ORISE
OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION

March 18, 2009

Mr. John Hickman
Mail Stop: T-8F5
Office of Federal and State Materials
and Environmental Management Programs
U.S. Nuclear Regulatory Commission
11545 Rockville Pike
Rockville, MD 20852

SUBJECT: DRAFT—CONFIRMATORY SURVEY REPORT FOR ACTIVITIES PERFORMED IN SEPTEMBER AND OCTOBER 2008 RANCHO SECO NUCLEAR GENERATING STATION HERALD, CALIFORNIA DCN 1695-SR-04-DRAFT (DOCKET NO. 50-312, RFTA NO. 06-003)

Dear Mr. Hickman:

The Oak Ridge Institute for Science and Education (ORISE) performed confirmatory survey activities on structural surfaces in the Auxiliary Building (Rooms 132 and 319), the Auxiliary Steam Supports, The Turbine Building (North Condensate Area, Condensate Pump Pit, Lube Oil Pit, North Central Floor, and Grade Level South), and the Fuel Storage Building [+40 Level and the Spent Fuel Pool (Floor, East Wall, West Wall, North Wall and South Wall)] at the Rancho Seco Nuclear Generating Station in Herald, California on September 9 through 11 and October 27 through 30, 2008. These survey activities were requested and approved by the U.S. Nuclear Regulatory Commission (NRC). Enclosed is the draft report that summarizes ORISE's survey procedures and results of the confirmatory surveys. The surveys included beta and gamma surface scans, direct measurements for total net beta activity, and smears for removable alpha and beta activity.

If you have any questions, please direct them to me at 865.576.0065 or Tim Vitkus at 865.576.5073.

Sincerely,

Wade C. Adams

Wade C. Adams
ORISE Health Physicist/Project Leader
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WCA:ar

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CONFIRMATORY SURVEY REPORT
FOR ACTIVITIES PERFORMED IN SEPTEMBER AND OCTOBER 2008
RANCHO SECO NUCLEAR GENERATING STATION
HERALD, CALIFORNIA

Prepared by

W. C. Adams

ORISE

Prepared for the

U.S. Nuclear Regulatory Commission

DRAFT REPORT

March 2009

This report is based on work performed by the Oak Ridge Institute for Science and Education under contract number DE-AC05-06OR23100 with the Department of Energy.

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ABBREVIATIONS AND ACRONYMS

b_i	number of background counts in the interval
d′	index of sensitivity
ε_i	instrument efficiency
ε_s	surface efficiency
ε_{total}	total efficiency
BKG	background
cm	centimeter
cm^2	square centimeter
Co-60	cobalt-60
COC	contaminants of concern
cpm	counts per minute
Cs-137	cesium-137
CsI(T1)	cesium iodide (thallium-activated)
DCGL	derived concentration guideline level
$DCGL_{EMC}$	DCGL elevated measurement comparison
DP	decommissioning plan
dpm/100 cm^2	disintegrations per minute per 100 square centimeters
DQOs	data quality objectives
DTBD	decommissioning technical basis document
FSS	final status survey
FSSP	final status survey plan
FSSR	final status survey report
GM	Geiger-Mueller
IEAV	Independent Environmental Assessment and Verification
ISFSI	independent spent fuel storage installation
ISM	Integrated Safety Management
ITP	Intercomparison Testing Program
JHA	job hazard analysis
keV	kiloelectron volts
LTP	license termination plan
mg	milligram
MAPEP	Mixed Analyte Performance Evaluation Program
MARSSIM	Multi-Agency Radiation Survey and Site Assessment Manual
MDC	minimum detectable concentration
MDCR	minimum detectable count rate
MeV	million electron volts
mrem/yr	millirem per year
msl	mean sea level
MWe	megawatt electric
NaI(T1)	sodium iodide (thallium-activated)
NIST	National Institute of Standards and Technology
NRC	U.S. Nuclear Regulatory Commission
NRIP	NIST Radiochemistry Intercomparison Program
ORAU	Oak Ridge Associated Universities

ABBREVIATIONS AND ACRONYMS (continued)

ORISE	Oak Ridge Institute for Science and Education
pCi/g	picocuries per gram
PSDAR	Post Shutdown Decommissioning Activities Report
PWR	pressurized water reactor
RSNGS	Rancho Seco Nuclear Generating Station
sec	second
SMUD	Sacramento Municipal Utility District
SU	survey unit
Sr/Y-90	strontium/yttrium-90
SRC	site release criteria
Tc-99	technetium-99
TEDE	total effective dose equivalent
T1-204	thallium-204

DRAFT
CONFIRMATORY SURVEY REPORT
FOR ACTIVITIES PERFORMED IN SEPTEMBER AND OCTOBER 2008
RANCHO SECO NUCLEAR GENERATING STATION
HERALD, CALIFORNIA

INTRODUCTION AND SITE HISTORY

The Sacramento Municipal Utility District (SMUD) operated the Rancho Seco Nuclear Generating Station (RSNGS) from 1976 to 1989 under Atomic Energy Commission Docket Number 50-312 and License Number DPR-54. RSNGS was a 913-megawatt electrical (MWe) pressurized water reactor (PWR) designed by Bechtel Power Corporation. The plant incorporated a pressurized water type nuclear steam supply system supplied by Babcock and Wilcox Company, a turbine generator and electrical systems, engineered safety features, radioactive waste systems, fuel handling systems, instrumentation and control systems, the necessary auxiliaries, and structures to house plant systems and other onsite facilities.

On June 7, 1989, RSNGS permanently shut down, due to a public vote the previous day, after approximately 14 years of operation. On August 29, 1989, SMUD formally notified the U.S. Nuclear Regulatory Commission (NRC) of the permanent cessation of operations at the RSNGS. In May 1991, SMUD submitted the Rancho Seco Decommissioning Plan (DP), which was approved by the NRC in March 1995. SMUD submitted the Post Shutdown Decommissioning Activities Report (PSDAR), in accordance with 10CFR50.82 (a) (4), in March 1997. SMUD began decommissioning activities in February 1997 and completed transfer of all the spent nuclear fuel in August 2002. SMUD is currently completing decontamination efforts and performing final status surveys (FSS) in the remaining structural surfaces and open land areas.

In April 2006, SMUD submitted a license termination plan (LTP) that the NRC approved on November 26, 2007 (SMUD 2006a and NRC 2007). SMUD is currently conducting decontamination efforts and performing FSS on the remaining structural surfaces and in open land areas. The major contaminants of concern (COC) identified by SMUD at RSNGS are beta-gamma emitters—fission and activation products—resulting from reactor operation. Cesium-137 (Cs-137) and cobalt-60 (Co-60) have been identified during characterization as the predominant radionuclides present on structural surfaces.

The NRC's Headquarters and Region IV Offices have requested that the Independent Environmental Assessment and Verification (IEAV) Program of the Oak Ridge Institute for Science and Education (ORISE) perform confirmatory surveys of structural surface survey units (SU) in several Auxiliary, Turbine and Fuel Storage Building rooms, the Pump Alley, and the Fuel Storage Building exterior excavation at the RSNGS (Figures A-1 and A-2). The confirmatory surveys were performed during the period of September 9 through 11 and October 27 through 30, 2008.

SITE DESCRIPTION

The RSNGS is located in the southeast part of Sacramento County, California and is approximately 26 miles northeast of Stockton and 25 miles southeast of Sacramento. The site lies between the Sierra Nevadas to the east and the Pacific Coast Range bordering the Pacific Ocean to the west in an area of flat to slightly rolling terrain at an elevation of approximately 200 feet above mean sea level.

The land surrounding the site is used almost entirely for agricultural purposes, as grazing land, and for grape production. The owner-controlled site is approximately 2,500 acres with all acreage being owned by SMUD. An 87-acre fence-enclosed Industrial Area (Figure A-2) containing the nuclear facility is within the owner-controlled area. Approximately 0.5 miles south of the Industrial Area boundary is a 30-acre gas-fired power plant. The site also contains the 560-acre Rancho Seco Reservoir and Recreation Area, a 50-acre solar power electrical generating station, and a 10-acre independent spent fuel storage installation (ISFSI).

The RSNGS design included several structures that were engineered and constructed to contain radioactive material. These structures were located within the Industrial Area boundaries and included the Auxiliary Building, the Containment/Reactor Building, the Spent Fuel Building, the Fuel Storage Building, the Turbine Building, the Cooling Towers and structures containing tanks for storage of radioactive liquids. The site also included ancillary facilities that were used to support normal plant operations. These facilities consisted of warehouses, water and sewage treatment plants, and administrative office buildings.

OBJECTIVE

The objective of the confirmatory survey was to generate independent radiological data for use by the NRC in evaluating the adequacy and accuracy of the licensee's FSS results.

DOCUMENT REVIEW

ORISE reviewed the licensee's preliminary final radiological survey data for adequacy and appropriateness, taking into account data quality objectives (DQOs) contained in the LTP (SMUD 2006a). ORISE also reviewed and evaluated final status survey plans (FSSP) and final status survey reports (FSSR) in accordance with the ORISE site-specific survey plan to ensure that FSS procedures and results adequately met site LTP commitments and *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) considerations (ORISE 2007a, SMUD 2006a and NRC 2000).

CONFIRMATORY SURVEY PROCEDURES

To expedite the confirmatory survey process, ORISE coordinated and worked with the NRC site representative to conduct confirmatory surveys as the licensee provided preliminary FSS survey data. This provided the NRC the quality assurance metric that the site's reported radiological status satisfied the site license termination criteria. ORISE survey activities were performed in a manner that addressed the confirmatory objective listed above. ORISE performed confirmatory survey activities in judgmentally selected survey units on the RSNGS site. These confirmatory survey activities assessed whether remediation activities met the DQO's for unrestricted release.

In September and October 2008, ORISE conducted radiological confirmatory survey activities of the RSNGS structural surfaces within the Auxiliary, Turbine and Fuel Storage buildings. Confirmatory surveys included beta and gamma surface scans and surface activity measurements, and collecting radiological soil samples. Locations of elevated direct radiation that potentially exceeded the derived concentration guideline levels (DCGLs) were marked for further investigation.

Confirmatory surveys were performed in accordance with a site-specific survey plan that was submitted to and approved by the NRC (ORISE 2007a). The site-specific survey plan followed the guidance provided in the IEAV Survey Procedures Manual and the Oak Ridge Associated Universities Quality Program Manual (ORISE 2008a and ORAU 2007).

ORISE performed confirmatory survey activities on structural surfaces within the following buildings and exterior areas:

TABLE 1: ORISE CONFIRMATORY SURVEY AREAS		
Building/Area	**Surveyed Areas**	**Figures**
Auxiliary Building	Rooms 51, 132, 208, 211, 319, 320, and the Auxiliary Steam Supports	A-3 through A-7
Turbine Building	Condensate Pits, the Lube Oil Pit, the Main Feed Pump Area, on the High Pressure Turbine Pedestals and at various locations on the grade level floor	A-8 through A-13
Fuel Storage Building	Spent Fuel Pool floor and walls, the +40 foot level floor and lower walls and the West Exterior Wall	A-14 through A-19
Other Exterior Areas	Pump Alley Access Corridor and the Industrial Area Railway Class 1 Areas	A-20 through A-21

REFERENCE SYSTEM

Measurements and sampling locations were referenced to the existing RSNGS grid system and/or on RSNGS provided figures.

SURFACE SCANS

Surface scans for beta and gamma radiation were performed on structural surfaces that could be safely accessed. Scan coverage percentage was based upon the SU classification and increased or decreased depending on findings as the survey progressed and project time constraints. Scans for gamma and beta radiation were performed using sodium iodide, thallium-activated [NaI(Tl)] scintillation, gas proportional, and/or Geiger-Mueller (GM) detectors. Particular attention was given to cracks and joints in the surfaces, exposed concrete surfaces, and other locations where material may have accumulated. Locations of elevated direct radiation, suggesting the presence of residual contamination, were marked and identified for judgmental measurements. All detectors were coupled to ratemeters or ratemeter-scalers with audible indicators.

SURFACE ACTIVITY MEASUREMENTS

Direct measurements for total beta activity were performed at judgmentally-selected locations where residual contamination, identified by surface scans, exhibited radiation levels potentially above acceptable unrestricted release limits established for the site. The number of judgmental direct measurements performed depended on findings as the survey progressed and project time constraints.

Based on beta and gamma surface scan results, direct measurements for beta activity were performed at 66 judgmentally-selected locations on the evaluated structural surfaces within the Auxiliary, Turbine, and Fuel Storage buildings. In addition, four direct measurements were performed in the Pump Alley Access Corridor and three direct measurements were performed in the Industrial Area Railway. Direct measurements were performed using hand-held gas proportional and GM detectors coupled to ratemeters-scalers. With the exception of the Industrial Area Railway, dry smears, for determining removable gross alpha and beta activity, were collected from each direct measurement location. Direct measurement and smear locations are indicated on Figures A-3 through A-21.

SAMPLE ANALYSIS AND DATA INTERPRETATION

Samples and data were returned to the ORISE laboratory in Oak Ridge, Tennessee for analysis and interpretation. Samples were analyzed in accordance with the ORISE Laboratory Procedures Manual (ORISE 2008b). Smears were analyzed for gross alpha and gross beta activity using a low-background proportional counter. Smear results and direct measurements for total surface activity were converted to units of disintegrations per minute per 100 square centimeters (dpm/100 cm^2). The data generated were compared with the licensee's gross beta and design DCGLs for each specific SU where confirmatory surveys were performed (Table B-1).

The primary COCs for the RSNGS are beta-gamma emitters—fission and activation products—resulting from reactor operation. Cesium-137 and Co-60 were identified by SMUD during characterization as the predominant radionuclides present on structural surfaces and in the soils. SMUD developed site-specific DCGLs, which were approved by the NRC, based on dose modeling to future occupants not to exceed 25 millirem per year (mrem/yr) total effective dose equivalent (TEDE) as presented in Section 6 of the LTP (SMUD 2006a and NRC 2007). The structural surface DCGL's were modified by SMUD to reflect the ratio of radionuclide concentrations (account for the presence of unmeasured contaminants based on contaminant ratios) in the specific SUs that were being evaluated. The DCGL's for the evaluated structural surfaces (refer to Table B-1) for these confirmatory surveys were provided in the preliminary FSS data packages for each evaluated SU and were derived from the LTP and decommissioning technical basis document (DTBD)-05-015 (SMUD 2006a and b).

Additional information regarding instrumentation and procedures may be found in Appendices C and D.

FINDINGS AND RESULTS

The results for the confirmatory surveys are provided below.

DOCUMENT REVIEW

ORISE's review of SMUD's preliminary FSS data packages indicated that the procedures and methods implemented for the FSS were appropriate and that the resultant data were acceptable.

SURFACE SCANS

Beta and gamma surface scans, in the Auxiliary, Turbine and Fuel Storage buildings, determined that localized areas of residual elevated beta and gamma radiation were present on floors, lower walls, and upper surfaces within the evaluated SUs.

Gamma scans of the Pump Alley Access Corridor and Industrial Area Railway did not detect any residual elevated gamma radiation levels. Beta scans of the Pump Alley Access Corridor also did not indicate any locations of elevated residual beta radiation.

The survey unit classifications and scan percent coverage are provided in Table B-2.

SURFACE ACTIVITY LEVELS

Total beta activity measurements ranged from -170 to 1,300,000 dpm/100 cm^2. Residual surface activity levels approaching and exceeding the site-specific gross beta DCGL but less than the SU specific design DCGL elevated measurement comparison ($DCGL_{EMC}$) were limited to small areas that were interspersed throughout the SUs.

Removable gross alpha and gross beta activity ranged from 0 to 6 and -5 to 190 dpm/100 cm^2, respectively.

Beta measurements were performed at seven locations within the Pump Alley Access Corridor and the Industrial Area Railway SUs. Total beta activity measurements ranged from -40 to 690 dpm/100 cm^2. Removable gross alpha activity for the concrete surfaces of the Pump Alley Access Corridor was 0 dpm/100 cm^2; beta activity in the same area ranged from -2 to 1 dpm/100 cm^2. Removable activity measurements were not performed in the Industrial Area Railway. Surface activity and removable activity level results are presented in Table B-3.

COMPARISON OF RESULTS WITH SITE RELEASE CRITERIA

With the exception of the Pump Alley Access Corridor and the Industrial Area Railway which had land area DCGL's, confirmatory survey data for structural surfaces were compared with the structural site-specific DCGL for the evaluated SUs. Fourteen of the 66 direct beta activity measurement results on the survey units that had structural surface DCGLs exceeded the Gross Beta DCGL of 43,000 dpm/100 cm^2. Using the gross activity DCGL as determined in DTBD-05-015 (SMUD 2006b) and the area factor determined for each SU, SMUD calculated Design $DCGL_{EMC}$ values which are also provided in Table B-1. The fourteen confirmatory survey results that exceeded the structural surface DCGLs were less than 1 m^2. All confirmatory direct surface activity measurements on the structural surfaces in the evaluated SUs were within the site-specific SU $DCGL_{EMC}$ as provided by SMUD in the preliminary FSS data packages. Also, the maximum gross beta activity measurement of the seven direct measurements performed on the Pump Alley Access Corridor and the Industrial Area Railway was 690 dpm/100 cm^2; and direct measurements in these SUs were well below the structural surface DCGL of 43,000 dpm/100 cm^2.

CONCLUSION

During the period of September 9 through 11 and October 27 through 30, 2008, ORISE performed confirmatory radiological survey activities which included beta and gamma surface scans, beta activity direct measurements, and removable gross alpha and gross beta activity measurements on structural surfaces within the Auxiliary, Turbine and Fuel Storage buildings.

Beta and gamma surface scans identified several areas of elevated beta radiation on the structural surfaces of the evaluated SUs. Additional investigations of these locations indicated that the majority of the elevated radiation levels were attributable to localized areas of residual beta-gamma radiation within the matrix of the concrete media. In general, the elevated surface activity was limited to small areas (less than 1 m^2) that were interspersed throughout the rooms. Direct measurements were performed at 66 locations. Fourteen direct measurements exceeded the site-specific gross beta DCGL but all were within the SU specific design $DCGL_{EMC}$ criteria. Direct measurements were also performed at seven locations on the Pump Alley Access Corridor concrete pad and the Industrial Area Railway asphalt pad surfaces. The maximum gross beta activity measurement on these pads was 690 dpm/100 cm^2 which is well below the structural surface DCGL of 43,000 dpm/100 cm^2.

