YANKEE NUCLEAR POWER STATION
FINAL STATUS SURVEY REPORT

REPORT NO.: YNPS-FSS-SVC-01-00

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List of Abbreviations and Acronyms

AL	Action Level
ALARA	As Low As Reasonably Achievable
c/d	Counts per Disintegration
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
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
VCC	Vertical Concrete Cask
VSP	Visual Sample Plan
YNPS	Yankee Nuclear Power Station

1.0 EXECUTIVE SUMMARY

A Final Status Survey (FSS) was performed of Survey Area SVC-01 in accordance with Yankee Nuclear Power Station's (YNPS) License Termination Plan (LTP). This FSS was conducted as a structure surface FSS with building occupancy Derived Concentration Guideline Levels (DCGLs) even though the SVC-01 structure will be subsurface at license termination. This practice conservatively implements LTP criteria that subsurface structure surfaces be evaluated for the presence of contamination.

1.1 Identification of Survey Area and Unit

SVC-01 is comprised of the service building foundation that was exposed during excavation campaigns to remove radiologically contaminated soil and PCB-contaminated soil from the "alley way", Survey Unit NOL-01-04. Survey Unit SVC-01-18 serves as the north boundary for Survey Unit NOL-01-04. It is approximately 512 ft2 (48m2) of concrete surface area. SVC-01-18 is a portion of the Service Building foundation that remained after demolition of the service building. It is the sole surviving SVC Survey Unit, the remainder was demolished and disposed of as non-radioactive, PCB waste.

1.2 Dates(s) of Survey

Table 1 Date of Surveys

Survey Unit	Survey Start Date	Survey End Date	DQA Date
SVC-01-18	11/17/2005	12/01/2005	9/06/2006

1.3 Number and Types of Measurements Collected

Final Status Survey Plan (FSSP) was developed for this Survey Unit in accordance with YNPS LTP and FSS procedures using the MARSSIM protocol. The planning and design of the survey plan 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 25 systematic direct measurement measurements were taken in the Survey Unit, providing data for the non-parametric testing of the Survey Area. In addition to the direct measurement samples, hand-held survey instrument scans were performed to provide 100 percent coverage of the Survey Area.

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. Direct measurement surveys indicated that none of the systematic measurements exceeded the $DCGL_W$, depicted in Attachment B. Retrospective power curves were generated and demonstrated that an adequate number of samples were collected to support the Data Quality Objectives. Therefore, the null hypothesis (H_o) (that the Survey Unit exceeds the release criteria) is rejected.

1.5 Conclusions

Based upon the evaluation of the data acquired for the FSS, SVC-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, including that from groundwater. 10CFR20 Subpart E ALARA requirements have been met as well as the site release criteria for the administrative level DCGLs that ensure that the Massachusetts Department of Public Health's 10 mRem/yr limit will also 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 peer review 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 Unit must be identified, and the Survey Unit classified. Survey Unit 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 direct 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 are used to determine 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 allows for 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 direct measurements/samples, 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 the FSS program 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 Description

SVC-01 is comprised of the service building foundation that was exposed during excavation campaigns to remove radiologically contaminated soil and PCB-contaminated soil from the “alley way”, Survey Unit NOL-01-04. Survey Unit SVC-

01-18 serves as the north boundary for Survey Unit NOL-01-04. It is approximately 512 ft2 (48m2) of concrete surface area. It is the sole surviving SVC Survey Unit, the remainder was demolished and disposed of as non-radioactive, PCB waste.

3.2 History of Survey Area

The Service Building is a structure that had been divided into three survey areas: SVC-01, SVC-02, and SVC-03. These survey areas are delineated based upon their construction, the systems present and operational history. SVC-02, SVC-03, and SCV-01-01 through SVC-01-17 were demolished and shipped off site as non-radioactive, PCB waste. A small portion of SCV-01 remained, SVC-01-18. The use of the Service Building spaces in survey area SVC-01 has changed over the life of the plant. The spaces identified as SVC-01 have always been maintained as a clean area.

3.3 Division of Survey Area into Survey Units

SVC-01 has a single Survey Unit, SVC-01-18 which is a Class 1 Survey Unit. SCV-01-01 through SVC-01-17 nomenclature was assigned to Survey Units that were demolished and disposed of as non-radioactive, PCB waste. SCV-01-01 through SVC-01-17 no longer exists on site, and will not be addressed.

4.0 SURVEY UNIT INFORMATION

4.1 Summary of Radiological Data Since Historical Site Assessment (HSA)

4.1.1 Chronology and Description of Surveys Since HSA

The FSS survey of SVC-01-18 was performed between November 30th, 2005 and December 1st, 2005.

4.1.2 Radionuclide Selection and Basis

During the initial DQO process, Co-60 was identified as the radiological nuclide of concern due to its more restrictive DCGL value when compared to Cs-137 (sampling of soil adjacent to the concrete indicated a relationship of approximately 80% Co-60 to 20% Cs-137). Characterization and survey data from the SVC building indicate no other LTP-specified radionuclides warrant consideration in the SVC-01 Survey Unit.

