefore, no investigations into the reason for failure or potential impact are warranted.

4.3.4 Unique Features of Survey Unit

There are no unusually unique features for this survey unit.

4.3.5 ALARA Practices and Evaluations

The generic ALARA evaluation for soils, as documented in Technical Report YA-REPT-00-003-05, "Generic ALARA Review for Final Status Survey of Soil at YNPS," (provided in Appendix A) concludes that no further remediation of soil below the 8.73 mrem DCGL is warranted.

4.4. Survey Unit NOL-01-04

4.4.1 Summary of Radiological Data Since HSA

4.4.1.1 Chronology and Description of Surveys Since HSA

Upon completion of the characterization effort, isolation and control measures were implemented for the FSS of the SFP excavation including ground and storm water controls. NOL-01-04 boundaries were marked with the Turbine and Service Building pads on its north, survey unit NOL-01-01 on the west, its south boundary with survey units NOL-01-02 and NOL-02-01, and its east boundary with survey area OOL-12. The condition of NOL-01-04 at the time of FSS was an open excavation consisting of soil and small rocks sloping downward from the north, east and west directions.

4.4.1.2 Radionuclide Selection and Basis

The FSS planning for NOL-01-04 used onsite gamma analysis results for 11 post-remediation soil samples collected from unit NOL-01-04. Co-60 and Cs-137 were the only plant-related gamma-emitting radionuclides identified in the samples, although not consistently at concentrations that were greater than the MDCs for the analyses. The mean soil concentrations of Co-60 and Cs-137 were 0.08 pCi/g ± 0.092 pCi/g and 0.03 pCi/g ± 0.024 pCi/g, respectively. The Co-60 and Cs-137 concentrations were all well below the respective DCGL (the Co-60 concentrations ranged from <MDA to 0.27pCi/g and the Cs-137 concentrations ranged from <MDA to 0.073 pCi/g).

The presence of all LTP-required radionuclides (gamma-emitters, HTD beta-emitters, and TRUs) in the soil was evaluated under the survey plan. The YNPS Chemistry Department analyzed each FSS soil sample for all LTP-listed gamma-emitting nuclides, except Cm-243/244. In addition, 4 FSS soil samples were sent to an independent laboratory for analyses of gamma-emitters, HTD beta-emitting radionuclides, and alpha-emitting radionuclides, including Cm-243/244.

4.4.1.3 Summary of Scoping/Characterization Survey Data

Table 4 summarizes scoping, characterization, and remedial action surveys for Survey Unit NOL-01-04.

Table 4

Survey Unit NOL-01-04 Surveys

Parameter	Characterization 11/09/05-11/11/05
Number of samples Collected	11
Co^{60}: Mean Concentration	0.08 pCi/g
Standard Deviation	0.09 pCi/g
Minimum Concentration	-0.00 pCi/g
Maximum Concentration	0.27 pCi/g
Cs^{137}: Mean Concentration	0.03 pCi/g
Standard Deviation	0.02 pCi/g
Minimum Concentration	0.00 pCi/g
Maximum Concentration	0.07 pCi/g

4.4.2 Basis for Classification

Based upon the historical use and radiological conditions NOL-01-04 was designated as MARSSIM Class 1. Based upon reviews of data and information obtained during the course of demolition and interviews with personnel, it was determined that NOL-01-04 would remain a Class 1 unit.

4.4.3 Remedial Actions and Further Investigations

Survey Unit NOL-01-04 has passed FSS; therefore, no investigations into the reason for failure or potential impact are warranted.

4.4.4 Unique Features of Survey Unit

A unique feature associated with NOL-01-04 was a depression in the south central portion of the survey unit, which was a portion of the former Spent Fuel Follower Tube location. There were two smaller depressions in the northeast section of the unit along with an exposed wellhead.

4.4.5 ALARA Practices and Evaluations

The generic ALARA evaluation for soils, as documented in Technical Report YA-REPT-00-003-05, "Generic ALARA Review for Final Status Survey of Soil at YNPS," (provided in Appendix A) concludes that no further remediation of soil below the 8.73 mrem DCGL is warranted.

5.0 FINAL STATUS SURVEY

5.1. Survey Unit NOL-01-01

5.1.1 Final Status Survey Plan and Associated DQOs

The FSS for NOL-01-01 (YNPS-FSSP-NOL01-01-01) was planned and developed in accordance with the LTP using the DQO process. Form DPF-8856.1, found in YNPS Procedure 8856, "Preparation of Survey Plans," was used to provide guidance and consistency during development of the FSS Plan and can be found in Appendix B. The DQO process allows for systematic planning and is specifically designed to address problems that require a decision to be made in a complex survey design and in turn provides alternative actions. The DQO process was used to develop an integrated survey plan providing the survey unit identification, sample size, selected analytical techniques, survey instrumentation, and scan coverage. The Sign Test was specified for non-parametric statistical testing for this survey unit, if required. The design parameters developed are presented in the Table 5.

Table 5

Survey Unit NOL-01-01 Design Parameters

Survey Unit	Design Parameter	Basis
Area	178 m^2	Class 1, <2,000 m^2
Number of Direct Measurements	15	Based on a LBGR of 0.5 (unity rule), sigma of 0.1 and an adjusted relative shift of 2 α=β= 0.05
Sample Area	11.9 m^2	178 m^2 / 15 = 11.9 m^2
Sample Grid Spacing with a triangular pitch	3.7 m	$(178/(0.866*15))^{1/2}$

Survey Unit	Design Parameter	Basis
Scan area	178 m^2	Class 1 Area – 100%
Scan Investigation Level	No audible indication > Bkgd. With a SPA-3	Based on a $f(DCGL_{EMC}) < 1$

5.1.2 Deviations from the FSS Plan as Written in the LTP

The null hypothesis (H_o) is stated and tested in the negative form: "Residual licensed radioactive materials in Survey Unit NOL-01-01 exceeds the release criterion." This null hypothesis is designed to protect the health of the public as well as to demonstrate compliance with the requirements set forth in the Yankee Rowe LTP. The tolerable limits established for this survey plan set the probability of Type I errors (a) at 0.05 and the probability of Type II errors (β) at 0.05. Investigation levels for the fixed measurements were set at:

(a) >$DCGL_{EMC}$ for either Cs-137 or Co-60, or

(b) a sum of $DCGL_{EMC}$ fractions >1.0, or

(c) >DCGL for either Cs-137 or Co-60 and greater than 3 times the standard deviation of the mean as defined in the LTP

The desired Minimum Detectable Concentration (MDC) for fixed measurements was set at 10% of the $DCGL_W$ for each applicable radionuclide; however, if it was impracticable to achieve those values, the MDCs were permissible to be as high as 50% of the $DCGL_W$. All MDCs for the surveys of NOL-01-01 were met in accordance with YNPS LTP. DCGL values and the associated MDC values can be found in Table 6.

Table 6

DCGLs and MDCs for Survey Area NOL-01-01

for All LTP Radionuclides

Nuclide	[1]$DCGL_W$ (pCi/g)	Required MDC (50% of the $DCGL_W$) pCi/g
H-3	1.3E+02	6.4E+01
C-14	1.9E+00	9.7E-01
Fe-55	1.0E+04	5.1E+03
[2]Co-60	1.4E+00	7.0E-01
Ni-63	2.8E+02	1.4E+02
Sr-90	6.0E-01	3.0E-01
[2]Nb-94	2.5E+00	1.3E+00

Nuclide	[1]DCGLw (pCi/g)	Required MDC (50% of the DCGLw) pCi/g
Tc-99	5.0E+00	2.5E+00
[2]Ag-108m	2.5E+00	1.3E+00
[2]Sb-125	1.1E+01	5.6E+00
[2]Cs-134	1.7E+00	8.7E-01
[2]Cs-137	3.0E+00	1.5E+00
[2]Eu-152	3.6E+00	1.8E+00
[2]Eu-154	3.3E+00	1.7E+00
[2]Eu-155	1.4E+02	6.9E+01
Pu-238	1.2E+01	5.8E+00
Pu-239, 240	1.1E+01	5.3E+00
Pu-241	3.4E+02	1.7E+02
Am-241	1.0E+01	5.1E+00
Cm-243, 244	1.1E+01	5.6E+00

[1] Based on 8.73 mrem/yr (TEDE)
[2] Gamma emitting nuclides

The FSSP design was performed to the criteria of the LTP; therefore, no subsequent LTP deviations with potential impact to this survey unit need to be evaluated.

5.1.3 DCGL Selection and Use

The LTP DCGLs for soil were calculated using the resident farmer scenario. For the resident farmer scenario, the average member of the critical group is the resident farmer who lives on the site, grows all of his/her diet onsite and drinks water from a groundwater source onsite. The residual radioactive material was assumed to be in the top 2.89 m soil layer, available for use in residential and light farming activities. The LTP DCGLs were performed using RESRAD Version 6.21 analyses and based upon a resulting dose of 25 mrem/yr.

The DCGLs in NOL-01-01 Survey Plan were derived by scaling the LTP DCGLs to 8.73 mrem/yr. The use of the 8.73 mrem/yr value was necessitated by the DPH site release criteria of 10 mrem/yr subtracting the maximum dose contribution for subsurface partial structures (0.5 mrem/yr) and the maximum dose contribution from groundwater (0.77 mrem/yr). The resulting scaled DCGL values and associated MDCs are in Table 6.

5.1.4 Measurements

The sample design required that 15 surface soil samples be used for the Sign Test based on the probability of error tolerance (α and β), LBGR and relative shift value found in Table 5. Two additional samples were added for the statistical test to increase the power of the survey. Two of the samples, in the sample set, were split and analyzed for LTP hard-to-detect HTD radionuclides in addition to the easy-to-detect ETD radionuclides. Two samples were designated as "recount" samples, thus satisfying the QC requirements of the QAPP.

The fixed-point sampling grid was developed as a systematic grid with spacing consisting of a triangular pitch pattern with a random starting point. With the aid of a GPS and AutoCAD-generated survey unit map, the systematic random start grid was developed utilizing Visual Sample Plan software. Sample measurement locations are provided with the GPS coordinates in Table 7.

Table 7

Sample Measurement Locations with GPS Coordinates

Designation	Northing	Easting
NOL-01-01-001-F	272451.2417	3093602.861
NOL-01-01-002-F	272467.2394	3093602.861
NOL-01-01-003-F	272443.2429	3093589.006
NOL-01-01-004-F	272459.2406	3093589.006
NOL-01-01-005-F	272475.2382	3093589.006
NOL-01-01-006-F	272491.2359	3093589.006
NOL-01-01-007-F	272435.2441	3093575.152
NOL-01-01-008-F	272451.2417	3093575.152
NOL-01-01-009-F	272467.2394	3093575.152
NOL-01-01-010-F	272483.237	3093575.152
NOL-01-01-011-F	272499.2347	3093575.152
NOL-01-01-012-F	272411.2476	3093561.298
NOL-01-01-013-F	272427.2453	3093561.298
NOL-01-01-014-F	272443.2429	3093561.298
NOL-01-01-015-F	272459.2406	3093561.298

5.1.5 Survey Implementation Activities

Table 8 provides a summary of daily activities performed during the Final Status Survey of NOL-01-01.

Table 8

FSS Activity Summary for Survey Unit NOL-01-01

Date	Activity
August 24, 2005	Performed walk-down of NOL-01-01 Established Isolation and Controls
August 25, 2005	Scanned 100% of NOL-01-01 with SPA-3
August 26, 2005	Commenced Investigative scans. GPS of fixed-point sample locations. Completed sampling of fixed-point and biased samples.
August 30, 2005	Commenced investigative sampling regimen
September 8, 2005	Performed successful remediation at investigative sample location NOL-01-027-F-I. FSS completed.

Remedial actions performed during the FSS of NOL-01-01 include the removal of soil at investigative location NOL-01-01-027-F-I.

The apparent cause of the area having the potential to contain undesirable quantities of residual radioactivity during FSS was that the turnover surveys, though designed similarly to FSS, were performed with hand-held scanning instrumentation.

In recognizing a more consistent, less human error-prone survey methodology in fixed-rig ISOCS surveys, the FSS Program implemented ISOCS final status surveys to as large an extent as radiologically and ergonomically practical. This practice led to a condition in which FSS sensitivities would likely result in more investigations and occasional elevated measurements that went undetected during hand-held instrument turnover surveys.

To mitigate this condition, Yankee management incorporated a Remediation Group into the RP organization during the fourth quarter of 2005. The Remediation Group uses FSS-quality instruments and ISOCS, as well as FSS-trained and experienced personnel, to guide remediation and conduct turnover surveys. Additionally, the group establishes administrative survey acceptance criteria at 50 percent of FSS investigation criteria, providing an increased level of assurance that FSS DCGLs will be met during FSS.

Initial efforts were somewhat hampered by limited FSS-quality ISOCS and crane support, but funding and resources have been aligned to provide the project with six FSS-quality ISOCS with adequate crane support for the duration of remaining remediation work.

5.1.6 Surveillance Surveys

5.1.6.1 Periodic Surveillance Surveys

Survey Unit NOL-01-01 is subject to periodic surveillance surveys in accordance with YNPS procedure DP-8860, "Area Surveillance Following Final Status Survey." These surveys provide assurance that areas with successful FSS remain unchanged until license termination.

5.1.6.2 Resurveys

No resurveys were required in NOL-01-01

5.1.6.3 Investigations

No investigation survey was warranted.

5.1.7 Survey Results

The onsite laboratory analyzed the 17 fixed-point soil samples collected from NOL-01-01. All samples were analyzed by gamma spectroscopy with sensitivity sufficient to achieve the MDCs in Table 6 for gamma-emitting nuclides. One sample (NOL-01-01-005-F-S) exceeded the $DCGL_W$ for C-14. The sample point adjacent to NOL-01-01-005-F-S (NOL-01-01-006-F-S) indicated a C-14 concentration less than $DCGL_W$, therefore, for conservatism; the AF for the elevated area was determined from the area outlined in the FSSP (Table 5). The concentration of C-14 in the elevated area was less than $DCGL_{EMC}$ and the sum-of-fractions were less than one (unity). The sign test was used on the data set as outlined in the FSSP and the survey unit passed FSS. Table 9 includes the gamma spectroscopy results as well as the offsite HTD analysis for radionuclides positively identified.

Two biased samples were taken. NOL-01-01-018-F-B and NOL-01-01-019-F-B soil samples were taken by the southeast section of the RSS ring foundation. These samples were counted onsite using the gamma spectroscopy system then shipped, without drying, to General Engineering Laboratories in Charleston, SC, for analysis of both ETD radionuclides and tritium. The results of these biased samples are included in Table 9.

Table 9
Summary of Sample Results for Survey Unit NOL-01-01

Sample Number	Co^{60} pCi/g	Cs^{137} pCi/g	Ag^{108m} pCi/g	C^{14} pCi/g	$Pu^{239/240}$ pCi/g	Tc^{99} pCi/g	Am^{241} pCi/g	H^3 pCi/g	f-DCGL*
FSS-NOL-01-01-001-F	1.2E-02	9.6E-03		0.27			0.09		0.16
FSS-NOL-01-01-002-F	1.1E-02	5.0E-02							0.02
FSS-NOL-01-01-003-F	2.8E-02	1.4E-01							0.05
FSS-NOL-01-01-004-F	-3.4E-03	9.6E-02							0.03
FSS-NOL-01-01-005-F	6.8E-02	1.4E-01		4.86					4.96
FSS-NOL-01-01-006-F	4.0E-02	3.3E-01		0.26					0.37
FSS-NOL-01-01-007-F	4.1E-02	9.3E-02							0.03
FSS-NOL-01-01-008-F	3.9E-02	9.7E-02							0.03
FSS-NOL-01-01-009-F	1.7E-02	6.4E-02							0.02
FSS-NOL-01-01-010-F	1.8E-01	-1.1E-02							0.18
FSS-NOL-01-01-011-F	1.0E-02	-3.1E-04							0.00 (<MDA)
FSS-NOL-01-01-012-F	-1.8E-03	5.0E-03							0.00 (<MDA)
FSS-NOL-01-01-013-F	-2.6E-03	-1.5E-03							0.00 (<MDA)
FSS-NOL-01-01-014-F	-2.6E-03	-1.1E-03						6.89	0.05
FSS-NOL-01-01-015-F	-2.7E-03	-2.8E-04							0.00 (<MDA)
FSS-NOL-01-01-016-F	1.1E-02	-6.5E-03							0.00 (<MDA)
FSS-NOL-01-01-017-F	-2.6E-03	1.1E-02							0.00 (<MDA)
FSS-NOL-01-01-018-F-B	0.0E+00	1.6E-01		0.644				0.00 (<MDA)	0.70
FSS-NOL-01-01-019-F-B	2.1E-02	2.5E-02						0.00 (<MDA)	
mean	**2.6E-02**	**6.0E-02**							
Standard deviation	**4.6E-02**	**8.8E-02**							

* DCGL fraction, Unity Rule applied

Table 10

Summary of Investigation Samples

in Survey Unit NOL-01-01

Sample Number	Co^{60} pCi/g	f-DCGL[1]	Cs^{137} pCi/g	f-DCGL[1]
NOL-01-01-020-F-I	9.7E-03	0.0069	-9.9E-03	-0.0033
NOL-01-01-021-F-I	8.1E-02	0.0577	**3.9E+00**	**1.2937**[2]
NOL-01-01-022-F-I	2.6E-02	0.0188	1.2E-01	0.0414
NOL-01-01-023-F-I	9.3E-03	0.0066	4.1E-02	0.0138
NOL-01-01-024-F-I	8.8E-03	0.0063	9.5E-02	0.0315
NOL-01-01-025-F-I	2.7E-02	0.0193	6.6E-02	0.0219
NOL-01-01-026-F-I	1.8E-02	0.0129	-1.1E-02	-0.0038
NOL-01-01-027-F-I	**6.7E+00**	**4.8206**[3]	**3.0E+00**	**0.9881**[3]
NOL-01-01-028-F-I	-2.3E-04	-0.0002	-4.1E-03	-0.0014
NOL-01-01-029-F-I	4.1E-03	0.0029	2.2E-02	0.0073
NOL-01-01-030-F-I	1.9E-02	0.0135	2.9E-02	0.0097
NOL-01-01-031-F-I	-3.2E-03	-0.0023	5.7E-03	0.0019
NOL-01-01-032-F-I	1.3E-02	0.0094	4.1E-03	0.0014
NOL-01-01-033-F-I	-1.3E-03	-0.0009	2.7E-03	0.0009
NOL-01-01-034-F-I	-5.2E-05	0.0000	6.7E-02	0.0223
NOL-01-01-035-F-I	1.7E-02	0.0124	1.8E-02	0.0061
NOL-01-01-036-F-I	9.3E-03	0.0066	-1.2E-02	-0.0040
NOL-01-01-037-F-I	7.6E-03	0.0054	-1.2E-02	-0.0039
NOL-01-01-038-F-I	5.8E-03	0.0041	-9.3E-03	-0.0031
NOL-01-01-039-F-I	-5.2E-03	-0.0037	-7.6E-03	-0.0025
NOL-01-01-040-F-I	-4.0E-03	-0.0028	-2.4E-03	-0.0008
NOL-01-01-041-F-I	-3.1E-03	-0.0022	4.6E-04	0.0002
NOL-01-01-042-F-I	4.1E-03	0.0029	2.3E-02	0.0078
NOL-01-01-043-F-I	-3.0E-03	-0.0022	1.4E-02	0.0047
NOL-01-01-044-F-I	1.2E-03	0.0008	5.4E-03	0.0018
NOL-01-01-045-F-I	-5.7E-04	-0.0004	2.3E-02	0.0076
NOL-01-01-046-F-I	1.4E-02	0.0099	2.6E-02	0.0085
NOL-01-01-047-F-I	2.9E-01	0.2102	5.7E-01	0.1911
NOL-01-01-048-F-I	1.2E+00	0.8877	1.1E+00	0.3549
NOL-01-01-049-F-I	3.6E-02	0.0256	1.2E-01	0.0407
NOL-01-01-050-F-I	1.7E+00	1.2026	1.9E+00	0.6346

[1] DCGL fraction, Unity Rule DCGL of "1" applied

[2] > $DCGL_W$ but < $DCGL_{EMC}$

[3] Location remediated (047, 048 and 049 are the post-remedial samples)

5.1.8 Data Quality Assessment

The Data Quality Assessment phase is the part of the FSS where survey design and data are reviewed for completeness and consistency, ensuring the validity of the results, verifying that the survey plan objectives were met, and validating the classification of the survey unit.

The sample design and the data acquired were reviewed and found to be in accordance with applicable YNPS procedures DP-8861, "*Data Quality Assessment*"; DP-8856, "*Preparation of Survey Plans*"; DP-8853, "*Determination of the Number and Locations of FSS Samples and Measurements*"; DP-8857, "*Statistical Tests*"; DP-8865, "*Computer Determination of the Number of FSS Samples and Measurements*"; and the QAPP.

A preliminary data review was performed and statistical quantities were calculated. The average concentrations and standard deviations of Co-60 and Cs-137 from Table 9 are smaller than the respective characterization data from Table 2. The retrospective power curve maintained sufficient power to pass the survey unit. The data range data for both the Cs-137 and Co-60 are within three standard deviations of the mean average value. Frequency plots for both Co-60 and Cs-137 show that the data is skewed slightly negative. The scatter plots generated for survey unit NOL-01-01 graphically illustrate that the data for Co-60 and Cs-137 shows a normal variance about their respective mean. The data posting plots for both radionuclides do not clearly reveal any systematic spatial trends. Review of the quantile plots for NOL-01-01 indicates some asymmetry in the lower quartiles.

Review of the data in Table 9 illustrates that one of the C-14 sample data points is above the $DCGL_W$, therefore requiring a statistical test (sign test) of the data.

Copies of the power curves, quantile plots, scatter plots and posting plots are found in Attachment B.

The actual level of residual activity was lower than the estimated level (i.e., values derived from characterization data) used for the survey design. The survey demonstrated sufficient power to indicate that the survey unit null hypothesis should be rejected.

5.2. Survey Unit NOL-01-02

5.2.1 Final Status Survey Plan and Associated DQOs

The FSS for NOL-01-02 (YNPS-FSSP-NOL01-02-03) was planned and developed in accordance with the LTP using the DQO process. Form DPF-8856.1, found in YNPS Procedure 8856, "Preparation of Survey Plans," was used to provide guidance and consistency during development of the FSS Plan and can be found in Appendix B. The DQO process allows for systematic planning and is specifically designed to address problems that require a decision to be made in a complex survey design and in turn provides alternative actions. The DQO process was used to develop an integrated survey plan providing the survey unit identification, sample size, selected analytical techniques, survey instrumentation, and scan coverage. The Sign Test was specified for non-parametric statistical testing for this survey unit, if required. The design parameters developed are presented in the Table 11.

Table 11

Survey Unit NOL-01-02 Design Parameters

Survey Unit	Design Parameter	Basis
Area	469 m^2	Class 1, <2,000 m^2
Number of Direct Measurements	15	Based on a LBGR of 0.5 (unity rule), sigma[1] of 0.12 and an adjusted relative shift of 2 α=β= 0.05
Sample Area	31.3 m^2	469 m^2 / 15 = 31.3 m^2
Sample Grid Spacing with a triangular pitch	6 m	$(469/(0.866*15))^{1/2}$
Scan Grid Area	ISOCS scans at 2 meters	2.6 m on center
Scan area	469 m^2	Class 1 Area – 100%
Scan Investigation Level	0.87 pCi/g Co^{60} 4.00 pCi/g Cs^{137} 1.3 pCi/g Ag^{108m}	Surrogated to Ni^{63}, Sr^{90} and H^3 (based on the 10 mrem/yr criteria)*

* Initially Co^{60}, Cs^{137} and Ag^{108m} Investigation levels were surrogated to account for HTD radionuclides (i.e. Ni^{63}, Sr^{90} and H^3) expected to be present in the survey unit. Subsequent off-site analysis of samples; however, has indicated that these HTD nuclides are not present in detectable levels.

5.2.2 Deviations from the FSS Plan as Written in the LTP

The null hypothesis (H_o) is stated and tested in the negative form: "Residual licensed radioactive materials in Survey Unit NOL-01-02 exceeds the release criterion." This null hypothesis is designed to protect the health of the public as well as to demonstrate compliance with the requirements set forth in the Yankee Rowe LTP. The tolerable limits established for this survey plan set the probability of Type I errors (a) at 0.05 and the probability of Type II errors (β) at 0.05. Investigation levels for the fixed measurements were set at >$DCGL_W$ and greater than 3 times the standard deviation from the mean or >$DCGL_{EMC}$. The desired MDC for fixed measurements was set at 10% of the $DCGL_W$ for each applicable radionuclide; however, if it was impracticable to achieve those values, the MDCs were permissible to be as high as 50% of the $DCGL_W$. All MDCs for the surveys of NOL-01-02 were met in accordance with YNPS LTP. DCGL values and the associated MDC values can be found in Table 12.

Table 12

DCGLs and MDCs for Survey Area NOL-01-02

for All LTP Radionuclides

Nuclide	[1]$DCGL_W$ (pCi/g)	Required MDC (50% of the $DCGL_W$) pCi/g
H-3	1.3E+02	6.4E+01
C-14	1.9E+00	9.7E-01
Fe-55	1.0E+04	5.1E+03
[2]Co-60	1.4E+00	7.0E-01
Ni-63	2.8E+02	1.4E+02
Sr-90	6.0E-01	3.0E-01
[2]Nb-94	2.5E+00	1.3E+00
Tc-99	5.0E+00	2.5E+00
[2]Ag-108m	2.5E+00	1.3E+00
[2]Sb-125	1.1E+01	5.6E+00
[2]Cs-134	1.7E+00	8.7E-01
[2]Cs-137	3.0E+00	1.5E+00
[2]Eu-152	3.6E+00	1.8E+00
[2]Eu-154	3.3E+00	1.7E+00
[2]Eu-155	1.4E+02	6.9E+01
Pu-238	1.2E+01	5.8E+00
Pu-239, 240	1.1E+01	5.3E+00
Pu-241	3.4E+02	1.7E+02
Am-241	1.0E+01	5.1E+00
Cm-243, 244	1.1E+01	5.6E+00

[1] Based on 8.73 mrem/yr (TEDE)
[2] Gamma emitting nuclides (or ETD radionuclides)

The FSSP design was performed to the criteria of the LTP; therefore, no subsequent LTP deviations with potential impact to this survey unit need to be evaluated.

5.2.3 DCGL Selection and Use

The LTP DCGLs for soil were calculated using the resident farmer scenario. For the resident farmer scenario, the average member of the critical group is the resident farmer who lives on the site, grows all of his/her diet onsite and drinks water from a groundwater source onsite. The residual radioactive material was assumed to be in the top 2.89 m soil layer, available for use in residential and light farming activities. The LTP DCGLs were performed using RESRAD Version 6.21 analyses and based upon a resulting dose of 25 mrem/yr.

The DCGLs in NOL-01-02 Survey Plan were derived by scaling the LTP DCGLs to 8.73 mrem/yr. The 8.73 mrem/yr value was necessitated by the DPH site release criteria of 10 mrem/yr subtracting the maximum dose contribution for subsurface partial structures (0.5 mrem/yr) and the maximum dose contribution from groundwater (0.77 mrem/yr). The resulting scaled DCGL values and associated MDCs are in Table 12.

5.2.4 Measurements

The sample design required that 15 surface soil samples be used for the Sign Test based on the probability of error tolerance (α and β), LBGR and relative shift value found in Table 11. Two of the samples were split and analyzed for LTP HTD radionuclides in addition to the ETD radionuclides. Two samples were designated as "recount" samples, thus satisfying the QC requirements of the QAPP. Based upon sample analysis results from NOL-01-03, the survey unit adjacent to NOL-01-02, containing small amounts of HTD nuclides, all of the samples from NOL-01-02 and NOL-01-03 were analyzed for HTD radionuclides.

The fixed-point sampling grid was developed as a systematic grid with spacing consisting of a triangular pitch pattern with a random starting point. With the aid of a GPS and AutoCAD-generated survey unit map, the systematic random start grid was developed utilizing Visual Sample Plan software. Sample measurement locations are provided with the GPS coordinates in Table 13.