The confirmatory survey results for the evaluated SUs are in agreement with the radiological status of these SUs as presented in the licensee's preliminary FSS data packages.

REFERENCES

Oak Ridge Associated Universities (ORAU). Quality Program Manual for the Independent Environmental Assessment and Verification Program. Oak Ridge, Tennessee; November 1, 2007.

Oak Ridge Institute for Science and Education (ORISE). Final Confirmatory Survey Plan for the Remaining Structural Surfaces, Embedded Piping, Standing Water and Open Land Area Survey Units, Rancho Seco Nuclear Generating Station, Herald California [Docket No. 50-312; RFTA No. 06-003]. Oak Ridge, Tennessee; August 10, 2007a.

Oak Ridge Institute for Science and Education. Survey Procedures Manual for the Independent Environmental Assessment and Verification Program. Oak Ridge, Tennessee; May 1, 2008a.

Oak Ridge Institute for Science and Education. Laboratory Procedures Manual for the Independent Environmental Assessment and Verification Program. Oak Ridge, Tennessee; December 5, 2008b.

Sacramento Municipal Utility District (SMUD). License Termination Plan, Rancho Seco Nuclear Generating Station, Herald, California; April 2006a.

Sacramento Municipal Utility District. Decommissioning Technical Basis Document: Structure Nuclide Fraction and DCGLs. DTBD-05-015, Revision 0. Rancho Seco Nuclear Generating Station, Herald, California; June 2, 2006b.

U.S. Nuclear Regulatory Commission (NRC). *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM), NUREG-1575; Revision 1. Washington, DC; August 2000.

U.S. Nuclear Regulatory Commission. Letter from J. Hickman (NRC-HQ) to S. Redeker (SMUD); SUBJECT: Rancho Seco Nuclear Generating Station – Issuance of Amendment RE: License Termination Plan (TAC No. J52668). Washington, DC; November 27, 2007.

APPENDIX A

FIGURES

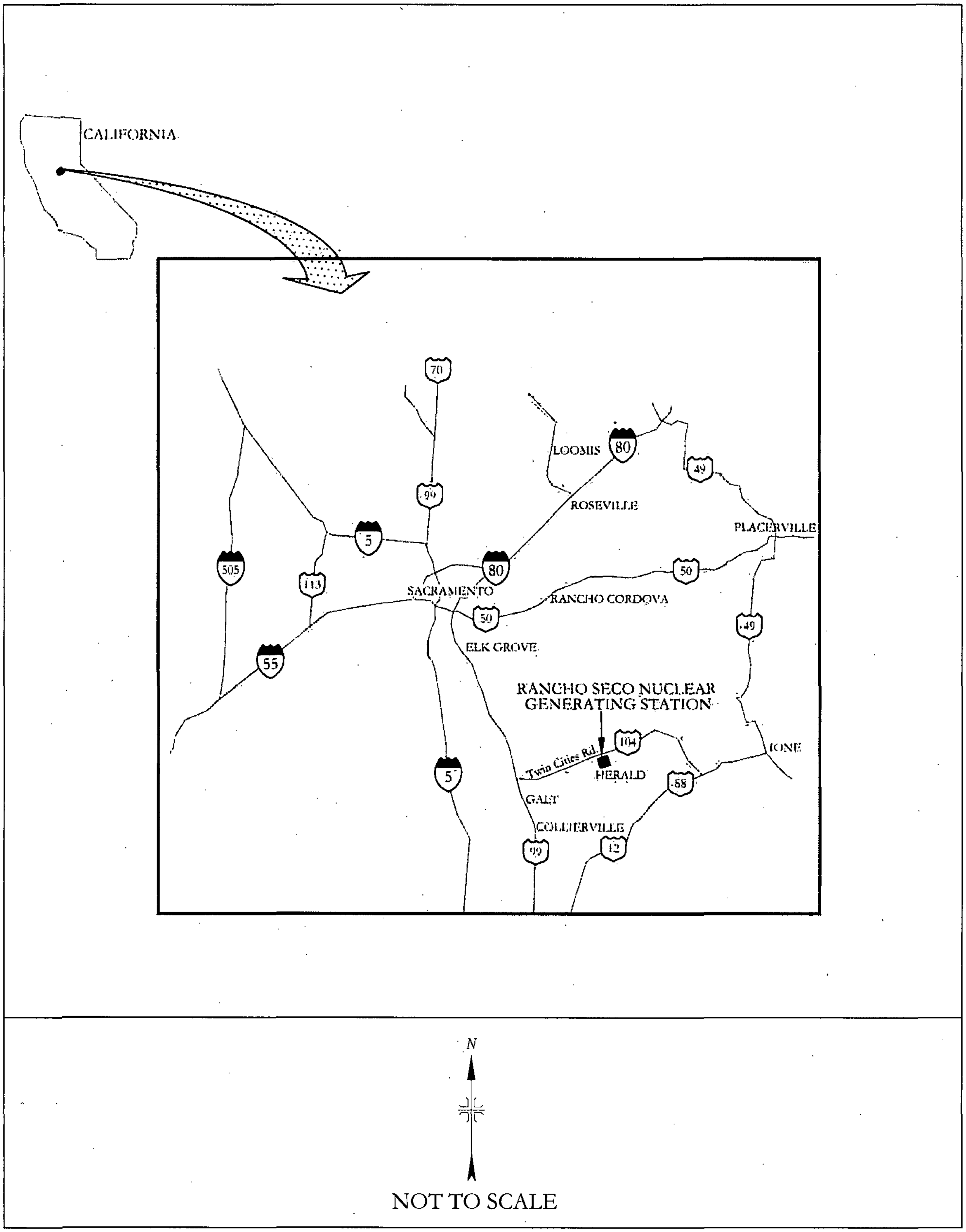

Figure A-1: Location of Rancho Seco Nuclear Generating Station, Herald, California

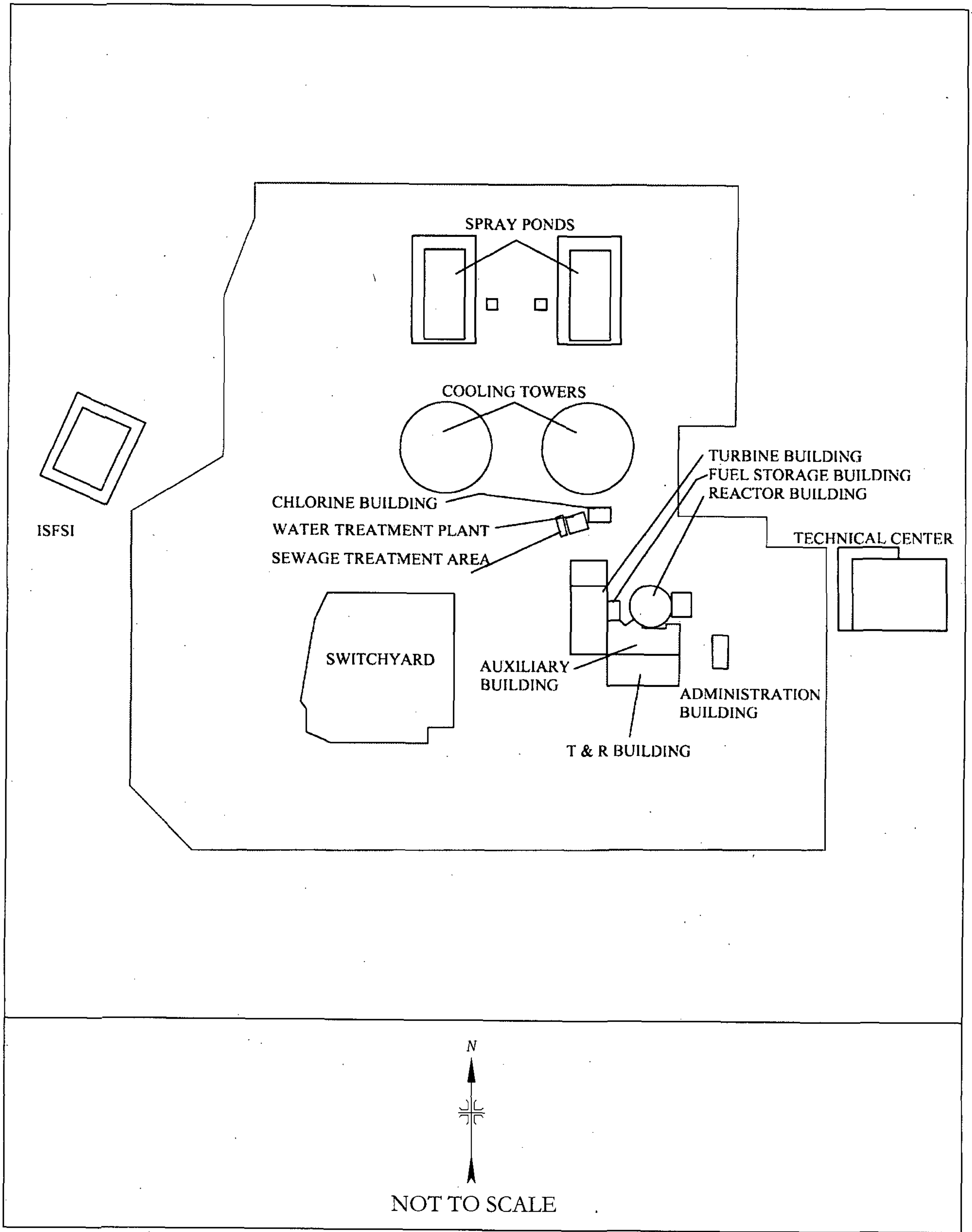

Figure A-2: Plot Plan of the Industrial Area at Rancho Seco Nuclear Generating Station

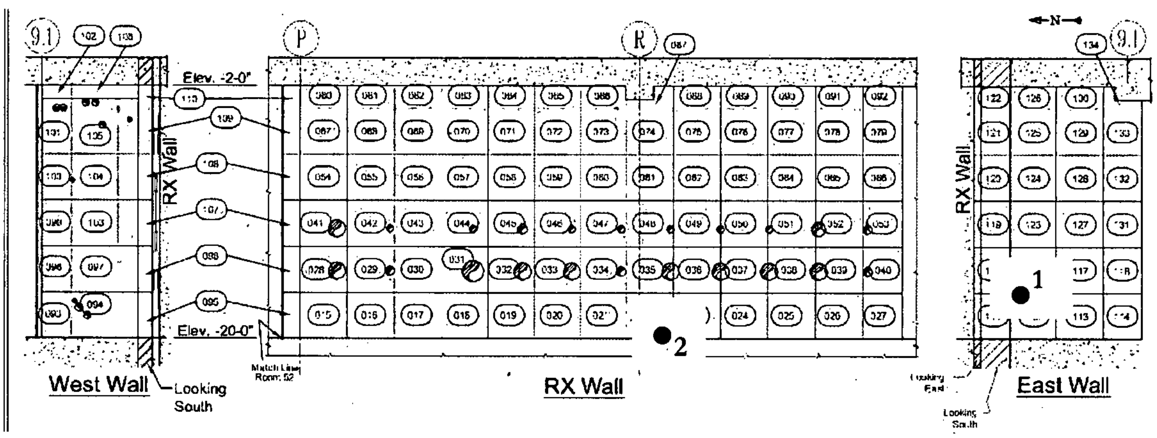

Figure provided by SMUD.

MEASUREMENT/SAMPLE LOCATION ●# SINGLE POINT – LOWER WALLS	N NOT TO SCALE

Figure A-3: Survey Unit F8130731, Auxiliary Building, Room 51, Section 3 Wall – Direct Measurement and Sampling Locations

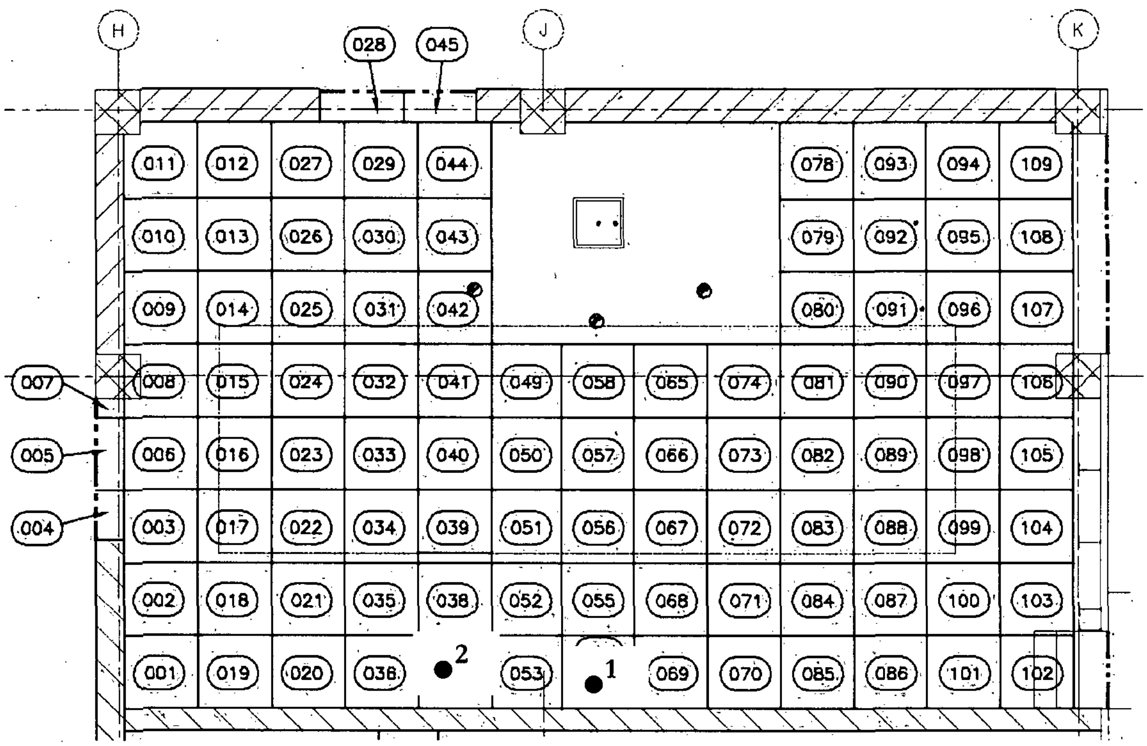

Figure provided by SMUD.

MEASUREMENT/SAMPLE LOCATION

●# SINGLE POINT –
FLOOR AND LOWER WALLS

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NOT TO SCALE

Figure A-4: Survey Unit F8131211, Auxiliary Building, Room 132 – Direct Measurement and Sampling Locations

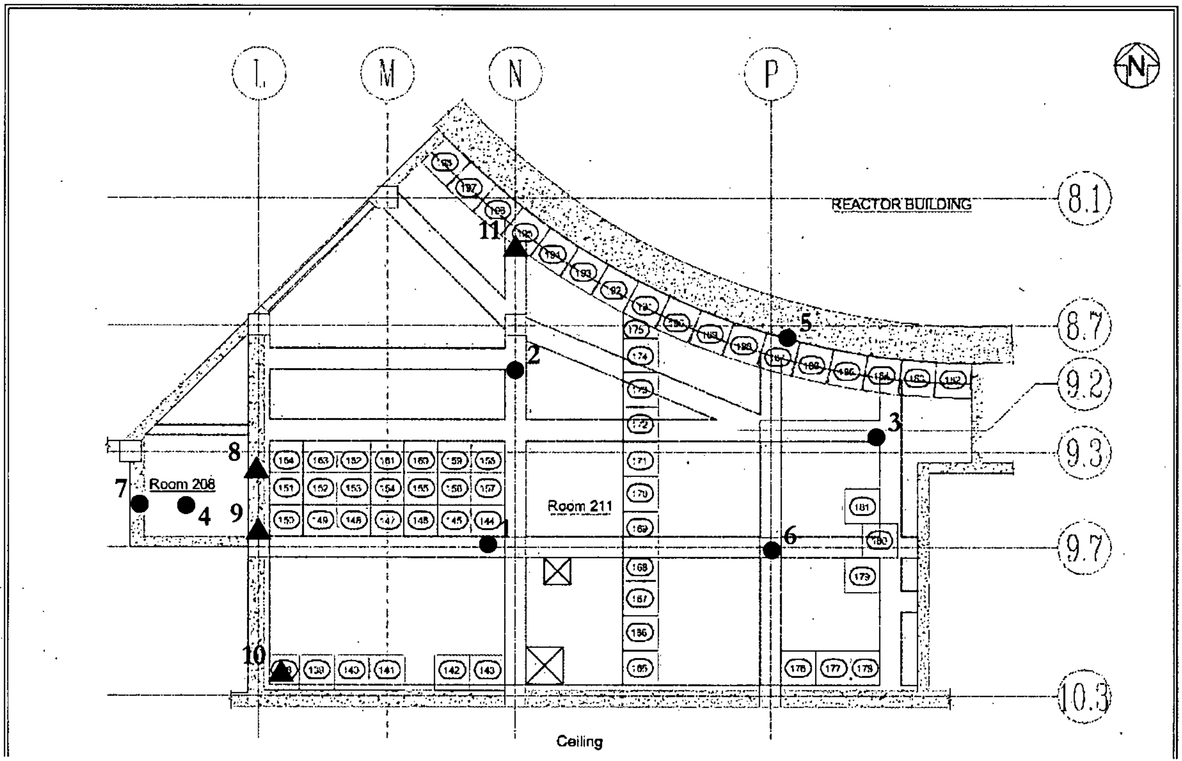

Figure provided by SMUD.

