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OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION

July 21, 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: CONFIRMATORY SURVEY REPORT FOR ACTIVITIES PERFORMED IN THE INDUSTRIAL AREA OF THE RANCHO SECO NUCLEAR GENERATING STATION HERALD, CALIFORNIA DCN 1695-SR-06-0 (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 exterior surfaces and soils within the Industrial Area at the Rancho Seco Nuclear Generating Station in Herald, California on March 10 through 12, 2009. These survey activities were requested and approved by the U.S. Nuclear Regulatory Commission (NRC). Enclosed is the final report that summarizes ORISE's survey procedures and results of the confirmatory surveys. NRC comments on the draft report issued on May 28, 2009 have been incorporated.

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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CONFIRMATORY SURVEY REPORT FOR ACTIVITIES PERFORMED IN THE INDUSTRIAL AREA OF THE RANCHO SECO NUCLEAR GENERATING STATION HERALD, CALIFORNIA

W. C. Adams

Prepared for the
Office of Federal and State Materials and
Environmental Management Programs
U.S. Nuclear Regulatory Commission

ORISE
Oak Ridge Institute for Science and Education

The Oak Ridge Institute for Science and Education (ORISE) is a U.S. Department of Energy facility focusing on scientific initiatives to research health risks from occupational hazards, assess environmental cleanup, respond to radiation medical emergencies, support national security and emergency preparedness, and educate the next generation of scientists. ORISE is managed by Oak Ridge Associated Universities. Established in 1946, ORAU is a consortium of 100 colleges and universities.

NOTICES

CONFIRMATORY SURVEY REPORT
FOR ACTIVITIES PERFORMED IN THE INDUSTRIAL AREA OF THE RANCHO SECO NUCLEAR GENERATING STATION
HERALD, CALIFORNIA

Prepared by

W. C. Adams

Prepared for the

U.S. Nuclear Regulatory Commission

FINAL REPORT

July 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.

Prepared by the Oak Ridge Institute for Science and Education, under interagency agreement (NRC FIN No. F1008) between the U.S. Nuclear Regulatory Commission and the U.S. Department of Energy.

CONFIRMATORY SURVEY REPORT
FOR ACTIVITIES PERFORMED IN THE INDUSTRIAL AREA OF THE
RANCHO SECO NUCLEAR GENERATING STATION
HERALD, CALIFORNIA

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ACKNOWLEDGMENTS

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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
C-14	carbon-14
cm	centimeter
cm^2	square centimeter
Co-60	cobalt-60
COC	contaminants of concern
cpm	counts per minute
Cs-137	cesium-137
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
GPS	global positioning system
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
m^2	square meters
mg	milligram
MAPEP	Mixed Analyte Performance Evaluation Program
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	minimum detectable concentration
MDCR	minimum detectable count rate
MeV	million electron volts
mrem/yr	millirem per year
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
ORISE	Oak Ridge Institute for Science and Education

ABBREVIATIONS AND ACRONYMS (continued)

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

CONFIRMATORY SURVEY REPORT
FOR ACTIVITIES PERFORMED IN THE INDUSTRIAL AREA OF THE 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 electric (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 10 CFR 50.82 (a) (4), in March 1997. SMUD began decommissioning activities in February 1997 and completed transfer of all the spent nuclear fuel in August 2002.

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

The NRC's Headquarters and Region IV Offices requested that the Oak Ridge Institute for Science and Education (ORISE) perform confirmatory surveys of structural surface and soil survey units (SU) in the Industrial Area exterior surfaces at the RSNGS (Figures A-1 and A-2). The confirmatory surveys were performed during the period of March 10 through 12, 2009.

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. A 30-acre gas-fired power plant is located approximately 0.5 miles south of the Industrial Area boundary. The site also contains the 560-acre Rancho Seco Reservoir and Recreation Area, a 50-acre solar powered 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 2007, 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 DQOs for unrestricted release.