Table 13

Sample Measurement Locations with GPS Coordinates

Designation	Northing	Easting
NOL-01-02-001-F	272451.2417	3093602.861
NOL-01-02-002-F	272467.2394	3093602.861
NOL-01-02-003-F	272443.2429	3093589.006
NOL-01-02-004-F	272459.2406	3093589.006
NOL-01-02-005-F	272475.2382	3093589.006
NOL-01-02-006-F	272491.2359	3093589.006
NOL-01-02-007-F	272435.2441	3093575.152
NOL-01-02-008-F	272451.2417	3093575.152
NOL-01-02-009-F	272467.2394	3093575.152
NOL-01-02-010-F	272483.237	3093575.152
NOL-01-02-011-F	272499.2347	3093575.152
NOL-01-02-012-F	272411.2476	3093561.298
NOL-01-02-013-F	272427.2453	3093561.298
NOL-01-02-014-F	272443.2429	3093561.298
NOL-01-02-015-F	272459.2406	3093561.298

A total of 65 ISOCS scans were performed in NOL-01-02 providing 100% coverage of the survey unit. The ISOCS scan grid used a 2.6-m point-to-point grid with no perimeter points farther than 1.3 m from the survey unit boundary. The ISOCS scan grid did not require a random start. ISOCS scans were performed at a height of 2 m from the surface positioned perpendicular to the scan point using a 90-degree collimator. The adjusted investigation levels, referenced in Table 3, (surrogated for HTD radionuclides) for the ISOCS were derived by multiplying the $DCGL_{EMC}$ ($DCGL_W$ * AF for a 1 m^2 elevated area) by the ratio of MDCs obtained from the 12.6 m^2 field of view relative to the MDC obtained for a 1 m^2 area at the edge of the 12.6 m^2 field of view, as this leads to a conservative model. The values developed for the 1 m^2 elevated area at the edge of the field of view used for the ISOCS scan investigative levels are sensitive enough to detect the elevated comparison values for the 31.3 m^2 area (from Table 11). MDC values for the Portable ISOCS scans were set at the $DCGL_{EMC}$ for the individual radionuclides. The technical basis for the use of the ISOCS is documented in Technical Report YA-REPT-00-018-05, "*Use of In-situ Gamma Spectrum Analysis to Perform Elevated Measurement Comparison in Support of Final Status Surveys*" (Appendix C).

5.2.5 Survey Implementation Activities

Table 14 provides a summary of daily activities performed during the Final Status Survey of NOL-01-02.

Table 14

FSS Activity Summary for Survey Unit NOL-01-02

Date	Activity
July 30, 2005	Performed walk-down of NOL-01-02 Established Isolation and Controls
August 1, 2005	Started gridding of Survey Unit. Commenced ISOCS scans
August 2, 2005	Continued ISOCS scans. Layout of fixed-point grid (GPS). Collected soil samples
August 3, 2005	Completed ISOCS scans
August 6, 2005	Initiated investigations in elevated scan survey points 004,006, 010,011,012 and 017. Found a small piece of concrete in 004, 006, 010,011, and 012. Removed concrete and drew soil samples and rescanned. Sampled and performed scans in elevated scan area 017.
August 8, 2005	Rescan elevated scan area 017. Drew soil samples to determine boundary of elevated scan area 017.
August 9, 2005	Continued rescans of elevated scan area 017
August 10, 2005	Drew soil samples to determine bounds of elevated scan area 017
August 11, 2005	Expanded boundary of elevated area 017. Drew soil samples for boundary identification
August 12, 2005	Boundary for elevated scan area 017 established. Drew four random selected soil samples for average activity in the elevated area.
August 15, 2005	Performed Scans and soil sampling in Unit due to heavy rains to assess possible impact
August 17, 2005	Performed Resurvey in Unit due to heavy rains possible impact
August 23, 2005	FSS Completed

Remedial actions implemented during the FSS include the removal of the piece of concrete in scan areas 004, 006, 010, 011 and 012. The removal of the concrete eliminated the source of the elevated scan readings as confirmed by the subsequent soil sampling and ISOCS scans.

While surveying NOL-01-02 and NOL-01-03, ORISE communicated that a number of elevated measurements were detected during their confirmatory surveying and requested sample preparation and onsite analysis support. Yankee provided this support and, thus, acquired firsthand knowledge and documentation of the ORISE sample results. ORISE reported that, with the exception of a rock that exhibited elevated gamma radiation believed to be attributable to naturally occurring radioactive materials, each case of elevated activity was due to discrete particles within the soil sample. Each area of the ORISE-detected elevated measurements was investigated applying the LTP, FSS procedures and FSS Plan criteria as applicable to Yankee-detected elevated measurements. This included the locations that did not contain sufficient radioactivity to warrant an elevated measurement comparison evaluation. In all but one location, the initial investigation samples indicated that $DCGL_W$ was met (see section 5.3.5).

5.2.6 Surveillance Surveys

5.2.6.1 Periodic Surveillance Surveys

Survey Unit NOL-01-02 is subject to periodic surveillance surveys in accordance with YNPS procedure DP-8860, "Area Surveillance Following Final Status Survey." These surveys provide assurance that areas with successful FSS remain unchanged until license termination.

5.2.6.2 Resurveys

A heavy rain event, after the FSS of NOL-01-02 and prior to backfill, necessitated a resurvey of the survey unit to assess the potential impact to the FSS. An area surveillance plan (ASP) was developed (YNPS-ASP-NOL01-02-01) to include biased soil samples and judgmental ISOCS scans. The samples and scans concentrated in the locations in which the FSS was most likely to have been impacted by the rain event. The ASP acceptance criterion was that no single survey point exceeds two standard deviations from the mean of the FSS for the survey unit. Data assessment of the resurvey concluded that no single data point exceeded the acceptance criteria; therefore, no investigation survey was warranted.

5.2.6.3 Investigations

No investigation survey was warranted.

5.2.7 Survey Results

The onsite laboratory analyzed the 15 fixed-point soil samples collected from NOL-01-02. All samples were analyzed by gamma spectroscopy with sensitivity sufficient to achieve the MDCs in Table 12 for gamma-emitting nuclides. No samples greater than the $DCGL_W$ for the radionuclides present were identified, and the sum-of-fractions were all less than 1 (unity rule). Therefore no statistical test was necessary. Table 15 includes the gamma spectroscopy results for the only radionuclides positively identified during onsite analysis.

Three biased samples were taken. NOL-01-02-016-F-B soil sample was taken in a temporary well used to pump water out of the SFP excavation. This sample was counted onsite using the gamma spectroscopy system. The other 2 biased samples were taken in the approximate location of a known groundwater tritium plume. These samples were shipped, without drying, to General Engineering Laboratories in Charleston, SC, for analysis of both ETD and HTD radionuclides. The results of these biased samples are included in Table 15.

Table 15
Summary of Sample Results
for Survey Unit NOL-01-02

Sample Number	Co^{60} pCi/g	Cs^{137} pCi/g	Ag^{108m} pCi/g	C^{14} pCi/g	$Pu^{239/240}$ pCi/g	Tc^{99} pCi/g	Am^{241} pCi/g	Sr^{90} pCi/g	f-DCGL*
FSS-NOL-01-02-001-F	0.04	0.369							0.15
FSS-NOL-01-02-002-F	0.043	0.306					0.05**		0.14
FSS-NOL-01-02-003-F	0.277	0.368							0.32
FSS-NOL-01-02-004-F	-0.0002	0.033							0.01
FSS-NOL-01-02-005-F	-0.001	0.136							0.04
FSS-NOL-01-02-006-F	0.008	0.126							0.05
FSS-NOL-01-02-007-F	0.164	0.401							0.25
FSS-NOL-01-02-008-F	0.251	0.564			0.04**				0.37
FSS-NOL-01-02-009-F	0.098	1.934							0.71
FSS-NOL-01-02-010-F	-0.0002	0.015							0.00
FSS-NOL-01-02-011-F	0.007	0.035							0.02
FSS-NOL-01-02-012-F	0.122	0.342							0.20
FSS-NOL-01-02-013-F	0.362	0.556							0.44
FSS-NOL-01-02-014-F	0.142	0.127	0.201						0.22
FSS-NOL-01-02-015-F	0.008	0.225							0.08
FSS-NOL-01-02-016-F-B	0.374	0.555							0.45
FSS-NOL-01-02-017-F-B	0.000	0.064		0.132**		0.243**	0.109**		0.15
FSS-NOL-01-02-018-F-B	0.201	0.395				0.187**		0.016**	0.34
Stdev	0.127	0.434							
Mean	0.118	0.364							

* DCGL fraction, Unity Rule applied
** Identified below the MDC value

Sixty-five ISOCS scans were performed and the results compared to the respective Action Levels. A summary of the ISOCS scans is provided in Table 16.

Table 16

Summary of ISOCS Scan Results for Survey Unit NOL-01-02

Sample Title	f (DCGL$_{EMC}$)	Sample Title	f (DCGL$_{EMC}$)
NOL-01-02-001-F-G	0.73	NOL-01-02-034-F-G	0.05
NOL-01-02-002-F-G	0.44	NOL-01-02-035-F-G	0.44
NOL-01-02-003-F-G	0.72	NOL-01-02-036-F-G	0.06
NOL-01-02-064-F-G-I	0.54*	NOL-01-02-037-F-G	0.09
NOL-01-02-005-F-G	0.95	NOL-01-02-038-F-G	0.13
NOL-01-02-065-F-G-I	0.52*	NOL-01-02-039-F-G	0.66
NOL-01-02-007-F-G	0.79	NOL-01-02-040-F-G	0.45**
NOL-01-02-008-F-G	0.59	NOL-01-02-041-F-G	0.07**
NOL-01-02-009-F-G	0.74	NOL-01-02-042-F-G	0.81
NOL-01-02-066-F-G-I	0.57*	NOL-01-02-043-F-G	0.80
NOL-01-02-067-F-G-I	0.63*	NOL-01-02-044-F-G	0.48
NOL-01-02-068-F-G-I	0.38*	NOL-01-02-045-F-G	0.06
NOL-01-02-014-F-G	0.31	NOL-01-02-046-F-G	0.04
NOL-01-02-015-F-G	0.09	NOL-01-02-047-F-G	0.05
NOL-01-02-016-F-G	0.04	NOL-01-02-048-F-G	0.06
NOL-01-02-017-F-G	See Table 17	NOL-01-02-049-F-G	0.06
NOL-01-02-018-F-G	0.81	NOL-01-02-050-F-G	0.10
NOL-01-02-019-F-G	0.00	NOL-01-02-051-F-G	0.23
NOL-01-02-020-F-G	0.60	NOL-01-02-052-F-G	0.25
NOL-01-02-021-F-G	0.61	NOL-01-02-053-F-G	0.38
NOL-01-02-022-F-G	0.55	NOL-01-02-054-F-G	0.15
NOL-01-02-023-F-G	0.30	NOL-01-02-055-F-G	0.27
NOL-01-02-024-F-G	0.89	NOL-01-02-056-F-G	0.05
NOL-01-02-025-F-G	0.54	NOL-01-02-057-F-G	0.15
NOL-01-02-026-F-G	0.53	NOL-01-02-058-F-G	0.64
NOL-01-02-027-F-G	0.06	NOL-01-02-059-F-G	0.57
NOL-01-02-028-F-G	0.24	NOL-01-02-060-F-G	0.04
NOL-01-02-029-F-G	0.56	NOL-01-02-061-F-G	0.30
NOL-01-02-030-F-G	0.29	NOL-01-02-062-F-G	0.06
NOL-01-02-031-F-G	0.59	NOL-01-02-063-F-G	0.43
NOL-01-02-032-F-G	0.65	NOL-01-02-064-F-G	0.54
NOL-01-02-033-F-G	0.00	NOL-01-02-065-F-G	0.52

* Investigations performed at these scan areas (004, 006, 010, 011, 012). Post remedial scan resulted in f(DCGL$_{EMC}$) < 1 as shown with the "as left" scan results.

** A 20% correction was applied to these ISOCS results to account for increased density due to moisture content in the soil.

Copies of the ISOCS reports are found in Attachment A.

An investigation was performed at scan location 017. Through the use of ISOCS scans and perimeter soil samples (gamma-specific boundary soil samples identified in Table 17), the boundaries of the elevated area were established at 2-m by 2.3-m. Four randomly selected soil sample locations were chosen by multiplying the length and the width of the area by random numbers taken from Table I.6 of MARSSIM. The results of the analysis of the random samples were then averaged to give the average elevated concentration within the elevated area and a fractional $DCGL_{EMC}$ was performed for the survey unit. The following calculation and table demonstrate the elevated measurement comparison.

Average elevated area concentration ($\overline{C}_{elevated}$): 0.25 pCi/g Co^{60}; 0.84 pCi/g Cs^{137}

$DCGL_W$: 1.4 pCi/g Co^{60}; 3.0 pCi/g Cs^{137}

Area factor for $6m^2$: Co^{60}= 3.2; Cs^{137}= 6.6

Mean of NOL-01-02 (δ): 0.10 pCi/g Co^{60}; 0.369 pCi/g Cs^{137}

Note: The non-elevated area Mean is identical to the Mean of the Survey Unit.

$$\frac{\delta}{DCGL_W} + \frac{\overline{C}_{elevated} - \delta}{(AreaFactor) \times DCGL_W} < 1$$

$$\frac{0.10}{1.4} + \frac{0.25 - 0.10}{(3.2) \times 1.4} = 0.10 \quad Co^{60};$$

$$\frac{.369}{3.0} + \frac{0.84 - .369}{(6.6) \times 3.0} = 0.15 \quad Cs^{137}$$

Table 17

Summary of Investigation Point #017 in Survey Unit NOL-01-02

Sample Number	Co^{60} pCi/g	Cs^{137} pCi/g	Ag^{108m} pCi/g	f-DCGL[2]
NOL-01-02-017-F-G				1.13
NOL-01-02-032-F-I[1]	0.439	1.382	ND[3]	0.774
NOL-01-02-033-F-I[1]	0.573	1.614	ND[3]	0.947
NOL-01-02-034-F-I[1]	0.053	0.366	ND[3]	0.16
NOL-01-02-035-F-I[1]	0.082	0.266	ND[3]	0.15
NOL-01-02-036-F-I[1]	0.001	0.23	ND[3]	0.08
NOL-01-02-038-F-I[1]	0.662	1.328	ND[3]	0.92
NOL-01-02-039-F-I[1]	0.548	1.034	ND[3]	0.74
NOL-01-02-050-F-I[1]	0.624	0.493	ND[3]	0.61
NOL-01-02-045-F-I	0.005	0.04	ND[3]	N/A[4]
NOL-01-02-046-F-I	0.523	0.993	ND[3]	N/A[4]
NOL-01-02-047-F-I	0.442	2.294	ND[3]	N/A[4]
NOL-01-02-048-F-I	0.045	0.044	ND[3]	N/A[4]

[1] Soil samples determining the boundaries of the elevated area (2 meters by 2.3 meters)
[2] DCGL fraction, Unity Rule DCGL of "1" applied
[3] Radionuclide Not Detected
[4] f-DCGL data Not Applicable (N/A) for the average concentration determination

5.2.8 Data Quality Assessment

The Data Quality Assessment phase is the part of the FSS where survey design and data are reviewed for completeness and consistency, ensuring the validity of the results, verifying that the survey plan objectives were met, and validating the classification of the survey unit.

The sample design and the data acquired were reviewed and found to be in accordance with applicable YNPS procedures DP-8861, "*Data Quality Assessment*"; DP-8856, "*Preparation of Survey Plans*"; DP-8853, "*Determination of the Number and Locations of FSS Samples and Measurements*"; DP-8857, "*Statistical Tests*"; DP-8865, "*Computer Determination of the Number of FSS Samples and Measurements*"; and the QAPP.

A preliminary data review was performed and statistical quantities were calculated. The average concentrations and standard deviations of Co-60 and Cs-137 from Table 15 are larger than the respective characterization data from Table 11. However, the retrospective power curve maintained sufficient power to pass the survey unit. The concentration data for Cs-137 indicated that one sample (FSS-NOL-01-02-009-F) was statistically higher than the remaining samples. However, this value (1.9 pCi/g) was less than the $DCGL_W$ (3 pCi/g). This data point skewed the average Cs-137 concentration value high. Without this value, the range of data would have been slightly over one standard deviation. The data range for Co-60 was approximately three standard deviations. Frequency plots for both Co-60 and Cs-137 show that the data is skewed negative with the Co-60 being skewed more so than the Cs-137. The scatter plots generated for NOL-01-02 graphically illustrate that the data for Co-60 and Cs-137 vary about their respective mean, with the exception of the higher Cs-137 sample result discussed above. The data posting plots for both radionuclides do not clearly reveal any systematic spatial trends. Review of the quantile plots for NOL-01-02 indicates some asymmetry about the mean and illustrates the elevated Cs-137 result. There were no especially unusual features in the quantile plot for Co-60.

Review of the data in Table 15 illustrates that all of the sample data for the soil concentrations of all plant-related LTP nuclides are below the $DCGL_W$ and the sum-of-fractions for these nuclides are less than unity. Therefore no statistical test is required.

Copies of the power curves, quantile plots, scatter plots and posting plots are found in <u>Attachment B</u>.

The actual level of residual activity was higher than the estimated level (i.e., values derived from characterization data) used for the survey design; however, the survey demonstrated sufficient power to indicate that the survey unit null hypothesis should be rejected. One elevated area existed in survey unit NOL-01-02 and upon assessment, it was determined that f($DCGL_{EMC}$) for the survey unit was less than unity. The area investigated where a small piece of concrete existed was successfully remediated by removing the piece of concrete and the area was resurveyed. No other remedial actions were required in NOL-01-02.

5.3. Survey Unit NOL-01-03

5.3.1 Status Survey Plan and Associated DQOs

The FSS for NOL-01-02 (YNPS-FSSP-NOL01-02-03) was planned and developed in accordance with the LTP using the DQO process. Form DPF-8856.1, found in YNPS Procedure 8856, "Preparation of Survey Plans," was used to provide guidance and consistency during development of the FSS Plan and can be found in Appendix B. The DQO process allows for systematic planning and is specifically designed to address problems that require a decision to be made in a complex survey design and in turn provides alternative actions. The DQO process was used to develop an integrated survey plan providing the survey unit identification, sample size, selected analytical techniques, survey instrumentation, and scan coverage. The Sign Test was specified for non-parametric statistical testing for this survey unit, if required. The design parameters developed are presented in the Table 18.

Table 18

Survey Unit NOL-01-03 Design Parameters

Survey Unit	Design Parameter	Basis
Area	655 m^2	Class 1, <2,000 m^2
Number of Direct Measurements	15	Based on a LBGR of 0.5 (unity rule), sigma[1] of 0.12 and an adjusted relative shift of 2 α=β= 0.05
Sample Area	43.7 m^2	655 m^2 / 15 = 43.7 m^2
Sample Grid Spacing with a triangular pitch	7.1 m	$(655/0.866*15)^{1/2}$
Scan Grid Area	ISOCS scans at 2 meters	2.6 m on center
Scan area	469 m^2	Class 1 Area – 100%

Survey Unit	Design Parameter	Basis
Scan Investigation Level	0.87 pCi/g Co^{60} 4.00 pCi/g Cs^{137} 1.3 pCi/g Ag^{108m}	Surrogated to Ni^{63}, Sr^{90} and H^3 (based on the 8.73 mrem/yr criteria)

5.3.2 Deviations from the FSS Plan as Written in the LTP

The null hypothesis (H_o) is stated and tested in the negative form: "Residual licensed radioactive materials in Survey Unit NOL-01-02 exceeds the release criterion." This null hypothesis is designed to protect the health of the public as well as to demonstrate compliance with the requirements set forth in the Yankee Rowe LTP. The tolerable limits established for this survey plan set the probability of Type I errors (a) at 0.05 and the probability of Type II errors (β) at 0.05. Investigation levels for the fixed measurements were set at >$DCGL_W$ and greater than 3 times the standard deviation and at >$DCGL_{EMC}$. The desired MDC for fixed measurements was set at 10% of the $DCGL_W$ for each applicable radionuclide; however, if it was impracticable to achieve those values, the MDCs were permissible to be as high as 50% of the $DCGL_W$. All MDCs for the surveys of NOL-01-02 were met in accordance with YNPS LTP. DCGL values and the associated MDC values can be found in Table 19.

Table 19

DCGLs and MDCs for Survey Area NOL-01-03

for All LTP Radionuclides

Nuclide	[1]$DCGL_W$ (pCi/g)	Required MDC (50% of the DCGLw) pCi/g
H-3	1.3E+02	6.4E+01
C-14	1.9E+00	9.7E-01
Fe-55	1.0E+04	5.1E+03
[2]Co-60	1.4E+00	7.0E-01
Ni-63	2.8E+02	1.4E+02
Sr-90	6.0E-01	3.0E-01
[2]Nb-94	2.5E+00	1.3E+00
Tc-99	5.0E+00	2.5E+00
[2]Ag-108m	2.5E+00	1.3E+00
[2]Sb-125	1.1E+01	5.6E+00
[2]Cs-134	1.7E+00	8.7E-01
[2]Cs-137	3.0E+00	1.5E+00
[2]Eu-152	3.6E+00	1.8E+00

Nuclide	[1]DCGL$_W$ (pCi/g)	Required MDC (50% of the DCGL$_W$) pCi/g
[2]Eu-154	3.3E+00	1.7E+00
[2]Eu-155	1.4E+02	6.9E+01
Pu-238	1.2E+01	5.8E+00
Pu-239, 240	1.1E+01	5.3E+00
Pu-241	3.4E+02	1.7E+02
Am-241	1.0E+01	5.1E+00
Cm-243, 244	1.1E+01	5.6E+00

[1] Based on 8.73 mrem/yr (TEDE)
[2] Gamma emitting nuclides (or ETD radionuclides)

The FSSP design was performed to the criteria of the LTP; therefore, no subsequent LTP deviations with potential impact to this survey unit need to be evaluated.

5.3.3 DCGL Selection and Use

The LTP DCGLs for soil were calculated using the resident farmer scenario. For the resident farmer scenario, the average member of the critical group is the resident farmer who lives on the site, grows all of his/her diet onsite and drinks water from a groundwater source onsite. The residual radioactive material was assumed to be in the top 2.89 m soil layer, available for use in residential and light farming activities. The LTP DCGLs were performed using RESRAD Version 6.21 analyses and based upon a resulting dose of 25 mrem/yr.

The DCGLs in NOL-01-03 Survey Plan were derived by scaling the LTP DCGLs to 8.73 mrem/yr. The 8.73 mrem/yr value was necessitated by the DPH site release criteria of 10 mrem/yr subtracting the maximum dose contribution for subsurface partial structures (0.5 mrem/yr) and the maximum dose contribution from groundwater (0.77 mrem/yr). The resulting scaled DCGL values and associated MDCs are in Table 19.

5.3.4 Measurements

The sample design required that 15 surface soil samples be used for the Sign Test based on the probability of error tolerance (α and β), LBGR and relative shift value found in Table 18. Two of the samples were split and analyzed for LTP HTD radionuclides in addition to the ETD radionuclides. Two samples were designated as "recount" samples, thus satisfying the QC requirements of the QAPP. Based upon sample analysis results from NOL-01-03 containing small amounts of HTD nuclides, all of the samples from NOL-01-02 and NOL-01-03 were analyzed for HTD radionuclides.

The fixed-point sampling grid was developed as a systematic grid with spacing consisting of a triangular pitch pattern with a random starting point. With the aid of a GPS and AutoCAD-generated survey unit map, the systematic random start grid was developed utilizing Visual Sample Plan. Sample measurement locations are provided with the GPS coordinates in Table 20.

Table 20

Sample Measurement Locations with GPS Coordinates

Designation	Northing	Easting
NOL-01-03-001-F	272429.8162	3093548.4972
NOL-01-03-002-F	272446.5794	3093548.4972
NOL-01-03-003-F	272463.3425	3093548.4972
NOL-01-03-004-F	272480.1057	3093548.4972
NOL-01-03-005-F	272421.4346	3093533.9799
NOL-01-03-006-F	272438.1978	3093533.9799
NOL-01-03-007-F	272454.9610	3093533.9799
NOL-01-03-008-F	272471.7241	3093533.9799
NOL-01-03-009-F	272488.4873	3093533.9799
NOL-01-03-010-F	272429.8162	3093519.4625
NOL-01-03-011-F	272446.5794	3093519.4625
NOL-01-03-012-F	272463.3425	3093519.4625
NOL-01-03-013-F	272480.1057	3093519.4625
NOL-01-03-014-F	272438.1978	3093504.9452
NOL-01-03-015-F	272454.9610	3093504.9452

A total of 68 ISOCS scans were performed in NOL-01-03 providing 100% coverage of the survey unit. The ISOCS scan grid used a 2.6-m point-to-point grid with no perimeter points farther than 1.3 m from the survey unit boundary. The ISOCS scan grid did not require a random start. ISOCS scans were performed at a height of 2 m from the surface positioned perpendicular to the scan point using a 90-degree collimator. The adjusted investigation levels, referenced in Table 18, (surrogated for HTD radionuclides) for the ISOCS were derived by multiplying the $DCGL_{EMC}$ ($DCGL_W$ * AF for a 1 m^2 elevated area) by the ratio of MDCs obtained from the 12.6 m^2 field of view relative to the MDC obtained for a 1 m^2 area at the edge of the 12.6 m^2 field of view, as this leads to a conservative model. The values developed for the 1 m^2 elevated area at the edge of the field of view used for the ISOCS scan investigative levels are sensitive enough to detect the elevated comparison values for the 43.7 m^2 area (from Table 3). MDC values for the Portable ISOCS scans were set at the $DCGL_{EMC}$ for the individual radionuclides. The technical basis for the use of the ISOCS is documented in Technical Report YA-REPT-00-018-05, "*Use of In-situ Gamma Spectrum Analysis to Perform Elevated Measurement Comparison in Support of Final Status Surveys*" (Appendix C).

5.3.5 Survey Implementation Activities

Table 21 provides a summary of daily activities performed during the Final Status Survey of NOL-01-03.

Table 21

FSS Activity Summary for Survey Unit NOL-01-03

Date	Activity
August 17, 2005	Performed walk-down of NOL-01-02 Established Isolation and Controls
August 4, 2005	Started gridding of Survey Unit. Commenced ISOCS scans. Layout of fixed-point grid (GPS). Collected soil samples
August 12, 2005	Performing investigations at NOL-01-03-12-F-G. Bounding the elevated area and determining the average concentration in the area.
August17, 2005	Performed resurvey after rain storm
August 19, 2005	Initiated investigations at scan location NOL-01-03-041-F-G. Performed remediation at this location.
August 23, 2005	Performed post-remedial scans and sampling. FSS complete.

While surveying NOL-01-02 and NOL-01-03, ORISE communicated that a number of elevated measurements were detected during their confirmatory surveying and they requested sample preparation and onsite analysis support. Yankee provided this support and, thus, acquired firsthand knowledge and documentation of the ORISE sample results. ORISE reported that, with the exception of a rock that exhibited elevated gamma radiation believed to be attributable to naturally occurring radioactive materials, each case of elevated activity was due to discrete particles within the soil sample. Each area of the ORISE-detected elevated measurements was investigated applying the LTP, FSS procedures and FSS Plan criteria as applicable to Yankee-detected elevated measurements. This included the locations that did not contain sufficient radioactivity to warrant an elevated measurement comparison evaluation. In all but one location, the initial investigation samples indicated that $DCGL_W$ was met. One sample NOL-01-03-036 indicated that, while radioactivity levels could have passed the elevated measurement comparison to 10CFR20.1402 criteria, further remediation was necessary to meet the lower DCGLs established by the Massachusetts criteria.

Remedial actions included the removal of soils around scan location NOL-01-03-041-F-G corresponding to sample location NOL-01-03-036. The removal of the soils eliminated the source of the elevated scan readings as confirmed by the subsequent soil sampling and ISOCS scans. This remediation was accomplished per Section 5.5.3.3 of the LTP. ORISE sampling results and corresponding YNPS results for NOL-01-03 are provided in Table 22.