4.1.3 Scoping & Characterization

Prior to commencing demolition activities in SVC-01, a pre-demolition survey was performed in accordance with AP-0831, Administrative Program for Radiological and Non-Radiological Characterization Surveys. The results of this survey identified no radiological contamination present within the bounds of SVC-01. This survey also served as the survey needed for free release of the demolition materials. FSS planning for unit SVC-01-18 used the survey data from adjacent Survey Unit SVC-01-10.

4.2 Basis for Classification

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 SVC-01 is identified as a Class 1 Area.

4.3 Remedial Actions and Further Investigations

No remedial action or investigations were required.

4.4 Unique Features of Survey Area

Survey Area SVC-01 exhibited surface characteristics ranging from smooth surfaces to heavily remediated irregular surfaces. Most of the pits and irregularities increased the source-to-detector distance by approximately ¼ - ½ inch, although some increase it as much as 1 - 2 inches. These types of irregularities in the concrete surfaces were taken into account through the efficiency factor applied to the measurements collected with the HP-100. Technical report YA-REPT-00-015-04 (Appendix B) provides instrument efficiency factors (ε_i) for various source-to-detector distances. The ε_i value for a source-to-detector distance of 1 inch was selected as a representative efficiency for data collected with the HP-100 from the irregular surfaces because it accounts for the ½ inch stand-off and the most common depth of pits and surface irregularities (¼ - ½ inch). In contrast to the irregular surfaces, the vertical walls of the structures are relatively smooth. Table 4.2 of the YA-REPT-00-015-04 (Appendix B) provides instrument efficiency factors (ε_i) for various source-to-detector distances. Detector efficiencies (HP-100C) were applied as follows: smooth surface 0.0603 c/d, irregular surface 0.0373 c/d.

4.5 ALARA Practices and Evaluations

An ALARA evaluation was developed for Survey Unit SVC-01-18 which concluded that additional remediation was not warranted. This evaluation is found in Appendix C.

5.0 SURVEY UNIT FINAL STATUS SURVEY

5.1 Survey Planning

5.1.1 Final Status Survey Plan and Associated DQOs

The FSS for SVC-01 Survey Unit 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. The FSS Plan can be found in Appendix A. 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 below.

Table 2 Survey Area SVC-01 Design Parameters

Survey Unit	Design Parameter	Value	Basis
SVC-01-18	Area	48 m2	Class 1, ≤2,000 m2
	Number of Direct Measurements	15 (calculated) (with direction to take more as space allows) 15+	α (Type I) = 0.05 β (Type II) = 0.05 σ: 727 dpm Relative Shift: 2 LBGR: 3,200 dpm
	Sample Area	3.2m2	Area / Sample #
	Sample Grid Spacing: Triangular	1.91m	Square Root (Area/(0.866*Sample #))
	Scan area	48 m2	Class 1 Area – 100%
	SPA-3 Scan Investigation Level	> Background Audible	Class 1 Area: > DCGLemc

5.1.2 Deviations from the FSS Plan as Written in the LTP

The FSSP design was performed to the criteria of the LTP; therefore, no LTP deviations with potential impact to this Survey Area need to be evaluated. However, during the DQA process, it was noted that the survey was designed to have a spacing of 6 foot 3 inches, but there was a typographical error in the FSSP that directed the survey to be performed at 63 inches, 12 inches smaller. This is more conservative grid spacing, so it does not affect the quality of the outcome, as 10 additional samples were added to the grid due to the smaller spacing. The result was more sample is a smaller gird pattern, which increases the statistical power of the survey.

5.1.3 DCGL Selection and Use

For the final evaluation of the SVC-01 Survey Area and throughout this report, the administrative acceptance criterion of 8.73 mRem/yr for Building Surface LTP-listed DCGL values has been applied. However, given that all of the remaining slab and foundation structure will be at least a three feet subsurface when site grading is complete and will be in such a state at license termination, the LTP, section 5.6.3.1.2, "Exterior Surfaces of Building Foundations," establishes the applicable guidance, as it addresses methods that may be applied to determine if subsurface structure surfaces will be acceptable by meeting LTP-required concrete volumetric DCGLs.

With the established LTP guidance, given that Co-60 and Cs-137 have been found to be the only radionuclides of significance in the area of concern, and conventional hand-held instrument survey criteria techniques being conservatively based on Co-60 beta emissions, performing a Class 1 survey applying Building Surface DCGLs has led to a very conservative approach in determining the final status of the Survey Unit. Additionally, applying this approach to evaluating subsurface conditions leaves no unanswered questions should future subsurface structure occupancy arise.