In March 2009, ORISE conducted radiological confirmatory survey activities of the exterior structural and soil surfaces in the immediate vicinity of the Industrial Area of the RSNGS. Confirmatory surveys included beta and gamma surface scans, direct measurements for total net beta activity, and soil sampling. Locations of elevated direct radiation that potentially exceeded the derived concentration guideline levels (DCGLs) were marked for further investigation. In addition, since SMUD also collected subsurface soil samples, ORISE requested archived subsurface soil samples for interlaboratory comparison analyses.

Confirmatory surveys were performed in accordance with a site-specific survey plan that was submitted to and approved by the NRC (ORISE 2007). The site-specific survey plan followed the guidance provided in the ORISE Survey Procedures and the Oak Ridge Associated Universities (ORAU) Quality Program Manuals (ORISE 2008 and ORAU 2009).

Based on the preliminary FSS data results, ORISE judgmentally selected several survey units for confirmatory surveys. ORISE performed confirmatory surveys on up to 100% of the selected survey units. Confirmatory survey activities on structural and soil surfaces were performed within the following survey units at RSNGS:

TABLE 1: ORISE CONFIRMATORY SURVEY AREAS		
Survey Unit	**Survey Unit Description**	**Classification**
F8000105	Industrial Area, North/South Roadway	2
F8080031	Cooling Tower Buffer	2
F8080032	Cooling Tower Buffer	2
F8080033	Cooling Tower Buffer	2
F8100011	Southwest Tank Farm	1
F8100021	Northwest Tank Farm	1
F8100031	Northeast Tank Farm	1
F8100041	Tank Farm, Condensate Storage Tank (CST) Pad	1
F8100042	Tank Farm, Demin RC Storage Tank (DRCST) Pad	2
F8100043	Tank Farm, Borated Water Storage Tank (BWST) Pad	1
F8100044	Tank Farm, Tritium Evaporator Pad	2
F8100052	Trench 1 East Surface	1
F8340012	Industrial Area Railway	2
F8370001	Auxiliary Boiler Pad and RHUT Land Areas	1

REFERENCE SYSTEM

Measurements and sampling locations were referenced to the existing RSNGS grid system and/or on RSNGS provided figures. For ORISE soil samples, global positioning system (GPS) coordinates were used for referencing measurement and sampling locations. The specific reference system used was the California State Plane Coordinate System (SPCS Zone 4202 US Survey Feet).

SURFACE SCANS

High density gamma radiation surface scans were conducted over the Class 1 SUs and medium to high density gamma scans were conducted over all Class 2 SUs. Limited (very low density) gamma surface scans were performed for the remaining Industrial Area walkover surveys which consisted of judgmental scans concentrating on transport routes deemed more likely to be susceptible to discrete particles findings (Refer to Table 2). Gamma surface scans were performed using sodium iodide (thallium-activated) [NaI(Tl)] scintillation detectors coupled to ratemeters or ratemeter-scalers with audible indicators. During some surface scans, the detectors were also coupled to GPS systems that enabled real-time gamma count rate and position data capture. Gamma scan walkover paths, for SUs where GPS systems were used, are presented in Figures A-3 through A-6 and A-12 through A-15. ORISE also performed beta radiation surface scans on some of the concrete/asphalt surfaces with a large area gas proportional detector that was also coupled to a GPS system. Beta scan walkover paths, for SUs where GPS systems were used, are presented in Figures A-7 through A-11.

Scan coverage percentage was based upon the SU classification and increased or decreased depending upon findings as the survey progressed and project time constraints.

TABLE 2:
SCAN DENSITY/PERCENTAGE (%) FOR RSNGS SU CLASSIFICATIONS

Class 1	High Density	50 to 100 %
Class 2	Medium Density	10 to 50 %
Class 3	Low Density	5 to 10 %
Remaining Industrial Areas	Very Low Density	Up to 5 %

Table B-2 provides the scan percent coverage for each SU. During the surface scans, particular attention was given to cracks and joints in the surfaces, exposed concrete surfaces, and other locations where material may have accumulated. Field personnel relied on the audio output to identify and mark for further investigations any locations of elevated direct gamma and/or beta radiation that might suggest the presence of residual contamination. All detectors were coupled to ratemeters or ratemeter-scalers with audible indicators.