Table 22
Samples in Response to ORISE Sampling

ORISE Sample Number	Date	Co-60 (pCi/	Cs-137 (pCi/g)	SOF	YNPS Sample Number [1]	Date	Co-60 (pCi/g)	Cs-137 (pCi/g)	SOF
1672S0001	8/10/05	8.75	1.84	6.86	NOL-01-03-049-F-I	8/24/05	0.18	0.53	0.31
1672S0002	8/10/05	0.01	347	115.67	NOL-01-03-035-F-I	8/17/05	0.00	0.27	0.09
1672S0003	8/10/05	14.02	0.54	10.19	NOL-01-03-036-F-I	8/16/05	4.47	0.91	3.50 [2]

[1] In response to ORISE sampling Yankee pulled samples at the ORISE sample locations.
[2] Yankee sample NOL-01-03-036 indicated a DCGL sum-of-fractions in excess of unity. Subsequent sampling determined that additional remediation was required in that location. Post-remedial sampling results indicated that the source of the elevated readings was removed and are summarized in Table 23, below.

Table 23
Post-Remediation Sampling of Location NOL-01-03-036-F-I

YNPS Sample Number	Date	Co-60 (pCi/g)	Cs-137 (pCi/g)	SOF
NOL-01-03-054-F-I	8/23/05	-0.008	0.021	0.00
NOL-01-03-055-F-I	8/24/05	0.006	0.001	0.00
NOL-01-03-056-F-I	8/23/05	0.378	0.685	0.50
NOL-01-03-057-F-I	8/23/05	-0.0001	-0.0005	0.00
NOL-01-03-058-F-I	8/23/05	0.139	0.426	0.24

5.3.6 Surveillance Surveys

5.3.6.1 Periodic Surveillance Surveys

Survey Unit NOL-01-03 is subject to periodic surveillance surveys in accordance with YNPS procedure DP-8860, "Area Surveillance Following Final Status Survey." These surveys provide assurance that areas with successful FSS remain unchanged until license termination.

5.3.6.2 Resurveys

A heavy rain event, after the FSS of NOL-01-03 and prior to backfill, necessitated a resurvey of the survey unit to assess the potential impact to the FSS. An area surveillance plan (ASP) was developed (YNPS-ASP-NOL01-03-01) to include biased soil samples and judgmental ISOCS scans. The samples and scans concentrated in the locations in which the FSS was most likely to have been impacted by the rain event. The ASP acceptance criterion was that no single survey point exceeds two standard deviations from the mean of the FSS for the survey unit. Data assessment of the resurvey concluded that no single data point exceeded the acceptance criteria; therefore, no investigation survey was warranted.

5.3.6.3 Investigations

No investigation survey was warranted.

5.3.7 Survey Results

The onsite laboratory analyzed the fifteen (15) fixed-point soil samples collected from NOL-01-03. All samples were analyzed by gamma spectroscopy with sensitivity sufficient to achieve the MDCs in Table 19 for gamma-emitting nuclides. No samples greater than the $DCGL_W$ for the radionuclides present were identified, and the sum-of-fractions were all less than 1 (unity rule). Therefore no statistical test was necessary. Table 24 includes the gamma spectroscopy results for the only radionuclides positively identified during onsite analysis.

Two biased samples were taken in temporary wells used to pump water out of the SFP excavation. The results of the biased samples are included in Table 24.

Table 24

Summary of Sample Results for

Survey Unit NOL-01-03

Sample Number	Co^{60} pCi/g	Cs^{137} pCi/g	C^{14} pCi/g	$Pu^{239/240}$ pCi/g	Pu^{241} pCi/g	Sr^{90} pCi/g	f-DCGL*
FSS-NOL-01-03-001-F	0.07	0.39					0.18
FSS-NOL-01-03-002-F	0.09	0.50					0.23
FSS-NOL-01-03-003-F	0.07	0.28					0.16
FSS-NOL-01-03-004-F	-0.01	0.22					0.07
FSS-NOL-01-03-005-F	0.04	0.09					0.06
FSS-NOL-01-03-006-F	0.49	1.48					0.84
FSS-NOL-01-03-007-F	0.00	0.00					0.00
FSS-NOL-01-03-008-F	0.03	1.18					0.50
FSS-NOL-01-03-009-F	0.00	0.13					0.04
FSS-NOL-01-03-010-F	0.03	0.02					0.03
FSS-NOL-01-03-011-F	0.01	0.01	0.29	0.19	21.9		0.24
FSS-NOL-01-03-012-F	0.02	-0.01					0.01
FSS-NOL-01-03-013-F	0.08	0.02					0.06
FSS-NOL-01-03-014-F	0.03	-0.01	0.47		10.3	0.04	0.37

Sample Number	Co^{60} pCi/g	Cs^{137} pCi/g	C^{14} pCi/g	$Pu^{239/240}$ pCi/g	Pu^{241} pCi/g	Sr^{90} pCi/g	f-DCGL*
FSS-NOL-01-03-015-F	0.03	0.01					0.02
FSS-NOL-01-03-016-F-B	0.06	0.19					0.10
FSS-NOL-01-03-017-F-B	0.26	0.48					0.35
Stdev	0.12	0.45					
Mean	0.064	0.287					

* DCGL fraction, Unity Rule applied

Sixty-five ISOCS scans were performed and the results compared to the respective Action Levels. A summary of the ISOCS scans is provided in Table 25.

Table 25

Summary of ISOCS Scan Results for Survey Unit NOL-01-03

Sample Title	f (DCGL$_{EMC}$)	Sample Title	f (DCGL$_{EMC}$)
NOL-01-03-001-F-G	0.05	NOL-01-03-034-F-G	0.65
NOL-01-03-002-F-G	0.04	NOL-01-03-035-F-G	0.24
NOL-01-03-003-F-G	0.06	NOL-01-03-036-F-G	0.23
NOL-01-03-004-F-G	0.21	NOL-01-03-037-F-G	0.08
NOL-01-03-005-F-G	0.15	NOL-01-03-038-F-G	0.12
NOL-01-03-006-F-G	0.06	NOL-01-03-039-F-G	0.47
NOL-01-03-007-F-G	0.30	NOL-01-03-040-F-G	0.00
NOL-01-03-008-F-G	0.60	NOL-01-03-099-R-G	0.06**
NOL-01-03-009-F-G	0.95	NOL-01-03-042-F-G	0.82
NOL-01-03-010-F-G	0.50	NOL-01-03-043-F-G	0.30
NOL-01-03-011-F-G	0.91	NOL-01-03-044-F-G	0.07
NOL-01-03-013-F-G	0.57	NOL-01-03-045-F-G	0.13
NOL-01-03-014-F-G	0.57	NOL-01-03-046-F-G	0.20
NOL-01-03-015-F-G	0.74	NOL-01-03-047-F-G	0.59
NOL-01-03-016-F-G	0.52	NOL-01-03-048-F-G	0.42
NOL-01-03-017-F-G	0.04	NOL-01-03-049-F-G	0.00
NOL-01-03-018-F-G	0.31	NOL-01-03-050-F-G	0.00
NOL-01-03-019-F-G	0.64	NOL-01-03-051-F-G	0.00
NOL-01-03-020-F-G	0.84	NOL-01-03-052-F-G	0.00
NOL-01-03-021-F-G	0.64	NOL-01-03-053-F-G	0.04
NOL-01-03-022-F-G	0.27	NOL-01-03-054-F-G	0.02
NOL-01-03-023-F-G	0.06	NOL-01-03-055-F-G	0.65
NOL-01-03-024-F-G	0.09	NOL-01-03-056-F-G	0.00
NOL-01-03-025-F-G	0.11	NOL-01-03-057-F-G	0.00
NOL-01-03-026-F-G	0.65	NOL-01-03-058-F-G	0.00
NOL-01-03-027-F-G	0.56	NOL-01-03-059-F-G	0.00

Sample Title	f(DCGL$_{EMC}$)	Sample Title	f(DCGL$_{EMC}$)
NOL-01-03-028-F-G	0.46	NOL-01-03-060-F-G	0.00
NOL-01-03-029-F-G	0.26	NOL-01-03-061-F-G	0.00
NOL-01-03-030-F-G	0.37	NOL-01-03-062-F-G	0.00
NOL-01-03-031-F-G	0.00	NOL-01-03-063-F-G	0.00
NOL-01-03-032-F-G	0.50	NOL-01-03-064-F-G	0.00
NOL-01-03-033-F-G	0.00	NOL-01-03-065-F-G	0.00

** Scan result represents post-remedial (i.e. "as left") condition

Copies of the ISOCS reports are found in Attachment A.

An investigation was performed at scan location NOL-01-03-012-F-G. Through the use of ISOCS scans and perimeter soil samples (gamma-specific boundary soil samples identified in Table 26), the boundaries of the elevated area were established at 2-m by 2-m. Four randomly selected soil sample locations were chosen by multiplying the length and the width of the area by random numbers taken from Table I.6 of MARSSIM. The results of the analysis of the random samples were then averaged to give the average elevated concentration within the elevated area and a fractional DCGL$_{EMC}$ was performed for the survey unit. The following calculation and table demonstrate the elevated measurement comparison:

Average elevated area concentration ($\overline{C}_{elevated}$):	4.3 pCi/g Co-60	1.79 Cs-137
DCGL$_W$:	1.4 pCi/g	3 pCi/g
Area factor for 4m^2 Co-60:	4.1 Co-60	8.5 Cs-137
Mean of NOL-01-03 (δ):	0.064 pCi/g Co-60	.287pCi/g Cs-137

Note: The non-elevated area Mean is identical to the Mean of the Survey Unit.

$$\frac{\delta}{DCGL_W}+\frac{\overline{C}_{elevated}-\delta}{(AreaFactor)\times DCGL_W}\langle 1$$

$$\frac{0.064}{1.4}+\frac{4.3-0.064}{(4.1)\times 1.4}=0.78 \quad \text{Co-60} \qquad \frac{0.287}{3}+\frac{1.79-0.287}{(8.5)\times 3}=0.15 \quad \text{Cs-137}$$

Table 26

Summary of Investigation Point #012 in Survey Unit NOL-01-03

Sample Number	Co^{60} pCi/g	Cs^{137} pCi/g	Ag^{108m} pCi/g	f-DCGL[2]
NOL-01-02-028-F-I[1]	0.06	0.06	ND[3]	0.06
NOL-01-02-029-F-I[1]	0.01	0.02	ND[3]	0.01
NOL-01-02-030-F-I[1]	-0.02	0.04	ND[3]	0.01
NOL-01-02-032-F-I[1]	0.439	1.382	ND[3]	0.774
NOL-01-02-033-F-I[1]	0.573	1.614	ND[3]	0.947
NOL-01-02-034-F-I[1]	0.053	0.366	ND[3]	0.16
NOL-01-03-037-F-I	0.052	1.82	ND[3]	N/A[4]
NOL-01-03-038-F-I	15.15	0.96	ND[3]	N/A[4]
NOL-01-03-039-F-I	1.862	4.12	ND[3]	N/A[4]
NOL-01-03-040-F-I	0.049	0.27	ND[3]	N/A[4]

[1] Soil samples determining the boundaries of the elevated area (2 meters by 2 meters)
[2] DCGL fraction, Unity Rule DCGL of "1" applied
[3]Radionuclide Not Detected
[4]f-DCGL data Not Applicable (N/A) for the average concentration determination

5.3.8 Data Quality Assessment

The Data Quality Assessment phase is the part of the FSS where survey design and data are reviewed for completeness and consistency, ensuring the validity of the results, verifying that the survey plan objectives were met, and validating the classification of the survey unit.

The sample design and the data acquired were reviewed and found to be in accordance with applicable YNPS procedures DP-8861, "*Data Quality Assessment*"; DP-8856, "*Preparation of Survey Plans*"; DP-8853, "*Determination of the Number and Locations of FSS Samples and Measurements*"; DP-8857, "*Statistical Tests*"; DP-8865, "*Computer Determination of the Number of FSS Samples and Measurements*"; and the QAPP.

A preliminary data review was performed and statistical quantities were calculated. The average concentrations and standard deviations of Co-60 and Cs-137 from Table 24 are larger than the respective characterization data from Table 18. However, the retrospective power curve maintained sufficient power to pass the survey unit. The concentration data for Co-60 indicated that one sample (NOL-01-03-006-F) was higher than the remaining samples. However, this value (0.49 pCi/g) was less than the $DCGL_W$ (1.4 pCi/g). This data point skewed the average Co-60 concentration value slightly high. Without this value, the range of data would have been within one standard deviation. The concentration data for Cs-137 indicated that two samples (NOL-01-03-006-F and NOL-01-03-008-F) were higher than the remaining samples, however, less than the $DCGL_W$. As with Co-60, without these data points the data set would have been within one standard deviation.

Frequency plots for both Co-60 and Cs-137 show a normal data set. The scatter plots generated for NOL-01-03 graphically illustrate that the data for Co-60 and Cs-137 vary about their respective mean, with the exception of the higher Co-60 and Cs-137 sample results discussed above. The data posting plots for both radionuclides do not clearly reveal any systematic spatial trends. Review of the quantile plots for NOL-01-03 indicates some asymmetry in the lower quartiles for both of the radionuclides being more prominent with Cs-137 and illustrates the elevated Co-60 and Cs-137 results.

Review of the data in Table 24 illustrates that all of the sample data for the soil concentrations of all plant-related LTP nuclides are below the $DCGL_W$ and the sum-of-fractions for these nuclides are less than unity. Therefore no statistical test is required.

Copies of the power curves, quantile plots, scatter plots and posting plots are found in Attachment B.

The actual level of residual activity was higher than the estimated level (i.e., values derived from characterization data) used for the survey design; however, the survey demonstrated sufficient power to indicate that the survey unit null hypothesis should be rejected. One elevated area existed in NOL-01-03 and upon assessment, it was determined that $f(DCGL_{EMC})$ for the survey unit was less than unity. One area was remediated by removing soils and subsequent scans and sampling indicated a successful remediation. No other remedial actions were required in NOL-01-03.

5.4. Survey Unit NOL-01-04

5.4.1 Status Survey Plan and Associated DQOs

The FSS for NOL-01-04 (YNPS-FSSP-NOL01-04-00) was planned and developed in accordance with the LTP using the DQO process. Form DPF-8856.1, found in YNPS Procedure 8856, "Preparation of Survey Plans," was used to provide guidance and consistency during development of the FSS Plan and can be found in Appendix B. The DQO process allows for systematic planning and is specifically designed to address problems that require a decision to be made in a complex survey design and in turn provides alternative actions. The DQO process was used to develop an integrated survey plan providing the survey unit identification, sample size, selected analytical techniques, survey instrumentation, and scan coverage. The Sign Test was specified for non-parametric statistical testing for this survey unit, if required. The design parameters developed are presented in the Table 27.

Table 27

Survey Unit NOL-01-04 Design Parameters

Survey Unit	Design Parameter	Basis
Area	881 m^2	Class 1, <2,000 m^2
Number of Direct Measurements	15	Based on a LBGR of 0.5 (unity rule), sigma[1] of 0.177 and a relative shift of 2.8 α=β= 0.05
Sample Area	58.7 m^2	881 m^2 / 15 = 31.3 m^2
Sample Grid Spacing with a triangular pitch	8.2 m	$(881/(0.866*15))^{1/2}$
Scan Grid Area	ISOCS scans at 2 meters	2.6 m on center
Scan area	881 m^2	Class 1 Area – 100%
Scan Investigation Level	1.0 pCi/g Co^{60} 4.3pCi/g Cs^{137}	(based on the 8.73 mrem/yr criteria)

5.4.2 Deviations from the FSS Plan as Written in the LTP

The null hypothesis (H_o) is stated and tested in the negative form: "Residual licensed radioactive materials in Survey Unit NOL-01-04 exceeds the release criterion." This null hypothesis is designed to protect the health of the public as well as to demonstrate compliance with the requirements set forth in the Yankee Rowe LTP. The tolerable limits established for this survey plan set the probability of Type I errors (a) at 0.05 and the probability of Type II errors (β) at 0.05. Investigation levels for the fixed measurements were set at>$DCGL_W$ and greater than 3 times the standard deviation or >$DCGL_{EMC}$. The desired MDC for fixed measurements was set at 10% of the $DCGL_W$ for each applicable radionuclide; however, if it was impracticable to achieve those values, the MDCs were permissible to be as high as 50% of the $DCGL_W$. All MDCs for the surveys of NOL-01-04 were met in accordance with YNPS LTP. DCGL values and the associated MDC values can be found in Table 28.

Table 28

DCGLs and MDCs for Survey Area NOL-01-04

for All LTP Radionuclides

Nuclide	[1]DCGLw (pCi/g)	Required MDC (50% of the DCGLw) pCi/g
H-3	1.3E+02	6.4E+01
C-14	1.9E+00	9.7E-01
Fe-55	1.0E+04	5.1E+03
[2]Co-60	1.4E+00	7.0E-01
Ni-63	2.8E+02	1.4E+02
Sr-90	6.0E-01	3.0E-01
[2]Nb-94	2.5E+00	1.3E+00
Tc-99	5.0E+00	2.5E+00
[2]Ag-108m	2.5E+00	1.3E+00
[2]Sb-125	1.1E+01	5.6E+00
[2]Cs-134	1.7E+00	8.7E-01
[2]Cs-137	3.0E+00	1.5E+00
[2]Eu-152	3.6E+00	1.8E+00
[2]Eu-154	3.3E+00	1.7E+00
[2]Eu-155	1.4E+02	6.9E+01
Pu-238	1.2E+01	5.8E+00
Pu-239, 240	1.1E+01	5.3E+00
Pu-241	3.4E+02	1.7E+02
Am-241	1.0E+01	5.1E+00
Cm-243, 244	1.1E+01	5.6E+00

[1] Based on 8.73 mrem/yr (TEDE)
[2] Gamma emitting nuclides (or ETD radionuclides)

The FSSP design was performed to the criteria of the LTP; therefore, no subsequent LTP deviations with potential impact to this survey unit need to be evaluated.

5.4.3 DCGL Selection and Use

The LTP DCGLs for soil were calculated using the resident farmer scenario. For the resident farmer scenario, the average member of the critical group is the resident farmer who lives on the site, grows all of his/her diet onsite and drinks water from a groundwater source onsite. The residual radioactive material was assumed to be in the top 2.89 m soil layer, available for use in residential and light farming activities. The LTP DCGLs were performed using RESRAD Version 6.21 analyses and based upon a resulting dose of 25 mrem/yr.

The DCGLs in NOL-01-04 Survey Plan were derived by scaling the LTP DCGLs to 8.73 mrem/yr. The 8.73 mrem/yr value was necessitated by the DPH site release criteria of 10 mrem/yr subtracting the maximum dose contribution for subsurface partial structures (0.5 mrem/yr) and the maximum dose contribution from groundwater (0.77 mrem/yr). The resulting scaled DCGL values and associated MDCs are in Table 28.

5.4.4 Measurements

The sample design required that 15 surface soil samples be used for the Sign Test based on the probability of error tolerance (α and β), LBGR and relative shift value found in Table 27. Four of the samples were split and analyzed for LTP HTD radionuclides in addition to the ETD radionuclides. Three biased samples were drawn and analyzed for both HTD and ETD radionuclides. Two samples were designated as "recount" samples, thus satisfying the QC requirements of the QAPP.

The fixed-point sampling grid was developed as a systematic grid with spacing consisting of a triangular pitch pattern with a random starting point. With the aid of a GPS and AutoCAD-generated survey unit map, the systematic random start grid was developed utilizing Visual Sample Plan. Sample measurement locations are provided with the GPS coordinates in Table 29.

Table 29

Sample Measurement Locations with GPS Coordinates

Designation	Northing	Easting
NOL-01-04-001	272496.7351	3093680.7947
NOL-01-04-002	272522.0591	3093680.7947
NOL-01-04-003	272458.7490	3093658.8634
NOL-01-04-004	272484.0731	3093658.8634
NOL-01-04-005	272509.3971	3093658.8634
NOL-01-04-006	272395.4389	3093636.9322
NOL-01-04-007	272420.7630	3093636.9322
NOL-01-04-008	272446.0870	3093636.9322
NOL-01-04-009	272471.4110	3093636.9322
NOL-01-04-010	272408.1010	3093615.0009
NOL-01-04-011	272433.4250	3093615.0009
NOL-01-04-012	272458.7490	3093615.0009
NOL-01-04-013	272395.4389	3093593.0697
NOL-01-04-014	272420.7630	3093593.0697

Designation	Northing	Easting
NOL-01-04-015	272408.1010	3093571.1384

A total of 167 ISOCS scans were performed in NOL-01-04 providing 100% coverage of the survey unit. The ISOCS scan grid used a 2.6-m point-to-point grid with no perimeter points farther than 1.3 m from the survey unit boundary. The ISOCS scan grid did not require a random start. ISOCS scans were performed at a height of 2 m from the surface positioned perpendicular to the scan point using a 90-degree collimator. The adjusted investigation levels, referenced in Table 27, for the ISOCS were derived by multiplying the $DCGL_{EMC}$ ($DCGL_W$ * AF for a 1 m^2 elevated area) by the ratio of MDCs obtained from the 12.6 m^2 field of view relative to the MDC obtained for a 1 m^2 area at the edge of the 12.6 m^2 field of view, as this leads to a conservative model. The values developed for the 1 m^2 elevated area at the edge of the field of view used for the ISOCS scan investigative levels are sensitive enough to detect the elevated comparison values for the 58.7 m^2 area (from Table 27). MDC values for the Portable ISOCS scans were set at the $DCGL_{EMC}$ for the individual radionuclides. The technical basis for the use of the ISOCS is documented in Technical Report YA-REPT-00-018-05, "*Use of In-situ Gamma Spectrum Analysis to Perform Elevated Measurement Comparison in Support of Final Status Surveys*" (Appendix B).

5.4.5 Survey Implementation Activities

Table 30 provides a summary of daily activities performed during the Final Status Survey of NOL-01-04.

Table 30

FSS Activity Summary for Survey Unit NOL-01-04

Date	Activity
November 17, 2005	Performed walk-down of NOL-01-02 Established Isolation and Controls
November 18, 2005	Started gridding of Survey Unit. Commenced ISOCS scans
November 22, 2005	Continued ISOCS scans. Layout of fixed-point grid (GPS).
November 29, 2005	Completed ISOCS scans. Completed soil sampling. FSS complete
December 2, 2005	Initiated Area Surveillance Plan in response to water and mud intrusion after a heavy rainstorm. Performed biased scans and soil sampling.

While performing surveys in NOL-01-04 ORISE communicated that an elevated measurement was detected during their confirmatory surveying and they requested sample preparation and onsite analysis support. Yankee provided this support and, thus, acquired firsthand knowledge and documentation of the ORISE sample results. On site separation of the ORISE sample determined that the source of the elevated activity was due to a discrete particle within the soil sample. The area of the ORISE-detected elevated measurement was investigated by scanning with no scan readings above background remaining at the ORISE sample site.

5.4.6 Surveillance Surveys

5.4.6.1 Periodic Surveillance Surveys

Survey Unit NOL-01-04 is subject to periodic surveillance surveys in accordance with YNPS procedure DP-8860, "Area Surveillance Following Final Status Survey." These surveys provide assurance that areas with successful FSS remain unchanged until license termination.

5.4.6.2 Resurveys

A heavy rain event, after the FSS of NOL-01-04 and prior to backfill, necessitated a resurvey of the survey unit to assess the potential impact to the FSS. An area surveillance plan (ASP) was developed (YNPS-ASP-NOL01-04-00) to include biased soil samples and judgmental ISOCS scans. The samples and scans concentrated in the locations in which the FSS was most likely to have been impacted by the rain event. ISOCS scans taken in the eastern section of the potentially impacted area were adjusted by 20% to account for the increased density due to the increased moisture content of the soil. The ASP acceptance criterion was that no single survey point exceeds two standard deviations from the mean of the FSS for the survey unit. Data assessment of the resurvey concluded that no single data point exceeded the acceptance criteria; therefore, no investigation survey was warranted.

5.4.6.3 Investigations

No investigation survey was warranted.

5.4.7 Survey Results

The onsite laboratory analyzed the 15 fixed-point soil samples collected from NOL-01-04. All samples were analyzed by gamma spectroscopy with sensitivity sufficient to achieve the MDCs in Table 28 for gamma-emitting nuclides. No samples greater than the $DCGL_W$ for the radionuclides present were identified, and the sum-of-fractions were all less than 1 (unity rule). Therefore no statistical test was necessary. Table 7 includes the gamma spectroscopy results for the only radionuclides positively identified during onsite analysis.

Three biased samples were taken. These samples were shipped, without drying, to General Engineering Laboratories in Charleston, SC, for analysis of both ETD and HTD radionuclides. The results of these biased samples are included in Table 31.

Table 31

Summary of Sample Results for Survey Unit NOL-01-04

Sample Number	Co^{60} pCi/g	Cs^{137} pCi/g	Ag^{108m} pCi/g	C^{14} pCi/g	$Pu^{239/240}$ pCi/g	Tc^{99} pCi/g	Am^{241} pCi/g	Sr^{90} pCi/g	f-DCGL*
FSS-NOL-01-02-001-F	3.09E-02	-1.56E-03							0.022
FSS-NOL-01-02-002-F	-1.50E-02	2.47E-02							-0.002
FSS-NOL-01-02-003-F	8.49E-02	2.91E-02							0.070
FSS-NOL-01-02-004-F	1.11E-02	2.33E-02							0.016
FSS-NOL-01-02-005-F	-2.46E-02	1.20E-02							-0.014
FSS-NOL-01-02-006-F	7.26E-02	-1.94E-02							0.045
FSS-NOL-01-02-007-F	9.91E-01	1.30E-01							0.751
FSS-NOL-01-02-008-F	2.96E-02	5.71E-02							0.040
FSS-NOL-01-02-009-F	9.11E-02	8.55E-02							0.094
FSS-NOL-01-02-010-F	3.61E-02	2.69E-02							0.035
FSS-NOL-01-02-011-F	2.20E-01	5.92E-02							0.177
FSS-NOL-01-02-012-F	3.32E-02	2.59E-02							0.032
FSS-NOL-01-02-013-F	1.19E-02	5.00E-02							0.025
FSS-NOL-01-02-014-F	2.32E-03	1.22E-02							0.006
FSS-NOL-01-02-015-F	7.71E-03	9.63E-02							0.038
FSS-NOL-01-02-135-F-B	-2.44E-03	1.67E-01							0.06
FSS-NOL-01-02-136-F-B	1.60E-02	1.71E-02							0.02
FSS-NOL-01-02-137-F-B	6.22E-02	1.73E-01							0.10
Stdev	0.25	0.04							

Sample Number	Co^{60} pCi/g	Cs^{137} pCi/g	Ag^{108m} pCi/g	C^{14} pCi/g	$Pu^{239/240}$ pCi/g	Tc^{99} pCi/g	Am^{241} pCi/g	Sr^{90} pCi/g	f-DCGL*
Mean	0.11	0.04							

* DCGL fraction, Unity Rule applied

One hundred and sixty seven ISOCS scans were performed and the results compared to the respective Action Levels. A summary of the ISOCS scans is provided in Table 32.