MEASUREMENT/SAMPLE LOCATION	
●# SINGLE POINT – FLOOR AND LOWER WALLS ▲# SINGLE POINT – UPPER SURFACES	N NOT TO SCALE

Figure A-5: Survey Unit F8131372, Auxiliary Building, Rooms 208 and 211 – Direct Measurement and Sample Locations

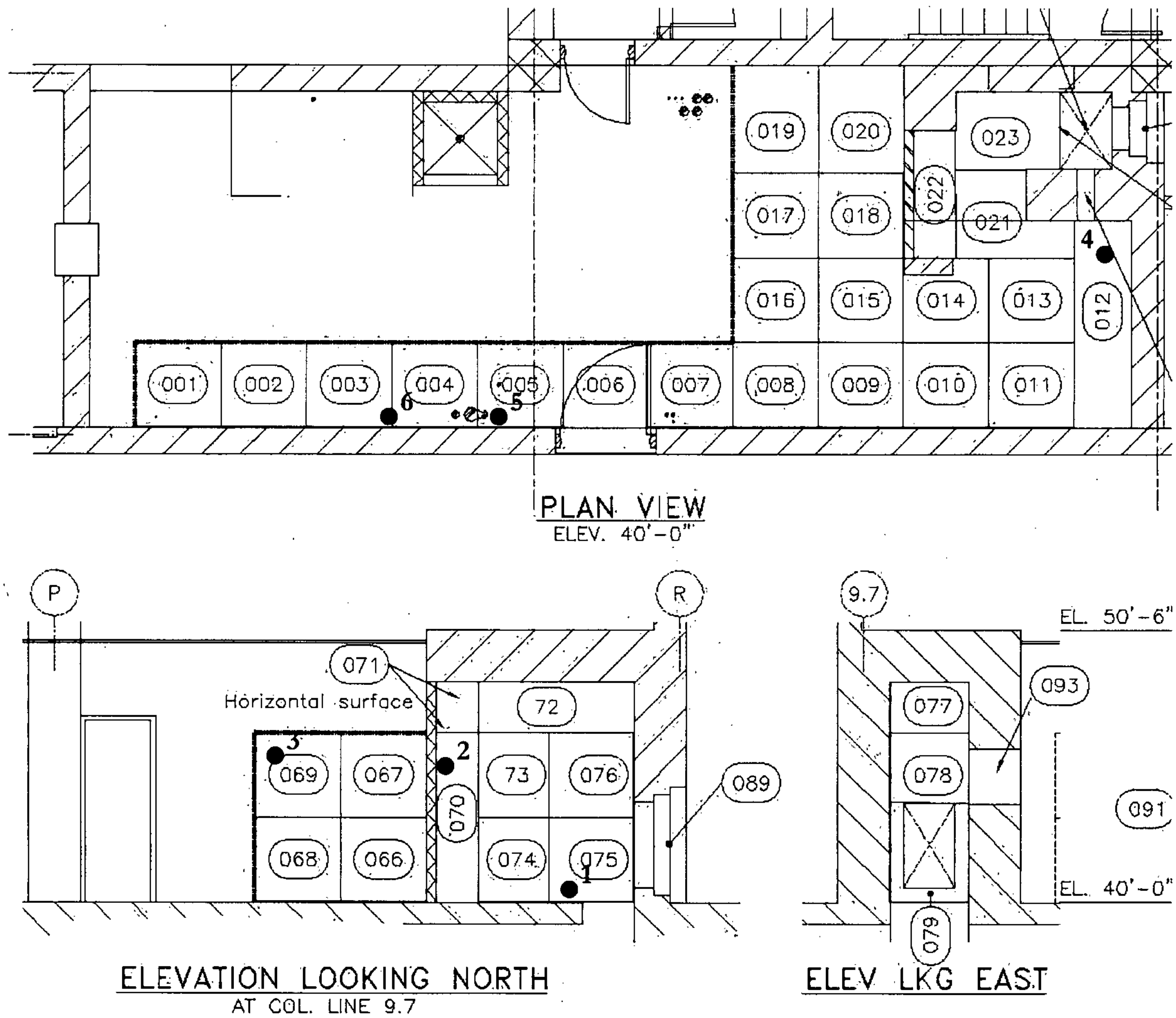

Figure provided by SMUD.

MEASUREMENT/SAMPLE LOCATION	
●# SINGLE POINT – FLOOR AND LOWER WALLS	N NOT TO SCALE

Figure A-6: Survey Unit F8131781, Auxiliary Building, Room 319 – Direct Measurement and Sample Locations

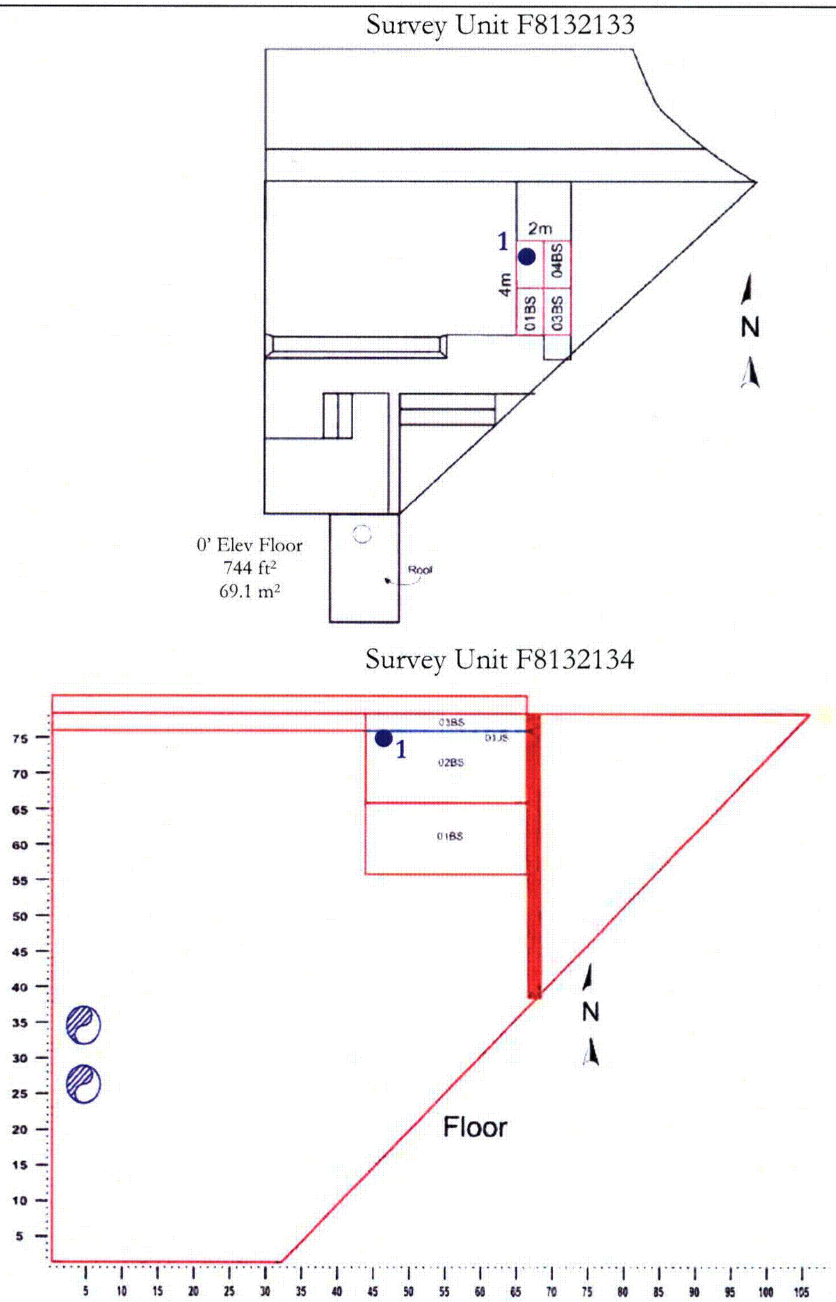

Figure provided by SMUD.

MEASUREMENT/SAMPLE LOCATION

● # SINGLE POINT – FLOOR

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Figure A-7: Survey Unit F8132133 and F8132134, Auxiliary Steam Support Pads – Direct Measurement and Sample Locations

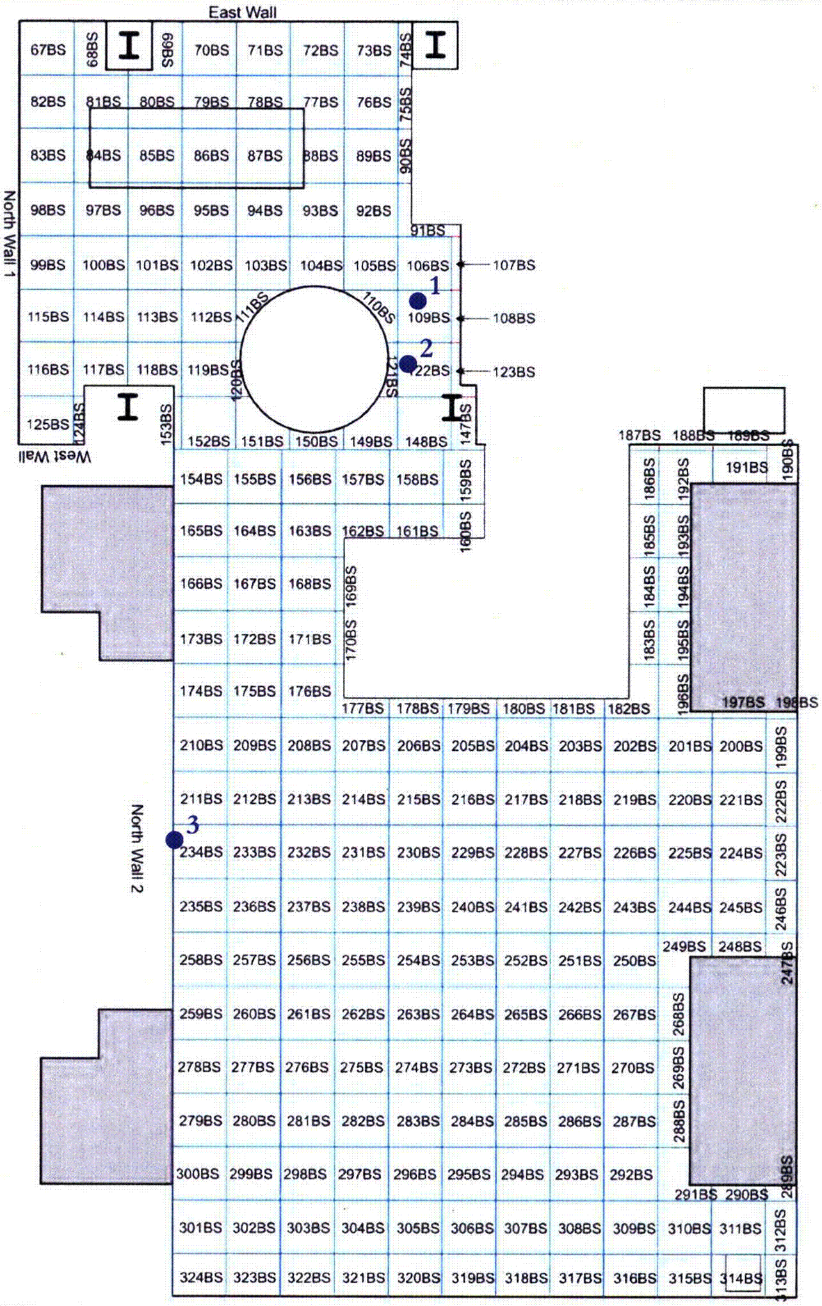

Figure provided by SMUD.

MEASUREMENT/SAMPLE LOCATION

● # SINGLE POINT – FLOOR AND LOWER WALLS

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Figure A-8: Survey Unit F8260010, Turbine Building, North Condensate Pit Area – Direct Measurement and Sample Locations

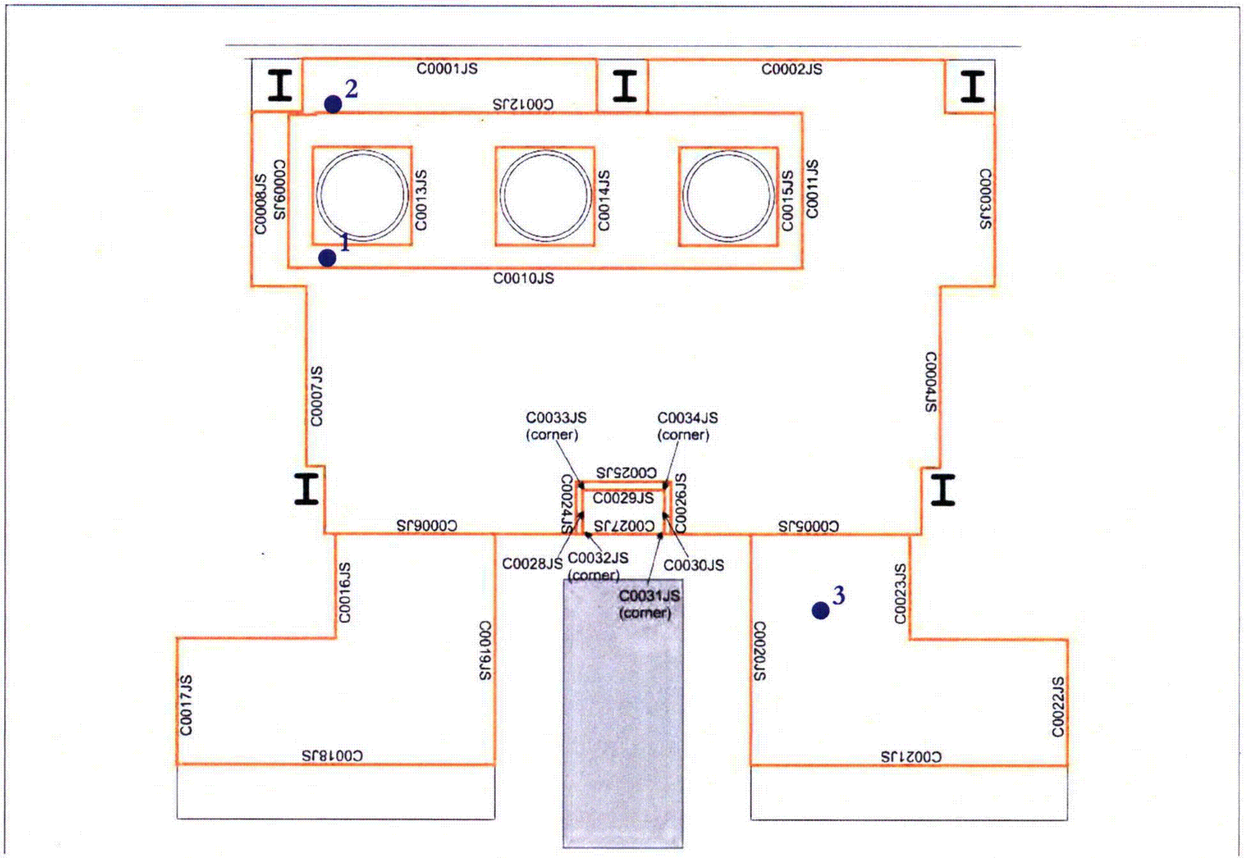

Figure provided by SMUD.

MEASUREMENT/SAMPLE LOCATION	
● # SINGLE POINT – FLOOR AND LOWER WALLS	N ◄ NOT TO SCALE

Figure A-9: Survey Unit F8260004, Turbine Building, Condensate Pump Pit – Direct Measurement and Sample Locations

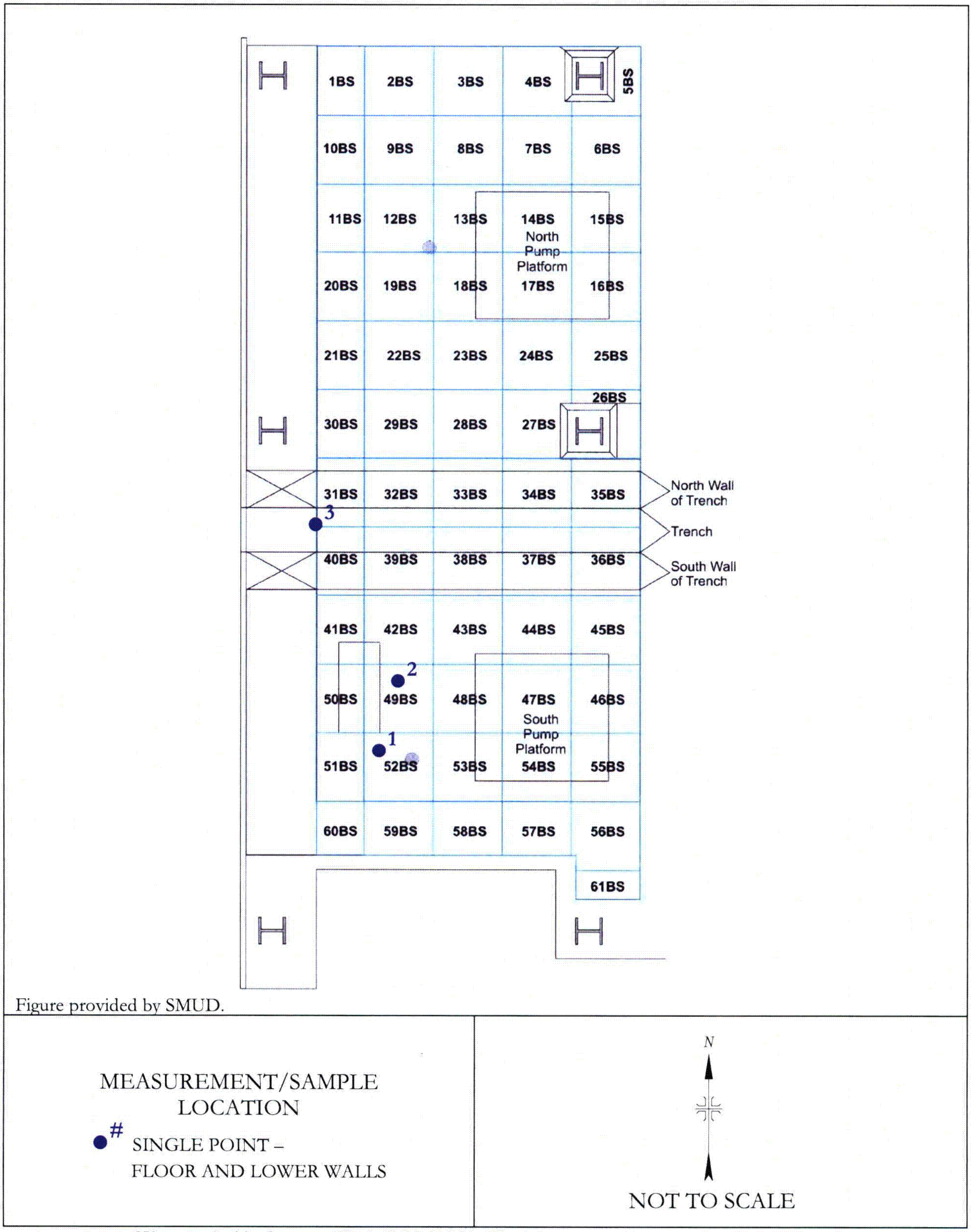

Figure A-10: Survey Unit F8260011, Turbine Building, Lube Oil Pit – Direct Measurement and Sample Locations

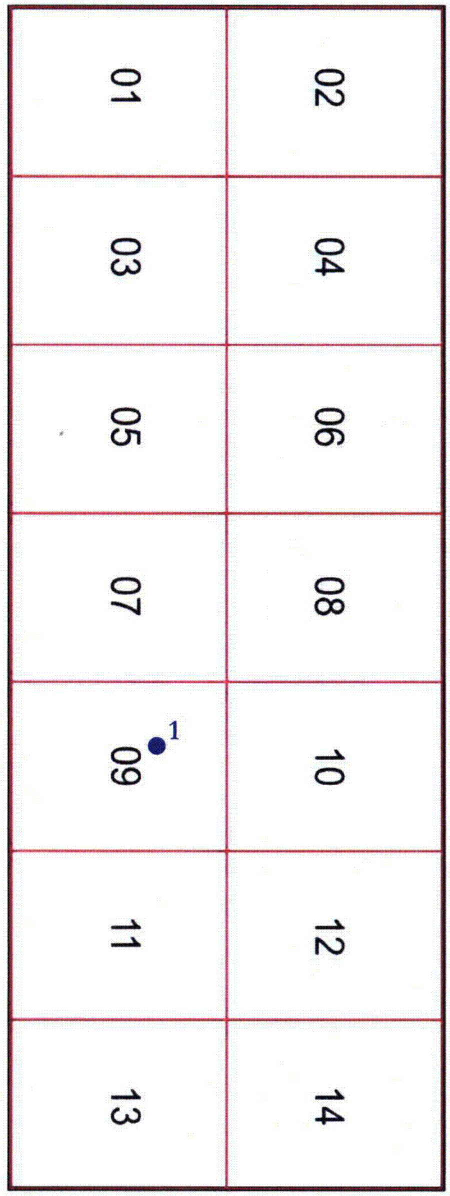

Figure provided by SMUD.