SURFACE ACTIVITY MEASUREMENTS

Based on beta and gamma surface scan results, direct measurements for beta activity were performed at 31 judgmentally-selected locations on the evaluated structural surfaces within the exterior area asphalt or concrete surfaces. Direct measurements were performed in eight SUs using hand-held gas proportional detectors coupled to ratemeter-scalers. Dry smears, for determining removable gross alpha and beta activity, were not collected from the exterior surfaces as they were deemed not necessary (all fixed direct measurement results for beta activity were less than 10% of the DCGL). Direct measurement locations are indicated on Figures A-16 through A-23.

Soil Sampling

ORISE collected judgmental surface (0 to 15 cm) soil samples from seven locations exhibiting elevated gamma radiation during gamma scans or at locations based on visual observations. ORISE also collected a sediment sample (Figure A-24; S0024) from a storm drain in SU F8000105, the Industrial Area North/South Roadway. Figure A-24 shows the soil and sediment sample locations.

Several of the SMUD SUs consisted of subsurface soils. ORISE requested and received, with NRC approval, ten judgmental subsurface soil samples from the SMUD archived soils. ORISE selected these samples based on SMUDs preliminary soil sample results.

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 2009). Soil and sediment samples were analyzed by gamma spectroscopy for Co-60 and Cs-137. The spectra were also reviewed for other identifiable photopeaks. Soil and sediment sample results were reported in units of picocuries per gram (pCi/g). Direct measurements for total surface activity were converted to units of disintegrations per minute per 100 square centimeters (dpm/100 cm^2).

The primary COCs for the RSNGS were Cs-137 and Co-60. 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 data generated were compared with the licensee's gross beta (for structural surfaces) and soil DCGLs for each specific SU where confirmatory surveys were performed. 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

The surface scanning results for structural and soil surfaces are discussed independently below.

Structural Surface Beta Activity Count Rates

Beta surface scans did not identify any locations of elevated surface beta radiation attributable to site contaminants. Structural surface beta scan count rates generally ranged from approximately 1,700 to 3,400 counts per minute (cpm) with the variability in the ambient beta radiation levels consistent with the localized structural surface material type and the respective beta detectors that were used during the survey activities (Table 3). Beta scan results are illustrated in Figures A-7 through A-11 for each area where the GPS units were used. Beta scan rate data are provided as the gross, observed count rates.

TABLE 3: SUMMARY RESULTS FOR BETA SCAN MEASUREMENTS OF STRUCTURAL SURFACES

Survey Unit	Survey Unit Description	Minimum Gross Count Rate (cpm)	Maximum Gross Count Rate (cpm)
F8080033	Cooling Tower Buffer, East	<1,900	3,400
F8100041	Tank Farm, CST Pad	<1,800	3,100
F8100042	Tank Farm, DRCST Pad	<1,700	2,300
F8100043	Tank Farm, BWST Pad	<1,900	2,600
F8100044	Tank Farm, Tritium Evaporation Pad	<1,700	2,300

Structural and Soil Surface Gamma Activity Count Rates

Gamma surface scans, on the Exterior Area grounds within the Industrial Area, identified three discrete particles on the soil surfaces within SUs F8100021 and F8100031. NRC and SMUD personnel were notified and the discrete particles were removed by SMUD personnel.

With the exception of the discrete particle locations, soil and structural surface gamma scan count rates generally ranged from approximately <1,600 to 15,000 cpm with the variability in the ambient gamma radiation levels consistent with the localized structural or soil surface material type and the respective gamma detectors that were used during the survey activities (Table 4). Gamma scan results are illustrated in Figures A-3 through A-6 and A-12 through A-15 for each area where the GPS units were used; for SUs were GPS data tracking was not available, gamma scan ranges were from 3,000 to 6,000 cpm. Gamma scan rate data is provided as the gross, observed count rates. The elevated gamma radiation levels at the west end of the Industrial Area Railway were due to the gamma radiation levels associated with the ISFSI.