Table 32

Summary of ISOCS Scan Results

for Survey Unit NOL-01-04

Sample Title	f ($DCGL_{EMC}$)	Sample Title	f ($DCGL_{EMC}$)	Sample Title	f ($DCGL_{EMC}$)
NOL-01-04-009-R- G	0.06	NOL-01-04-039-F- G	0.00	NOL-01-04-071-F-G	0.00
NOL-01-04-010-R- G	0.35	NOL-01-04-040-F- G	0.18	NOL-01-04-072-F-G	0.00
NOL-01-04-011-R- G	0.00	NOL-01-04-041-F- G	0.16	NOL-01-04-073-F-G	0.00
NOL-01-04-012-R- G	0.00	NOL-01-04-042-F- G	0.26	NOL-01-04-074-F-G	0.13
NOL-01-04-013-R- G	0.30	NOL-01-04-043-F- G	0.17	NOL-01-04-075-F-G	0.00
NOL-01-04-014-R- G	0.00	NOL-01-04-044-F- G	0.00	NOL-01-04-076-F-G	0.00
NOL-01-04-016-F- G	0.36*	NOL-01-04-045-F- G	0.38	NOL-01-04-077-F-G	0.00
NOL-01-04-017-F- G	0.10	NOL-01-04-046-F- G	0.00	NOL-01-04-078-F-G	0.00
NOL-01-04-019-F- G	0.00	NOL-01-04-047-F- G	0.00	NOL-01-04-079-F-G	0.02
NOL-01-04-020-F- G	0.24	NOL-01-04-048-F- G	0.00	NOL-01-04-080-F-G	0.00
NOL-01-04-021-F- G	0.00*	NOL-01-04-049-F- G	0.16	NOL-01-04-081-F-G	0.00
NOL-01-04-021-F- G	0.18	NOL-01-04-050-F- G	0.17	NOL-01-04-082-F-G	0.00
NOL-01-04-022-F- G	0.00	NOL-01-04-051-F- G	0.00	NOL-01-04-083-F-G	0.00
NOL-01-04-023-F- G	0.00	NOL-01-04-052-F- G	0.00	NOL-01-04-084-F-G	0.12
NOL-01-04-024-F- G	0.00	NOL-01-04-053-F- G	0.03	NOL-01-04-085-F-G	0.00
NOL-01-04-025-F- G	0.00	NOL-01-04-054-F- G	0.03	NOL-01-04-086-F-G	0.02
NOL-01-04-026-F- G	0.00*	NOL-01-04-055-F- G	0.00	NOL-01-04-087-F-G	0.00
NOL-01-04-026-F- G	0.00	NOL-01-04-056-F- G	0.16	NOL-01-04-088-F-G	0.30
NOL-01-04-027-F- G	0.00	NOL-01-04-057-F- G	0.18	NOL-01-04-089-F-G	0.00
NOL-01-04-028-F- G	0.00	NOL-01-04-058-F- G	0.03	NOL-01-04-090-F-G	0.00
NOL-01-04-029-F- G	0.00	NOL-01-04-059-F- G	0.00	NOL-01-04-091-F-G	0.00
NOL-01-04-030-F- G	0.00	NOL-01-04-060-F- G	0.00	NOL-01-04-092-F-G	0.00
NOL-01-04-031-F- G	0.00	NOL-01-04-061-F- G	0.00	NOL-01-04-093-F-G	0.00
NOL-01-04-031-F- G	0.00*	NOL-01-04-062-F- G	0.15	NOL-01-04-094-F-G	0.00
NOL-01-04-032-F- G	0.14	NOL-01-04-063-F- G	0.00	NOL-01-04-094-F-G	0.00
NOL-01-04-032-F- G	0.19*	NOL-01-04-064-F- G	0.00	NOL-01-04-095-F-G	0.00
NOL-01-04-033-F- G	0.41	NOL-01-04-065-F- G	0.00	NOL-01-04-096-F-G	0.00
NOL-01-04-034-F- G	0.14	NOL-01-04-066-F- G	0.00	NOL-01-04-097-F-G	0.00
NOL-01-04-035-F- G	0.12	NOL-01-04-067-F- G	0.18	NOL-01-04-098-F-G	0.00

Sample Title	f (DCGL$_{EMC}$)	Sample Title	f (DCGL$_{EMC}$)	Sample Title	f (DCGL$_{EMC}$)
NOL-01-04-036-F- G	0.00	NOL-01-04-068-F- G	0.00	NOL-01-04-099-F-G	0.21
NOL-01-04-037-F- G	0.45*	NOL-01-04-069-F- G	0.20	NOL-01-04-100-F-G	0.02
NOL-01-04-038-F- G	0.31	NOL-01-04-070-F- G	0.00	NOL-01-04-101-F-G	0.00
NOL-01-04-102-F-G	0.04	NOL-01-04-147-F-G	0.02	NOL-01-04-176-F-G	0.19
NOL-01-04-103-F-G	0.00	NOL-01-04-148-F-G	0.00	NOL-01-04-177-F-G	0.00
NOL-01-04-104-F-G	0.03	NOL-01-04-149-F-G	0.00	NOL-01-04-178-F-G	0.00
NOL-01-04-105-F-G	0.00	NOL-01-04-150-F-G	0.03	NOL-01-04-179-F-G	0.00
NOL-01-04-106-F-G	0.00	NOL-01-04-151-F-G	0.08	NOL-01-04-180-F-G	0.00
NOL-01-04-107-F-G	0.00	NOL-01-04-152-F-G	0.00	NOL-01-04-181-F-G	0.00
NOL-01-04-108-F-G	0.00	NOL-01-04-153-F-G	0.00		
NOL-01-04-109-F-G	0.00	NOL-01-04-153-F-G	0.00		
NOL-01-04-110-F-G	0.00	NOL-01-04-154-F-G	0.11		
NOL-01-04-111-F-G	0.00	NOL-01-04-154-F-G	0.00		
NOL-01-04-112-F-G	0.00	NOL-01-04-155-F-G	0.00		
NOL-01-04-113-F-G	0.00	NOL-01-04-156-F-G	0.30		
NOL-01-04-114-F-G	0.00	NOL-01-04-157-F-G	0.00		
NOL-01-04-115-F-G	0.00	NOL-01-04-158-F-G	0.00		
NOL-01-04-116-F-G	0.00	NOL-01-04-159-F-G	0.00		
NOL-01-04-117-F-G	0.00	NOL-01-04-160-F-G	0.24		
NOL-01-04-118-F-G	0.00	NOL-01-04-161-F-G	0.24		
NOL-01-04-119-F-G	0.00	NOL-01-04-162-F-G	0.03		
NOL-01-04-120-F-G	0.00	NOL-01-04-163-F-G	0.00		
NOL-01-04-121-F-G	0.00	NOL-01-04-164-F-G	0.00		
NOL-01-04-123-F-G	0.00	NOL-01-04-165-F-G	0.00		
NOL-01-04-125-F-G	0.00	NOL-01-04-166-F-G	0.21		
NOL-01-04-127-F-G	0.00	NOL-01-04-167-F-G	0.03		
NOL-01-04-138-F-G	0.12	NOL-01-04-168-F-G	0.02		
NOL-01-04-139-F-G	0.00	NOL-01-04-169-F-G	0.16		
NOL-01-04-140-F-G	0.00	NOL-01-04-170-F-G	0.04		
NOL-01-04-141-F-G	0.00	NOL-01-04-171-F-G	0.00		
NOL-01-04-142-F-G	0.13	NOL-01-04-172-F-G	0.00		
NOL-01-04-143-F-G	0.00	NOL-01-04-172-F-G	0.00		
NOL-01-04-144-F-G	0.28	NOL-01-04-173-F-G	0.00		
NOL-01-04-145-F-G	0.32	NOL-01-04-174-F-G	0.00		
NOL-01-04-146-F-G	0.37	NOL-01-04-175-F-G	0.12		

- ISOCS results adjusted 20% to account for increased density due to moisture content of the soil.

Copies of the ISOCS reports are found in Attachment C.

5.4.8 Data Quality Assessment

The Data Quality Assessment phase is the part of the FSS where survey design and data are reviewed for completeness and consistency, ensuring the validity of the results, verifying that the survey plan objectives were met, and validating the classification of the survey unit.

The sample design and the data acquired were reviewed and found to be in accordance with applicable YNPS procedures DP-8861, "*Data Quality Assessment*"; DP-8856, "*Preparation of Survey Plans*"; DP-8853, "*Determination of the Number and Locations of FSS Samples and Measurements*"; DP-8857, "*Statistical Tests*"; DP-8865, "*Computer Determination of the Number of FSS Samples and Measurements*"; and the QAPP.

A preliminary data review was performed and statistical quantities were calculated. The average concentrations and standard deviations of Co-60 and Cs-137 from Table 31 are larger than the respective characterization data from Table 4. However, the retrospective power curve maintained sufficient power to pass the survey unit. The concentration data for Co-60 indicated that one sample (FSS-NOL-01-04-007-F) was statistically higher than the remaining samples; however, this value (0.99 pCi/g) was less than the $DCGL_W$. This data point skewed the average Co-60 concentration value slightly high. Without this value, the range of data would have been within one standard deviation of the mean. The data range for Cs-137 was approximately three standard deviations of the mean. Frequency plots for both Co-60 and Cs-137 demonstrate a normal data distribution with the Co-60 being skewed high. The scatter plots generated for NOL-01-04 graphically illustrate that the data for Co-60 and Cs-137 vary about their respective Mean, with the exception of the higher Co-60 sample result discussed above. The data posting plots for both radionuclides do not clearly reveal any systematic spatial trends. Review of the quantile plots for NOL-01-04 indicates some asymmetry in the lower quartiles and illustrates the elevated Co-60 result.

Review of the data in Table 31 illustrates that all of the sample data for the soil concentrations of all plant-related LTP nuclides are below the $DCGL_W$ and the sum-of-fractions for these nuclides are less than unity. Therefore no statistical test is required.

Copies of the power curves, quantile plots, scatter plots and posting plots are found in Attachment B.

The actual level of residual activity was higher than the estimated level (i.e., values derived from characterization data) used for the survey design; however, the survey demonstrated sufficient power to indicate that the survey unit null hypothesis should be rejected.

6.0 QUALITY ASSURANCE AND QUALITY CONTROL

6.1 Instrument QC Checks

Operation of the portable ISOCS was in accordance with DP-8871,"*Operation of the Canberra Portable ISOCS System,*" with QC checks performed in accordance with DP-8869,"*In-situ (ISOCS) Gamma Spectrum Assay System Calibration Procedure*" and DP-8871, "*Operation of the Canberra Portable ISOCS System.*" Operation of the E-600 w/SPA-3 was in accordance with DP-8535,"*Setup and Operation of the Eberline E-600 Digital Survey Instrument,*" with QC checks preformed in accordance with DP-8540, "*Operation and Source Checks of Portable Friskers.*" Instrument response checks were performed prior to and after use for the E-600 w/SPA-3 and once per shift for the Portable ISOCS. Any flags (i.e. anomalies in the QC results) encountered during the ISOCS QC Source Count were corrected/resolved prior to surveying. All instrumentation involved with the FSS of NOL-01 satisfied the above criteria for the survey. QC records are found in Attachment E.

6.2. Split Samples and Recounts

Samples NOL-02-03-005-F-S and NOL-02-03-010-F-S were designated as split samples and sent for full analysis by the offsite laboratory for all LTP radionuclides. The results of the offsite analyses were compared with the onsite results in accordance with DP-8864, "*Split Sample Assessment for Final Status Survey.*" Two recount samples (NOL-01-02-007-F and NOL-01-02-012-F) were counted twice on site and the results compared in accordance with DP-8864,"*Split Sample Assessment for Final Status Survey.*" Split sample locations and recount samples were selected randomly using the Microsoft® Excel "RANDBETWEEN" function. There was acceptable agreement between field-split results as well as the recounts. The sample analysis vendor maintains QA/QC plans as part of normal operation. Onsite gamma spectroscopy analysis is performed in accordance with MARLAP protocol. DP-9600, "Chemistry Laboratory Quality Control Program," and DP-9610, "Preparation of Quality Control Charts," govern the QA/QC.

6.3. Self-Assessments

No self-assessments were performed during the FSS of NOL-01.

7.0 CONCLUSION

The FSS of NOL-01 has been performed in accordance with YNPS LTP and applicable FSS procedures. Evaluation of the fixed-point sample data has shown that none of the LTP radionuclide values exceeded the $DCGL_W$ and the sum-of-fractions for those nuclides is less than unity. Therefore, the null hypothesis (H_o) is rejected. One (*this could be more with the inclusion of other survey units*) elevated area was identified and bounded. The fractional sum of $DCGL_{EMC}$ is less than unity. No large anomalies were observed in the graphical representation of the data collected. The retrospective power curve generated shows adequate power was achieved.

NOL-01 meets the objectives of the Final Status Survey.

Based upon the evaluation of the data acquired for the FSS, NOL-01 meets the release requirements set forth in YNPS LTP. The TEDE to members of the critical group does not exceed 25 mrem/yr, including that from groundwater and the requirement of 10CFR20 Subpart E for ALARA has been met.

Figure 1

Map of Survey Units Relative to Structures

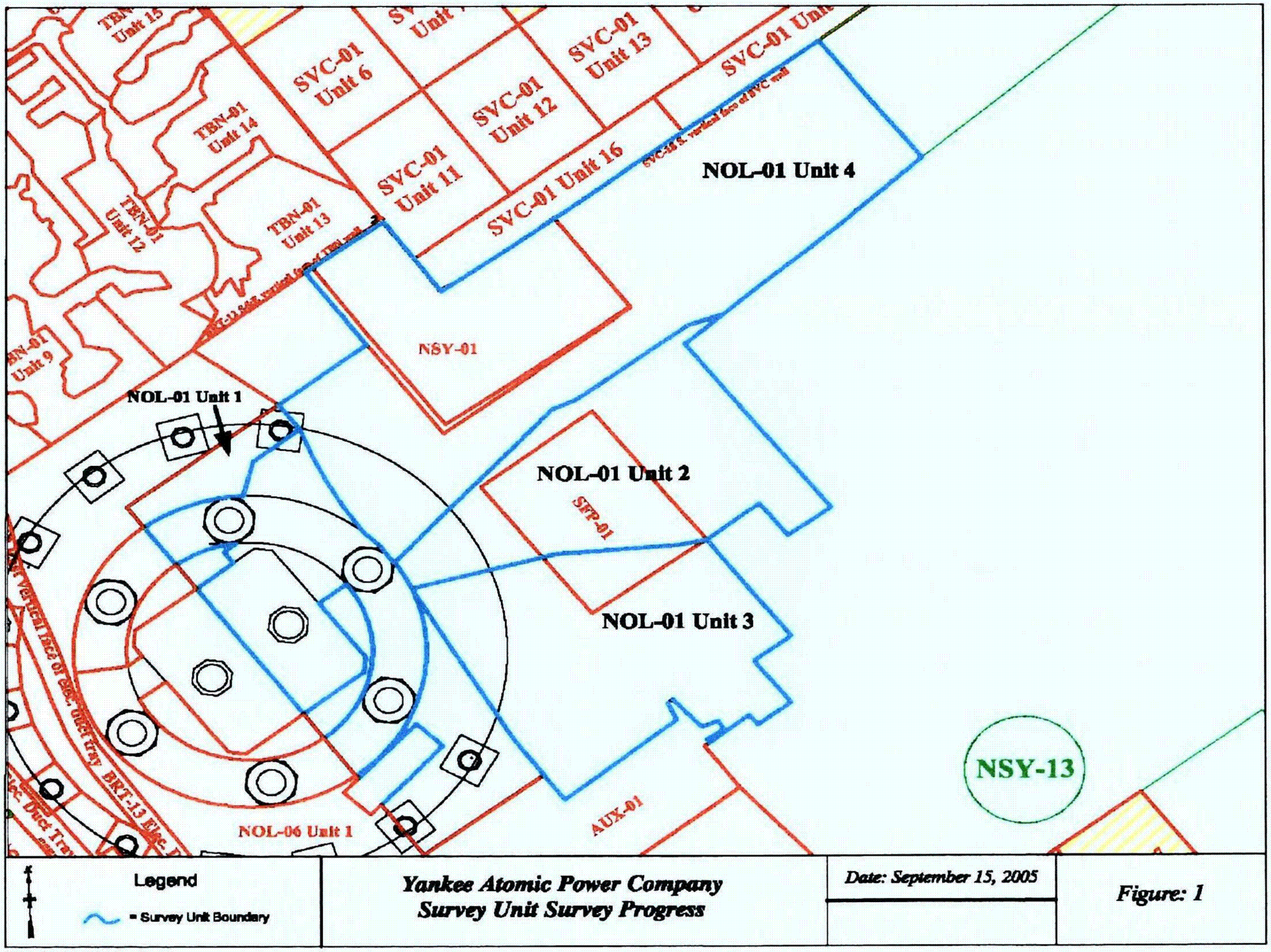
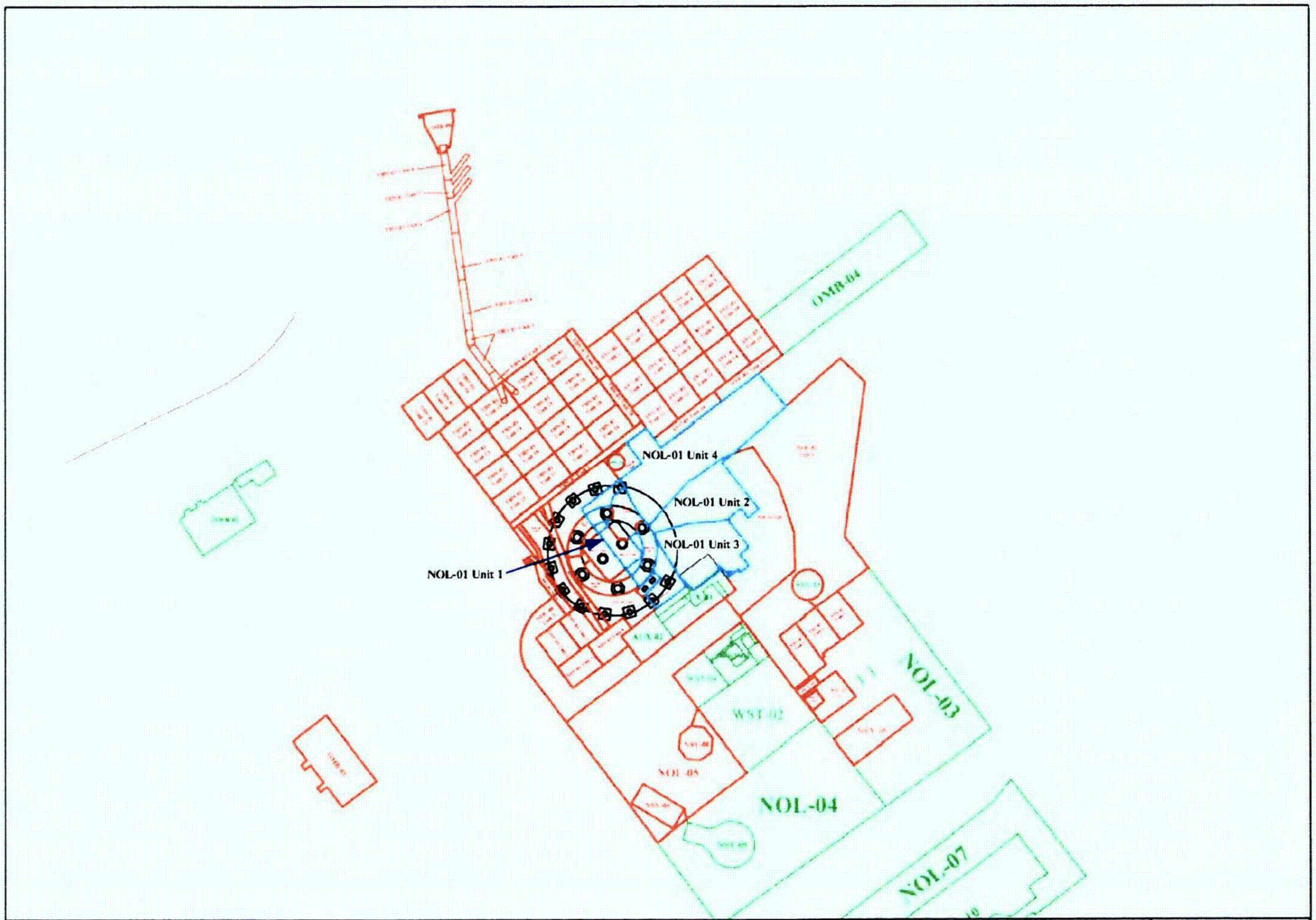


Figure 2
Site Map



Legend

Survey Unit Boundary

Yankee Atomic Power Company
Survey Unit Survey Progress

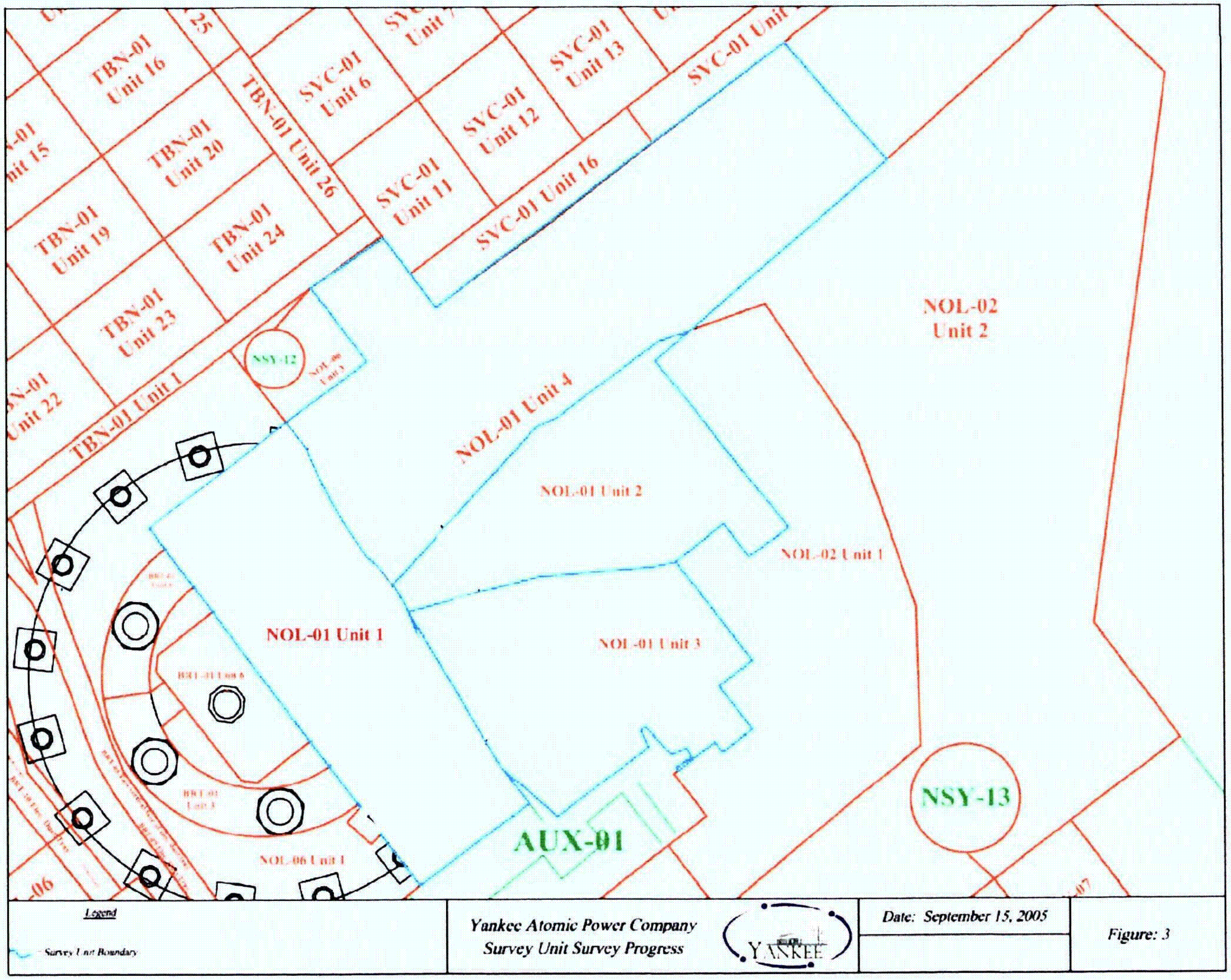
YANKEE

Date: September 15, 2005

Figure: 1

Figure 3

Map of Survey Units Relative to Survey Area



Attachment A
ISOCS Results

NOL-01-02 | **NOL-01-03** | **NOL-01-04**

Attachment A has been provided on the enclosed CD.

Attachment B

Data Quality Assessment Plots and Curves

NOL-01-01 **NOL-01-02** **NOL-01-03** **NOL-01-04**

Attachment B has been provided on the enclosed CD.

Appendix A

YA-REPT-00-003-05
Generic ALARA Review for Final Status Survey of Soil at YNPS

TECHNICAL REPORT TITLE PAGE

Generic ALARA Review for Final Status Survey of Soil at YNPS

Title

YA-REPT-00-003-05

Technical Report Number

Approvals (Print & Sign Name)

Preparer: J. Hummer signature on file Date: 1/18/05

Reviewer: J. Bisson signature on file Date: 1/18/05

Approver (Cognizant Manager): D. C. Smith signature on file Date: 1/18/05

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Executive Summary

In addition to the requirement to limit the dose from residual, plant-related radioactivity in soil to members of the critical group to 25 mrem in any year, the License Termination Plan (LTP) requires an evaluation demonstrating that these levels are as low as reasonably achievable (ALARA). If compliance with the ALARA criterion cannot be demonstrated, remediation of the soil is required, even though this would further reduce the otherwise acceptable exposure to the critical group to levels below those required. This report is intended to provide a generic ALARA review to bound the conditions under which no further remediation is necessary for soils. Calculations were performed using LTP equations and conservative assumptions. The conclusion is that it is not cost-beneficial to remediate soil in which the levels of residual, plant-related radioactivity are below LTP release criteria.

The State of Massachusetts requirement limits dose to 10 mrem/year. Remediation below this level would be even less practical.

Introduction

Section 4.3.1 of the LTP [1] states that a generic ALARA evaluation for soils will be developed to determine if the clean-up of soils beyond the DCGLs will be cost-beneficial for YNPS. Appendix 4A of the LTP [1] provides an equation and default values for this calculation. This process will be followed, assuming that the soil is at the DCGL and using conservative estimates of costs, distances and other inputs that the worksheet requires. The equation will calculate an action level (AL) that represents the ratio of concentration to the DCGL that would be cost-beneficial to remediate. If that ratio is greater than 1, remediation is not cost-beneficial.

This calculation is meant to apply to areas of any MARSSIM class and any size. In a Class 1 area, where values of residual contamination may exceed the $DCGL_W$ in limited areas, the mean concentration may never exceed the $DCGL_W$. Since it is assumed that the entire volume of soil removed is at $DCGL_W$, the assumed mean will be at $DCGL_W$. Therefore, the assumed case will be bounding.

Discussion

The total cost ($Cost_T$) will be calculated using LTP equation B-2 (from Appendix 4, section 4.A.1.1 of the LTP[1]):

$$Cost_T = Cost_R + Cost_{WD} + Cost_{ACC} + Cost_{TF} + Cost_{WDose} + Cost_{PDose}$$

These terms are defined and their values calculated as follows:

Cost of performing remediation work ($Cost_R$):

- Initially it will be assumed that the job is big enough to require earthmoving equipment. At a minimum, this would be either an excavator or a loader and truck. This turns out not to be a constraint, as explained later.
- To come up with a conservative scenario, the cost of remediating one square meter from a larger project is calculated. Any smaller job by, itself, would have planning and administration costs that would be dominant. Factors contributing to $Cost_R$ are identified in Attachment 1. The initial estimate for $Cost_R$ is based on a job to

remediate 2000 square meters of soil, but to make it comparable to the other costs, that value is adjusted to reflect the cost of 1 square meter.

- The adjusted value of $Cost_R$ is $7.32 to remediate 1 square meter of soil.
- Rounding down to the dollar, $Cost_R$ = $7

Note: The value of $Cost_R$ calculated above bounds the cost of a smaller excavation, e.g., one that doesn't require earthmoving equipment. For example, two workers who take an hour to dig up some soil and bring it back in wheelbarrow, with no work order or other formal planning, would cost the project about $100 in labor costs (assuming the cost to the project is $50/hr). So, the constraint that this only applies to jobs big enough to require earthmoving equipment can be removed.