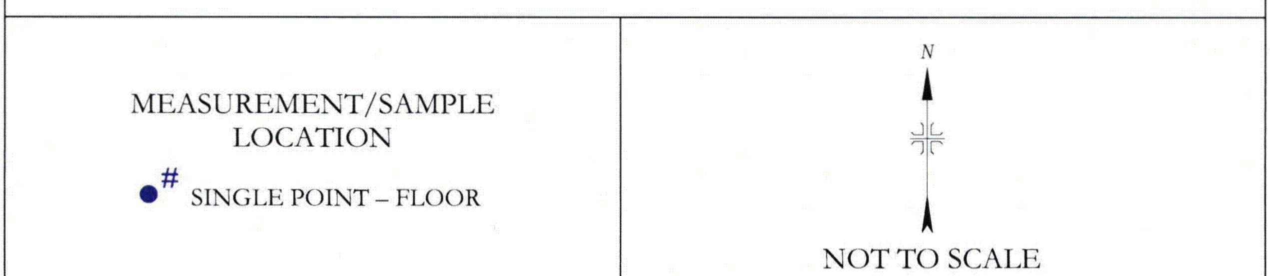

Figure A-11: Survey Unit F8260171, Turbine Building, North Central Floor – Direct Measurement and Sample Locations

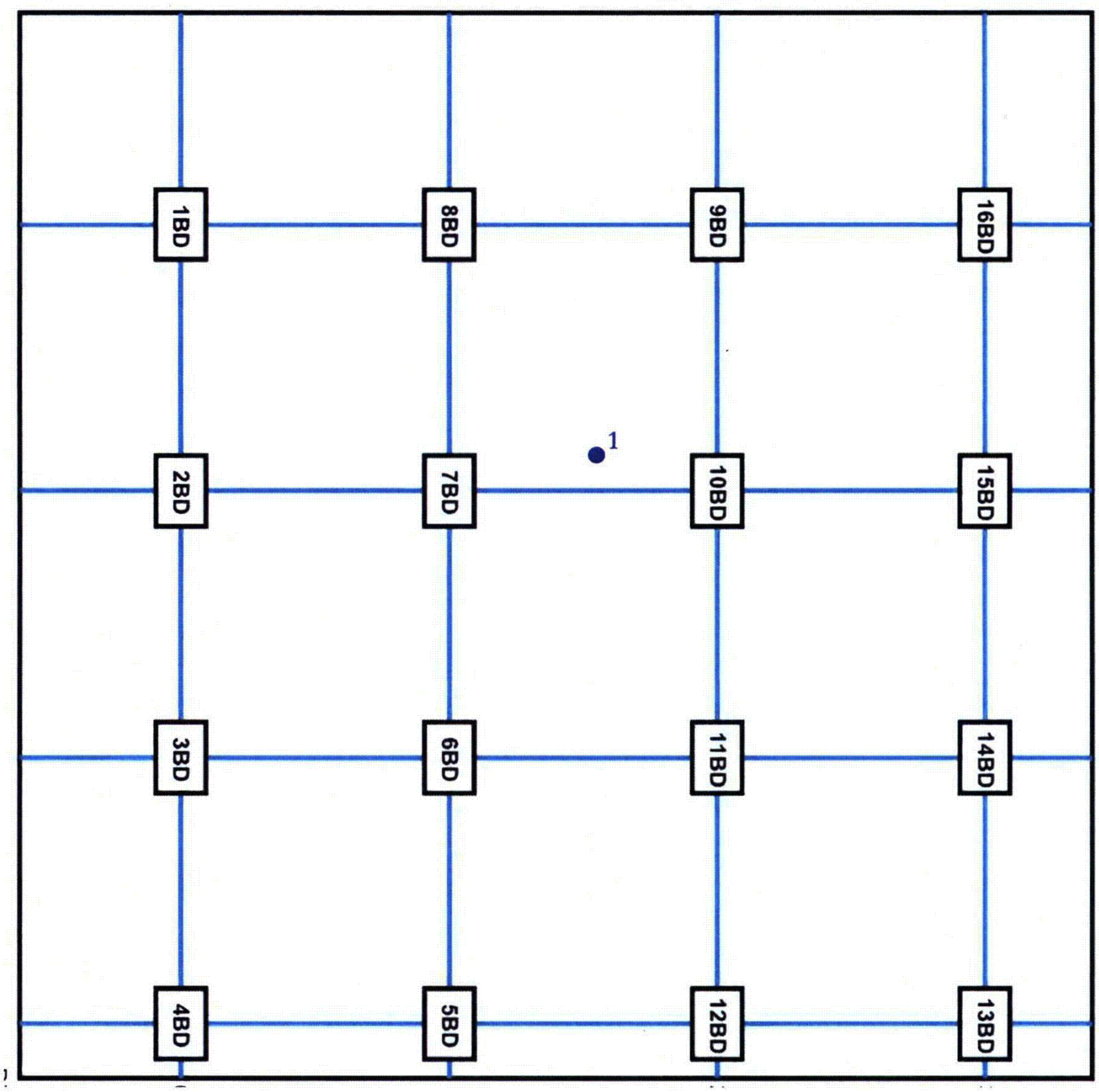

Figure provided by SMUD.

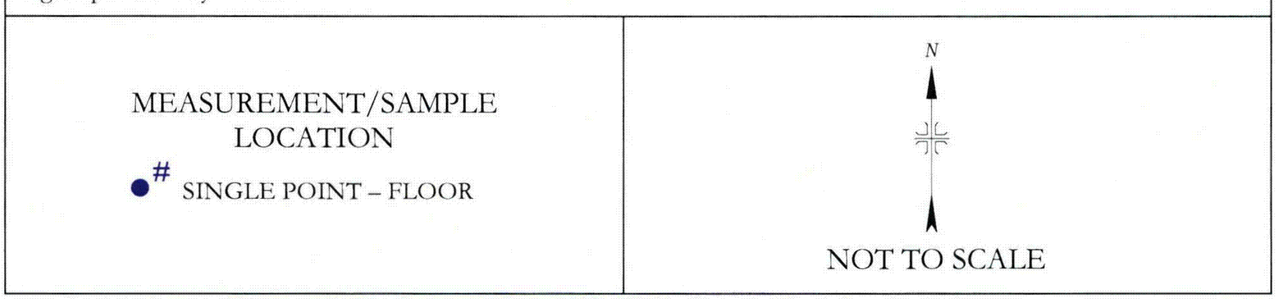

Figure A-12: Survey Unit F8260151, South Turbine Building – Direct Measurement and Sample Locations

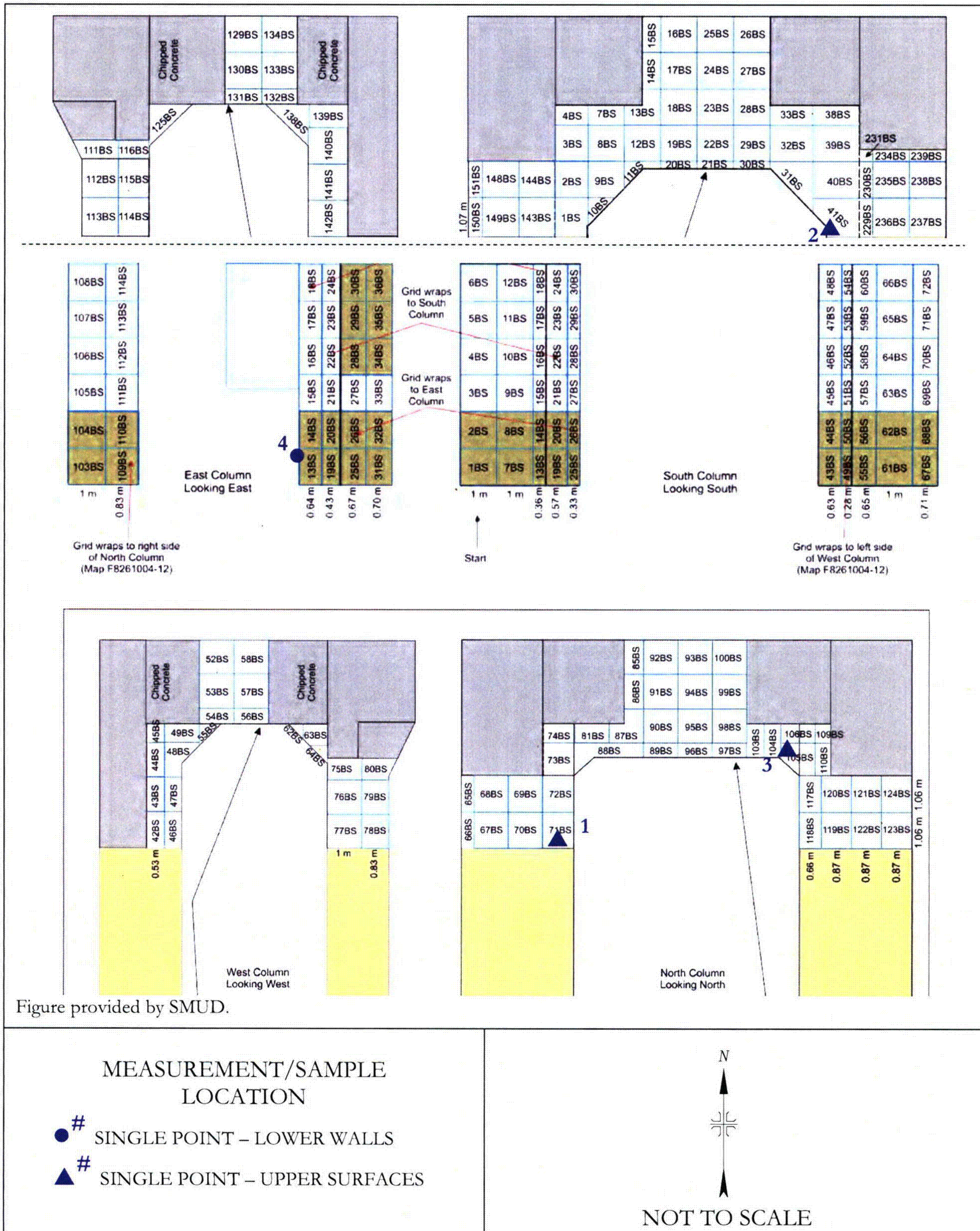

Figure provided by SMUD.

Figure A-13: Survey Units F8261003 and F8261004, High Pressure Turbine Pedestals – Direct Measurement and Sample Locations

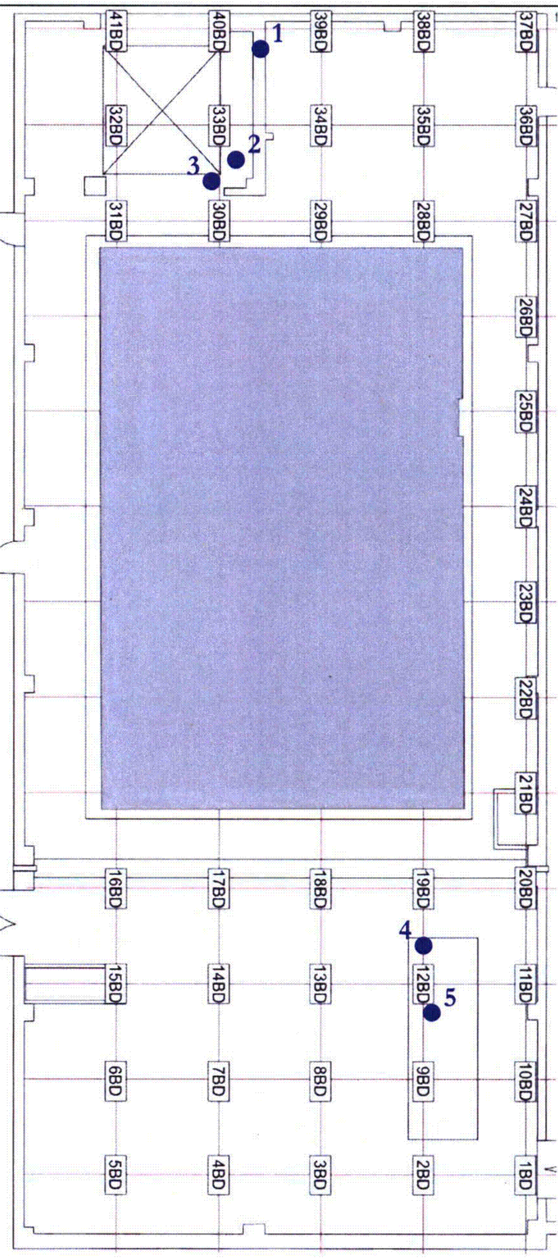

Figure provided by SMUD.

MEASUREMENT/SAMPLE LOCATION

● # SINGLE POINT – FLOOR

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NOT TO SCALE

Figure A-14: Survey Unit F8121001, Fuel Storage Building +40' Elevation – Direct Measurement and Sample Locations

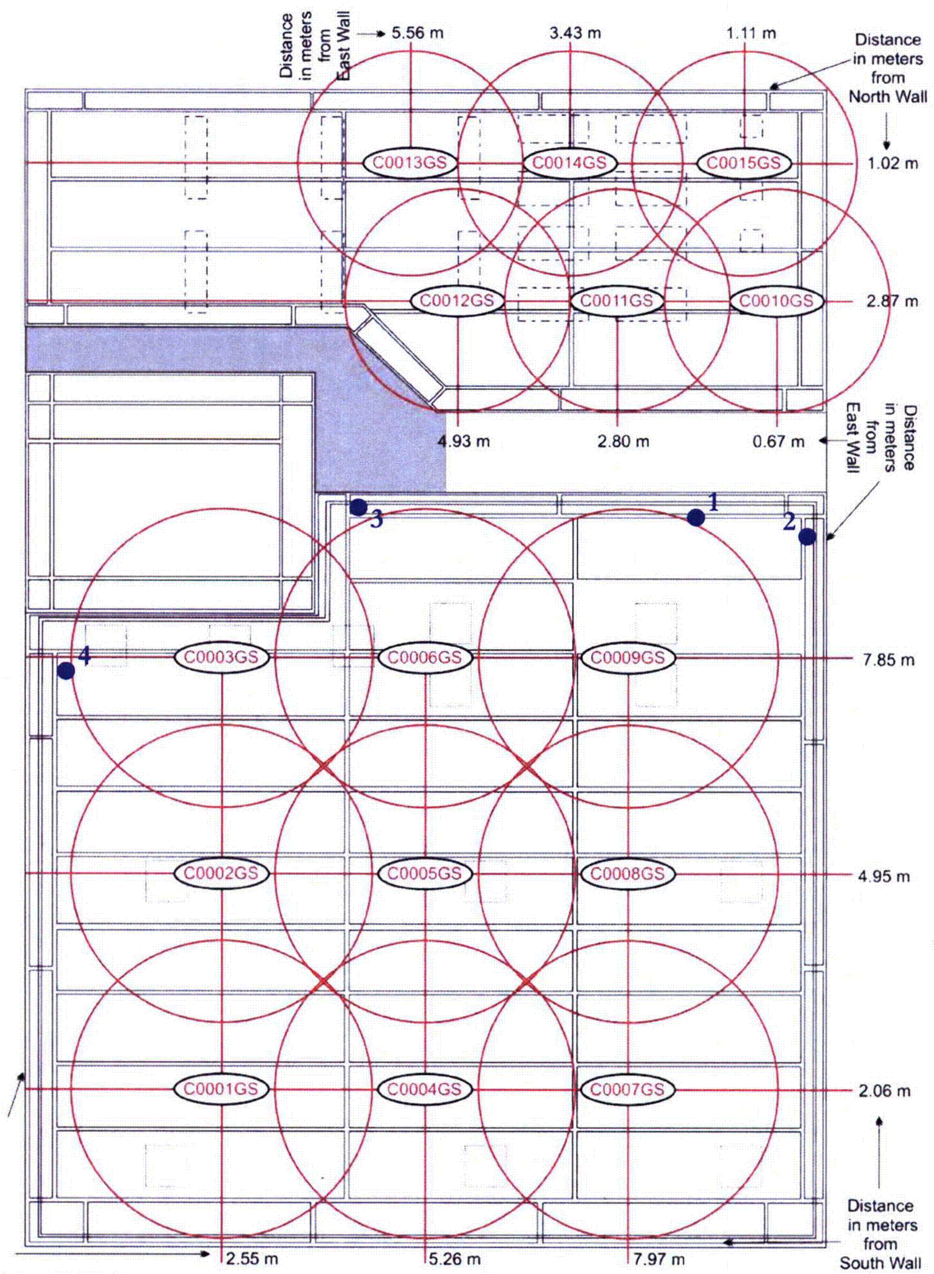


Figure provided by SMUD.