TABLE 4
SUMMARY RESULTS FOR GAMMA SCAN MEASUREMENTS ON STRUCTURAL AND SOIL SURFACES

Survey Unit	Survey Unit Description	Minimum Gross Count Rate (cpm)	Maximum Gross Count Rate (cpm)
F8000105	Industrial Area Central Yard	<3,100	4,800
F8080031	Cooling Tower Buffer	<3,200	13,000
F8030032	Cooling Tower Buffer, West	<3,900	6,300
F8030033	Cooling Tower Buffer, East	<1,600	15,000
F8100052	Trench 1, East Surface	<3,700	4,800
F8340012	Industrial Area Railway	<2,000	11,600
F8370001	Auxiliary Boiler Pad and RHUT Land Areas	<3,200	5,700
Industrial Area	Remaining Industrial Area Soils	<2,500	5,500

SURFACE ACTIVITY LEVELS

Total beta activity measurements ranged from 350 to 4,400 dpm/100 cm^2. Surface activity measurements are documented in Table B-3.

SOIL SAMPLES

Based on gamma scans results, ORISE found discrete particles at three locations within SUs F8100021 and F8100031 and notified NRC and SMUD personnel. SMUD personnel removed the discrete particles and ORISE collected split soil samples from these three location. The soil samples collected by SMUD personnel from these locations of elevated residual gamma radiation were analyzed onsite by SMUD personnel. SMUD's analyses indicated that the samples contained discrete particles of Co-60 and/or Cs-137. In an email dated March 25, 2009[1], the NRC requested that SMUD perform an evaluation of the significance of the discrete particles found by ORISE and that SMUD personnel perform a gamma walkover resurvey of the transport routes and all outdoor Class 1 areas.

Soil sample concentrations from the ORISE collected soil samples ranged from -0.03 to 0.28 pCi/g for Co-60 and 0.00 to 6.41 pCi/g for Cs-137. Subsurface soil sample concentrations, for samples collected by SMUD, ranged from -0.01 to 0.43 pCi/g for Co-60 and 0.01 to 39.4 pCi/g for Cs-137. Individual soil sample concentrations are documented in Table B-4.

COMPARISON OF RESULTS WITH SITE RELEASE CRITERIA

Confirmatory survey data for structural surfaces were compared with the structural site-specific DCGL for the evaluated SUs. None of the 31 direct beta activity measurement results on the selected survey units had structural surface activity levels that exceeded the gross beta DCGL of 43,000 dpm/100 cm^2. All confirmatory direct surface activity measurements on the structural surfaces in the evaluated SUs were well below the site-specific DCGLs as provided by SMUD in the preliminary FSS data packages.

Confirmatory survey data for soil surfaces were compared with the soil site-specific DCGL for the evaluated SUs. None of the 18 soil sample results for the survey units had soil concentrations that exceeded the surrogate soil DCGL of 51.2 pCi/g for Cs-137. All confirmatory soil concentrations in the evaluated SUs were within the site-specific SU DCGL as provided by SMUD in the preliminary FSS data packages.

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[1] Electronic mail from J. Hickman (NRC-HQ) to E. Ronningen (SMUD). Subject: Discrete Particle Issues. March 25, 2009.

CONCLUSION

During the period of March 10 through 12, 2009, ORISE performed confirmatory radiological survey activities which included beta and gamma surface scans, beta activity direct measurements, and soil sampling on Exterior Area grounds within the Industrial Area (Figure A-2) at the RSNGS.

Beta and gamma surface scans of the selected structural surfaces did not identify any locations of elevated radiation. However, gamma soil surface scans identified several areas exhibiting elevated gamma radiation. Additional investigations of these locations indicated three discrete particles within the surface soil in SUs F8100021 (Northwest Tank Farm) and F8100031 (Northeast Tank Farm). SMUD personnel remediated these locations and initiated a Potential Deviation from Quality report concerning the discrete particle findings by ORISE. Based on the discrete particle findings, the confirmatory survey results for two of the evaluated surface soil SUs (F8100021 and F8100031) were not in agreement with the radiological status of these SUs as presented in the licensee's preliminary FSS data packages. The NRC has tasked the licensee with performing additional evaluations of the significance of the discrete particles found by ORISE and with performing a gamma walkover resurvey of the transport routes and all outdoor Class 1 areas.