Cost of waste disposal ($Cost_{WD}$):

- As above, it will be assumed that one square meter of surface soil is to be remediated. Surface soil is considered to be the top 15 cm. The estimated waste volume will therefore be 15 cm times the area of 1 m^2. This comes to 0.15 m^3.
- The current cost of waste disposal for radiologically contaminated soil is $19 per cubic foot [2]. This includes burial fees and shipping.
- Since 1 ft^3 equals .0283 m^3, this comes to $100.70 to dispose of the assumed volume.
- Rounding down to the dollar, $Cost_{WD}$ = $100

Cost of workplace accident ($Cost_{ACC}$):

- $Cost_{ACC}$ = ($3,000,000)x(4.2E-8/h)x(Time to perform remediation) ... (Equation 4A-4, LTP[1])
- $3,000,000 is the monetary value of a fatality equivalent to $2000 per person-rem.
- 4.2E-8 is the workplace fatality rate, in fatalities per hour worked.
- For a 1 square meter excavation, this would not be more than a few person-hours. (Assume Time = 2 hr)
- ($3,000,000) x (4.2E-8/h) x (2 h) = $0.25
- Rounding down to the dollar, $Cost_{ACC}$ = $0

Cost of traffic fatality ($Cost_{TF}$):

- $Cost_{TF}$ = ($3,000,000)x(3.8E-8/km)x(Volume)x(Distance)/(Volume/shipment) ... (Equation 4A-5, LTP[1].)
- Round trip distance from YNPS to Memphis, TN: 2550 km/shipment ... (from Yahoo Maps)
- Waste volume per shipment: 13.6 m^3/shpmt ... (default in LTP [1], section 4.A.1.1 and consistent with YNSD shipping agent's [3] figure of 500 ft^3 or 14 m^3)
- ($3,000,000)x(3.8E-8/km)x(0.15 m^3)(2550 km/shpmt)/(13.6 m^3/shpmt) = $3.21
- Rounding down to the dollar, $Cost_{TF}$ = $3

Cost of worker dose ($Cost_{WDose}$):

- $Cost_{WDose}$ = ($2000/person-rem)x(Worker dose rate)x(Time) … (Equation 4A-6, LTP[1]).
- Dose rates would be insignificant. (Assume dose rate = 0.1 mrem/h = 1E-4 rem/h)
- ($2000/person-rem) x (1E-4 rem/h) x (2 h) = $0.40
- Rounding down to the dollar, $Cost_{WDose}$ = $0

Cost of Dose to the Public ($Cost_{PDose}$):

- $Cost_{DP}$ is assumed to be no more than the $Cost_{WD}$.
- Assumed $Cost_{PDose}$ = $0

Total $Cost_T$:

- $Cost_T = Cost_R + Cost_{WD} + Cost_{ACC} + Cost_{TF} + Cost_{WDose} + Cost_{PDose}$
- $Cost_T$ = $110

Calculation

ALARA Action Level (AL):

$$AL = \frac{Conc}{DCGL_W} = \frac{Cost_T}{\$2000 \times PD \times 0.025 \times F \times A} x \frac{r + \lambda}{1 - e^{-(r+\lambda)N}} \quad \text{(LTP [1], Equation 4A.1)}$$

where:

- $Cost_T$ has been calculated above
- $2000 is the monetary value of one person-rem (Section 4A.1, LTP[1])
- F = removable fraction = 1 … (most conservative possible)
- 0.025 is the annual dose in rem to an average member of critical group from residual radioactivity (This is the LTP[1] limit, state of Massachusetts limit is 0.010, which would make the remediation less practical.)
- r = monetary discount rate = 0.03/y … (Table 4A-1, LTP [1])
- N = Number of years over which the collective dose is calculated = 1000 y … (Table 4A-1, LTP [1])
- PD = Population density for the critical group = 0.0004 people/m^2 … (Table 4A-1, LTP [1])
- A = Area being evaluated = 1 m^2
- Most conservative nuclide of concern is that with the longest half-life, Tc-99, with a half-life of 2.13E5 years (Table 2-6, LTP[1]) and a decay constant (λ) of 3.254E-6 y^{-1} (Note: With the values for other variables used for this calculation, the 1-e… term equals 1 for any value of λ. Therefore, the smallest AL, which is the most conservative, will occur when λ, in the top of the equation, is smallest.)

Applying these values to the equation:

$$AL = \frac{\$110}{\$2000 \times 0.0004 \times 0.025 \times 1 \times 1} \times \frac{0.03 + 3.254E-6}{1 - e^{-(0.03+3.254E-6)1000}}$$

$\underline{AL = 165}$

If Tc-99 were at DCGL:

- Sum of DCGL Fractions = 1

Since AL is greater than the Sum of DCGL Fractions, remediation is not cost-beneficial. In fact, remediation would not be cost-beneficial unless the concentration of any LTP nuclide in soil were at least 165 times the DCGL.

Conclusions

Based upon the results of this ALARA evaluation, it is not cost-beneficial to remediate soil in which the levels of residual, plant-related radioactivity are below LTP release criteria.

References

1. YNPS License Termination Plan
2. Interview with Rod Dee, Contracts Administrator, 1/13/05.
3. Interview with Don Maffei, YNSP Shipping Agent, 1/11/05.

ATTACHMENT 1

Cost estimate for remediation work ($Cost_R$)

Assume larger project, to dilute fixed costs: 2000 m^2, removing the top 15 cm of soil

	Time (hr)	Rate ($/hr)	Cost
Const. Planner, Rad engineer	50	$100.00	$5,000.00
Supervision/management	1	$200.00	$200.00
Resurvey	50	$50.00	$2,500.00
Additional off-site analysis (2 samples)			$2,440.00
Additional 0n-site analysis (15 samples)			$1,500.00
Equip + operators	10	$250.00	$2,500.00
HP coverage	10	$50.00	$500.00
Total for 2000 m^2:			$14,640.00
Cost per m^2:			$7.32

Appendix B

YNPS-FSSP-NOL01-01-01 through YNPS-FSSP-NOL01-04-00
Final Status Planning Worksheet

NOL-01-01 **NOL-01-02** **NOL-01-03** **NOL-01-04**

Final Status Survey Planning Worksheet

GENERAL SECTION

Survey Area #: NOL-01	Survey Unit #: 01
Survey Unit Name: RSS Footprint Within The East Lower RCA Yard	
FSSP Number: YNPS-FSSP-NOL01-01-01 **(Rev. 1 changes are in bold font)**	

PREPARATION FOR FSS ACTIVITIES

Check marks in the boxes below signify affirmative responses and completion of the action.

1.1 Files have been established for survey unit FSS records. ☑

1.2 ALARA review has been completed for the survey unit. ☑ (YA-REPT-00-003-05)

1.3 The survey unit has been turned over for final status survey. ☑

1.4 An initial DP-8854 walkdown has been performed and a copy of the completed Survey Unit Walkdown Evaluation is in the survey area file. ☑

1.5 Activities conducted within area since turnover for FSS have been reviewed. ☑

Based on reviewed information, subsequent walkdown: ☑ not warranted ☐ warranted

If warranted, subsequent walkdown has been performed and documented per DP-8854. ☐

OR

The basis has been provided to and accepted by the FSS Project Manager for not performing a subsequent walkdown. ☐

1.6 A final classification has been performed. ☑

Classification: CLASS 1 ☑ CLASS 2 ☐ CLASS 3 ☐

DATA QUALITY OBJECTIVES (DQO)

1.0 Statement of problem:

NOL01-01 consists of a soil area falling inside the RSS footprint within Survey Area NOL-01. The soil area in NOL01-01 extends south from the common boundary with Survey Unit NOL06-01 (to the north), ending at the face of the foundation of the PAB (Survey Areas AUX-01 and AUX-02). The east boundary is formed with the SFP excavation and the remaining Survey Area NOL-01. Survey Unit NOL06-01 forms the west boundary. Portions of the RSS ring and mat foundations are present in, but are not part of, Survey Unit NOL01-01. The total area (soil plus concrete structures) falling within the unit's boundaries is approximately 7,254 ft^2 (674 m^2). However, excluding the concrete ring and mat foundations, the remaining area is significantly smaller at approximately 1,919 ft^2 (178 m^2). Only the soil area is considered under this survey plan. The concrete structures are not included in Survey Unit NOL01-01 and will be surveyed under separate survey plans. The data collected under this plan will be used to determine whether or not residual plant-related radioactivity in soil of Survey Unit NOL01-01 meet LTP release criteria.

The planning team for this effort consists of the FSS Project Manager, FSS Radiological Engineer, FSS Field Supervisor, and FSS Technicians. The FSS Rad. Engineer will make primary decisions with the concurrence of the FSS Project Manager.

2.0 Identify the decision:

Does residual plant-related radioactivity, if present in the survey unit, exceed LTP release criteria? Alternative actions that may be implemented in this effort are investigations and remediation followed by re-surveying.

3.0 Identify the inputs to the decision:

Sample media: soil

Types of measurements: soil samples and gamma scans.

Radionuclide-of-concern: Cs-137 and Co-60

A large amount of the soil area in the RSS footprint was remediated for both radiological (elevated concentrations of Cs-137 and Co-60) and environmental (PCB-contamination) reasons. Characterization data (post-remediation soil samples) from areas NOL-01 and NOL-06 were used in the FSS planning for unit NOL01-01. Cesium-137 and Co-60 were the only easy-to-detect plant-related radionuclides identified in the characterization (post-remediation) surface soil samples. The average Cs-137 concentration was 0.17 pCi/g and the average Co-60 concentration was 0.064 pCi/g, both average values were below the respective 10-mrem/y DCGLs. The average Cs-137 concentration represented approximately 73% of the identified plant-related activity and the average Co-60 concentration represented approximately 27%.

One pre-remediation soil sample was sent to an offsite laboratory for analyses of HTD nuclides. Several HTD radionuclides (i.e., C-14, Ni-63, and Sr-90) were identified in that sample. Post-remediation soil samples identified Cs-137 and Co-60 at concentrations that were acceptable for area turnover (i.e., concentrations below the respective DCGL values), but the post-remediation soil samples were not analyzed for HTD nuclides.

The presence all LTP-listed radionuclides (gamma-emitters, HTD beta-emitters, and TRUs) in the soil will be evaluated under this survey plan. The YNPS Chemistry Dept. will analyze each soil sample for all LTP-listed gamma-emitting nuclides, and at least 5, which is more than the minimum requirement of 5% of the FSS soil samples, will be sent to an independent laboratory for analyses of gamma-emitters and HTD radionuclides.

Applicable DCGL: The DCGLs applied under this survey plan correspond to annual doses of 8.73 mrem/y (the 10-mrem/y DCGL adjusted for the dose contributions from sub-surface concrete structures and tritium in ground water).

Nuclide	DCGL (pCi/g)	Nuclide	DCGL (pCi/g)	Nuclide	DCGL (pCi/g)
Co-60	1.4E+0	Eu-152	3.5E+0	Sr-90	5.9E-1
Nb-94	2.5E+0	Eu-154	3.3E+0	Tc-99	4.8E+0
Ag108m	2.5E+0	Eu-155	1.4E+2	Pu-238	1.1E+1
Sb125	1.1E+1	H-3	1.3E+2	Pu-239/240	1.0E+1
Cs-134	1.7E+0	C-14	1.9E+0	Pu-241	3.4E+2
Cs-137	3.0E+0	Fe-55	1.0E+4	Am-241	1.0E+1
		Ni-63	2.8E+2	Cm-243/244	1.1E+1

Average concentration: Cs-137 = 0.17 pCi/g and Co-60 = 0.064 pCi/g

Standard deviation (σ): Cs-137 = 0.19 pCi/g and Co-60 = 0.11 pCi/g

Weighted sum σ = 0.1 pCi/g

$DCGL_{EMC}$: Cs-137 = 11.1 pCi/g (based on AF =3.7), Co-60 = 2.5 pCi/g (based on AF = 1.8)

If needed, $DCGL_{EMC}$ values for other LTP-nuclides will be calculated using AF values associated with 25 m^2.

Investigation Level for soil samples: (a) >$DCGL_{EMC}$ for either Cs-137 or Co-60, or

(b) a sum of $DCGL_{EMC}$ fractions >1.0, or

(c) >DCGL for either Cs-137 or Co-60 and a statistical outlier as defined in the LTP

Note: the same criteria will be applied to any other LTP-listed if identified in the FSS soil samples.

Investigation Level for scan: >background indication using an audible signal with headphones

Radionuclides for analysis: <u>All</u> LTP-listed nuclides with the focus on Cs-137 and Co-60.

MDCs for gamma analysis of soil samples:

Nuclide	Target MDC (pCi/g)	Nuclide	Target MDC (pCi/g)	Nuclide	Target MDC (pCi/g)
Co-60	1.4E-1	Sb125	1.1E+0	Eu-152	3.5E-1
Nb-94	2.5E-1	Cs-134	1.7E-1	Eu-154	3.3E-1
Ag108m	2.5E-1	Cs-137	3.0E-1	Eu-155	1.4E+1

Note: If a target MDC value cannot be achieved in analysis, then a value no greater than 5X the listed value must be achieved in the analysis.

MDCs for analyses of HTD nuclides:

Nuclide	Target MDC (pCi/g)	Nuclide	Target MDC (pCi/g)	Nuclide	Target MDC (pCi/g)
H-3	1.3E+1	Sr-90	5.9E-2	Pu-241	3.4E+1
C-14	1.9E-1	Tc-99	4.8E-1	Am-241	1.0E+0
Fe-55	1.0E+3	Pu-238	1.1E+0	Cm-243/244	1.1E+0
Ni-63	2.8E+1	Pu-239/240	1.0E+0		

Note: If a target MDC value cannot be achieved in analysis, then a value no greater than 5X the listed value must be achieved in the analysis.

Scan coverage: SPA-3 scans will be performed for 100% of the total surface of the soil area in the survey unit. The expected ambient background is 15,000 – 20,000 cpm.

MDCR for SPA-3: The accompanying table provides MDCR values by various background levels.

MDC(fDCGL$_{EMC}$) for SPA-3 scans: The accompanying table also provides MDC values by various background levels.

QC checks and measurements: QC checks for the SPA-3 will be performed in accordance with DP-8540. Four QC split samples will be collected, and QC recounts for 2 soil samples will be performed by the YNPS Chemistry Lab.

4.0 Define the boundaries of the survey:

Boundaries of NOL01-01 are as shown on the attached map. The survey will be performed under normal weather conditions and in daylight hours (allowing adequate daylight time for ingress and egress).

5.0 Develop a decision rule:

(a) If all the sample data show that the soil concentrations of all plant-related nuclides are below the DCGL and the sum of the DCGL fractions for identified nuclides is <1, reject the null hypothesis (i.e., Survey Unit meets the release criteria).
(b) If the investigation level is exceeded, then perform an investigation survey.
(c) If the average concentrations of all LTP-listed radionuclides are below the DCGL, or if the sum of the fractions for identified LTP-listed radionuclides <1, but some individual measurements exceed the DCGL, then apply a statistical test as the basis for accepting or rejecting the null hypothesis.
(d) If the average concentration of any LTP-listed nuclide exceeds the DCGL or the sum of the fractions exceeds one, then accept the null hypothesis (i.e., Survey Unit fails to meet the release criteria).

6.0 Specify tolerable limits on decision errors:

Null hypothesis: Residual plant-related radioactivity in Survey Unit NOL01-01 exceeds the release criteria.

Probability of type I error: 0.05

Probability of type II error: 0.05

LBGR: 0.5

7.0 Optimize Design:

Type of statistical test: WRS Test ☐ Sign Test ☑

Basis including background reference location (if WRS test is specified): N/A

Number samples (per DP-8853): 15. Refer to the completed DPF-8853.2 in the survey package file.

Note: The number of samples will be increased by 2 (bringing the total of systematic samples to 17), which increases the statistical power for the data set.

Biased samples: 2 from soil by the SE section of the ring foundation for H-3 evaluation.

GENERAL INSTRUCTIONS

1. The FSS Field Supervisor is responsible for contacting the QA Department regarding the FSS activities identified as QA notification points.

2. Standing water must be removed prior to the collection of any FSS measurement in that area.

3. Mark the sampling points at the coordinates provided with the attached map. If a measurement location is obstructed such that a sample cannot be collected, select an alternate location in accordance with DP-8856.

4. Collect 17 systematic (grid) soil samples and 2 biased soil samples in accordance with DP-8120, using sampling equipment as stated in DP-8120. Five of the 17 grid soil samples will be QC split samples. Soil sample designations are as follows:

(a) Grid soil sample designations: NOL-01-01-001-F through NOL-01-01-017-F corresponding to FSS samples collected at locations 001 through 017.

(b) 5 QC split sample designations: NOL-01-01-005-F-S, NOL-01-006-F-S, NOL-01-01-008-F-S, NOL-01-01-012-F-S, and NOL-01-017-F-S collected at sample locations 005, 006, 008, 012, and 017, respectively. The results will be compared in accordance with DP-8864.

(c) Biased soil sample designations: NOL-01-01-018-F-B and NOL-01-01-019-F-B.

Note: Samples NOL-01-01-005-F-S, NOL-01-006-F-S, NOL-01-01-008-F-S, NOL-01-01-012-F-S, and NOL-01-017-F-S are to be sent to the off-site laboratory as collected from the field (i.e., without drying) for analyses of gamma-emitters, HTD beta-emitters (including H-3), and TRUs. Samples NOL-01-01-018-F-B and NOL-01-01-019-F-B also are to be sent to the off-site laboratory as collected from the field (i.e., without drying) for analyses of gamma-emitters and H-3. YNPS chemistry will count these 7 samples in the "wet" condition prior to shipment to the offsite laboratory.

Note: Soil samples NOL-01-01-007-F and NOL-01-01-013-F are QC recounts (to be performed by the YNPS Chemistry Lab) and the results will be compared in accordance with DP-8864. The designations for the recount analyses are NOL-01-01-007-F-RC and NOL-01-01-013-F-RC, respectively.

5. All soil samples will be received and prepared in accordance with DP-8813.

6. Chain of Custody form is to be used in accordance with DP-8123 for the soil samples sent to an off-site laboratory. The required MDCs for the analyses performed by the off-site laboratory will be communicated to the Lab via the Chain-of-Custody form or an attachment to the form.

7. Scanning will cover 100% of the survey unit. The FSS Field Supervisor will record information relevant to the SPA-3 scans on DPF-8856.2.

8. Survey instrument: Operation of the E-600 w/SPA-3 will be in accordance with DP-8535, with QC checks performed in accordance with DP-8540. The instrument response checks shall be performed before issue and after use.

9. The job hazards associated with this survey are addressed in the accompanying JHA for NOL-06-01.

10. All personnel participating in this survey shall be trained in accordance with DP-8868.

SPECIFIC INSTRUCTIONS

1. SPA-3 scans are to be performed by moving the detector at a speed no greater than 0.25 m/s, keeping the probe at a distance of less than 3 inches from the ground surface, and following a serpentine pattern that includes at least 3 passes across each square meter. When scanning and walking, a slow pace (i.e., 1 step per second) shall be used. FSS Technicians will wear headphones while scanning and the survey instrument will be in the rate-meter mode. Surveyors will listen for upscale readings, to which they will respond by slowing down or stopping the probe to distinguish between random fluctuations in the background and greater than background readings. A location where detectable-above-background scan measurement is found will be investigated. Note: The FSS Field Supervisor shall monitor and time scan speeds for at least 50% of scanned areas to ensure that the scan speed of 0.25 m/s is maintained.

A first level investigation may be done with the SPA-3/E-600 to determine if an observed elevated scan measurement is reproducible and if it is due to a rock/boulder or to an outside source of radiation (e.g., the ISFSI or a nearby waste). If it can be demonstrated that the cause of the elevated scan reading is a rock/boulder or an outside source, record that finding on form DPF-8856.2. If it is demonstrated that the rocks and boulders do not account for an above background SPA-3 measurement, a soil sample will be collected at the point of the highest SPA-3 reading in the scanned area. Flag the location of an investigation sample. Detailed descriptions of investigation actions are to be recorded on form DPF-8856.2 and the location of the elevated scan measurement and sample are to be indicated on the survey map. If investigation samples are collected, the designations will continue in sequence beginning with NOL-01-01-020-F-I.

If a cluster of greater-than-background indications are found in a small, localized area (e.g., within a 1m^2 area):

1. **Measure a 1-m square that surrounds the cluster (a fabricated 1m^2 frame may be used instead of measuring).**
2. **Repeat the scan to find the highest reading within the 1m^2, and collect a soil sample at that point.**
3. **Designate the soil sample as described above.**

2. YNPS Chemistry will dry and analyze all soil samples for gamma-emitting radionuclides, except samples NOL-01-01-005-F-S, NOL-01-006-F-S, NOL-01-01-008-F-S, NOL-01-01-012-F-S, NOL-01-017-F-S, NOL-01-01-018-F-B, NOL-01-01-019-F-B. YNPS chemistry will count these 7 samples in the "wet" condition prior to shipment to the offsite laboratory. If the results of the gamma analyses identify radionuclides at concentrations greater than the investigation level, an investigation survey will be conducted under a separate plan.

3. Soil samples NOL-01-01-005-F-S, NOL-01-006-F-S, NOL-01-01-008-F-S, NOL-01-01-012-F-S, and NOL-01-017-F-S will be sent to the off-site laboratory. These samples will be analyzed for H-3, gamma-emitting nuclides, HTD beta-emitting nuclides, and TRUs. Ensure that the lid to the 1-liter marinelli container for each sample is secured to prevent loss of moisture during shipping. If the results of the offsite laboratory's analyses identify radionuclides at concentrations greater than the investigation level, an investigation survey will be conducted under a separate plan.

4. Soil samples NOL-01-01-018-F-B and NOL-01-019-F-B also will be sent to the off-site laboratory. These samples will be analyzed for H-3 and gamma-emitting nuclides. Ensure that the lid to the 1-liter marinelli container for each sample is secured to prevent loss of moisture during shipping. If the results of the offsite laboratory's analyses identify radionuclides at concentrations greater than the investigation level, an investigation survey will be conducted under a separate plan.

5. On-site and off-site analyses of the FSS samples shall achieve the required MDC values stated in Section 3 of this plan. The MDCs will be communicated to the laboratory using an attachment to the Chain-of-Custody form.
NOTIFICATION POINTS
QA notification* point(s) (y/n) __y (1) Date/time of initial pre-survey briefing ______ QA signature: ______ (2) Date/time of commencement of soil sampling ______ QA signature: ______ (3) Date/time of initial scan measurement ______ QA signature: ______ * E-mail notification to Trudeau@yankee.com with a copy to Calsyn@yankee.com satisfies this step. FSI point(s) (y/n) __n______ Specify: ______

Prepared by______________________ Date______________
FSS Radiological Engineer

Reviewed by______________________ Date______________
FSS Radiological Engineer

Approved by______________________ Date______________
FSS Project Manager

Final Status Survey Planning Worksheet

GENERAL SECTION

Survey Area #: NOL-01	Survey Unit #: 02
Survey Unit Name: Spent Fuel Pit Excavation Northwest	
FSSP Number: YNPS-FSSP-NOL01-02-03 **Revisions are in Bold**	

PREPARATION FOR FSS ACTIVITIES

Check marks in the boxes below signify affirmative responses and completion of the action.

1.1 Files have been established for survey unit FSS records. ☒

1.2 ALARA review has been completed for the survey unit. ☒ See YA-REPT-00-003-05

1.3 The survey unit has been turned over for final status survey. ☒

1.4 An initial DP-8854 walkdown has been performed and a copy of the completed Survey Unit Walkdown Evaluation is in the survey area file. ☒

1.5 Activities conducted within area since turnover for FSS have been reviewed. ☐

Based on reviewed information, subsequent walkdown: ☒ not warranted ☐ warranted

Note: Based upon Rad Engineer walkdown at the Final Turnover

If warranted, subsequent walkdown has been performed and documented per DP-8854. ☐

OR

The basis has been provided to and accepted by the FSS Project Manager for not performing a subsequent walkdown. ☐

1.6 A final classification has been performed. ☒

Classification: CLASS 1 ☒ CLASS 2 ☐ CLASS 3 ☐

DATA QUALITY OBJECTIVES (DQO)

1.0 State the problem:

Survey Area NOL-01-02 is the previous site of the Spent Fuel Pool Pit and some surrounding land areas towards the former Reactor Support Structure.The Spent Fuel Pool Pit was designed for the transfer of new fuel into the reactor, and transfer/storage of spent fuel out of the reactor. Original demolition plans called for the SFP floor, foundations, and sub-grade structures to remain in place after demolition, however, it has since been determined that most sub-surface structures will be removed as part of the deconstruction process, which was accomplished in this area. The soils located around and under NOL-01-02 include backfill, overburden, and glacio-lacustrine till. Permeability to groundwater flow is varied with the till being the most impermeable and the backfill being the least impermeable. Geoprobe soil samples taken from around the SFP have shown amounts in excess of the DCGL values for Co-60, Cs-137 and Ag-108m and subject soil was removed during excavation. Demolition activities have since been completed in NOL-01-02.

Post excavation remediation and a Characterization Survey have been performed in NOL-01-02. Characterization sampling indicates levels of Co-60 less than 0.6 pCi/gm and Cs-137 levels less than 1.5 pCi/gm. Initial scans were performed using SPA-3 and ISOCS with remediation carried out at locations that indicated elevated levels of radioactivity.

Based upon the radiological condition of this survey area identified in the operating history, and as a result of the decommissioning activities performed to date, survey area NOL-01-02 is identified as a Class 1 Area.

The problem, therefore, is to ascertain that the accumulation of licensed radioactive materials, existing in Survey Unit NOL-01-02, meets the release criterion.

The planning team for this effort consists of the FSS Project Manager, FSS Radiological Engineer, Radiation Protection Manager, FSS Field Supervisor, and FSS Technicians. The FSS Radiological Engineer will make primary decisions with the concurrence of the FSS Project Manager.

2.0 Identify the decision:

The decision to be made can be stated "Does residual plant-related radioactivity, if present in the survey unit, exceed the release criteria?"

Alternative actions that may be employed are investigation, remediation and re-survey.

3.0 Identify the inputs to the decision:

Inputs to the decision include information that will be required to resolve the decision. The information will address such topics as:

- Survey techniques and analytical methodologies selected to generate the required analytical data
- Types and number of samples required to demonstrate compliance with the release criterion
- Identification of the radionuclides-of-concern and their corresponding DCGLs

The various aspects of the data such as quality and data sensitivity ensure accurate information is utilized in the testing of the hypothesis.

Sample media: soil

Types of measurements: soil samples and 100% scans

Radionuclides-of-concern: Co^{60}, $Cs^{137,}$ $AG^{108m}$and H^{3}

Table 1

8.73 mrem/yr DCGL

Radionuclide	Soil (pCi/gm)
H^3	130
Co^{60}	1.4
Nb^{94}	2.5
Ag^{108m}	2.5
Sb^{125}	11
Cs^{134}	1.7
Cs^{137}	3.0
Eu^{152}	3.5
Eu^{154}	3.3
Eu^{155}	140
C^{14}	1.9
Fe^{55}	1.0E04
Ni^{63}	280
Sr^{90}	0.6
Tc^{99}	4.8
Pu^{238}	11
$Pu^{239, 240}$	10
Pu^{241}	340
Am^{241}	10
$Cm^{243, 244}$	11

***SPA-3Scan MDCR and MDC(fDCGL$_{EMC}$)*:** See Attachment 2

***SPA-3 DCGL$_{EMC}$*:** 6.9 pCi/gm

***Surrogate DCGLs (ISOCS)*:** Co-60 (1.2 pCi/gm) Cs-137 (2.8 pCi/gm) Ag108m (2.1 pCi/gm)

***DCGL$_{EMC}$ (surrogated)*:** Co-60 13 pCi/gm Cs-137 (61 pCi/gm) Ag-108m (19 pCi/gm)

Note: Surrogates were developed based upon the nuclide mix in sample SFP-GP-12-01

Radionuclides for analysis: All LTP nuclides with the focus on Co^{60}, Cs^{137}, Ag-108m

***ISOCS Nuclide Library*:** Library will include the gamma emitters listed in Table 2

***Investigation Level for soil samples*:** Investigation Level for soil samples will be at the DCGL for all nuclides specified in the LTP.

***Adjusted investigation Level for ISOCS Measurements*:**

- Co-60 (0.87 pCi/gm)
- Cs-137 (4.0 pCi/gm)
- Ag-108m (1.3 pCi/gm)
- Cs-134 (1.80 pCi/gm)

Note: The $DCGL_{EMC}$ for the SPA-3 was developed using area factors for a $43.7m^2$ area (the area in the systematic grid). The adjusted investigation levels for the ISOCS were derived by multiplying the $DCGL_{EMC}$ ($DCGL_W$ * AF for a $1m^2$ elevated area) by the ratio of MDAs obtained from the 12.6 m^2 field of view relative to the MDA obtained for a $1m^2$ area at the edge of the 12.6 m2 field of view as this leads to a conservative model. Cs-134 was not surrogated due to its absence in the characterization samples. The values developed for the $1m^2$ elevated area at the edge of the field of view used for the ISOCS scan investigative levels are sensitive enough to detect the elevated comparison values for the $43.7m^2$ area.