MEASUREMENT/SAMPLE LOCATION

●# SINGLE POINT – FLOOR

N

NOT TO SCALE

Figure A-15: Survey Unit F8120005, Spent Fuel Pool Floor – Direct Measurement and Sample Locations

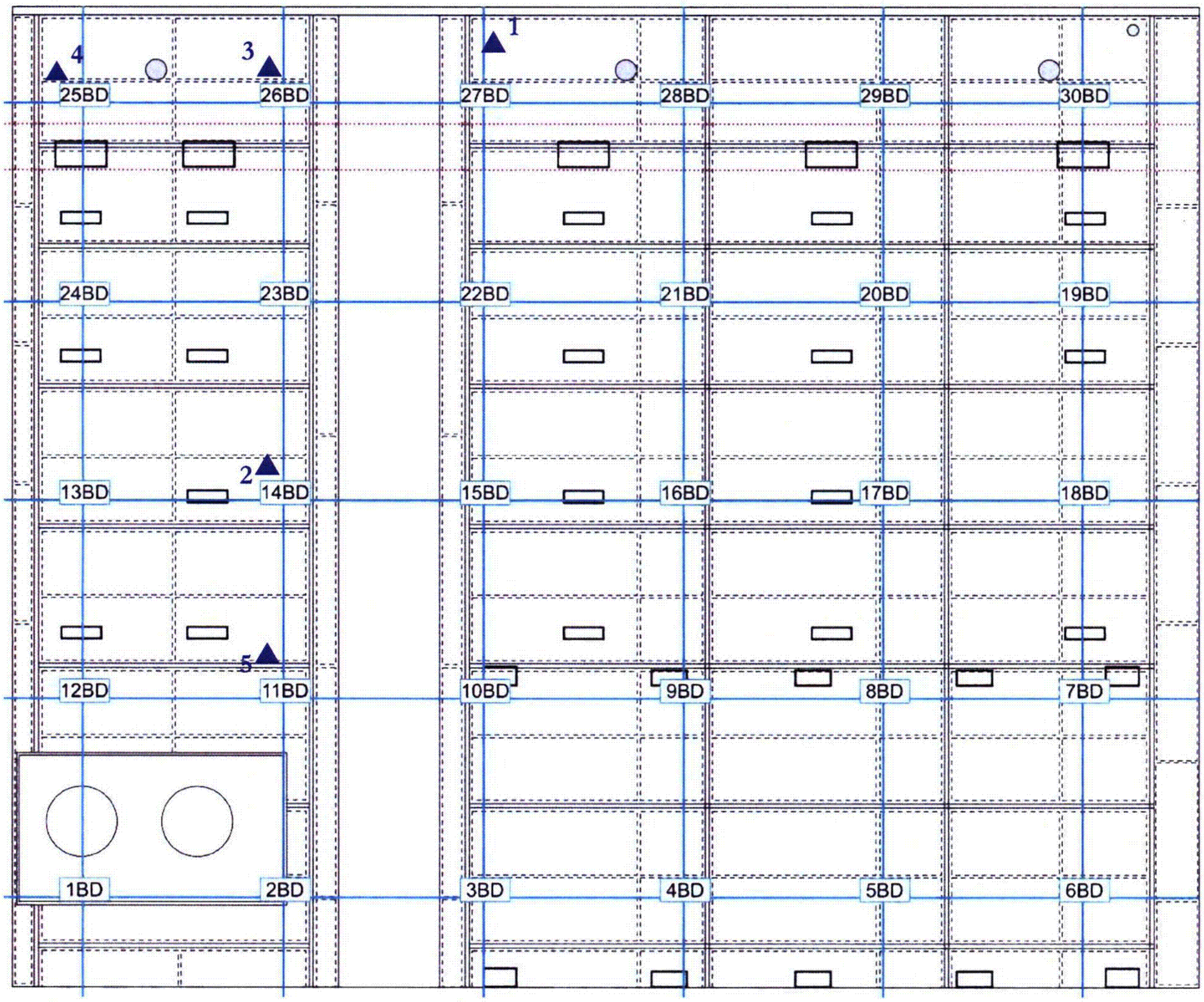


Figure provided by SMUD.

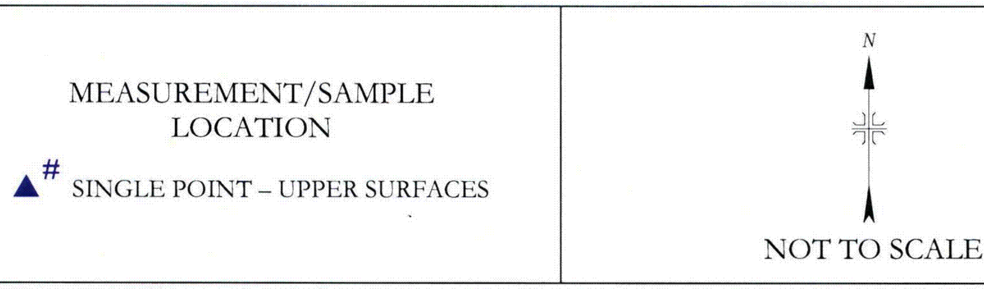


Figure A-16: Survey Unit F8120003, Spent Fuel Pool, East Wall – Direct Measurement and Sample Locations

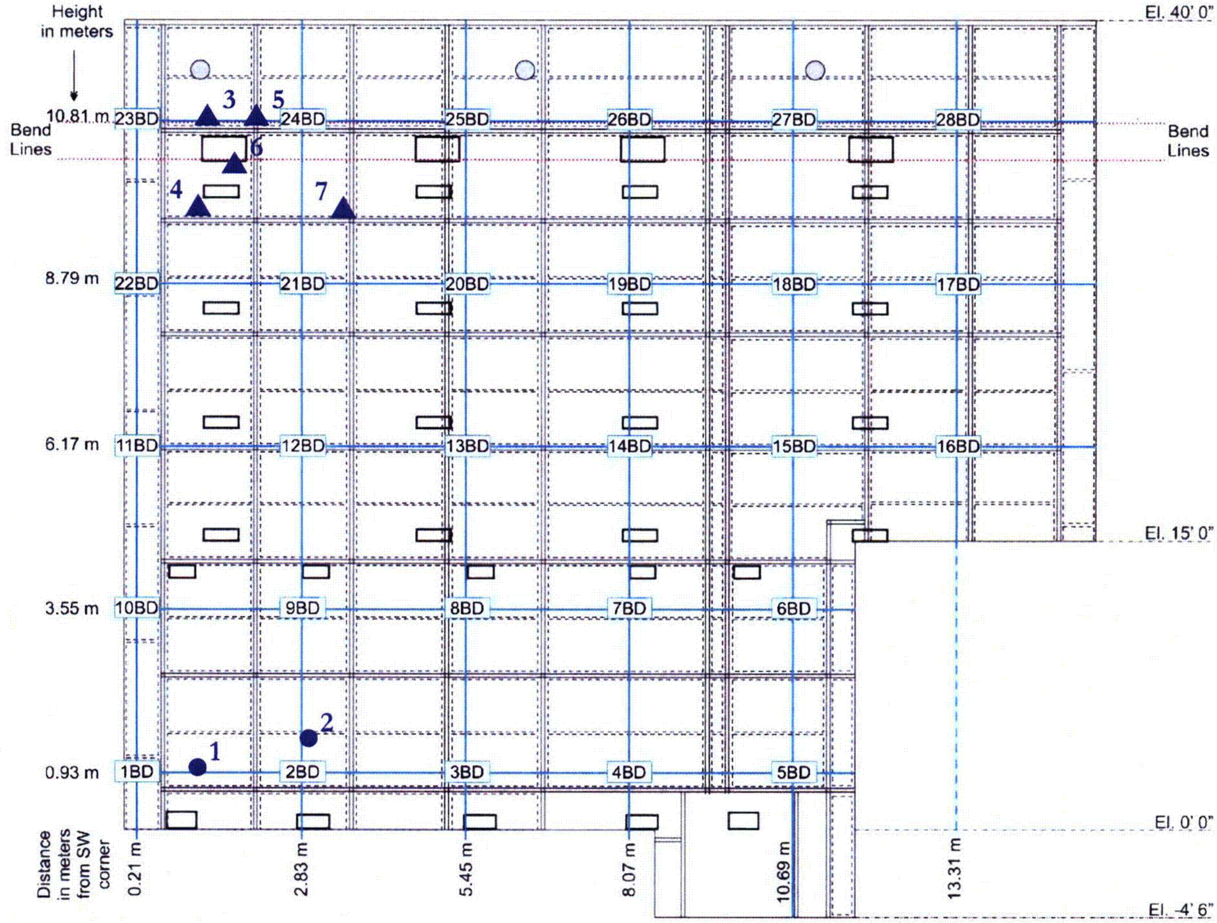


Figure provided by SMUD.

MEASUREMENT/SAMPLE LOCATION

● # SINGLE POINT – LOWER WALLS

▲ # SINGLE POINT – UPPER SURFACES

N

NOT TO SCALE

Figure A-17: Survey Unit F8120001, Spent Fuel Pool, West Wall – Direct Measurement and Sample Locations

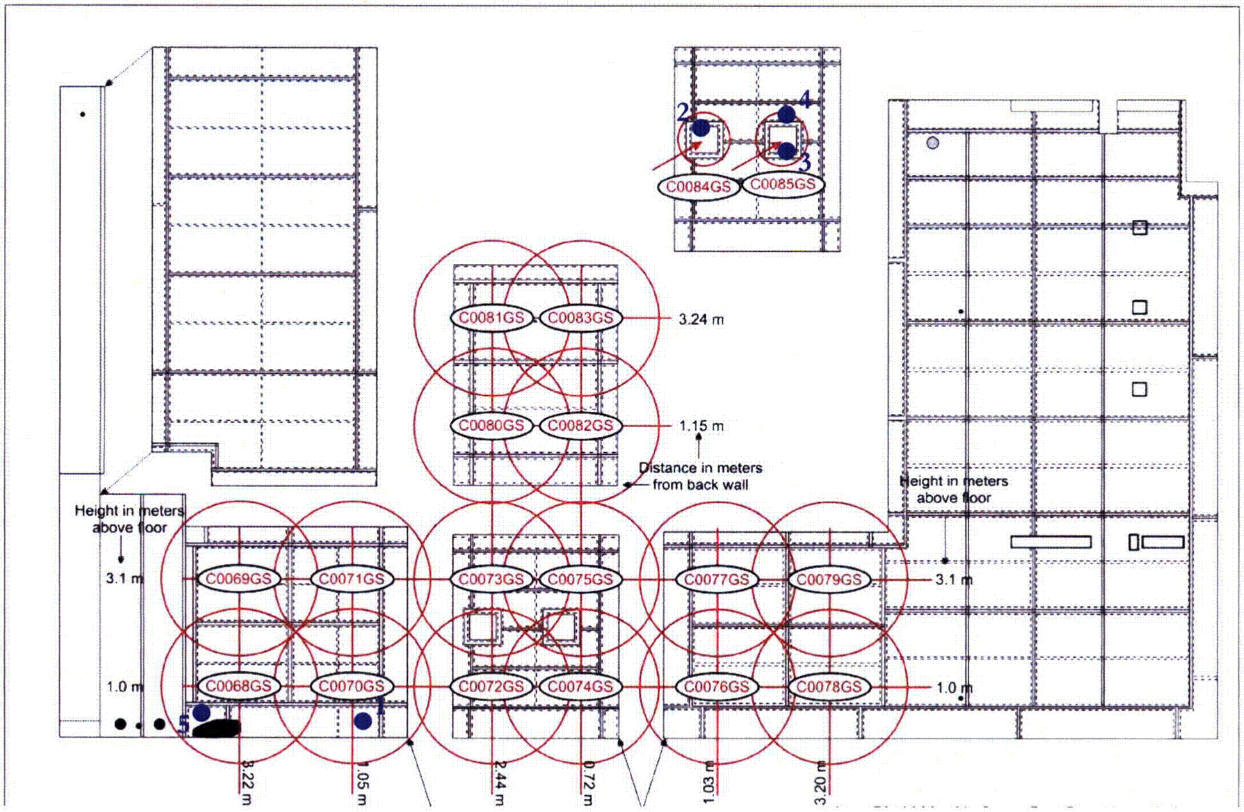
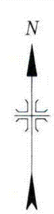


Figure provided by SMUD.

MEASUREMENT/SAMPLE LOCATION

● # SINGLE POINT – LOWER WALLS



NOT TO SCALE

Figure A-18: Survey Unit F8120004, Spent Fuel Pool, North Wall – Direct Measurement and Sample Locations

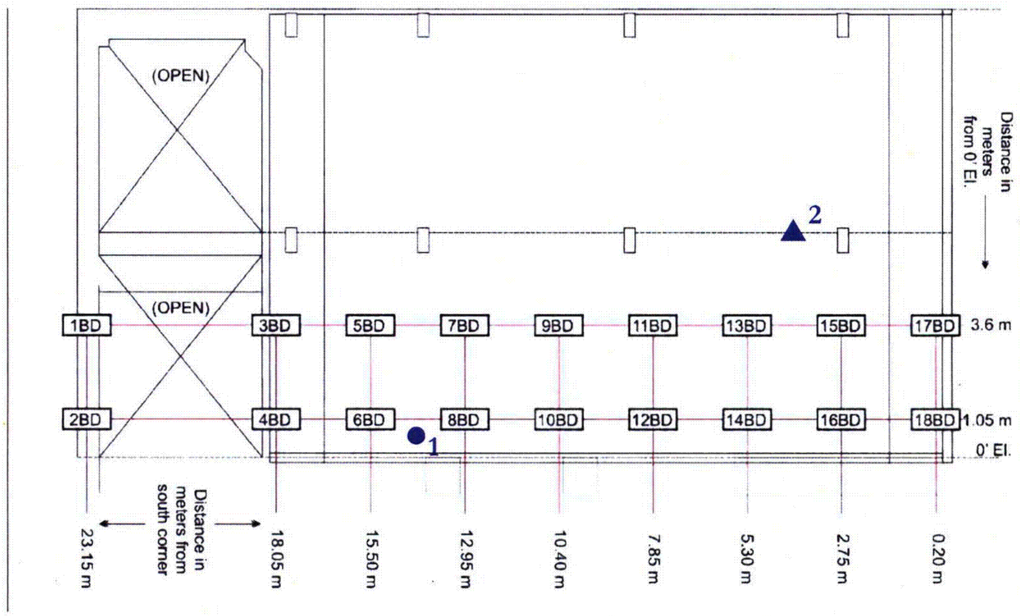


Figure provided by SMUD.

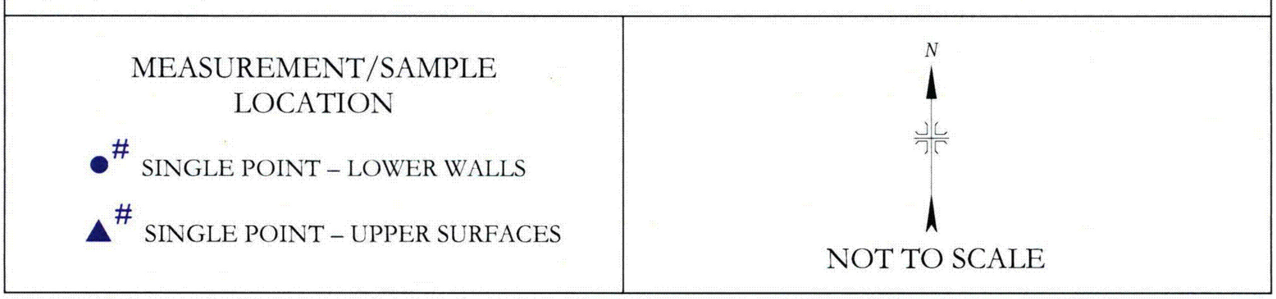


Figure A-19: Survey Unit F8120121, Fuel Storage Building, West Exterior Wall – Direct Measurement and Sample Locations

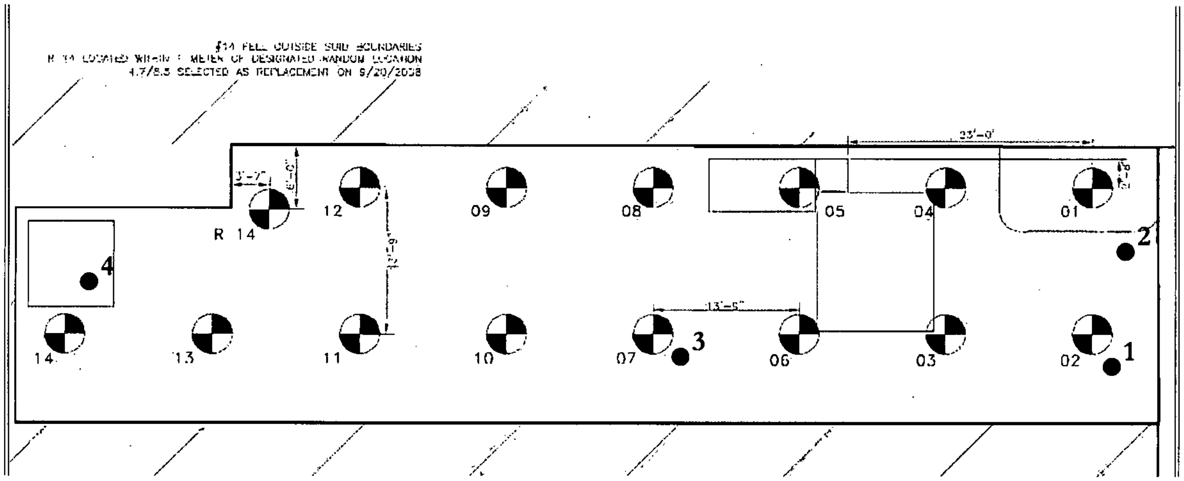


Figure provided by SMUD.