Direct measurements for gross beta activity were performed at 31 locations, none of which exceeded the site-specific gross beta DCGL. The confirmatory survey results for the evaluated structural surface SUs were in agreement with the radiological status of these SUs as presented in the licensee's preliminary FSS data packages.

REFERENCES

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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, 2007.

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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

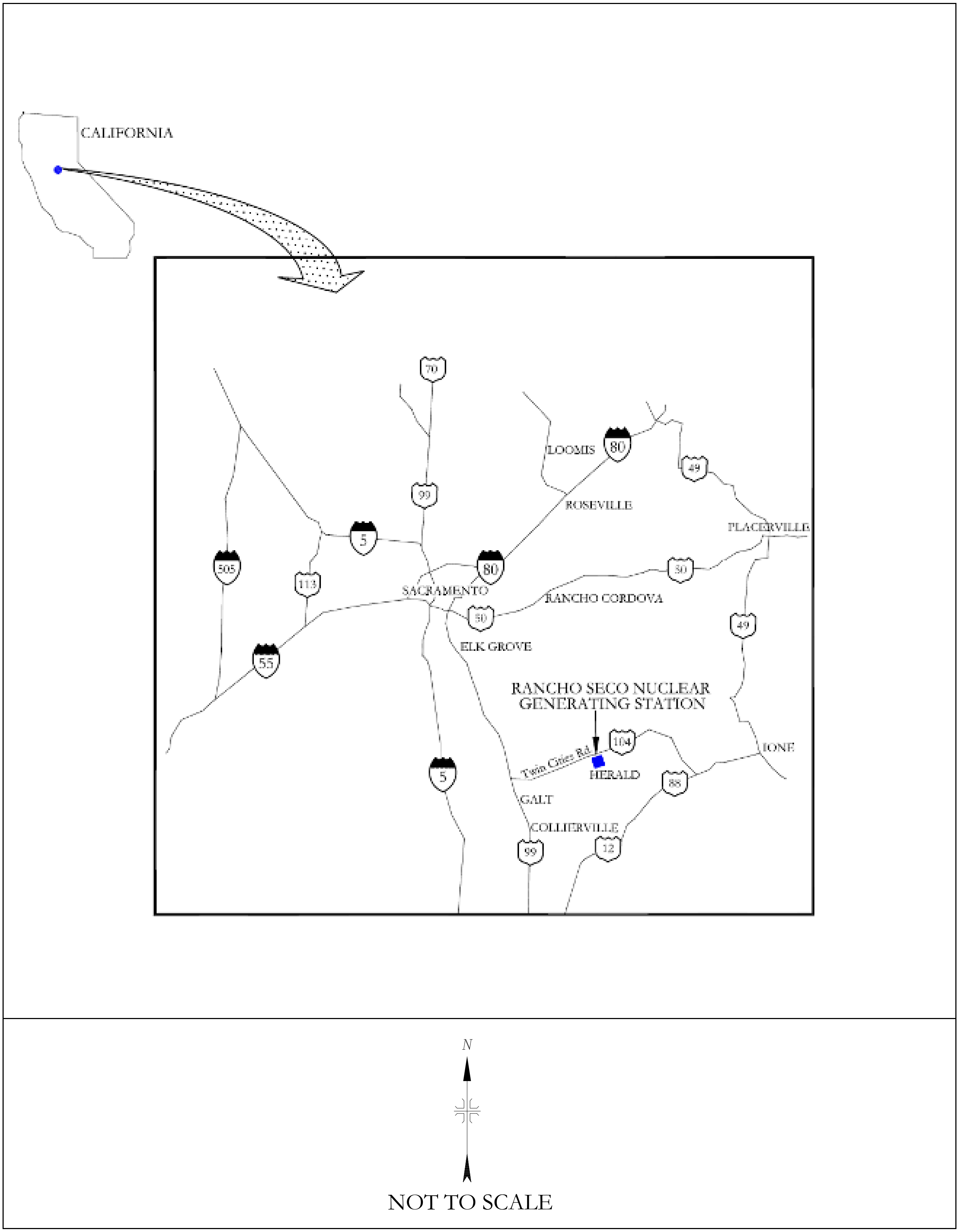

Figure A-1: Location of Rancho Seco Nuclear Generating Station, Herald, California