***Investigation Level for SPA-3/E-600*:** Audible increases above background that are reproducible

MDCs for gamma analysis of soil samples:

Table 2

MDCs for gamma emitters

Nuclide	10-50% $DCGL_W$ (pCi/gm
Co-60	0.14-0.70
Nb-94	0.25-1.2
Ag-108m	0.25-1.2
Sb-125	1.1-5.5
Cs-134	0.17-0.86
Cs-137	0.30-1.5
Eu-152	0.35-1.8
Eu-154	0.33-1.7
Eu-155	14-70

The desired MDCs in the laboratory analysis of FSS soil samples should be the 10% values. If it is impractical to achieve those, the 50% $DCGL_W$ values must be achieved in the laboratory analysis of the FSS soil samples. ISOCS measurements will meet the 10-50% $DCGL_{EMC}$ values for the LTP gamma emitting nuclides.

MDCs for HTD nuclides: In addition to the MDC values listed above, the following MDC values will also be transmitted to the outside laboratory via the chain-of-custody form accompanying the FSS soil samples:

Table 3

MDCs for Hard-to-Detect nuclides

Nuclide	10-50% $DCGL_W$ (pCi/gm)
H-3	13-65
C-14	0.19-0.95
Fe-55	1E03-5E03
Ni-63	28-140
Sr-90	0.06-0.29
Tc-99	0.48-2.4
Pu-238	1.1-5.7
Pu-239,240	1.0-5.2
Pu-241	34-170
Am-241	1.0-5.2
Cm-243, 244	1.1-5.5

***Survey coverage*:** Scan measurements, or ISOCS, will provide a 100% coverage of the survey area

***QC checks and measurements*:** QC checks for the Portable ISOCS will be in accordance with DP-8869 and DP-8871. Two samples will be chosen as QC split samples and will be analyzed by an off-site laboratory for all LTP nuclides. Additionally, two samples will be analyzed twice in-house by gamma spectroscopy and the results compared.

4.0 Define the boundaries of the survey:

Survey Unit NOL-01-02 is located within the RCA and is bounded by NOL-01 on the north, NOL-02-03 on the east, AUX-01 on the south, and NOL-01 on the west.

Surveying of NOL-01-02 will be performed during daylight hours when weather conditions will not adversely affect the data acquisition.

5.0 Develop a decision rule:

Null hypothesis: The null hypothesis (H_o), as required by MARSSIM, is stated and tested in the negative form: "Residual licensed radioactive materials in Survey Unit 02 exceeds the release criterion. The null hypothesis, as stated in this manner, is designed to protect the health of the public as well as to demonstrate compliance with the requirements set forth in the Yankee Rowe License Termination Plan. In general, hypothesis testing will result in the following assessments:

a. If all of the sample data show that the soil concentrations of all plant-related LTP nuclides are below the DCGLs and the sum of fractions for these nuclides are less than unity, reject the null hypothesis (i.e. NOL-01-02 meets the release criteria).

b. If the investigation levels are exceeded, then perform an investigation survey.

c. If the average concentration is below the DCGL, but individual measurements exceed the DCGL then apply a statistical test to either accept or reject the null hypothesis.

d. If the average concentration of any individual nuclide exceeds the DCGL or if the sum of fractions exceeds unity, then accept the null hypothesis (i.e. NOL-01-02 does not meet the release criteria).

6.0 Specify tolerable limits on decision errors:

***Probability of type I (α) error*:** 0.05
***Probability of type II (β) error*:** 0.05

***LBGR*:** 0.5

7.0 Optimize Design:

Type of statistical test: WRS Test ☐ Sign Test ☒

Basis including background reference location (if WRS test is specified): N/A

***Number of samples*:** 15 Random Selected

***Split Samples*:** Two samples will be split samples

***Hard-to-Detect analyses*:** Two samples sent for off-site analysis will be analyzed for all LTP hard-to-detect radionuclides referenced in this survey plan

***Sample Recounts*:** Two samples will be recounted on-site

***Biased Samples*:** 3 biased samples will be taken. One sample taken in the well will be gamma spec counted on-site and the two samples taken in the tritium plume will be gamma spec counted on-site and then sent off-site for tritium analysis.

GENERAL INSTRUCTIONS

1. Notify QA of date and time of the pre-survey briefing, commencement of soil sampling and any other scheduled activities subject to QA notification that are currently known.
2. Soil samples will be collected in accordance with DP-8120 in one-liter marinelli beakers. Extraneous materials (e.g. vegetation, debris, rocks, etc.) will be removed prior to placing the soil into the marinellis.

2. Collect the unbiased soil samples at 15 systematic locations with a random start point.

3. Soil sample designation:

   a. FSS soil samples: NOL-01-02-001-F through NOL-01-02-015-F.

   b. Samples NOL-02-03-005-F-S, NOL-02-03-010-F-S will be designated as split samples sent for full analysis by the off-site laboratory for all LTP nuclides.

   c. Biased samples will be collected in the following sample sites:

      - NOL-01-02-016-F-B will be taken in the well indicated on Attachment 2.
      - NOL-01-02-017-F-B and NOL-01-02-018-F-B will be taken in the approximate location of the tritium plume indicated on Attachment 2. NOL-01-02-017-F-B and NOL-01-02-018-F-B will be counted onsite for gamma analysis then will be sent off site for tritium analysis.

   d. The off-site gamma spec. results will be compared with the on-site results in accordance with DP-8864.

Two recount samples: NOL-01-02-007-F and NOL-01-02-012-F will be counted twice on site and the results compared in accordance with DP-8864.

4. All soil samples will be received and prepared in accordance with DP-8813.

5. Chain-of-Custody form will be used in accordance with DP-8123 for all the split samples.

6. The sampling locations will be identified using GPS. In cases where the location cannot be determined directly using GPS, an offset will be used to describe the distance and bearing from a known GPS location. Each location will be marked by a flag, either prior to or at the time of the sampling. The FSS Radiological Engineer or FSS Field Supervisor will guide the FSS Technician to the sample locations.

7. Verify that QA has been notified of the date and time of the commencement of the first ISOCS measurements.

8. Survey instrument: Operation of the Portable ISOCS will be in accordance with DP-8871, with QC checks performed in accordance with DP-8869 and DP-8871. Operation of the E-600 w/SPA-3 will be in accordance with DP-8535, with QC checks preformed in accordance with DP-8540. Instrument response checks shall be performed prior to and after use for the E-600 w/SPA-3 and once per shift for the Portable ISOCS. Any flags encountered during the ISOCS QC Source Count must be corrected/resolved prior to surveying. If anomalies cannot be corrected or resolved, contact the Cognizant FSS Engineer for assistance.

9. The job hazards associated with the FSS in Survey Unit 02 are addressed in the accompanying JHA for NOL-01-02.

10. All personnel participating in this survey shall be trained in accordance with DP-8868.

SPECIFIC INSTRUCTIONS

1. ISOCS measurements will be performed in accordance with DP-8871 "Operation of the Canberra Portable ISOCS".

Grid NOL-01-02 for 100% scan coverage by placing markers 3 meters on center in rows no more than 3 meters apart with every other row shifted 1½ meters off axis from the adjacent row forming a triangular scan grid pattern or place parallel rows of markers forming a square pattern at a maximum distance of 2.6 meters apart. Continue marking the survey unit until there are no markers greater than 1.3 meters from the boundary of NOL-01-02 (add additional scan points closer than 3 meters apart as necessary). Using the 90° collimator, position the ISOCS detector directly at each marker 2 meters from the surface to be scanned. Angle the detector as necessary perpendicular to the scan surface and perform an analysis in accordance with DP-8871 employing a preset count time sufficient to meet the MDAs referenced in this survey plan **Review the report and verify that the MDAs have been met for the nuclides**. Identify radionuclides representing licensed radioactive material and compare their concentration to their respective $DCGL_{EMC}$ value. Record the ISOCS measurement location on the survey map using the appropriate FSS numbering protocol (e.g. NOL-01-02-xxx (sequential number)-F-G).

Note: Only radionuclides associated with licensed material (i.e. nuclides listed in the LTP) will be assessed through the use of the unity rule. Nuclides associated with natural background radiation will not be included in the assessment.

The unity rule is represented by the following expression:

$$\frac{C_1}{DCGL_W} + \frac{C_2}{DCGL_W} + \cdots \frac{C_n}{DCGL_W} \leq 1$$

Where:

C = concentration

$DCGL_W$ = $DCGL_W$ value for each individual radionuclide (1,2...n)

Formula in accordance with LTP Section 5.7.4 Equation 5-27

2. If an analysis of a survey area is equal to or greater than unity then an investigation of that area shall be performed as follows:

   a. Further subdivide the survey area into equal sub-areas.
   b. Place a marker in the center of each sub-area.
   c. Lower the ISOCS detector to approximately 1 meter above the surface and center directly above the marker.
   d. Perform an analysis of that sub-area in accordance with DP-8871.
   e. Repeat the analysis sequence for each of the sub-areas within the survey area.
   f. In lieu of using ISOCS for first level investigations, SPA-3 scanning may be used for first level investigations.

3. If SPA-3 scanning is utilized for initial scans (i.e. ISOCS scanning is inaccessible, etc.) FSS Technicians will perform scans by moving the SPA-3 detector at a speed 0.25 m/s, keeping the probe within approximately three inches of the ground surface, and following a serpentine pattern that includes at least three passes across each square meter. The FSS Field Supervisor will time and monitor a minimum of 50% of these scans. When scanning and walking, a slow pace (i.e., 1 step per second) shall be used. Scanning will be performed in the rate-meter mode with the audible feature on. Surveyors will listen for upscale readings, to which they will respond by slowing down or stopping the probe to distinguish between random fluctuations in the background and greater than background readings. Location(s) where detectable-above-background scan readings are found will be investigated.

4. If ISOCS is used for investigations, and a sub-area is determined to contain radiologically elevated areas, then scan the sub-area with a SPA-3 to identify and determine the boundaries of the elevated area. SPA-3 investigative scanning is performed similar in manner as described in step 3 with the exception of the scan speed (move detector 2 to 3 inches per second) and the detector need not be moved in a serpentine pattern.

Note: Background levels for the SPA-3 should range between 10000 and 20000 cpm. If the background levels exceed 24000 cpm, contact a Radiological Engineer prior to commencing/continuing the scan with the SPA-3.

Note: Standing water may shield gamma contamination. Standing water should be removed from the excavation prior to scanning.

5. Once the elevated area, requiring an investigation, has been identified and bounded, locate the point of the highest SPA-3 reading within the bounded area and collect a one-liter soil sample for analysis. If a soil sample is collected during the first level investigation, the sample designation will consist of the next sequential measurement location code plus the letter "I" (for investigation). For example, if a soil sample is collected during a first level investigation at measurement location 019, it will be designated NOL-01-02-019-F-I. If the investigation calls for more than one sample, sequentially number the investigation samples (e.g. NOL-01-02-020-F-I). A gamma analysis will be performed on all investigative soil samples. If it can be demonstrated that the presence of rocks and boulders is the cause of an increased count rate during a SPA-3 scan, record that finding form DPF-8856.2 and no soil sample is required. The responsible FSS Radiological Engineer will evaluate analysis of any investigation samples for the LTP suite of nuclides.

Detailed descriptions of investigative actions will be recorded on form DPF-8856.2 and the location of the investigation analyses along with the sample designation will be recorded on the survey map. The location description must provide sufficient detail (i.e.) to allow revisiting the spot at a later time.

All sample analysis will achieve the MDC values stated in he DQO section of this plan.

NOTIFICATION POINTS

QA notification point(s) (y/n) ___y*___ QA Signature/Date:

(1) Date/time of initial pre-survey briefing ____________ /__________

(2) Date/time of commencement of soil sampling ____________ /__________

(3) Date/time of first scan measurement ____________ /__________

(4) Date/time of daily pre-survey briefing ____________ /__________

* Email notification to trudeau@yankee.com with a copy to calsyn@yankee.com satisfies this step

FSI point(s) (y/n) _ n FSS Radiological Engineer Signature/Date:

(1)____________ ____________ /__________

(2)____________ ____________ /__________

Prepared by____________ Date____________

FSS Radiological Engineer

Reviewed by_________________________________ Date____________________

FSS Radiological Engineer

Approved by_________________________________ Date____________________

FSS Project Manager

GENERAL SECTION	
Survey Area #: NOL-01	Survey Unit #: 03
Survey Unit Name: Spent Fuel Pit Excavation Southwest	
FSSP Number: YNPS-FSSP-NOL01-03-01 **Note: changes notated in bold type**	

PREPARATION FOR FSS ACTIVITIES

Check marks in the boxes below signify affirmative responses and completion of the action.

1.1 Files have been established for survey unit FSS records. ☒

1.2 ALARA review has been completed for the survey unit. ☒ See YA-REPT-00-003-05

1.3 The survey unit has been turned over for final status survey. ☒

1.4 An initial DP-8854 walkdown has been performed and a copy of the completed Survey Unit Walkdown Evaluation is in the survey area file. ☒

1.5 Activities conducted within area since turnover for FSS have been reviewed. ☒

Based on reviewed information, subsequent walkdown: ☒ not warranted ☐ warranted

Note: Based upon Rad Engineer walkdown at the Final Turnover

If warranted, subsequent walkdown has been performed and documented per DP-8854. ☐

OR

The basis has been provided to and accepted by the FSS Project Manager for not performing a subsequent walkdown. ☐

1.6 A final classification has been performed. ☒

Classification: CLASS 1 ☒ CLASS 2 ☐ CLASS 3 ☐

DATA QUALITY OBJECTIVES (DQO)

1.0 State the problem:

Survey Area NOL-01-03 is the previous site of the Spent Fuel Pool Pit, IX Pit and Elevator Shaft and some surrounding land areas towards the former Reactor Support Structure. The Spent Fuel Pool Pit was designed for the transfer of new fuel into the reactor, and transfer/storage of spent fuel out of the reactor. The IX Pit was used for housing the Reactor Water cleanup ion exchangers. During plant operation known leaks were discovered in the SFP and IX Pit. Original demolition plans called for the SFP floor, foundations, and sub-grade structures as well as a portion of the IX Pit to remain in place after demolition, however, it has since been determined that most sub-surface structures will be removed as part of the deconstruction process, which was accomplished in this area. The soils located around and under NOL-01-03 include backfill, overburden, and glacio-lacustrine till. Permeability to groundwater flow is varied with the till being the most impermeable and the backfill being the least impermeable. Geoprobe soil samples taken from around the SFP and IX Pit have shown amounts in excess of the DCGL values for Co-60, Cs-137 and Ag-108m and the subject soil was removed during excavation. Demolition activities have since been completed in NOL-01-03.

Post excavation remediation and a Characterization Survey have been performed in NOL-01-03. Characterization sampling indicates levels of Co-60 less than 0.6 pCi/gm and Cs-137 levels less than 1.5 pCi/gm. Initial scans were performed using SPA-3 and ISOCS with remediation carried out at locations that indicated elevated levels of radioactivity.

Based upon the radiological condition of this survey area identified in the operating history, and as a result of the decommissioning activities performed to date, survey area NOL-01-03 is identified as a Class 1 Area.

The problem, therefore, is to determine whether the accumulation of licensed radioactive materials generated during plant operation, existing in Survey Unit NOL-01-03, meets the release criterion.

The planning team for this effort consists of the FSS Project Manager, FSS Radiological Engineer, Radiation Protection Manager, FSS Field Supervisor, and FSS Technicians. The FSS Radiological Engineer will make primary decisions with the concurrence of the FSS Project Manager.

2.0 Identify the decision:

The decision to be made can be stated "Does residual plant-related radioactivity, if present in the survey unit, exceed the release criteria?"

Alternative actions that may be employed are investigation, remediation and re-survey.

3.0 Identify the inputs to the decision:

Inputs to the decision include information that will be required to resolve the decision. The information will address such topics as:

- Survey techniques and analytical methodologies selected to generate the required analytical data
- Types and number of samples required to demonstrate compliance with the release criterion
- Identification of the radionuclides-of-concern and their corresponding DCGLs

The various aspects of the data such as quality and data sensitivity ensure accurate information is utilized in the testing of the hypothesis.

Sample media: soil

Types of measurements: soil samples and 100% scans

Radionuclides-of-concern: Co^{60}, Cs^{137}, Ag^{108m} and H^3

Table 1

8.73 mrem/yr DCGL

Radionuclide	Soil (pCi/gm)
H^3	**130**
Co^{60}	1.4
Nb^{94}	2.5
Ag^{108m}	2.5
Sb^{125}	11
Cs^{134}	1.7
Cs^{137}	3.0
Eu^{152}	3.5
Eu^{154}	3.3
Eu^{155}	140
C^{14}	1.9
Fe^{55}	1.0E+04
Ni^{63}	**280**
Sr^{90}	0.6
Tc^{99}	4.8
Pu^{238}	**11**
$Pu^{239, 240}$	**10**
Pu^{241}	**340**
Am^{241}	**10**
$Cm^{243, 244}$	11

***SPA-3Scan MDCR and MDC(fDCGL$_{EMC}$)*:** See Attachment 1

***SPA-3 DCGL$_{EMC}$*:** 6.94 pCi/gm

***Surrogate DCGLs (ISOCS)*:** Co-60 (**1.2** pCi/gm) Cs-137 (**2.8** pCi/gm) Ag108m (2.1 pCi/gm)

***DCGL$_{EMC}$ (surrogated)*:** Co-60 **13** pCi/gm Cs-137 (**61** pCi/gm) Ag-108m (**19** pCi/gm)

Note: Surrogates were developed based upon the nuclide mix in sample SFP-GP-12-01

Radionuclides for analysis: All LTP nuclides with the focus on Co^{60}, Cs^{137} and Ag^{108m}

***ISOCS Nuclide Library*:** Library will include **the gamma emitters listed in Table 2**

***Investigation Level for soil samples*:** Investigation Level for soil samples will be at the

$DCGL_W$ for all nuclides specified in the LTP.

***Adjusted investigation Level ($DCGL_{EMC}$) for ISOCS Measurements*:**

- Co-60 (0.87 pCi/gm)
- Cs-137 (**4.0** pCi/gm)
- Ag-108m (**1.3** pCi/gm)
- Cs-134 (1.80 pCi/gm)

Note: The $DCGL_{EMC}$ for the SPA-3 was developed using area factors for a 43.7m^2 area (the area in the systematic grid). The adjusted investigation levels for the ISOCS were derived by multiplying the $DCGL_{EMC}$ ($DCGL_W$ * AF for a 1m^2 elevated area) by the ratio of MDAs obtained from the 12.6 m^2 field of view relative to the MDA obtained for a 1m^2 area at the edge of the 12.6 m2 field of view as this leads to a conservative model. Cs-134 was not surrogated due to its absence in the characterization samples. The values developed for the 1m^2 elevated area at the edge of the field of view used for the ISOCS scan investigative levels are sensitive enough to detect the elevated comparison values for the 43.7m^2 area.

***Investigation Level for SPA-3/E-600*:** Audible increases above background that are reproducible

MDCs for gamma analysis of soil samples:

Table 2

MDCs for gamma emitters

Nuclide	10-50% $DCGL_W$ (pCi/gm
Co-60	0.14-0.70
Nb-94	0.25-**1.2**
Ag-108m	0.25-**1.2**
Sb-125	1.10-**5.50**
Cs-134	0.17-0.86
Cs-137	0.30-**1.5**
Eu-152	0.35-**1.8**
Eu-154	0.33-**1.7**
Eu-155	14-70

The desired MDCs in the laboratory analysis of FSS soil samples should be the 10% values. If it is impractical to achieve those, the 50% $DCGL_W$ values must be achieved in the laboratory analysis of the FSS soil samples. ISOCS measurements will meet the 10-50% $DCGL_{EMC}$ values for the LTP gamma emitting nuclides.

MDCs for HTD nuclides: In addition to the MDC values listed above, the following MDC values will also be transmitted to the outside laboratory via the chain-of-custody form accompanying the FSS soil samples:

Table 3

MDCs for Hard-to-Detect nuclides

Nuclide	10-50% $DCGL_W$ (pCi/gm)
H-3	**13-64**
C-14	0.19-0.95
Fe-55	1E03-5E03
Ni-63	**28-140**
Sr-90	0.06-0.29
Tc-99	0.48-2.4
Pu-238	1.1-5.7
Pu-239,240	1.0-5.2
Pu-241	**34-170**
Am-241	1.0-5.2
Cm-243, 244	1.1-5.5

***Survey coverage*:** Scan measurements, or ISOCS (the primary method of scans), will provide a 100% coverage of the survey area

***QC checks and measurements*:** QC checks for the Portable ISOCS will be in accordance with DP-8869 and DP-8871. Two samples will be chosen as QC split samples and will be analyzed by an off-site laboratory for all LTP nuclides. Additionally, two samples will be analyzed twice in-house by gamma spectroscopy and the results compared.

4.0 Define the boundaries of the survey:

Survey Unit NOL-01-03 is located within the RCA and is bounded by NOL-01-02 on the north, NOL-02-03 on the east, AUX-01 on the south, and NOL-01 on the west.

Surveying of NOL-01-03 will be performed during daylight hours when weather conditions will not adversely affect the data acquisition.

5.0 Develop a decision rule:

Null hypothesis: The null hypothesis (H_0), as required by MARSSIM, is stated and tested in the negative form: "Residual licensed radioactive materials in Survey Unit 03 exceeds the release criterion. The null hypothesis, as stated in this manner, is designed to protect the health of the public as well as to demonstrate compliance with the requirements set forth in the Yankee Rowe License Termination Plan. In general, hypothesis testing will result in the following assessments:

a. If all of the sample data show that the soil concentrations of all plant-related LTP nuclides are below the DCGLs and the sum of fractions for these nuclides are less than unity, reject the null hypothesis (i.e. NOL-01-03 meets the release criteria).

b. If the action levels are exceeded, then perform an investigation survey.

c. If the average concentration is below the DCGL, but individual measurements exceed the DCGL then apply a statistical test to either accept or reject the null hypothesis.

d. If the average concentration of any individual nuclide exceeds the DCGL or if the sum of fractions exceeds unity, then accept the null hypothesis (i.e. NOL-01-03 does not meet the release criteria).

6.0 Specify tolerable limits on decision errors:

Probability of type I (α) error: 0.05
Probability of type II (β) error: 0.05

LBGR: **0.5**

7.0 Optimize Design:

Type of statistical test: WRS Test ☐ Sign Test ☒

Basis including background reference location (if WRS test is specified): N/A

Number of samples: 15 Random Selected

Split Samples: Two samples will be split samples

Hard-to-Detect analyses: Two samples sent for off-site analysis will be analyzed for all LTP hard-to-detect radionuclides referenced in this survey plan

Sample Recounts: Two samples will be recounted on-site

Biased Samples: 2 biased samples will be taken, one in each well, and will be gamma spec. counted on-site

GENERAL INSTRUCTIONS

1. Notify QA of date and time of the pre-survey briefing, commencement of soil sampling and any other scheduled activities subject to QA notification that are currently known.

2. Soil samples will be collected in accordance with DP-8120 in one-liter marinelli beakers. Extraneous materials (e.g. vegetation, debris, rocks, etc.) will be removed prior to placing the soil into the marinellis.

2. Collect the unbiased soil samples at 15 systematic locations with a random start point.

3. Soil sample designation:

   a. FSS soil samples: NOL-01-03-001-F through NOL-01-03-015-F.

   b. Samples NOL-02-03-0011-F-S, NOL-02-03-014-F-S will be designated as split samples sent for full analysis by the off-site laboratory for all LTP nuclides.

   c. Biased samples will be collected in the following sample sites:

      - NOL-01-03-016-F-B and NOL-01-03-17-F-B will be taken in the wells indicated on Attachment 2.

   d. The off-site gamma spec. results will be compared with the on-site results in accordance with DP-8864.

Two recount samples: NOL-01-03-002-F and NOL-01-03-008-F will be counted twice on site and the results compared in accordance with DP-8864.

4. All soil samples will be received and prepared in accordance with DP-8813.

5. Chain-of-Custody form will be used in accordance with DP-8123 for all the split samples.

6. The sampling locations will be identified using GPS. In cases where the location cannot be determined directly using GPS, an offset will be used to describe the distance and bearing from a known GPS location, Each location will be marked by a flag, either prior to or at the time of the sampling. The FSS Radiological Engineer or FSS Field Supervisor will guide the FSS Technician to the sample locations.

7. Verify that QA has been notified of the date and time of the commencement of the first ISOCS measurements.

8. Survey instrument: Operation of the Portable ISOCS will be in accordance with DP-8871, with QC checks performed in accordance with DP-8869 and DP-8871. Operation of the E-600 w/SPA-3 will be in accordance with DP-8535, with QC checks preformed in accordance with DP-8540. Instrument response checks shall be performed prior to and after use for the E-600 w/SPA-3 and once per shift for the Portable ISOCS. Any flags encountered during the ISOCS QC Source Count must be corrected/resolved prior to surveying. If anomalies cannot be corrected or resolved, contact the Cognizant FSS Engineer for assistance.

9. The job hazards associated with the FSS in Survey Unit 03 are addressed in the accompanying JHA for NOL-01-03.

10. All personnel participating in this survey shall be trained in accordance with DP-8868.

SPECIFIC INSTRUCTIONS

1. ISOCS measurements will be performed in accordance with DP-8871 "Operation of the

Canberra Portable ISOCS".

Grid NOL-01-03 for 100% scan coverage by placing markers 3 meters on center in rows no more than 3 meters apart with every other row shifted 1½ meters off axis from the adjacent row forming a triangular scan grid pattern or place parallel rows of markers forming a square pattern at a maximum distance of 2.6 meters apart. Continue marking the survey unit until there are no markers greater than 1.3 meters from the boundary of NOL-01-03 (add additional scan points closer than 3 meters apart as necessary). Using the 90° collimator, position the ISOCS detector directly at each marker 2 meters from the surface to be scanned. Angle the detector as necessary perpendicular to the scan surface and perform an analysis in accordance with DP-8871 employing a preset count time sufficient to meet the MDAs referenced in this survey plan. At the completion of the analysis review the report and verify that the MDAs have been met for the nuclides. Identify radionuclides representing licensed radioactive material and compare their concentration to their respective $DCGL_{EMC}$ value. Record the ISOCS measurement location on the survey map using the appropriate FSS numbering protocol (e.g. NOL-01-03-xxx(sequential number)-F-G).

Note: Only radionuclides associated with licensed material (i.e. nuclides listed in the LTP) will be assessed through the use of the unity rule. Nuclides associated with natural background radiation will not be included in the assessment.

2. If an analysis of a survey area is equal to or greater than the investigation level then an investigation of that area shall be performed as follows:

   a. Further subdivide the survey area into equal sub-areas.
   b. Place a marker in the center of each sub-area.
   c. Lower the ISOCS detector to approximately 1 meter above the surface and center directly above the marker.
   d. Perform an analysis of that sub-area in accordance with DP-8871.
   e. Repeat the analysis sequence for each of the sub-areas within the survey area.
   f. In lieu of using ISOCS for first level investigations, SPA-3 scanning may be used for first level investigations.

3. If SPA-3 scanning is utilized for initial scans (i.e. ISOCS scanning is inaccessible, etc.) FSS Technicians will perform scans by moving the SPA-3 detector at a speed 0.25 m/s, keeping the probe within approximately three inches of the ground surface, and following a serpentine pattern that includes at least three passes across each square meter. The FSS Field Supervisor will time and monitor a minimum of 50% of these scans. When scanning and walking, a slow pace (i.e., 1 step per second) shall be used. Scanning will be performed in the rate-meter mode with the audible feature on. Using the headsets, surveyors will listen for upscale readings, to which they will respond by slowing down or stopping the probe to distinguish between random fluctuations in the background and greater than background readings. Location(s) where detectable-above-background scan readings are found will be investigated.