Table 3 $DCGL_W$

Nuclide	**DCGLw** Bldg Surface
Co-60	6.3E+03 dpm/100 cm^2 equal to 8.73 mRem/y
Cs-137	2.2E+04 dpm/100 cm^2 equal to 8.73 mRem/y

5.1.4 Measurements

Error tolerances and characterization sample population statistics drove the selection of the number of fixed point measurements. 15 measurements were needed in the event the Sign test may have been used. In addition to the 15 statistical measurements needed, 10 additional samples were added to the statistical measurements.

The direct measurement sampling grid was developed as a systematic grid with spacing consisting of a triangular pitch pattern with a random starting point. Sample measurement locations are provided in Attachment A.

5.2 Survey Implementation Activities

Table 3 provides a summary of daily activities performed during the Final Status Survey of Survey Unit in SVC-01.

Table 4 FSS Activity Summary for SVC-01 Survey Area

Survey Unit	Date	Activity
SVC-01-18	11-17-05	Performed walk-down of Survey Unit
	11-17-05	Established Isolation and Controls
	11-17-05	Performed Job Hazard Analysis
	11-22-05	Performed Unit Classification
	11-22-05	Performed Sample Quantity Calculations, established DQOs
	11-23-05	Generated FFS Sample Plans
	11-30-05 to 12-01-05	Initiated Scans, and Direct measurements.
	09-09-06	Performed DQA, FSS Complete

5.3 Surveillance Surveys

5.3.1 Periodic Surveillance Surveys

Upon completion of the FSS of Survey Area SVC-01, the Survey Unit footprint was placed into the program for periodic surveillance surveys on a quarterly basis 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.

5.3.2 Resurveys

No resurveys were performed.

5.3.3 Investigations

No additional investigations were required for this Survey Unit due to surveillance surveys.

5.4 Survey Results

Direct measurement surveys indicated that no Survey Unit's systematic measurements exceeded the $DCGL_W$, depicted in Attachment B. Retrospective power curves were generated and demonstrated that an adequate number of measurements were collected to support the Data Quality Objectives. Therefore, the null hypothesis (H_o) (that the Survey Unit exceeds the release criteria) is rejected.

Table 5 Direct Measurement Summary (DPM/100cm2)

Sample Description	Activity
SVC-01-18-001-F-FM	576
SVC-01-18-002-F-FM	809
SVC-01-18-003-F-FM	991
SVC-01-18-004-F-FM	825
SVC-01-18-005-F-FM	809
SVC-01-18-006-F-FM	892
SVC-01-18-007-F-FM	1254
SVC-01-18-008-F-FM	825
SVC-01-18-009-F-FM	2165
SVC-01-18-010-F-FM	875
SVC-01-18-011-F-FM	1024
SVC-01-18-012-F-FM	1605
SVC-01-18-013-F-FM	958
SVC-01-18-014-F-FM	1190
SVC-01-18-015-F-FM	742
SVC-01-18-016-F-FM	1041
SVC-01-18-017-F-FM	1804
SVC-01-18-018-F-FM	858
SVC-01-18-019-F-FM	958
SVC-01-18-020-F-FM	1041
SVC-01-18-021-F-FM	1200
SVC-01-18-022-F-FM	2460
SVC-01-18-023-F-FM	759
SVC-01-18-024-F-FM	560
SVC-01-18-025-F-FM	643
Max	2460
Average	1075
Standard Deviation	471

5.5 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.

A preliminary data review was performed. The retrospective power curve possessed adequate power to pass the survey with the final standard deviation less than the projected standard deviation. The data set was within three standard deviations and displayed a normal dispersion about the mean. The quantile plot exhibits some asymmetry in the lower quartile due to the number of low values, however the posting plot does not clearly reveal any systematic spatial trends. The data set verifies the assumptions of the statistical test.

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 DP-8852, "*Final Status Survey Quality Assurance Project Plan*".

The Data Quality Assessment power curves, scatter, quantile and frequency plots are found in Attachment B. Posting Plots are found in Attachment A.

6.0 QUALITY ASSURANCE AND QUALITY CONTROL

6.1 Instrument QC Checks

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. All instrumentation involved with the FSS of SVC-01 satisfied the above criteria for the survey. QC records are found in Attachment C.

6.2 Split Samples and Recounts

DP-8864,"*Split Sample Assessment for Final Status Survey*" deals strictly with soil samples and provides no criteria for fixed-point measurements therefore no measurement comparison were made.

6.3 Self-Assessments

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

7.0 CONCLUSION

The FSS of SVC-01 has been performed in accordance with YNPS LTP and applicable FSS procedures. Evaluation of the direct measurement data has shown none of the systematic direct measurements exceeded the $DCGL_W$, depicted in Attachment B. Retrospective power curves were generated and demonstrated that an adequate number of samples were collected to support the Data Quality Objectives. Therefore, the null hypothesis (H_o) is rejected.

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

Based upon the evaluation of the data acquired for the FSS, SVC-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, including that from groundwater. 10CFR20 Subpart E ALARA requirements have been met as well as the site release criteria for the administrative level DCGLs that ensure that the Massachusetts Department of Public Health's 10 mRem/yr limit will also be met.

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