MEASUREMENT/SAMPLE LOCATION	N
●# SINGLE POINT – FLOOR	NOT TO SCALE

Figure A-20: Survey Unit F8000104, Pump Alley Access Corridor – Direct Measurement and Sample Locations

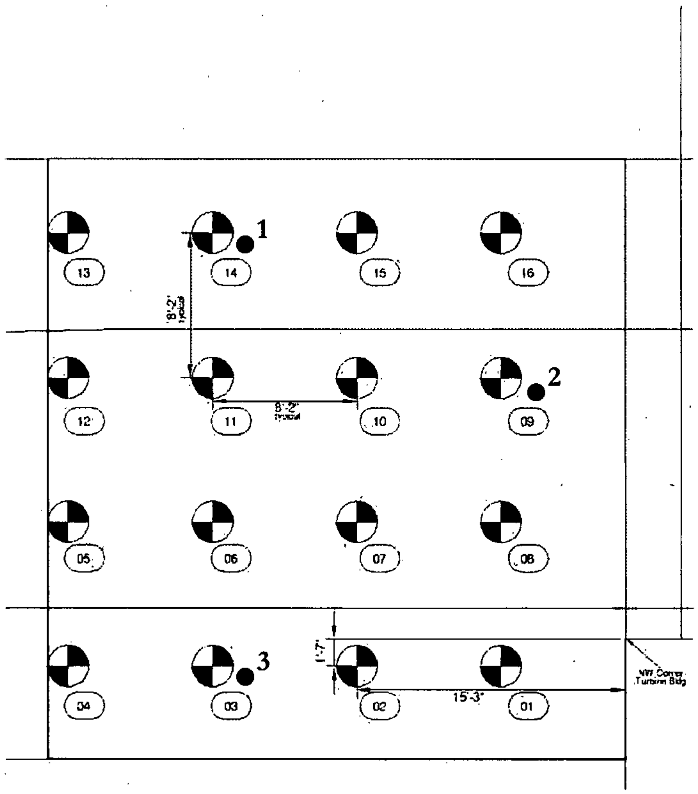


Figure provided by SMUD.

MEASUREMENT LOCATION	N
● # SINGLE POINT – FLOOR	NOT TO SCALE

Figure A-21: Survey Unit F8340011, Industrial Area Railway – Direct Measurement Locations

APPENDIX B

TABLES

TABLE B - 1: DERIVED CONCENTRATION GUIDELINE LEVELS AND ELEVATED MEASUREMENT COMPARISONS FOR SURVEYED AREAS RANCHO SECO NUCLEAR GENERATING STATION HERALD, CALIFORNIA			
Survey Unit/ Building/Room[a]	**Class**	**Gross Beta DCGL[b] (dpm/100 cm^2)**	**Design $DCGL_{EMC}$[c] (dpm/100 cm^2)/Area Factor**
F8130731, Auxiliary Building, Room 51	1	43,000	154,800/3.6
F8131211, Auxiliary Building, Room 132	2	43,000	Class 2[d]/NA
F8131371, Auxiliary Building Rooms 208 and 211 Floor	1	43,000	154,800/17.11
F8131372, Auxiliary Building Rooms 208 and 211 Walls and Ceiling	2	43,000	Class 2[d]/NA
F8131781, Auxiliary Building, Room 319	1	43,000	167,700/3.9
F8132133, Auxiliary Steam Support	1	43,000	215,900/5.02
F8132134, Auxiliary Steam Support	1	43,000	3,551,800[e]/82.6
F8260010, Turbine Building, North Condensate Area	1	43,000	154,800/3.6
F8260004, Turbine Building, Condensate Pump Pit	1	43,000	154,800/3.6
F8260011, Turbine Building, Lube Oil Pit	1	43,000	154,800/3.6
F8260171, Turbine Building, North Central Floor	1	43,000	563,500/13.1
F8260151, Turbine Building, Grade Level South	1	43,000	640,700/14.9

TABLE B - 1: DERIVED CONCENTRATION GUIDELINE LEVELS AND ELEVATED MEASUREMENT COMPARISONS FOR SURVEYED AREAS RANCHO SECO NUCLEAR GENERATING STATION HERALD, CALIFORNIA			
Survey Unit/ Building/Room[a]	**Class**	**Gross Beta DCGL**[b] **(dpm/100 cm^2)**	**Design $DCGL_{EMC}$**[c] **(dpm/100 cm^2)/Area Factor**
F8261003 and F8261004, Turbine Building High Pressure Turbine Pedestals	1	43,000	163,400/3.8
F8121001, Spent Fuel Building +40	1	43,000	154,800/3.6
F8120005, Spent Fuel Pool Floor	1	43,000	154,800/3.6
F8120003, Spent Fuel Pool East Wall	1	43,000	154,800/3.6
F8120001, Spent Fuel Pool West Wall	1	43,000	154,800/3.5
F8120002, Spent Fuel Pool South Wall	1	43,000	154,800/3.6
F8120004, Spent Fuel Pool North Wall	1	43,000	154,367/3.6
F8120121 West Exterior Wall	1	43,000	154,800/3.6
F8000105 Pump Alley Access Corridor	2	NA[f]	NA
F8340011 Industrial Area Railway	1	NA	NA

[a]Refer to Figures A-3 through A-21.
[b]Gross beta DCGL accounts for radionuclide fractions and hard to detects as specified in the DTBD-05-15 (SMUD 2006b).
[c]$DCGL_{EMC}$ provided by SMUD and accounted for area factors (also provided by SMUD) determined for each specific survey unit.
[d]Class 2 Survey Unit, $DCGL_{EMC}$ not applicable.
[e]The original survey unit (F8132132) was a Class 2 area; however, based on FSS findings, a 2-meter portion was classified as Class 1 resulting in a high $DCGL_{EMC}$ value. Final SMUD scan data did not exceed 31,000 dpm/100 cm^2.
[f]NA = Not applicable; survey units were considered land areas and DCGL's were in pCi/g. Pump Alley Access Corridor DCGL and $DCGL_{EMC}$ were 51.2 and 97.8 pCi/g, respectively. Industrial Area Railway DCGL and $DCGL_{EMC}$ were 51.2 and 154.28 pCi/g, respectively.

TABLE B - 2: SURVEY UNIT CLASSIFICATION AND SCAN COVERAGE RANCHO SECO NUCLEAR GENERATING STATION HERALD, CALIFORNIA					
Building Survey Unit/Room[a]	Class	Percent Scan Coverage			
		Gamma Floor/Lower Wall	Beta Floor	Beta Lower Wall	Beta Upper Surfaces
Auxiliary Building					
F8130731 Room 51Reactor Wall	1	NA[b]/75	NA	75	---[c]
F8131211 Room 132	2	100/---	75	75	---
F8131212 Room 132	1	100/---	100	75	---
F8131371 Rooms 208 and 211 Floor	1	100/NA	75	NA	NA
F8131372 Rooms 208 and 211 Walls/Ceiling	2	NA/---	NA	75	10
F8131781 Room 319	1	100/---	75	75	10
F8131791 Room 320	2	100/---	75	75	---
F8132133 Auxiliary Steam Supports	1	100/NA	75	NA	NA
F8132134 Auxiliary Steam Supports	1	100/NA	100	NA	NA
Turbine Building					
F8260010 North Condensate Pit	1	100/---	90	75	---
F8260004 Condensate Pump Pit	1	100/---	75	75	---
F8260011 Lube Oil Pit	1	100/---	90	75	---
F8260032 Main Feed Pump Area	2	100/---	75	25	NA
F8260171 North Central Floor	1	100/NA	100	NA	NA
F8260151 Grade Level South	1	100/NA	100	NA	NA
F8261003 and F8261004 High Pressure Turbine Pedestals	1	NA/---	NA	75	5

TABLE B - 2: SURVEY UNIT CLASSIFICATION AND SCAN COVERAGE RANCHO SECO NUCLEAR GENERATING STATION HERALD, CALIFORNIA					
Building Survey Unit/Room[a]	Class	Percent Scan Coverage			
		Gamma Floor/Lower Wall	Beta Floor	Beta Lower Wall	Beta Upper Surfaces
Turbine Building - continued					
F8260161 North Turbine Building 0' Elevation	1	100/---	100	---	---
Fuel Storage Building					
F8121001 +40 Level Floor	1	100/---	75	NA	NA
F8121003 +40 Level Lower Walls	1	NA/---	NA	75	NA
F8120005 Spent Fuel Floor	1	100/NA	75	NA	NA
F8120003 East Wall	1	NA/75	NA	60	3
F8120001 West Wall	1	NA/100	NA	75	5
F8120002 South Wall	1	NA/75	NA	---	---
F8120004 North Wall	1	NA/---	NA	10	---
F8120121 West Exterior Wall	1	NA/---	NA	75	---
Exterior Areas					
F8000104 Pump Alley Access Corridor	1	100/NA	90	NA	NA
F8340011 Industrial Area Railway	1	100/NA	5	NA	NA

[a]Refer to Figures A-3 through A-21.
[b]Not Applicable.
[c]Scans not performed.

TABLE B - 3: SURFACE ACTIVITY LEVELS RANCHO SECO NUCLEAR GENERATING STATION HERALD, CALIFORNIA					
Survey Unit/ Location[a]	Surface[b]	Total Beta Activity (dpm/100 cm^2)[c]	Removable Activity (dpm/100 cm^2)		Activity Meets Gross Beta DCGL/DCGL$_{EMC}$[d]
			Alpha	Beta	
F8130731, Auxiliary Building, Room 51					
1	LW	48,000	0	3	NO/YES
2	LW	19,000	0	4	YES/YES
F8131211, Auxiliary Building, Room 132					
1	FL	2,800	0	1	YES/NA
2	LW	15,000	2	15	YES/NA
F8131371, Auxiliary Building, Rooms 208 and 211					
1	FL	6,600	0	1	YES/YES
2	FL	720	0	-1	YES/YES
3	FL	420	0	4	YES/YES
4	FL	760	0	-1	YES/YES
F8131372, Auxiliary Building, Rooms 208 and 211					
5	LW	13,000	2	74	YES/NA[e]
6	LW	280	2	-2	YES/NA
7	LW	17	0	-3	YES/NA
8	US	630	2	6	YES/NA
9	US	640	0	-1	YES/NA
10	US	1,000	0	9	YES/NA
11	US	210	0	-3	YES/NA
F8131781, Auxiliary Building, Room 319					
1	LW	39,000	0	10	YES/YES
2	LW	4,700	0	-1	YES/YES
3	LW	36	0	-1	YES/YES
4	FL	6,300	2	6	YES/YES
5	FL	22,000	0	-2	YES/YES
6	FL	22,000	2	6	YES/YES
F8132133, Auxiliary Building, Steam Support					
1	FL	1,700	0	2	YES/YES
F8132134, Auxiliary Building, Steam Support					
1	FL	12,000	0	5	YES/YES

TABLE B - 3: SURFACE ACTIVITY LEVELS RANCHO SECO NUCLEAR GENERATING STATION HERALD, CALIFORNIA					
Survey Unit/ Location[a]	Surface[b]	Total Beta Activity (dpm/100 cm^2)[c]	Removable Activity (dpm/100 cm^2)		Activity Meets Gross Beta DCGL/DCGL$_{EMC}$[d]
			Alpha	Beta	
F8260010, Turbine Building, North Condensate Area					
1	FL	22,000	0	-4	YES/YES
2	FL	3,200	0	-3	YES/YES
3	LW	8,800	0	1	YES/YES
F8260004, Turbine Building, Condensate Pump Pit					
1	FL	5,700	0	2	YES/YES
2	LW	6,500	0	3	YES/YES
3	FL	280	0	-4	YES/YES
F8260011, Turbine Building, Lube Oil Pit					
1	FL	9,900	0	-2	YES/YES
2	FL	6,000	0	1	YES/YES
3	LW	360	0	-2	YES/YES
F8260171, Turbine Building, North Central Floor					
1	FL	4,300	0	-5	YES/YES
F8260151, Turbine Building, Grade Level South					
1	FL	4,400	2	2	YES/YES
F8261003 and F8261004, High Pressure Turbine Pedestals					
1	US	-88	0	-3	YES/YES
2	US	9	0	1	YES/YES
3	US	40	0	-3	YES/YES
4	LW	2,400	0	3	YES/YES
F8121001, Fuel Storage Building +40					
1	FL	5,400	0	3	YES/YES
2	FL	6,400	0	3	YES/YES
3	FL	16,000	0	-4	YES/YES
4	FL	17,000	0	6	YES/YES
5	FL	7,900	2	-1	YES/YES

TABLE B - 3: SURFACE ACTIVITY LEVELS RANCHO SECO NUCLEAR GENERATING STATION HERALD, CALIFORNIA					
Survey Unit/ Location[a]	Surface[b]	Total Beta Activity (dpm/100 cm^2)[c]	Removable Activity (dpm/100 cm^2)		Activity Meets Gross Beta DCGL/DCGL$_{EMC}$[d]
			Alpha	Beta	
F8120005, Spent Fuel Pool Floor					
1	FL	20,000	0	-2	YES/YES
2	FL	13,000	0	2	YES/YES
3	FL	17,000	6	7	YES/YES
4	FL	7,200	0	-3	YES/YES
F8120003, Spent Fuel Pool East Wall					
1	US	1,300,000	2	48	NO/YES
2	US	27,000	0	17	YES/YES
3	US	27,000	0	5	YES/YES
4	US	590,000	0	48	NO/YES
5	US	53,000	0	10	NO/YES
F8120001, Spent Fuel Pool West Wall					
1	LW	140,000	0	6	NO/YES
2	LW	32,000	0	-4	YES/YES
3	US	220,000	0	18	NO/YES
4	US	200,000	2	14	NO/YES
5	US	98,000	0	3	NO/YES
6	US	51,000	0	8	NO/YES
7	US	240,000	0	59	NO/YES
F8120004, Spent Fuel Pool North Wall					
1	LW	43,000	2	31	NO/YES
2	LW	130,000	2	130	NO/YES
3	LW	170,000	2	190	NO/YES
4	LW	76,000	0	19	NO/YES
5	LW	5,700	2	13	YES/YES
F8120121, Fuel Storage Building, West Exterior Wall					
1	LW	19,000	0	-1	YES/YES
2	US	-170	0	3	YES/YES

TABLE B - 3: SURFACE ACTIVITY LEVELS RANCHO SECO NUCLEAR GENERATING STATION HERALD, CALIFORNIA					
Survey Unit/ Location[a]	Surface[b]	Total Beta Activity (dpm/100 cm^2)[c]	Removable Activity (dpm/100 cm^2)		Activity Meets Gross Beta DCGL/$DCGL_{EMC}$[d]
			Alpha	Beta	
F8000105, Pump Alley Access Corridor					
1	FL	650	0	-2	NA
2	FL	600	0	1	NA
3	FL	690	0	-2	NA
4	FL	43	0	1	NA
F8340011, Industrial Area Railway					
1	FL	120	--[f]	--	NA
2	FL	-40	--	--	NA
3	FL	88	--	--	NA

[a]Refer to Figures A-3 through A-21.
[b]Structural surfaces; FL = floor, LW = lower wall, and US = upper surfaces.
[c]Direct measurement results rounded to two significant digits.
[d]DCGL values are provided in Table B-1. All surface activity measurements that were greater than the gross beta DCGL were less than the design $DCGL_{EMC}$s determined for each specific survey unit based on the area factors for the survey unit.
[e]Not Applicable.
[f]Measurement not performed.

APPENDIX C

MAJOR INSTRUMENTATION

APPENDIX C

MAJOR INSTRUMENTATION

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

SCANNING INSTRUMENT/DETECTOR COMBINATIONS

Beta

Ludlum Floor Monitor Model 239-1
combined with
Ludlum Ratemeter-Scaler Model 2221
coupled to
Ludlum Gas Proportional Detector Model 43-37, Physical Area: 550 cm^2
(Ludlum Measurements, Inc., Sweetwater, TX)

Ludlum Ratemeter-Scaler Model 2221
coupled to
Ludlum Gas Proportional Detector Model 43-68, Physical Area: 126 cm^2
(Ludlum Measurements, Inc., Sweetwater, TX)

Ludlum Ratemeter-Scaler Model 2221
(Ludlum Measurements, Inc., Sweetwater, TX)
coupled to
Eberline Geiger-Mueller Detector Model HP-260, Physical Area: 20 cm^2
(Eberline, Santa Fe, NM)

Gamma

Ludlum Pulse Ratemeter Model 12
(Ludlum Measurements, Inc., Sweetwater, TX)
coupled to
Fluke Miomedical NaI(Tl) Scintillation Detector Model 489-55, Crystal: 3.2 cm x 3.8 cm
(Fluke Biomedical, Cleveland, OH)

DIRECT MEASUREMENT INSTRUMENT/DETECTOR COMBINATIONS

Beta

Ludlum Ratemeter-Scaler Model 2221
coupled to
Ludlum Gas Proportional Detector Model 43-68, Physical Area: 126 cm^2
(Ludlum Measurements, Inc., Sweetwater, TX)

DIRECT MEASUREMENT INSTRUMENT/DETECTOR COMBINATIONS (CONTINUED)

Ludlum Ratemeter-Scaler Model 2221
(Ludlum Measurements, Inc., Sweetwater, TX)
coupled to
Eberline Geiger-Mueller Detector Model HP-260, Physical Area: 20 cm^2
(Eberline, Santa Fe, NM)

LABORATORY ANALYTICAL INSTRUMENTATION

Low Background Gas Proportional Counter
Model LB-5100-W
(Tennelec/Canberra, Meriden, CT)

APPENDIX D
SURVEY AND ANALYTICAL PROCEDURES

APPENDIX D

SURVEY AND ANALYTICAL PROCEDURES

PROJECT HEALTH AND SAFETY

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

Pre-survey activities included the evaluation and identification of potential health and safety issues. Survey work was performed per the ORISE generic health and safety plans and a site-specific integrated safety management (ISM) pre-job hazard checklist. SMUD also provided site-specific safety awareness training.