4. If ISOCS is used for investigations, and a sub-area is determined to contain radiologically elevated areas, then scan the sub-area with a SPA-3 to identify and determine the boundaries of the elevated area. SPA-3 investigative scanning is performed similar in manner as described in step 3 with the exception of the scan speed (move detector 2 to 3 inches per second) and the detector need not be moved in a serpentine pattern.

Note: Background levels for the SPA-3 should range between 10000 and 20000 cpm. If the background levels exceed 24000 cpm, contact a Radiological Engineer prior to commencing/continuing the scan with the SPA-3.

Note: Standing water may shield gamma contamination. Standing water should be removed from the excavation prior to scanning.

5 Once the elevated area, requiring an investigation, has been identified and bounded, locate the point of the highest SPA-3 reading within the bounded area and collect a one-liter soil sample for analysis. If a soil sample is collected during the first level investigation, the sample designation will consist of the next sequential measurement location code plus the letter "I" (for investigation). For example, if a soil sample is collected during a first level investigation it will be designated NOL-01-02-018-F-I. If the investigation calls for more than one sample, sequentially number the investigation samples (e.g. NOL-01-02-019-F-I). A gamma analysis will be performed on all investigative soil samples. If it can be demonstrated that the presence of rocks and boulders is the cause of an increased count rate during a SPA-3 scan, record that finding form DPF-8856.2 and no soil sample is required. The responsible FSS Radiological Engineer will evaluate analysis of any investigation samples for the LTP suite of nuclides.

Detailed descriptions of investigative actions will be recorded on form DPF-8856.2 and the location of the investigation analyses along with the sample designation will be recorded on the survey map. The location description must provide sufficient detail (i.e.) to allow revisiting the spot at a later time.

All sample analysis will achieve the MDC values stated in the DQO section of this plan.

NOTIFICATION POINTS

QA notification point(s) (y/n) __y*__ QA Signature/Date:

(1) Date/time of initial pre-survey briefing ________/________

(2) Date/time of commencement of soil sampling ________/________

(3) Date/time of first scan measurement ________/________

(4) Date/time of daily pre-survey briefing ________/________

* Email notification to trudeau@yankee.com with a copy to calsyn@yankee.com satisfies this step

FSI point(s) (y/n) _ n FSS Radiological Engineer Signature/Date:

(1)________ ________/________

(2)________ ________/________

Prepared by________________ Date__________
FSS Radiological Engineer

Reviewed by________________ Date__________
FSS Radiological Engineer

Approved by________________ Date__________
FSS Project Manager

GENERAL SECTION

Survey Area #: NOL-01	Survey Unit #: 04
Survey Unit Name: Eastern Lower RCA Yard – The "Alley Way"	
FSSP Number: YNPS-FSSP-NOL01-04-00	

PREPARATION FOR FSS ACTIVITIES

Check marks in the boxes below signify affirmative responses and completion of the action.

1.1 Files have been established for survey unit FSS records. ☑

1.2 ALARA review has been completed for the survey unit. ☑ (YA-REPT-00-003-05)

1.3 The survey unit has been turned over for final status survey. ☑

1.4 An initial DP-8854 walkdown has been performed and a copy of the completed Survey Unit Walkdown Evaluation is in the survey area file. ☑

1.5 Activities conducted within area since turnover for FSS have been reviewed. ☑

Based on reviewed information, subsequent walkdown: ☑ not warranted ☐ warranted

If warranted, subsequent walkdown has been performed and documented per DP-8854. ☐

OR

The basis has been provided to and accepted by the FSS Project Manager for not performing a subsequent walkdown. ☐

1.6 A final classification has been performed. ☑

Classification: CLASS 1 ☑ CLASS 2 ☐ CLASS 3 ☐

DATA QUALITY OBJECTIVES (DQO)

1.0 Statement of problem:

Survey Unit NOL01-04 consists of the excavated open land area in the section of the eastern lower RCA yard that abuts the Turbine Building and Service Building foundations. It is referred to as the "alley way." The unit shares its west boundary with survey unit NOL01-01, its south boundary with survey units NOL01-02 and NOL02-01, and its east boundary with survey area OOL-12. The NOL01-04 footprint is approximately 9,483 ft^2 (881 m^2). The data collected under this plan will be used to determine whether or not residual plant-related radioactivity in soil of Survey Unit NOL01-04 meets the LTP release criteria.

The planning team for this effort consists of the FSS Project Manager, FSS Radiological Engineer, FSS Field Supervisor, and FSS Technicians. The FSS Rad. Engineer will make primary decisions with the concurrence of the FSS Project Manager.

2.0 Identify the decision:

Does residual plant-related radioactivity, if present in the survey unit, exceed LTP release criteria? Alternative actions that may be implemented in this effort are investigations and remediation followed by re-surveying.

3.0 Identify the inputs to the decision:

Sample media: soil

Types of measurements: soil samples, ISOCS assays, and gamma scans.

Radionuclide-of-concern: Cs-137 and Co-60

FSS planning used onsite gamma analysis results for 11 post-remediation soil samples collected from unit NOL01-04. Co-60 and Cs-137 were the only plant-related gamma-emitting radionuclides identified in the samples, although not consistently at concentrations that were greater than the MDCs for the analyses. The mean soil concentrations of Co-60 and Cs-137 were 0.08 pCi/g ± 0.092 pCi/g and 0.03 pCi/g ± 0.024 pCi/g, respectively. The Co-60 and Cs-137 concentrations were all well below the respective DCGL (the Co-60 concentrations ranged from <MDA to 0.27pCi/g and the Cs-137 concentrations ranged from <MDA pCi/g to 0.073 pCi/g).

The presence of all LTP-listed radionuclides (gamma-emitters, HTD beta-emitters, and TRUs) in the soil will be evaluated under this survey plan. The YNPS Chemistry Dept. will analyze each FSS soil sample for all LTP-listed gamma-emitting nuclides, except Cm-243/244. In addition, 4 FSS soil samples will be sent to an independent laboratory for analyses of gamma-emitters, HTD beta-emitting radionuclides, and alpha-emitting radionuclides, which will include Cm-243/244.

Applicable DCGL: The DCGLs applied under this survey plan correspond to annual doses of 8.73 mrem/y (the 10-mrem/y DCGL adjusted for the dose contributions from sub-surface concrete structures and tritium in ground water).

Nuclide	DCGL (pCi/g)	Nuclide	DCGL (pCi/g)	Nuclide	DCGL (pCi/g)
Co-60	1.4E+0	Eu-152	3.5E+0	Sr-90	5.9E-1
Nb-94	2.5E+0	Eu-154	3.3E+0	Tc-99	4.8E+0
Ag108m	2.5E+0	Eu-155	1.4E+2	Pu-238	1.1E+1
Sb125	1.1E+1	H-3	1.3E+2	Pu-239/240	1.0E+1
Cs-134	1.7E+0	C-14	1.9E+0	Pu-241	3.4E+2
Cs-137	3.0E+0	Fe-55	1.0E+4	Am-241	1.0E+1
		Ni-63	2.8E+2	Cm-243/244	1.1E+1

Average concentration: Cs-137 = 0.03 pCi/g and Co-60 = 0.08 pCi/g

Standard deviation (σ): Cs-137 = 0.024 pCi/g and Co-60 = 0.092 pCi/g

Weighted sum σ = 0.066 pCi/g

$DCGL_{EMC}$: Cs-137 = 8.7 pCi/g (based on AF = 2.9), Co-60 = 2.0 pCi/g (based on AF = 1.4)

Investigation Level for soil samples: (a) >$DCGL_{EMC}$ for either Cs-137 or Co-60, or

(b) a sum of $DCGL_{EMC}$ fractions >1.0, or

(c) >DCGL for either Cs-137 or Co-60 and a statistical outlier as defined in the LTP

Note: the same criteria will be applied to any other LTP-listed if identified in the FSS soil samples.

ISOCS assays coverage: 100% of the surface area, ensured by overlapping field-of-views

Investigation Level for ISOCS assays: 1.0 pCi/g Co-60, 4.3 pC/g Cs-137, or a sum of their fractions >1.0.

Note: The investigation levels for the ISOCS assays were derived by multiplying the $DCGL_{EMC}$ associated with a $1m^2$ area by the ratio of the MDC for the full field of view ($12.6m^2$ for overhead assays and $3.14m^2$ for side assays) to the MDC for a $1m^2$ area at the edge of the full field of view. Additional details regarding the investigation levels for ISOCS assays can be found in YA-REPT-00-018-05. The investigation levels developed in this manner are sensitive enough to detect the Co-60 and Cs-137 $DCGL_{EMC}$ values based on the grid area (2.0 pCi/g and 8.7 pCi/g, respectively).

MDCs forISOCS measurements:

Nuclide	MDC (pCi/g)	Nuclide	MDC (pCi/g)	Nuclide	MDC (pCi/g)
Co-60	2.0E-1	Sb-125	1.3E+0	Eu-152	4.2E-1
Nb-94	3.0E-1	Cs-134	3.6E-1	Eu-154	4.3E-1
Ag-108m	3.0E-1	Cs-137	8.7E-1	Eu-155	1.7E+1

Note: The MDCs listed in the above table are 10% of the $DCGL_{EMC}$ values (based on nuclide-specific AF value for 75 m^2 from LTP, Appendix 6Q). If the MDC values in the above table cannot be achieved in a reasonable count time, then an MDC no greater than 5X the table value must be achieved.

Scan coverage: SPA-3 scans will be performed only for the surface soil within the field-of-view of an ISOCS assay that exceeds the investigation criteria. The SPA-3 scan will cover 100% of the total field-of-view area ($12.6m^2$).

Investigation Level for SPA-3 scan: >background indication using an audible signal with headphones

Radionuclides for analysis: All LTP-listed nuclides with the focus on Cs-137 and Co-60.

MDCs for gamma analysis of soil samples:

Nuclide	Target MDC (pCi/g)	Nuclide	Target MDC (pCi/g)	Nuclide	Target MDC (pCi/g)
Co-60	1.4E-1	Sb125	1.1E+0	Eu-152	3.5E-1
Nb-94	2.5E-1	Cs-134	1.7E-1	Eu-154	3.3E-1
Ag108m	2.5E-1	Cs-137	3.0E-1	Eu-155	1.4E+1
Am-241	1.0E+0				

Note: If a target MDC value cannot be achieved in analysis, then a value no greater than 5X the listed value must be achieved in the analysis.

MDCs for analyses of HTD nuclides:

Nuclide	Target MDC (pCi/g)	Nuclide	Target MDC (pCi/g)	Nuclide	Target MDC (pCi/g)
H-3	1.3E+1	Sr-90	5.9E-2	Pu-241	3.4E+1
C-14	1.9E-1	Tc-99	4.8E-1	Am-241	1.0E+0
Fe-55	1.0E+3	Pu-238	1.1E+0	Cm-243/244	1.1E+0
Ni-63	2.8E+1	Pu-239/240	1.0E+0		

Note: If a target MDC value cannot be achieved in analysis, then a value no greater than 5X the listed value must be achieved in the analysis.

QC checks and measurements: QC checks for the SPA-3 will be performed in accordance with DP-8540. Four QC split samples will be collected, and QC recounts for 2 soil samples will be performed by the YNPS Chemistry Lab. QC checks for the ISOCS will be in accordance with DP-8869 and DP-8871.

4.0 Define the boundaries of the survey:

Boundaries of NOL01-04 are as shown on the attached maps. Map 1 identifies the locations of FSS soil samples. Map 2 shows the planned coverage of ISOCS assays for the horizontal surface. Map 3 shows the planned coverage of ISOCS assays for the sloping walls of the main excavation. The survey will be performed under weather conditions that permit surveying.

5.0 Develop a decision rule:

(a) If all the sample data show that the soil concentrations of all plant-related nuclides are below the DCGL and the sum of the DCGL fractions for identified nuclides is <1, reject the null hypothesis (i.e., Survey Unit meets the release criteria).

(b) If the investigation level is exceeded, then perform an investigation survey.

(c) If the average concentration of the radionuclide-of-concern is below the DCGL, or if the sum of the fractions for identified radionuclides-of-concern <1, but some measurements exceed the DCGL, then apply a statistical test as the basis for accepting or rejecting the null hypothesis.

(d) If the average concentration of any LTP-listed nuclide exceeds the DCGL or the sum of the fractions exceeds one, then accept the null hypothesis (i.e., Survey Unit fails to meet the release criteria).

6.0 Specify tolerable limits on decision errors:

Null hypothesis: Residual plant-related radioactivity in Survey Unit NOL01-04 exceeds the release criteria.

Probability of type I error: 0.05

Probability of type II error: 0.05

LBGR: 0.5

7.0 Optimize Design:

Type of statistical test: WRS Test ☐ Sign Test ☑

Basis including background reference location (if WRS test is specified): N/A

Number samples (per DP-8853): 15.

Biased samples: Three

GENERAL INSTRUCTIONS

1. The FSS Field Supervisor is responsible for contacting the QA Department regarding the FSS activities identified as QA notification points.

2. Standing water must be removed prior to the collection of any FSS measurement in that area. Do not perform this survey if there is a solid snow cover; FSS activities will be performed under a revised plan.

3. Mark the sampling points at the coordinates provided with the attached map. If a measurement location is obstructed such that a sample cannot be collected, select an alternate location in accordance with DP-8856.

4. Collect 18 soil samples in accordance with DP-8120, using sampling equipment as stated in DP-8120. Four of the 18 soil samples will be QC split samples. Soil sample designations are as follows:

(a) Grid soil sample designations: NOL-01-04-001-F through NOL-01-04-015-F corresponding to FSS samples collected at locations 001 through 015 (refer to map 1).

(b) Biased soil sample designation: NOL-01-04-135-F-B through NOL-01-04-137-F-B, corresponding to the FSS sample collected at location 135 through 137 (refer to map 1).

(c) 4 QC split sample designations: NOL-01-04-001-F-S, NOL-01-04-002-F-S, NOL-01-04-005-F-S, and NOL-01-04-014-F-S, collected at sample locations 001, 002, 005, and 014, respectively. The results will be compared in accordance with DP-8864.

Note: Samples NOL-01-04-001-F-S, NOL-01-04-002-F-S, NOL-01-04-003-F-S, and NOL-01-04-014-F-S will be sent to the off-site laboratory as collected from the field (i.e., without drying). YNPS Chemistry will count these 4 soil samples in the "wet" condition prior to shipment to the offsite laboratory, where they will be analyzed for gamma-emitters, HTD beta-emitters (including H-3), and TRUs.

Note: Soil samples NOL-01-04-006-F and NOL-01-04-011-F are QC recounts (to be performed by the YNPS Chemistry Lab) and the results will be compared in accordance with DP-8864. The designations for the recount analyses are NOL-01-04-006-F-RC and NOL-01-04-011-F-RC, respectively.

5. Collect 119 (or more, as determined necessary in the field) ISOCS measurements in accordance with DP-8871. In all assays, use the 90° collimator and a preset count time ensuring that the MDC values listed in DQO 3.0 are met.

(a) The location (center-point) for 87 ISOCS assays for the horizontal surface area will be identified by GPS coordinates and marked (refer to map 2). If the field-of-view of an ISOCS assay includes a large amount of miscellaneous concrete structure present in the unit, record that observation on DP-8856.2.

(b) The location of the ISOCS assays on the excavation slopes must be identified through measurement, such as with a tape measure or "calibrated" rope. (refer to map 3). Note: The number of ISOCS assays shown in map 3 was based on an estimated area for walls of the main excavation in unit NOL01-04. The actual number of assays required to assure 100% coverage of the surface area may be more (or fewer) than indicated in map 3.

(c) Position the ISOCS at 2m directly above (and perpendicular to) the assay center point (the center of the field of view for the ISOCS assay), angling the detector as necessary to keep it perpendicular to the area being surveyed. Each ISOCS assay has been assigned a measurement code, which appears at the center of the fields of view shown in maps 2 and 3. Designate the assays as NOL-01-04-016-F-G through NOL-01-04-134-F-G, as shown by maps 2 and 3.

Note: If additional ISOCS assays are necessary to assure 100% coverage of the survey unit, designate them in continuing sequence from the last number assigned to an ISOCS measurement. Record detailed information about any additional ISOCS assay on DPF-8856.2.

Note: If the results of an ISOCS assay exceed an investigation level, investigate the area within the field-of-view area for that ISOCS assay as directed in Specific Instructions 1.

6. All soil samples will be received and prepared in accordance with DP-8813.

7. Chain of Custody form will be used in accordance with DP-8123 for all soil samples sent to an off-site laboratory. The required MDCs for the analyses performed by the off-site laboratory will be communicated to the Lab via the Chain-of-Custody form or an attachment to that form.

8. Survey instrument: Operation of the E-600 will be in accordance with DP-8534. Pre- and post-use QC checks for survey instruments are to be performed.

9. ISOCS: Operation of the ISOCS will be in accordance with DP-8871, with QC checks performed once per shift in accordance with DP-8869 and DP-8871. Any flag encountered during the ISOCS QC source count must be corrected/resolved prior to surveying. If an anomaly cannot be corrected or resolved, contact the cognizant FSS Engineer for assistance.

10. The job hazards associated with this survey, particularly accessing the sloping walls of the excavation, are addressed in the JHA for NOL01-04 and also will be addressed in the Yankee Rowe Project Daily Activity Plan and discussed at the pre-survey briefing.

11. All personnel participating in this survey shall be trained in accordance with DP-8868.

SPECIFIC INSTRUCTIONS

1. If the results of a 2-m ISOCS assay exceed an investigation level, perform a first level investigation as follows:

a) Collect 9 additional ISOCS assays in accordance with DP-8871 (use the 90° collimator and a preset count time ensuring that the MDC values listed in DQO 3.0 are met). Use Figure 1 as a reference for positioning the detector.

(1) Position the ISOCS at 1m directly above (and perpendicular to) the center point of the ISOCS assay that exceeded the investigation level, angling the detector as necessary to keep it perpendicular to the area being surveyed. Designate this ISOCS assay as NOL-01-04-xxx-F-G-I, where "xxx" continues from the last ISOCS assay.

(2) Measure a distance of 1.25 meters from the center point of the ISOCS assay that exceeded the investigation level. Position the ISOCS at 1m directly above (and perpendicular to) that point, angling the detector as necessary to keep it perpendicular to the area being surveyed. Before collecting the ISOCS measurement, ensure that the position of the detector agrees with Figure 1. Designate this ISOCS assay as NOL-01-04-xxx-F-G-I, where "xxx" continues from the last ISOCS assay.

(3) In the clockwise direction, measure a distance of 1.25 meters from the center point (of the ISOCS assay that exceeded the investigation level) that also forms a 45° angle to the previous ISOCS measurement location. Position the ISOCS at 1m directly above (and perpendicular to) that point, angling the detector as necessary to keep it perpendicular to the area being surveyed. Before collecting the ISOCS measurement, ensure that the position of the detector agrees with Figure 1. Designate this ISOCS assay as NOL-01-04-xxx-F-G-I, where "xxx" continues from the last ISOCS assay.

b) Review the ISOCS results to identify the location of elevated activity.

c) Perform a SPA-3 scan of the area ($3.1m^2$) within the field-of-view of the 1-meter ISOCS identifying the highest amount of plant-related activity. If the results for other 1-meter ISOCS (i.e., adjacent, overlapping assays) results are within 25% of the highest identified activity, perform SPA-3 scans in the fields-of-view for those ISOCS measurement also.

2. If a SPA-3 scan is performed in response to exceeding an ISOCS assay investigation level:

- The FSS Field Supervisor should monitor and time scan speeds for at least 50% of scanned areas to ensure that the scan speed of 0.25 m/s is maintained, and record that action on DPF-8856.2,
- Ensure that the name of the FSS Technician performing the scan, the instrument serial numbers, and scan path are recorded on the survey map or on DPF-8856.2.

a) SPA-3 scans are to be performed by moving the detector at a speed no greater than 0.25 m/s, keeping the probe at a distance of less than 3 inches from the ground surface, and following a serpentine pattern that includes at least 3 passes across each square meter. When scanning and walking, a slow pace (i.e., 1 step per second) shall be used. FSS Technicians will wear headphones while scanning and the survey instrument will be in the rate-meter mode. Surveyors will listen for upscale readings, to which they will respond by slowing down or stopping the probe to distinguish between random fluctuations in the background and greater than background readings. Location(s) with the $3.1m^2$ field-of-view of the ISOCS measurement will be marked, and a soil sample will be collected at the location of the highest SPA-3 reading.

b) Detailed descriptions of investigation actions will be recorded on form DPF-8856.2 and the location of the investigation soil sample will be recorded on the survey map. If investigation samples are collected, the designations will continue in sequence as NOL-01-04-xxx-F-I, where "xxx" continues from the last number assigned to an FSS measurement.

2. Soil samples NOL-01-04-005-F-S, NOL-01-04-007-F-S, NOL-01-04-008-F-S, NOL-01-04-012-F-S, and NOL-01-04-135-F-B through NOL-01-04-137-F-B are to be sent to the off-site laboratory. These samples will be analyzed for H-3, gamma-emitting nuclides, HTD beta-emitting nuclides, and TRUs. Ensure that the lid to the 1-liter marinelli container for each sample is secured to prevent loss of moisture during shipping. If the results of the offsite laboratory's analyses identify radionuclides at concentrations greater than the investigation level, an investigation survey will be conducted under a separate plan.

4. On-site and off-site analyses of the FSS samples shall achieve the required MDC values stated in Section 3 of this plan. The MDCs will be communicated to the laboratory using an attachment to the Chain-of-Custody form.

5. Remove the trash left in the well-head stand area when conducting FSS activities in that area.

6. Remove minor pieces of concrete from the unit during FSS activities.

NOTIFICATION POINTS

QA notification* point(s) (y/n) y

(1) Date/time of initial pre-survey briefing QA signature: ______

(2) Date/time of commencement of soil sampling QA signature: ______

(3) Date/time of commencement of ISOCS measurements QA signature: ______

(4) Time(s) of daily pre-shift briefing (for each shift that the FSS is performed) QA signature: ______

* Voice mail notification or E-mail notification to Trudeau@yankeerowe.com with a copy to Marchi@cyapco.com satisfies this step.

FSI point(s) (y/n) n Specify: ______

Prepared by______ Date______
FSS Radiological Engineer

Reviewed by______ Date______
FSS Radiological Engineer

Approved by______ Date______

Appendix C

YA-REPT-00-018-05
Use of *In-Situ* Gamma Spectrum Analysis to Perform Elevated Measurement Comparison in Support of Final Status Surveys

Use Of In-Situ Gamma Spectrum Analysis To Perform Elevated Measurement Comparisons In Support Of Final Status Surveys

YA-REPT-00-018-05

Approvals	**(Print & Sign Name)**		
Preparer:	Greg Astrauckas/Signature on file	Date:	10/10/05
Preparer:	Gordon Madison, CHP/Signature on file	Date:	10/11/05
Reviewer:	Jim Hummer, CHP/Signature on file	Date:	10/18/05
Approver (FSS Manager):	Dann Smith, CHP/Signature on file	Date:	11/4/05

Rev. 0

Technical Report YA-REPT-00-018-05, Rev. 0

Use Of In-Situ Gamma Spectrum Analysis To Perform
Elevated Measurement Comparisons In Support Of Final Status Surveys

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1.0 REPORT

1.1 Introduction

The ISOCS In-Situ Gamma Spectrum detector system manufactured by Canberra Industries is being employed to perform elevated measurement comparison (EMC) surveys in support of the Final Status Surveys at Yankee Atomic's Yankee Rowe facility. This system uses an HPGe detector and specialized efficiency calibration software designed to perform in-situ gamma-spectroscopy assays. The ISOCS system will primarily be employed to evaluate survey units for elevated measurement comparisons. The ISOCS system can obtain a static measurement at a fixed distance from a pre-determined location. Count times can be tailored to achieve required detection sensitivities. Gamma spectroscopy readily distinguishes background activity from plant-related licensed radioactivity. This attribute is particularly beneficial where natural radioactivity introduces significant investigation survey efforts. Additionally, background subtraction or collimation can be employed where background influences are problematic due to the presence of stored spent fuel (ISFSI).

This technical report is intended to outline the technical approach associated with the use of ISOCS for implementing a MARSSIM-based Final Status Survey with respect to scanning surveys for elevated measurement comparisons for both open land areas and building surfaces. While the examples and discussions in this report primarily address open land areas, the same approach and methodology will be applied when deriving investigation levels, grid spacing and measurement spacing for evaluating building surfaces.

Validation of the ISOCS software is beyond the scope of this technical report. Canberra Industries has performed extensive testing and validation on both the MCNP-based detector characterization process and the ISOCS calibration algorithms associated with the calibration software. The full MCNP method has been shown to be accurate to within 5% typically. ISOCS results have been compared to both full MCNP and to 119 different radioactive calibration sources. In general, ISOCS is accurate to within 4-5% at high energies and 7-11% at 1 standard deviation for low energies. Additionally, the ISOCS technology has been previously qualified in Yankee Atomic Technical Report YA-REPT-00-022-04, "Use Of Gamma Spectrum Analysis To Evaluate Bulk Materials For Compliance With License Termination Criteria."

1.2 Discussion

1.2.1 Detector Description

Two ISOCS-characterized HPGe detectors manufactured by Canberra Industries have been procured. Each detector is a reverse-electrode HPGe detector rated at 50% efficiency (relative to a NaI detector). Resolution for these detectors is 2.2 keV @ 1332 keV. As the project progresses, other ISOCS detectors (e.g. standard electrode coaxial), if available, may be used to increase productivity. The key element regarding the use of other types of ISOCS® detectors is that specific efficiency calibrations will be developed to account for each detector's unique characteristics.

The HPGe detector is mounted on a bracket designed to hold the detector / cryostat assembly and associated collimators. This bracket may be mounted in a wheeled cart or in a cage-like frame. Both the wheeled cart and frame permit the detector to be oriented (pointed) over a full range from a horizontal to vertical position. The frame's design allows the detector to be suspended above the ground. Photographs of the frame-mounted system are presented in Attachment 1. During evaluations of Class1 areas for elevated radioactivity, the detector will generally be outfitted with the 90-degree collimator. Suspending the detector at 2 meters above the target surface yields a nominal field-of-view of 12.6 m^2.

The InSpector (MCA) unit that drives the signal chain and the laptop computer that runs the acquisition software (Genie-2000) are mounted either in the frame or on the wheeled cart. These components are battery powered. Back-up power supplies (inverter or UPS) are available to support the duty cycle. A wireless network has been installed at the site so that the laptop computers used to run the systems can be completely controlled from any workstation at the facility. This configuration also enables the saving of data files directly to a centralized file server. Radio communication will be used to coordinate system operation.

1.2.2 Traditional Approach

With respect to Class 1 Survey Units, small areas of elevated activity are evaluated via the performance of scan surveys. The size of the potential area of elevated activity affects the $DCGL_{EMC}$ and is typically determined by that area bounded by the grid points used for fixed measurements. This area in turn dictates the area factor(s) used for deriving the associated $DCGL_{EMC}$.

These scan surveys are traditionally conducted with hand-held field instruments that have a detection sensitivity sufficiently low to identify areas of localized activity above the $DCGL_{EMC}$. Occasionally, the detection sensitivity of these instruments is greater than the $DCGL_{EMC}$. In order to increase the $DCGL_{EMC}$ to the point where hand-held instrumentation can be reasonably employed, the survey design is augmented to require additional fixed-point measurements. The effect of these additional measurement points is to tighten the fixed measurement grid spacing, thus reducing the area applied to deriving the $DCGL_{EMC}$ and increasing the detection sensitivity criteria.

Background influences (from the ISFSI) and natural terrestrial sources further impact the sensitivity of these instruments. To address these impacts, the fixed-point grid spacing would again need to be reduced (requiring even more samples) in order to increase the $DCGL_{EMC}$ to the point where hand-held instrumentation can be used. Generally, the collection of additional fixed measurements (i.e. samples) increases project costs.