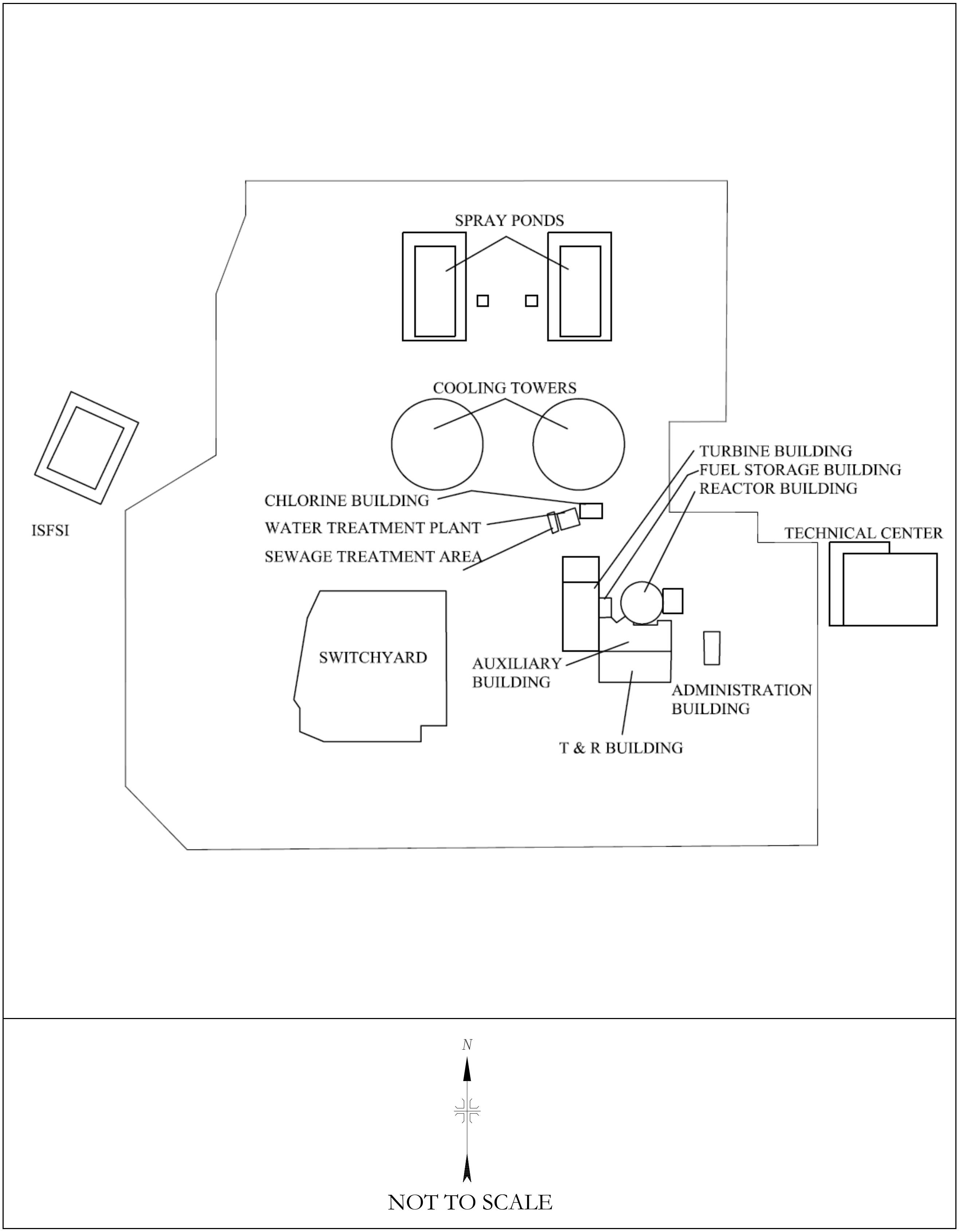

Figure A-2: Plot Plan of the Industrial Area at Rancho Seco Nuclear Generating Station