CALIBRATION AND QUALITY ASSURANCE

Calibration of all field and laboratory instrumentation was based on standards/sources, traceable to the National Institute of Standards and Technology (NIST).

Analytical and field survey activities were conducted in accordance with procedures from the following ORAU and ORISE documents:

- Survey Procedures Manual (May 2008)
- Laboratory Procedures Manual (December 2008)
- Quality Program Manual (November 2007)

The procedures contained in these manuals were developed to meet the requirements of 10 CFR 830 Subpart A, *Quality Assurance Requirements*, Department of Energy Order 414.1C *Quality Assurance*, and the U.S. Nuclear Regulatory Commission *Quality Assurance Manual for the Office of Nuclear Material Safety and Safeguards* and contain measures to assess processes during their performance.

Quality control procedures include:

- Daily instrument background and check-source measurements to confirm that equipment operation is within acceptable statistical fluctuations.

- Participation in MAPEP, NRIP, and ITP Laboratory Quality Assurance Programs.
- Training and certification of all individuals performing procedures.
- Periodic internal and external audits.

CALIBRATION PROCEDURES

Detectors used for assessing surface activity were calibrated in accordance with ISO-7503[1] recommendations. The total beta efficiency (ε_{total}) was determined for the instrument/detector combination used for all surface activity measurements and consisted of the product of the 2π instrument efficiency (ε_i) and surface efficiency (ε_s): $\varepsilon_{total} = \varepsilon_i \times \varepsilon_s$. The total surface efficiency was determined based on a beta energy multi-point calibration, development of instrument efficiency to beta energy calibration curves, and the calculation of the weighted efficiency representing the primary contaminants of concern (Cs-137 and Co-60) for the RSNGS site. SMUD calculated the radionuclide mix fraction of Cs-137 to Co-60 as 0.87 and 0.13, respectively (SMUD 2006b).

Carbon-14 (C-14), technetium-99 (Tc-99), thallium-204 (Tl-204), and strontium/yttrium-90 (Sr/Y-90) were selected as the beta calibration sources to represent the energy distribution of the detectable beta-emitters at the RSNGS. The 2π interpolated ε_i factors for the detectable beta-emitters ranged from 0.34 to 0.67 for the gas proportional detectors (Figures D-1 through D-3) and were 0.09 to 0.66 for the GM detector (Figure D-4). ISO-7503 recommends an ε_s of 0.25 for beta emitters with a maximum energy of less than 0.4 MeV and an ε_s of 0.5 for maximum beta energies greater than 0.4 MeV. The ORISE calculated multi-point calibration total weighted static ε_{total} values for the hand-held gas proportional detectors used for the confirmatory surveys were 0.23 and 0.24 as presented in Figures D-1 through D-3; the ORISE calculated multi-point calibration total weighted static ε_{total} value for the GM detector used for the confirmatory surveys was 0.18 as presented in Figure D-4.

[1]International Standard. ISO 7503-1, Evaluation of Surface Contamination - Part 1: Beta-emitters (maximum beta energy greater than 0.15 MeV) and alpha-emitters. August 1, 1988.

SURVEY PROCEDURES

Action Levels

The field action level for the hand-held gas proportional instrument based on the specific site criteria and background was calculated as follows:

- SMUD Site Release Criteria (SRC): 43,000 dpm/100 cm^2
- 43-68 multipoint total efficiency (ε_{total}): 0.24
- Background (BKG): 250cpm
- Time (T): 1 minute count time
- $G = \text{geometry} = \dfrac{\textit{Physical Detector Area } cm^2}{100}$

Determine Action Level

- Action Level (cpm) = (SRC * ε_{total} * G * T) + (BKG * T)
- Action Level = 13,253 cpm

In a similar calculation, the action level for the GM detector was determined to be 1,602 counts per minute (cpm). A field count at or above the calculated action level value indicates that further investigation of the area would be necessary.

Surface Scans

Structural surface scans were performed by passing the detectors slowly over the surface; the distance between the detector and the surface was maintained at a minimum—nominally about 1 cm. Building surfaces were scanned using a floor monitor (550 cm^2), a small area (126 cm^2) hand-held gas proportional, and/or a GM pancake (20 cm^2) detector. A NaI scintillation detector was used to scan for elevated gamma radiation throughout the SUs. Identification of elevated radiation levels was based on increases in the audible signal from the recording and/or indicating instrument.

Specific scan minimum detectable concentrations (MDC) for the NaI scintillation detector for Cs-137 and Co-60 in concrete were not specifically determined as the instrument was used solely as a qualitative means to identify elevated gamma activity where further investigation would be required. MDCs for radionuclides in the concrete would approximate those contained in NUREG-1507.

Beta surface scan MDCs were estimated using the calculational approach described in NUREG-1507.[2] The scan MDC is a function of many variables, including the background level. Additional parameters selected for the calculation of scan MDCs included a one-second observation interval, a specified level of performance at the first scanning stage of 95% true positive rate and 25% false positive rate, which yields a *d′* value of 2.32 (NUREG-1507, Table 6.1), and a surveyor efficiency of 0.5. The scanning ε_{total} was determined for the hand-held gas proportional, GM and floor monitor detectors in the same fashion as above for the static hand-held gas proportional and GM detectors except typical scanning efficiencies for the detectors were used rather than specific calibrations for this survey. The scanning ε_{total} value for a hand-held gas proportional detector was 0.18 (Figure D-5); 0.03 for a GM detector (Figure D-6); and, 0.15 for a floor monitor (Figure D-7).

To illustrate an example for a hand-held gas proportional detector using a concrete background of 560 cpm, the minimum detectable count rate (MDCR) and scan MDC can be calculated using the following relationships:

$$s_i = d'(b_i)^{1/2};$$

$$MDCR = s_i * (60/i); \text{ and}$$

$$MDCR_{surveyor} = MDCR/(p)^{1/2}$$

Where:

s_i = the minimum detectable number of source counts

d' = the specified level of performance of 2.32

b_i = the number of background counts in the observation interval

MDCR = minimum detectable count rate

i = observation interval

p = surveyor efficiency of 0.5

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

The equations are combined and the variables are then calculated as follows:

b_i = (250 cpm)(1 s)(1 min/60 s) = 4.17 counts,

MDCR = (2.32)(4.17 counts)$^{1/2}$ [(60 s/min)/(1 s)] = 284 cpm,

$MDCR_{surveyor}$ = 284/(0.5)$^{1/2}$ = 402 cpm

The scan MDC is calculated assuming a total efficiency (ε_{total}) of 0.18:

$$ScanMDC = \frac{MDCR_{surveyor}}{(\varepsilon_{total})} dpm/100\,cm^2$$

For the given background, the estimated scan MDC was 2,228 dpm/100 cm^2 for the hand-held gas proportional detector. In the same manner, the scan MDCs for the GM and floor monitor detectors were 5,822 and 6,367 dpm/100 cm^2, respectively (Refer to Figures D-5 through D-7).

Surface Activity Measurements

Measurements of total beta surface activity levels were performed using hand-held hand-held gas proportional and GM detectors coupled to portable ratemeter-scalers. Count rates which were integrated over one minute with the detector held in a static position, were converted to activity levels (dpm/100 cm^2) by dividing the count rate by the total static efficiency ($\varepsilon_i \times \varepsilon_s$) and correcting for the physical area of the detector. ORISE did not determine construction material-specific backgrounds for each surface type encountered for determining net count rates. Instead, ORISE took the conservative approach and did not subtract material specific backgrounds in determining surface activity levels.

The MDC for surface activity measurements was calculated using the following equation:

$$MDC = \frac{3 + (4.65\sqrt{B})}{T * \varepsilon_{Total} * G}$$

Where:

B = background (total counts) in time interval, T

T = count time (min) used for field instruments

ε_{Total} = total efficiency = ε_i x ε_s

ε_i = instrument efficiency

ε_s = source efficiency

G = geometry (physical detector area $cm^2/100$)

The beta static MDC for the gas proportional detector was 258 dpm/100 cm^2 using the total efficiency of 0.24 and an instrument background of 250 cpm (Figure D-1). The physical surface area assessed by the gas proportional detector used was 126 cm^2. The beta static MDC for the GM detector was 1,019 dpm/100 cm^2 using the total efficiency of 0.18 and an instrument background of 54 cpm (Figure D-4). The physical surface area assessed by the GM detector used was 20 cm^2.

Removable Activity Measurements

Smear samples for removable gross alpha and gross beta contamination were obtained from biased direct measurement locations based on surface activity measurement results. Removable activity samples were collected using numbered filter paper disks, 47 mm in diameter. Moderate pressure was applied to the smear and approximately 100 cm^2 of the surface was wiped. Smears were placed in labeled envelopes with the location and other pertinent information recorded.

RADIOLOGICAL ANALYSIS

Gross Alpha/Beta

Smears were counted on a low-background gas proportional system for gross alpha and beta activity. The MDCs of the procedure were 11 dpm/100 cm^2 and 14 dpm/100 cm^2 for a 2-minute count time for gross alpha and gross beta, respectively.

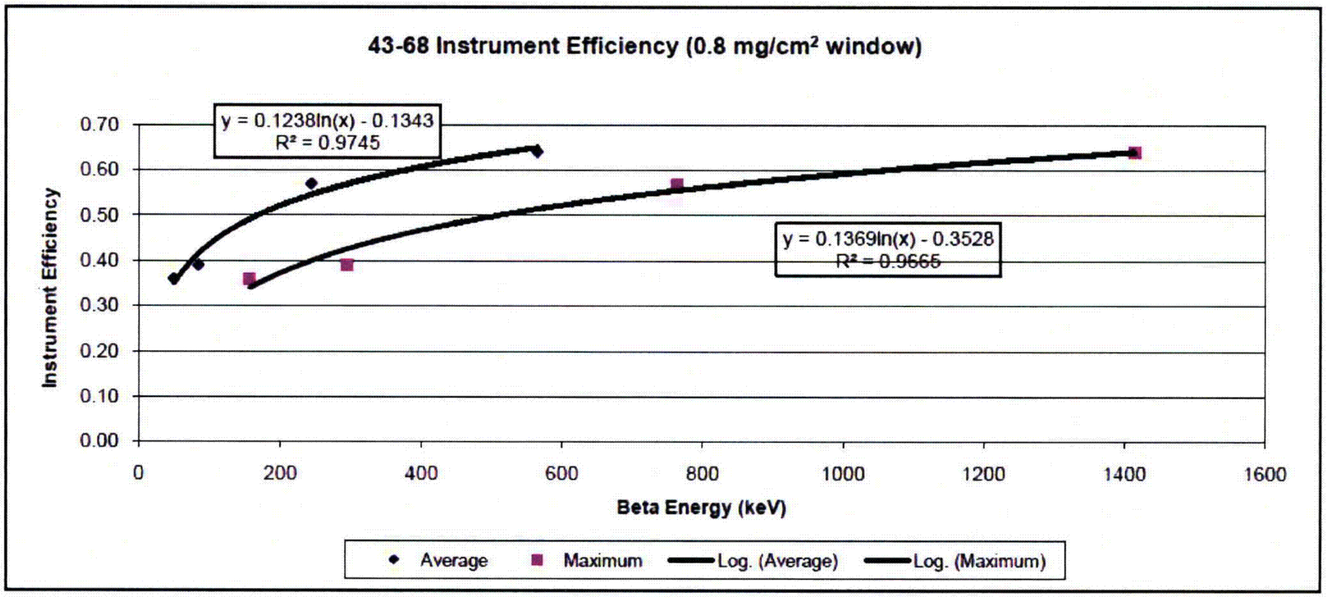
DETECTION LIMITS

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

Task Number:	1695	**SITE: Rancho Seco**	Data Entry

Instrument:	2221 #6	
Detector:	43-68 #6	(0.8 mg/cm2 window)
Site BKG Avg (cpm):	250	

Calibration Data			
Radionuclide	Average Beta Energy (keV)[1]	Maximum Beta Energy (keV)[1]	Instrument Efficiency
C-14	49.47	156.5	0.36
Tc-99	84.6	293.5	0.39
Tl-204	244.03	763.4	0.57
Sr/Y-90[2]	564.75	1413.05	0.64



Radionuclide Mix Calculation						
Radionuclide	Average Beta Energy (keV)[1]	Maximum Beta Energy (keV)[1]	Fraction[3]	Instrument Efficiency[4]	Surface Efficiency	Weighted Efficiency
Cs-137	187	550	0.87	0.51	0.50	0.22
Co-60	96	318	0.13	0.43	0.25	0.01
					Total Efficiency:	0.24
					Static MDC (dpm/100 cm²):	258

[1] http://www.nndc.bnl.gov/nudat2/dec_searchi.jsp

[2] Average and maximum Sr/Y-90 beta energies calculated by adding the average and maximum energies of both radionuclides, respectively, and dividing by two

[3] Fraction based on data provided by SMUD

[4] Calculated using exponential curve shown above for average beta energy

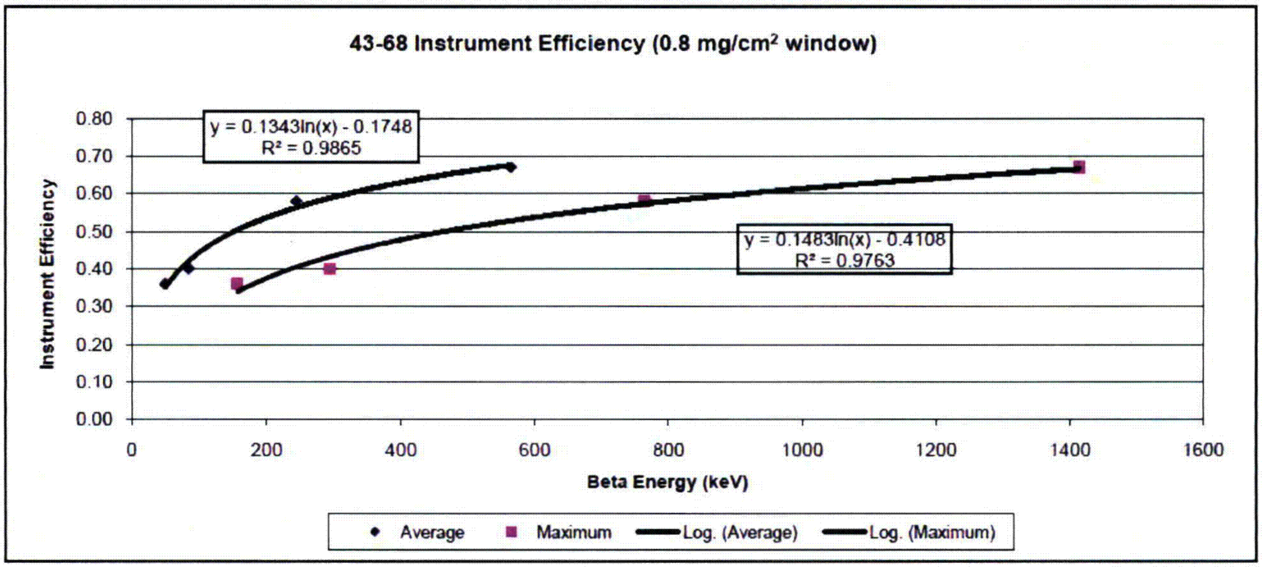
Figure D-1: Multipoint Hand-Held Gas Proportional Detector Static MDC – Instrument #6

Task Number: 1695 SITE: Rancho Seco

Data Entry

Instrument:	2221 #15	
Detector:	43-68 #15	(0.8 mg/cm2 window)
Site BKG Avg (cpm):	271	

Calibration Data			
Radionuclide	Average Beta Energy (keV)[1]	Maximum Beta Energy (keV)[1]	Instrument Efficiency
C-14	49.47	156.5	0.36
Tc-99	84.6	293.5	0.40
Tl-204	244.03	763.4	0.58
Sr/Y-90[2]	564.75	1413.05	0.67



Radionuclide Mix Calculation						
Radionuclide	Average Beta Energy (keV)[1]	Maximum Beta Energy (keV)[1]	Fraction[3]	Instrument Efficiency[4]	Surface Efficiency	Weighted Efficiency
Cs-137	187	550	0.87	0.53	0.50	0.23
Co-60	96	318	0.13	0.44	0.25	0.01
					Total Efficiency:	0.24
					Static MDC (dpm/100 cm²):	258

[1] http://www.nndc.bnl.gov/nudat2/dec_searchi.jsp

[2] Average and maximum Sr/Y-90 beta energies calculated by adding the average and maximum energies of both radionuclides, respectively, and dividing by two

[3] Fraction based on data provided by SMUD

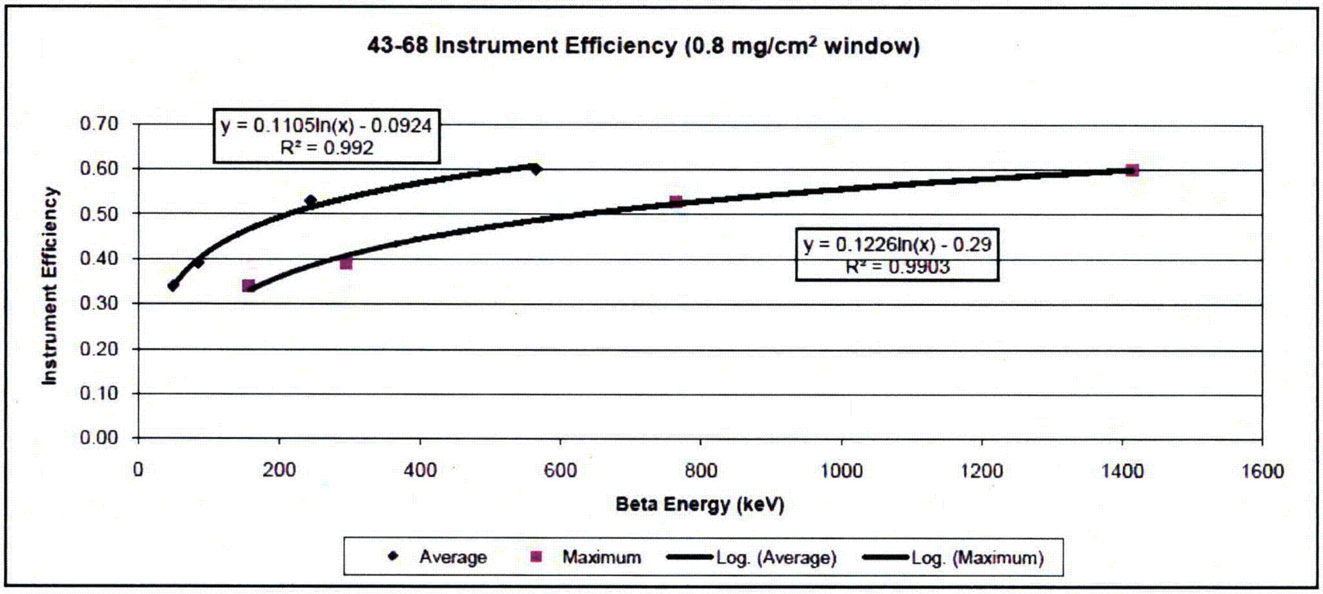
[4] Calculated using exponential curve shown above for average beta energy