Survey designs for Class 2 and Class 3 survey units are not driven by the elevated measurement comparison because areas of elevated activity are not expected. In Class 2 areas, any indication of activity above the $DCGL_W$ requires further investigation. Similarly, in Class 3 areas, any positive indication of licensed radioactivity also requires further investigation. Because the $DCGL_{EMC}$ is not applicable to Class 2 or Class 3 areas, adjustments to grid spacing do not occur. However, the increased field-of-view associated with the in-situ gamma spectroscopy system improves the efficiency of the survey's implementation.

1.2.3 <u>Innovative Approach</u>

In-situ assays allow fixed-point grid spacing to be uncoupled from the derivation of applicable investigation levels. In contrast to the traditional approach where the $DCGL_{EMC}$ (based on grid size) determines both investigation levels and detection sensitivities, the use of this technology provides two independent dynamics as follows:

- Detection sensitivity is determined by the $DCGL_{EMC}$ associated with the (optimal) fixed-point grid spacing.
- Investigation levels are based on the detector's field-of-view and adjusted for the smallest area of concern (i.e. 1 m^2).

1.2.4 <u>Investigation Level</u>

Development of the investigation (action) levels applied to in-situ assay results is a departure from the traditional approach for implementing a MARSSIM survey. Examples are provided for both open land areas (i.e. soil) and for building surfaces, however the approach for both is identical.

To support the use of in-situ spectroscopy to evaluate areas of elevated activity the HPGe detector's field-of-view was characterized. Attachment 2 presents data from the field-of-view characterization for a detector configured with a 90-degree collimator positioned 2 meters from the target surface. Alternate configurations will be evaluated in a similar manner before being employed. As exhibited in Attachment 2, when the detector is positioned at 2 meters above the target surface the field-of-view has a radius of at least 2.3

meters. This value was rounded down to 2.0 meters for implementation purposes, introducing a conservative bias (approximately 9%) in reported results. The example provided in this technical report assumes a 2-meter source-to-detector distance, yielding a nominal field-of-view surface area of 12.6 m^2.

Occasionally, alternate source-to-detector distances (using the 90-degree collimator) may be employed, particularly in a characterization or investigation capacity. In such cases, the detector's field-of-view will be calculated by setting the radius equal to the source-to-detector distance, thereby maintaining the conservative attribute previously described. If alternative collimator configurations are used to perform elevated measurement comparisons, then specific evaluations will be documented in the form of a technical evaluation or similar. Associated investigation levels will be derived using the same approach and methodology outlined below in this section.

After the detector's field-of-view is determined, an appropriate investigation level is developed to account for a potential one-meter square area of elevated activity. $DCGL_{EMC}$ values for a one-square meter area are presented in Table 1.

TABLE 1, SOIL $DCGL_{EMC}$ FOR 1 m^2

	Soil $DCGL_W$ (pCi/g) (NOTE 1)	Soil $DCGL_W$ (pCi/g) (NOTE 2)	Area Factor for 1 m^2 (NOTE 3)	$DCGL_{EMC}$ for 1 m^2 (pCi/g) (NOTE 4)
Co-60	3.8	1.4	11	15
Ag-108m	6.9	2.5	9.2	23
Cs-134	4.7	1.7	16	28
Cs-137	8.2	3.0	22	66

NOTE 1 – LTP Table 6-1
NOTE 2 – Adjusted to 8.73 mRem/yr
NOTE 3 – LTP Appendix 6Q
NOTE 4 – Soil $DCGL_W$ (adjusted to 8.73 mRem/yr) for a 1 m^2 area

The ${}^{1m2}DCGL_{EMC}$ values listed in Table 1 do not account for a source positioned at the edge of the field-of-view. Therefore, the ${}^{1m2}DCGL_{EMC}$ values are adjusted via a correction factor. To develop this correction factor, a spectrum free of plant-related radioactivity was analyzed using two different efficiency calibrations (i.e. geometries). The first scenario assumes radioactivity uniformly distributed over the detector's 12.6 m^2 field-of-view. The second scenario assumes radioactivity localized over a 1 m^2 situated at the edge of the detector's field-of-view. The resultant MDC values were compared to characterize the difference in detection efficiencies between the two scenarios. As expected, the condition with localized (1 m^2) radioactivity at the edge of the detector's field-of-view yielded higher MDC values. The ratio between the reported MDC values for the two scenarios is used as a correction factor. This correction factor is referred to as the offset geometry adjustment factor. The investigation levels for soils presented in Table 2 were calculated as follows:

Nuclide Investigation Level (pCi/g) = $(DCGL_{EMC})$ * CF

Where: $DCGL_{EMC} = (DCGL_W \text{ or } DCGL_{SURR}) * AF_{(1\ m^2)}$, and
CF = Mean offset geometry adjustment factor

TABLE 2. SOIL INVESTIGATION LEVEL DERIVATION

	MDC pCi/g (NOTE 1)	MDC pCi/g (NOTE 2)	RATIO (NOTE 3)	$DCGL_{EMC}$ for 1 m^2 (NOTE 5)	INVESTIGATION LEVEL pCi/g (NOTE 6)
Co-60	0.121	1.86	0.0651	15	1.0
Ag-108m	0.184	2.82	0.0652	23	1.5
Cs-134	0.189	2.90	0.0652	28	1.8
Cs-137	0.182	2.78	0.0655	66	4.3
Offset Geometry Adjustment Factor (NOTE 4)			**0.0653**		

NOTE 1 – Assumed activity distributed over the 12.6 m^2 field-of-view.
NOTE 2 – Efficiency calibration modeled for a 1 m^2 area situated (off-set) at the edge of the detector's field-of-view. The model assumes that all activity is distributed within the 1 m^2.
NOTE 3 – Ratio = (12.6 m^2 MDC ÷ 1 m^2 MDC).
NOTE 4 – The mean value of the ratios is applied as the off-set geometry adjustment factor.
NOTE 5 – $DCGL_{EMC}$ values for 1 m^2 (from Table 1)
NOTE 6 – Investigation levels derived by applying of the off-set geometry adjustment factor (e.g. 0.0653) to the $DCGL_{EMC}$ for a 1 m^2 area for each radionuclide.

With respect to building surfaces, the development of the investigation level is identical to that for soil surfaces. The one-meter square $DCGL_{EMC}$ for building surfaces are presented in Table 3.

TABLE 3. BUILDING SURFACE $DCGL_{EMC}$ FOR 1 m^2

	Bldg $DCGL_W$ (dpm/100 m^2) (NOTE 1)	Bldg $DCGL_W$ (dpm/100 cm^2) (NOTE 2)	Area Factor For 1 m^2 (NOTE 3)	$DCGL_{EMC}$ For 1 m^2 (dpm/100 cm^2) (NOTE 4)
Co-60	18,000	6,300	7.3	46,000
Ag-108m	25,000	8,700	7.2	62,600
Cs-134	29,000	10,000	7.4	74,000
Cs-137	63,000	22,000	7.6	167,000

NOTE 1 – LTP Table 6-1
NOTE 2 – Adjusted to 8.73 mRem/yr
NOTE 3 – LTP Appendix 6S
NOTE 4 – Building $DCGL_W$ (adjusted to 8.73 mRem/yr) for a 1 m^2 area

Using the same approach described for soils, a correction factor to account for efficiency differences due to geometry considerations is developed the one-meter square $DCGL_{EMC}$. ISOCS efficiency calibrations for activity distributed over the detector's field-of-view and for activity within one-square meter located at the edge of the detector's field-of-view were developed. The MDC values for these two geometries were compared to characterize the difference in detection efficiencies. As expected, the condition with localized (1 m^2)

radioactivity at the edge of the detector's field-of-view yielded higher MDC values. The ratio between the reported MDC values for the two scenarios is used as the offset geometry adjustment factor. The MDC values, the associated ratios, and the derived investigation level for building surfaces are presented in Table 4.

TABLE 4, BUILDING SURFACE INVESTIGATION LEVEL DERIVATION

	12.6 m^2 MDC (dpm/100cm²) (NOTE 1)	1 m^2 MDC (dpm/100cm²) (NOTE 2)	RATIO (NOTE 3)	$DCGL_{EMC}$ For 1 m^2 (dpm/100cm²) (NOTE 5)	BUILDING SURFACE INVESTIGATION LEVEL (dpm/100cm²) (NOTE 6)
Co-60	785	12,400	0.0633	46,000	2,900
Ag-108m	839	13,000	0.0645	62,600	3,900
Cs-134	900	14,200	0.0634	74,000	4,700
Cs-137	922	14,600	0.0632	167,000	10,600
Offset Geometry Adjustment Factor (NOTE 4)			**0.0636**		

NOTE 1 – Assumed activity distributed over the 12.6 m^2 field-of-view.
NOTE 2 – Efficiency calibration modeled for a 1 m^2 area situated (off-set) at the edge of the detector's field-of-view. The model assumes that all activity is distributed within the 1 m^2.
NOTE 3 – Ratio = (12.6 m^2 MDC ÷ 1 m^2 MDC).
NOTE 4 – The mean value of the ratios is applied as the off-set geometry adjustment factor.
NOTE 5 – $DCGL_{EMC}$ values for 1 m^2 (from Table 3)
NOTE 6 – Investigation levels derived by applying of the off-set geometry adjustment factor (e.g. 0.0636) to the one-square meter $DCGL_{EMC}$.

In summary, effective investigation levels for both open land areas (i.e. soils) and for building surfaces can be derived and applied to in-situ gamma spectroscopy results. Note the MDC values associated with the detector's field-of-view were well below the derived investigation levels.

The investigation levels presented in Table 2 and Table 4 do not address the use of surrogate DCGLs. Use of surrogate DCGLs will be addressed in Final Status Survey Plans, particularly where it is necessary to evaluate non-gamma emitting radionuclides on building surfaces. When surrogate DCGLs are employed, investigation levels will be developed on a case-by-case basis using the approach outlined in this document. Similarly, the offset geometry adjustment factor presented in Table 2 and Table 4 will vary for different geometries. Although unlikely, if different geometries are employed, this value will be determined on a case-by-case basis using the methodology reflected in Table 2 and will be documented in the applicable Final Status Survey Plan.

For both open land areas and for building surfaces, when an investigation level is encountered, investigatory protocols will be initiated to evaluate the presence of elevated activity and bound the region as necessary. Such evaluations may include both hand-held field instrumentation as well as the in-situ HPGe detector system. After investigation activities are completed, subsequent (follow-up) scanning evaluations will most likely be conducted using the in-situ gamma spectroscopy system.

1.2.5 Detector Sensitivity

For Class 1 scan surveys, the minimum detectable concentration is governed by the $DCGL_{EMC}$ associated with the grid area used to locate fixed-point measurements. The system's count time can be controlled to achieve the required detection sensitivity. Therefore, the grid spacing for the fixed-point measurements can be optimized thus eliminating unnecessary increases to the number of fixed-point measurements while ensuring that elevated areas between fixed measurement locations can be identified and evaluated.

Based on preliminary work, it has been determined that a count time of 900 seconds will yield an acceptable sensitivity for many areas on the site. This count time provides MDC values well below the investigation levels presented in Table 2 and Table 4. Count times will be adjusted as necessary as survey unit-specific investigation levels are derived or where background conditions warrant to ensure that detection sensitivities are below the applicable investigation level. Since each assay report includes a report of the MDC values achieved during the assay, this information is considered technical support that required MDC values were met.

1.2.6 Area Coverage

Based on the nominal 12.6 m^2 field-of-view, a 3-meter spacing between each survey point will result in well over 100% of the survey unit to be evaluated for elevated activity. This spacing convention typically employs a grid pattern that is completely independent from the grid used to locate fixed-point measurements. An example of the grid pattern and spacing is presented in Attachment 3.

Alternate spacing conventions may be applied on a case-by-case basis. For instance, spacing may be decreased when problematic topographies are encountered. Note that decreased grid spacing in this context is not associated to the fixed-point measurements. Occasionally it may be necessary to position the detector at one meter or less from the target surface to evaluate unusual (e.g. curved) surfaces or to assist in bounding areas of elevated activity. In cases where it may be desirable to increase the field-of-view via collimator or source-to-detector distances, grid-spacing conventions (and applicable investigation levels) will be determined using the approach described in this document.

1.2.7 Moisture Content in the Soil Matrix

In-situ gamma spectroscopy of open land areas is inherently subject to various environmental variables not present in laboratory analyses. Most notably is the impact that water saturation has on assay results. This impact has two components. First, the total activity result for the assay is assigned over a larger, possibly non-radioactive mass introduced by the presence of water. Secondly, water introduces a self-absorption factor.

The increase in sample mass due to the presence of water is addressed by the application of a massimetric efficiency developed by Canberra Industries. Massimetric efficiency units are defined as [counts per second]/[gammas per second per gram of sample]. Mathematically, this is the product of traditional efficiency and the mass of the sample. When the efficiency is expressed this way, the efficiency asymptotically approaches a constant value as the sample becomes very large (e.g. infinite). Under these conditions changes in sample size, including mass variations from excess moisture, have little impact on the counting efficiency. However, the massimetric efficiency does not completely address attenuation characteristics associated with water in the soil matrix.

To evaluate the extent of self-absorption, (traditional) counting efficiencies were compared for two densities. Based on empirical data associated with the monitoring wells, typical nominally dry in-situ soil is assigned a density of 1.7 g/cc. A density of 2.08 g/cc, obtained from a technical reference publication by Thomas J. Glover, represents saturated soil. A density of 2.08 g/cc accounts for a possible water content of 20%. A summary of this comparison is presented in Table 5.

TABLE 5, COUNTING EFFICIENCY COMPARISONS

keV	Efficiencies		Deviation due to density increase (excess moisture)
	1.7 g/cc	2.08 g/cc	
434	3.3 E-6	2.7 E-6	-18.7%
661.65	2.9 E-6	2.4 E-6	-17.5%
1173.22	2.5 E-6	2.1 E-6	-15.4%
1332.49	2.4 E-6	2.1 E-6	-14.8%

In cases when the soil is observed to contain more than "typical" amounts of water, potential under-reporting can be addressed in one of two manners. One way is to adjust the investigation level down by 20%. The second way is to reduce the sample mass by 20%. Either approach achieves the same objective: to introduce a conservative mechanism for triggering the investigation level where the presence of water may inhibit counting efficiency. The specific mechanism to be applied will be prescribed in implementing procedures.

The presence of standing water (or ice or snow) on the surface of the soil being assayed will be accounted for in customized efficiency calibrations applied during data analysis activities.

1.2.8 Discrete Particles in the Soil Matrix

Discrete particles are not specifically addressed in the License Termination Plan. However, an evaluation was performed assuming all the activity in the detector's field-of-view, to a depth of 15 cm, was situated in a discrete point-source configuration. A concentration of 1.0 pCi/g (Co-60), corresponding to the investigation level presented in Table 2, correlates to a discrete point-source of approximately 3.2 µCi. This activity value is considered as the discrete particle of concern. Since the presence of any discrete particles will most likely be accompanied by distributed activity, the investigation level may provide an opportunity to detect discrete particles below 3.2 µCi.

Discrete particles exceeding this magnitude would readily be detected during characterization or investigation surveys. The MDCs associated with hand-held field instruments used for scan surveys are capable of detecting very small areas of elevated radioactivity that could be present in the form of discrete point sources. The minimum detectable particle activity for these scanning instruments and methods correspond to a small fraction of the TEDE limit provided in 10CFR20 subpart E. Note that the MDC values presented in Table 2 are significantly lower than those published in Table 5-4 of the License Termination Plan.

When the investigation level in a Class 1 area is observed, subsequent investigation surveys will be performed to include the use of hand-held detectors. The detection sensitivities of instruments used for these surveys have been previously addressed in the LTP. Furthermore, discrete point sources do not contribute to the uniformly distributed activity of the survey unit. It is not expected that such sources at this magnitude would impact a survey unit's ability to satisfy the applicable acceptance criteria.

Noting that Class 2 or Class 3 area survey designs do not employ elevated measurement comparisons, associated investigation levels are based on positive indications of licensed radioactivity above the $DCGL_W$ or above background. Because such areas are minimally impacted or disturbed, potential discrete particles would most likely be situated near the soil surface where detection efficiencies are highest.

1.2.9 Procedures And Guidance Documents

General use of the portable ISOCS system is administrated by departmental implementing procedures that address the calibration and operation activities as well as analysis of the data. These procedures are listed as follows:

- DP-8869, "In-Situ (ISOCS) Gamma Spectrum Assay System Calibration Procedure."
- DP-8871, "Operation Of The Canberra Portable ISOCS Assay System."
- DP-8872, "ISOCS Post Acquisition Processing And Data Review."

Where the portable ISOCS® system is used for Final Status Surveys, the applicable FSS Plan will address detector and collimator configurations, applicable (surrogated) investigation levels, MDC requirements, and appropriate Data Quality Objectives, as applicable.

A secondary application of the portable ISOCS® system is to assay surfaces or bulk materials for characterization or unconditional release evaluations. Use of the portable ISOCS® system for miscellaneous evaluations will be administrated under a specific guidance document (e.g. Sample Plan, etc.). Operating parameters such as physical configuration, efficiency calibrations, count times, and MDCs will be applied so as to meet the criteria in the associated controlling documents. Such documents will also address any unique technical issues associated with the application and may provide guidance beyond that of procedure AP-0052, "Radiation Protection Release of Materials, Equipment and Vehicles."

1.2.10 Environmental Backgrounds

If background subtraction is used, an appropriate background spectrum will be collected and saved. Count times for environmental backgrounds should exceed the count time associated with the assay. In areas where the background radioactivity is particularly problematic (e.g. ISFSI), the background will be characterized to the point of identifying gradient(s) such that background subtractions are either appropriate or conservative. Documentation regarding the collection and application of environmental backgrounds will be provided as a component of the final survey plan.

1.2.11 Quality Control

Quality Control (QC) activities for the ISOCS system ensure that the energy calibration is valid and detector resolution is within specifications. A QC file will be set up for each detector system to track centroid position, FWHM, and activity. Quality Control counts will be performed on a shiftly basis prior to the system's use to verify that the system's energy calibration is valid. The Na-22 has a 1274.5 keV photon which will be the primary mechanism used for performance monitoring. If the energy calibration is found to be out of an acceptable tolerance (e.g. greater than ±4 channels), then the amplifier gain may be adjusted and a follow-up QC count performed. If the detector's resolution is found to be above the factory specification, then an evaluation will be performed to determine if the detector should be removed from service and/or if the data is impacted. Evaluations associated with QC counts shall be documented. Such documentation may be limited to a remark directly on the applicable QC report or in a logbook if the resolution does not render the system out of service. Otherwise the evaluation should be separately documented (e.g. Condition Report, etc.) so as to address the impact of any assay results obtained since the last acceptable QC surveillance.

Where it is determined that background subtraction is necessary, a baseline QC background will be determined specific to that area or region. When background subtraction is required, a QC background surveillance will be performed before a set of measurements are made to verify the applicability of the background to be subtracted. Due to the prevailing variability of the background levels across the site, the nature and extent of such surveillances will be on a case-by-case basis and should be addressed in the documentation associated with the applicable survey plan(s).

In addition to the routine QC counts, each assay report is routinely reviewed with respect to K-40 to provide indications where amplifier drift impacts nuclide identification routines. This review precludes the necessity for specific (i.e. required) after-shift QC surveillances. It also minimizes investigations of previously collected data should the system fail a before-use QC surveillance on the next day of use.

1.2.12 Data Collection

Data collection to support FSS activities will be administered by a specific Survey Plan. Survey Plans may include an index of measurement locations with associated spectrum filenames to ensure that all the required measurements are made and results appropriately managed. Personnel specifically trained to operate the system will perform data collection activities.

Data collection activities will address environmental conditions that may impact soil moisture content. Logs shall be maintained so as to provide a mechanism to annotate such conditions to ensure that efficiency calibration files address the in-situ condition(s). In extreme cases (e.g. standing water, etc.) specific conditions will be addressed to ensure that analysis results reflect the conditions. As previously discussed with respect to water, when unique environmental conditions exist that may impact analysis results, conservative compensatory factors will be applied to the analysis of the data.

1.2.13 Efficiency Calibration

The central feature of the portable ISOCS technology is to support in-situ gamma spectroscopy via the application of mathematically derived efficiency calibrations. Due to the nature of the environment and surfaces being evaluated (assayed), input parameters for the ISOCS efficiency calibrations will be reviewed on a case-by-case basis to ensure the applicability of the resultant efficiency. Material densities applied to efficiency calibrations will be documented. In practice, a single efficiency calibration file may be applied to the majority of the measurements.

The geometry most generally employed will be a circular plane assuming uniformly distributed activity. Efficiency calibrations will address a depth of 15 cm for soil and a depth up to 5 cm for concrete surfaces to account for activity embedded in cracks, etc. Other geometries (e.g. exponential circular plane, rectangular plane, etc.) will be applied if warranted by the physical attributes of the area or surface being evaluated. Efficiency calibrations are developed by radiological engineers who have received training with respect to the ISOCS® software. Efficiency calibrations will be documented in accordance with procedure DP-8869, "In-Situ (ISOCS) Gamma Spectrum Assay System Calibration Procedure."

1.2.14 Data Management

Data management will be implemented in various stages as follows:

- An index or log will be maintained to account for each location where evaluations for elevated activity are performed. Raw spectrum files will be written directly or copied to a central file server.

- Data Analysis – After the spectrum is collected and analyzed, a qualified Radiological Engineer will review the results. The data review process includes application of appropriate background, nuclide libraries, and efficiency calibrations. Data reviews also verify assay results with respect to the applicable investigation levels and the MDCs achieved. Data reviews may include monitoring system performance utilizing K-40. When the data analysis is completed, the analyzed data file will be archived to a unique directory located on a central file server.

- Data Reporting – The results of data files whose reviews have been completed and are deemed to be acceptable may be uploaded to a central database for subsequent reporting and statistical analysis.

- Data Archiving – Routinely (daily) the centralized file server(s) where the raw and analyzed data files are maintained will be backed up to tape.

1.3 Conclusions/Recommendations

The in-situ gamma spectroscopy system is a cost-effective technology well-suited to replace traditional scanning survey techniques to evaluate areas for elevated radioactivity. The static manner in which this system is operated eliminates many variables and limitations inherent to hand-held detectors moving over a surface. This system provides a demonstrably lower detection sensitivity than those offered by hand-held field instruments. This attribute qualifies this system as an alternative technology in lieu of hand-held NaI field instruments in areas where background radiation levels would prohibit the use of such detectors to evaluate for elevated gross activity. The MDC to which this system will be operated satisfies (or exceeds) criteria applied to traditional scan surveys using hand-held field instruments.

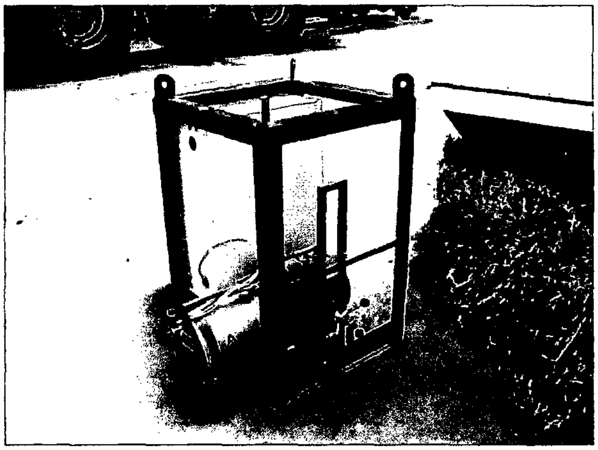
Effective investigation levels for both open land areas (i.e. soils) and for building surfaces can be derived and applied to in-situ gamma spectroscopy results. Where surrogate DCGLs are employed, investigation levels will developed on a case-by-case basis using the approach outlined in this document.

The manner in which investigation levels are derived employs several conservative decisions and assumptions. Additionally, adequate spacing applied to scanning survey locations yields an overlap in surface coverage providing 100-percent coverage of Class 1 areas and redundant opportunities in a significant portion of the survey area to detect localized elevated activity.

1.4 References

1. YNPS License Termination Plan, Revision 1
2. Multi-Agency Radiation Survey And Site Investigation Manual (MARSSIM) Revision 1, 2000
3. Canberra User's Manual Model S573 ISOCS Calibration Software, 2002
4. Decommissioning Health Physics - A Handbook for MARSSIM Users, E.W. Abelquist, 2001
5. Canberra's Genie 2000 V3.0 Operations Manual, 2004
6. In-Situ (ISOCS) Gamma Spectrum Assay System Calibration Procedure DP-8869, Revision 0
7. Operation of the Canberra Portable ISOCS Assay System DP-8871 Revision 0
8. Technical Ref., by Thomas J. Glover.

Attachment 1
Portable ISOCS® Detector System Photos



Attachment 2
Field-Of-View Characterization

Generally, the HPGe detector will be outfitted with a 90-degree collimator situated at 2 meters perpendicular to the surface being evaluated. Note that characterizing the detector's field-of-view could be performed without a source by comparing ISOCS-generated efficiencies for various geometries. If a different collimator configuration is to be employed, a similar field-of-view characterization will be performed.

To qualify the field-of-view for this configuration, a series of measurements were made at various off-sets relative to the center of the reference plane. The source used for these measurements was a 1.2 μCi Co-60 point-source with a physical size of approximately 1 cm^3. Each spectrum was analyzed as a point source both with and without background subtract. It was observed that the detector responded quite well to the point source.

Figure 1 presents the results with background subtraction applied. Note that there is a good correlation with the expected nominal activity and that outside the 2-meter radius of the "working" field-of-view (i.e. at 90 inches) some detector response occurs. This validates that the correct attenuation factors are applied to the algorithms used to compute the efficiency calibration.

FIGURE 1

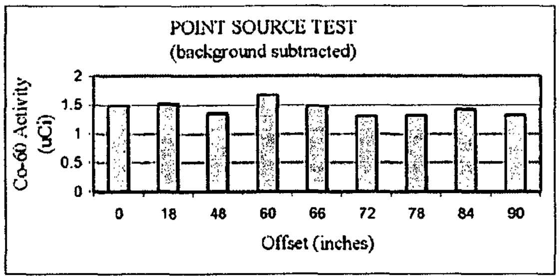
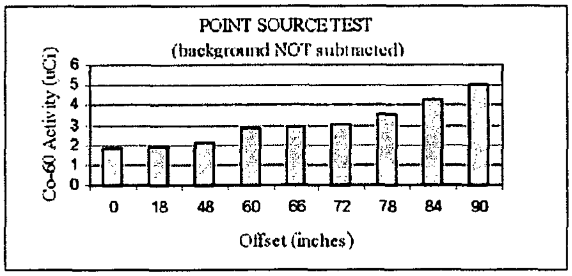
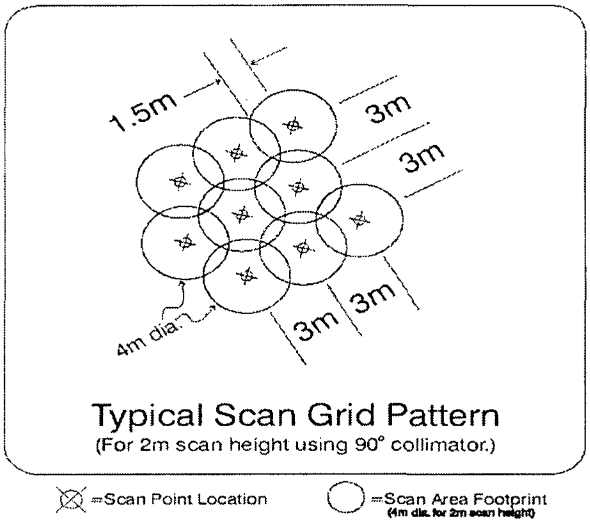


Figure 2 shows the effect of plant-derived materials present in the reference background, which indicates an increasing over-response the further the point source is moved off center. Detector response outside the assumed (i.e. 2-meter) field-of-view would yield conservative results. Normally, source term adjacent to the survey units should be reduced to eliminate background interference.

FIGURE 2


POINT SOURCE TEST
(background NOT subtracted)
Co-60 Activity (uCi)
0
1
2
3
4
5
6
0
18
48
60
66
72
78
84
90
Offset (inches)

Attachment 3
Typical Grid Pattern For In-Situ Gamma Spectroscopy



Typical Scan Grid Pattern
(For 2m scan height using 90° collimator.)