Figure D-2: Multipoint Hand-Held Gas Proportional Detector Static MDC – Instrument #15

Task Number:	1695	SITE: Rancho Seco	Data Entry

Instrument:	2221 #5	
Detector:	43-68 #5	(0.8 mg/cm2 window)
Site BKG Avg (cpm):	232	

Calibration Data			
Radionuclide	Average Beta Energy (keV)[1]	Maximum Beta Energy (keV)[1]	Instrument Efficiency
C-14	49.47	156.5	0.34
Tc-99	84.6	293.5	0.39
Tl-204	244.03	763.4	0.53
Sr/Y-90[2]	564.75	1413.05	0.60



Radionuclide Mix Calculation						
Radionuclide	Average Beta Energy (keV)[1]	Maximum Beta Energy (keV)[1]	Fraction[3]	Instrument Efficiency[4]	Surface Efficiency	Weighted Efficiency
Cs-137	187	550	0.87	0.49	0.50	0.21
Co-60	96	318	0.13	0.41	0.25	0.01
					Total Efficiency:	0.23
					Static MDC (dpm/100 cm²):	259

[1] http://www.nndc.bnl.gov/nudat2/dec_searchi.jsp

[2] Average and maximum Sr/Y-90 beta energies calculated by adding the average and maximum energies of both radionuclides, respectively, and dividing by two

[3] Fraction based on data provided by SMUD

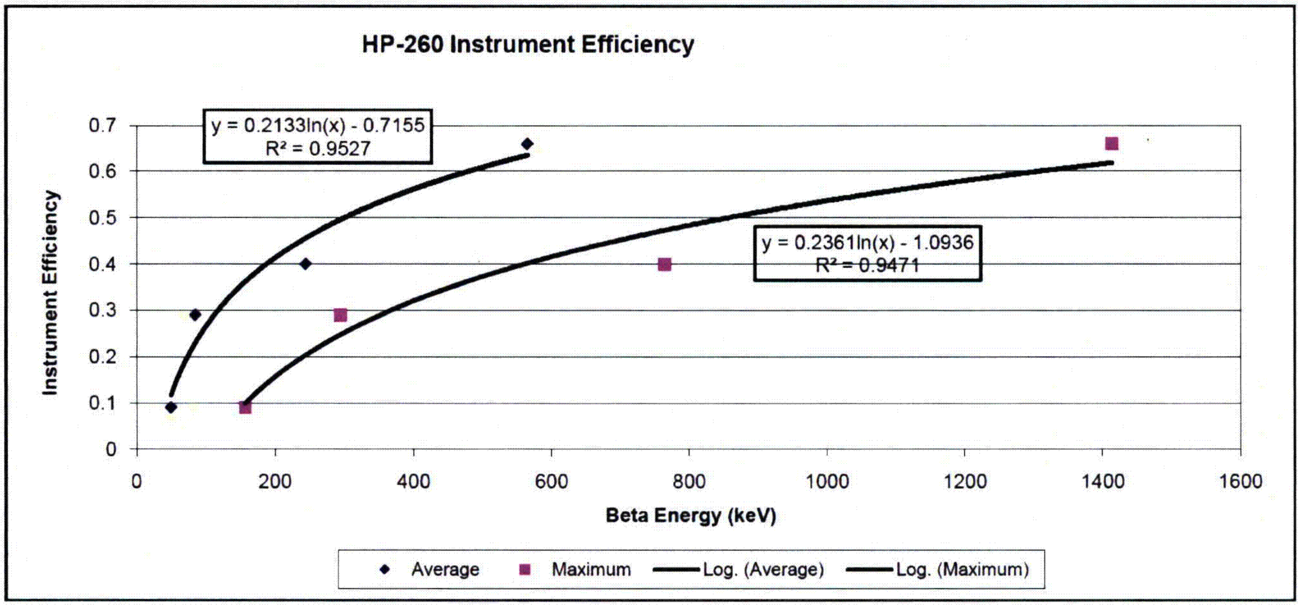
[4] Calculated using exponential curve shown above for average beta energy

Figure D-3: Multipoint Hand-Held Gas Proportional Detector Static MDC – Instrument #5

Task Number:	1695	**SITE: Rancho Seco**	Data Entry

Instrument:	2221 #2
Detector:	HP-260 #2
Cal. BKG Avg (cpm):	54

Calibration Data			
Radionuclide	**Average Beta Energy (keV)**[1]	**Maximum Beta Energy (keV)**[1]	**Instrument Efficiency**
C-14	49.47	156.5	0.09
Tc-99	84.6	293.5	0.29
Tl-204	244.03	763.4	0.40
Sr/Y-90[2]	564.75	1413.05	0.66



Radionuclide Mix Calculation						
Radionuclide	**Average Beta Energy (keV)**[1]	**Maximum Beta Energy (keV)**[1]	**Fraction**[3]	**Instrument Efficiency**[4]	**Surface Efficiency**	**Weighted Efficiency**
Cs-137	187	550	0.87	0.40	0.50	0.17
Co-60	96	318	0.13	0.26	0.25	0.01
					Total Efficiency:	0.18
					Static MDC (dpm/100 cm²):	1,019

[1] http://www.nndc.bnl.gov/nudat2/dec_searchi.jsp

[2] Average and maximum Sr/Y-90 beta energies calculated by adding the average and maximum energies of both radionuclides, respectively, and dividing by two

[3] Fraction based on data provided by SMUD

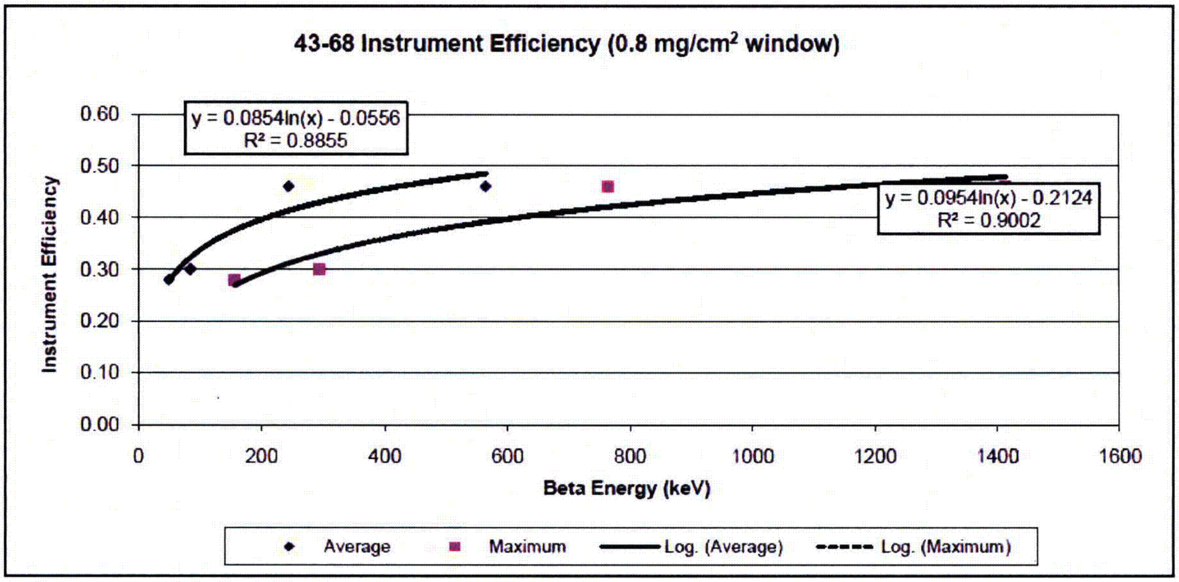
[4] Calculated using exponential curve shown above for average beta energy

Figure D-4: Multipoint Hand-Held Geiger-Mueller Detector Static MDC – Instrument #2

Task Number:	1695	**SITE: Rancho Seco**	Data Entry		
			o_i =	1	sec
Instrument:	2221 #6		Surveyor Eff. =	0.5	--
Detector:	43-68 #6	(0.8 mg/cm2 window)	b_i =	4.2	counts
Cal. BKG Avg (cpm):	250		MDCR =	284	cpm
			$MDCR_{surveyor}$ =	402	cpm

Calibration Data

Radionuclide	Average Beta Energy (keV)[1]	Maximum Beta Energy (keV)[1]	Instrument Efficiency[2]
C-14	49.74	156.5	0.28
Tc-99	84.6	293.5	0.30
Tl-204	244.03	763.4	0.46
Sr/Y-90[3]	564.75	1413.05	0.46



Radionuclide Mix Calculation

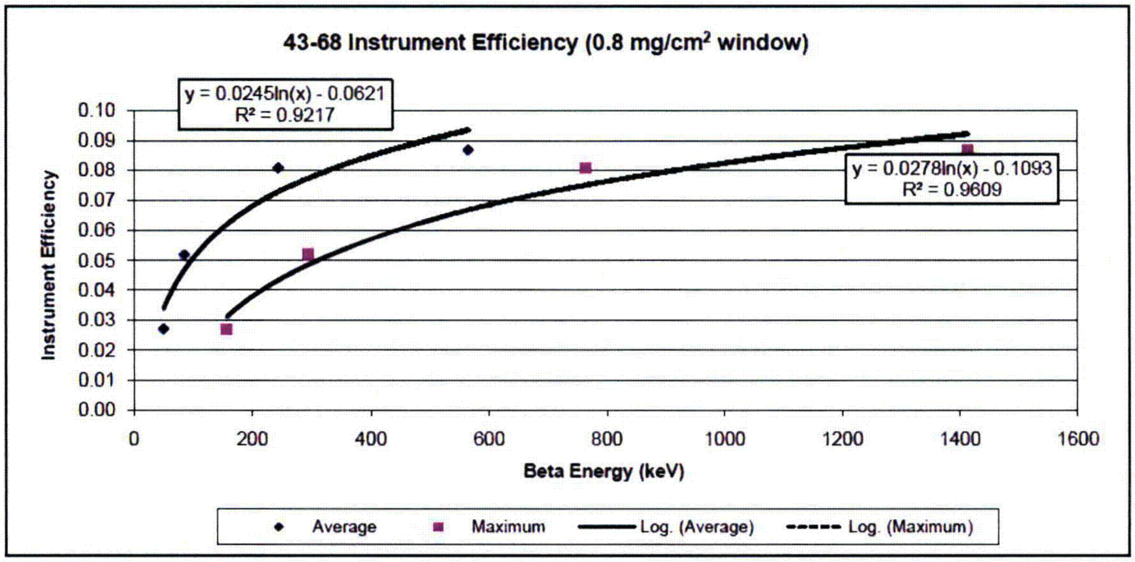
Radionuclide	Average Beta Energy (keV)[1]	Maximum Beta Energy (keV)[1]	Fraction[4]	Instrument Efficiency[5]	Surface Efficiency	Weighted Efficiency
Cs-137	187	550	0.87	0.39	0.50	0.17
Co-60	96	318	0.13	0.33	0.25	0.01
					Total Efficiency:	0.18
					Scan MDC (dpm/100 cm²):	2,228

[1] http://www.nndc.bnl.gov/nudat2/dec_searchi.jsp
[2] Decommissioning Health Physics, Table 9.3
[3] Average and maximum Sr/Y-90 beta energies calculated by adding the average and maximum energies of both radionuclides, respectively, and dividing by two
[4] Fraction based on data provided by SMUD
[5] Calculated using exponential curve shown above for average beta energy

Figure D-5: Multipoint Hand-Held Gas Proportional Detector Scan MDC – Instrument #6

Task Number:	1695	SITE: Rancho Seco	Data Entry		
			o_i =	1	sec
Instrument:	2221 HP#2		Surveyor Eff. =	0.5	--
Detector:	HP-260#2		b_i =	0.9	counts
Cal. BKG Avg (cpm):	54		MDCR =	132	cpm
			$MDCR_{surveyor}$ =	187	cpm

Calibration Data			
Radionuclide	Average Beta Energy (keV)[1]	Maximum Beta Energy (keV)[1]	Instrument Efficiency[2]
C-14	49.74	156.5	0.03
Tc-99	84.6	293.5	0.05
Tl-204	244.03	763.4	0.08
Sr/Y-90[3]	564.75	1413.05	0.09



Radionuclide Mix Calculation						
Radionuclide	Average Beta Energy (keV)[1]	Maximum Beta Energy (keV)[1]	Fraction[4]	Instrument Efficiency[5]	Surface Efficiency	Weighted Efficiency
Cs-137	187	550	0.87	0.07	0.50	0.03
Co-60	96	318	0.13	0.05	0.25	0.00
					Total Efficiency:	0.03
					Scan MDC (dpm/100 cm²):	5,822

[1] http://www.nndc.bnl.gov/nudat2/dec_searchi.jsp

[2] Decommissioning Health Physics, Table 9.1

[3] Average and maximum Sr/Y-90 beta energies calculated by adding the average and maximum energies of both radionuclides, respectively, and dividing by two

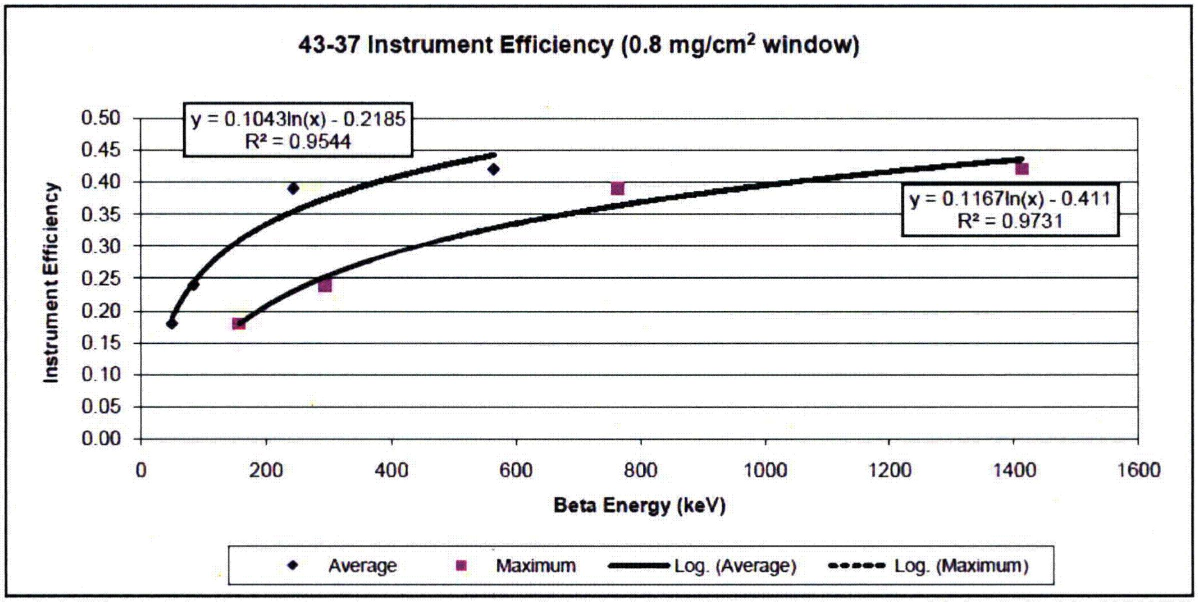
[4] Fraction based on data provided by SMUD

[5] Calculated using exponential curve shown above for average beta energy

Figure D-6: Multipoint Hand-Held Geiger-Mueller Detector Scan MDC – Instrument #2

Task Number:	1695	SITE: Rancho Seco	Data Entry		
			o_i =	1	sec
Instrument:	2221 FM#2		Surveyor Eff. =	0.5	--
Detector:	43-37 #9	(0.8 mg/cm2 window)	b_i =	24.2	counts
Cal. BKG Avg (cpm):	1450		MDCR =	684	cpm
			$MDCR_{surveyor}$ =	968	cpm

Calibration Data			
Radionuclide	Average Beta Energy (keV)[1]	Maximum Beta Energy (keV)[1]	Instrument Efficiency[2]
C-14	49.74	156.5	0.18
Tc-99	84.6	293.5	0.24
Tl-204	244.03	763.4	0.39
Sr/Y-90[3]	564.75	1413.05	0.42



Radionuclide Mix Calculation						
Radionuclide	Average Beta Energy (keV)[1]	Maximum Beta Energy (keV)[1]	Fraction[4]	Instrument Efficiency[5]	Surface Efficiency	Weighted Efficiency
Cs-137	187	550	0.87	0.33	0.50	0.14
Co-60	96	318	0.13	0.26	0.25	0.01
					Total Efficiency:	0.15
					Scan MDC (dpm/100 cm²):	6,367

[1] http://www.nndc.bnl.gov/nudat2/dec_searchi.jsp

[2] Decommissioning Health Physics, Table 9.2

[3] Average and maximum Sr/Y-90 beta energies calculated by adding the average and maximum energies of both radionuclides, respectively, and dividing by two

[4] Fraction based on data provided by SMUD

[5] Calculated using exponential curve shown above for average beta energy

Figure D-7: Multipoint Floor Monitor Gas Proportional Detector Scan MDC – Instrument #2/#9