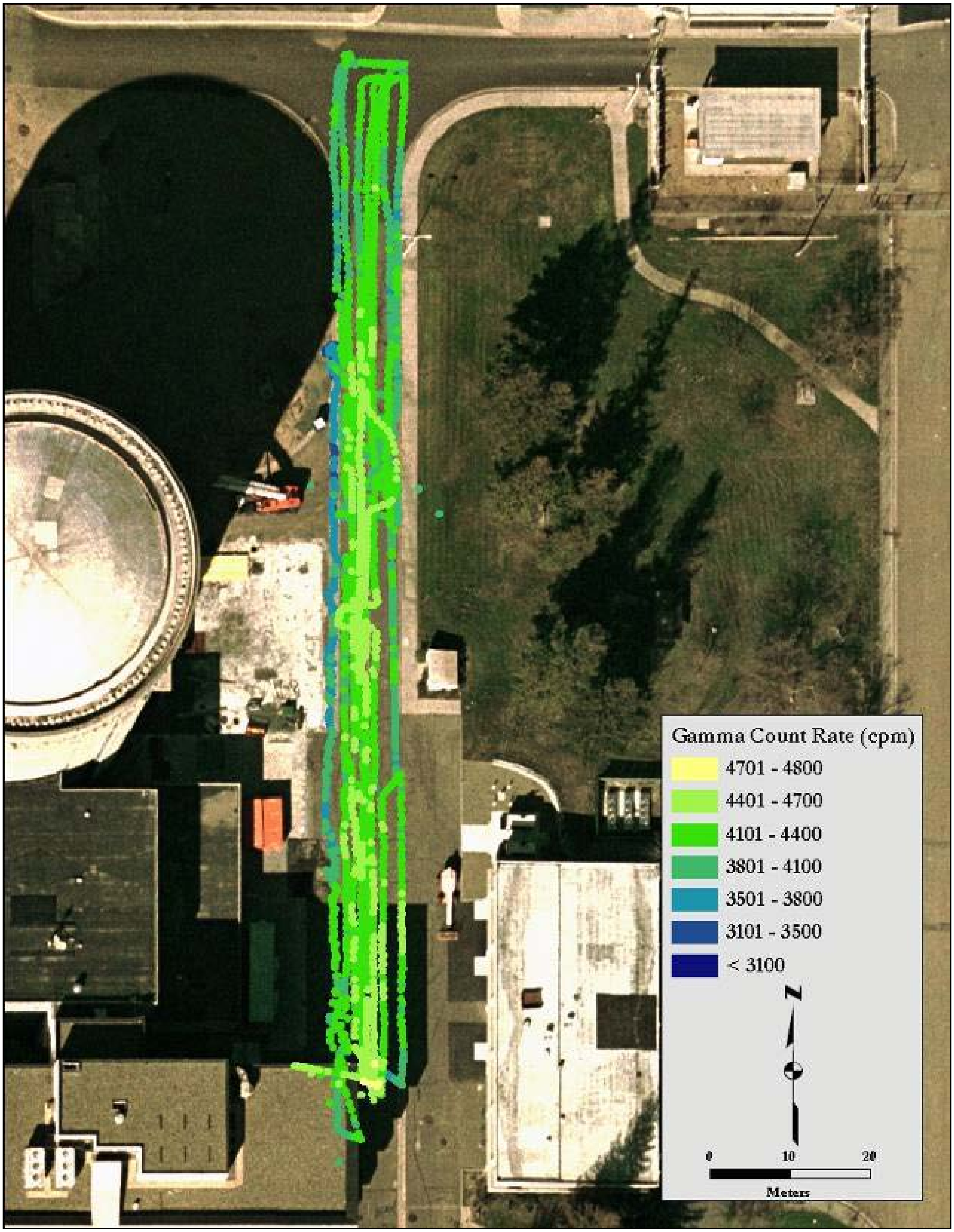

Figure A-3: Survey Unit F8000105, Industrial Area Central Yard - Gamma Surface Scans

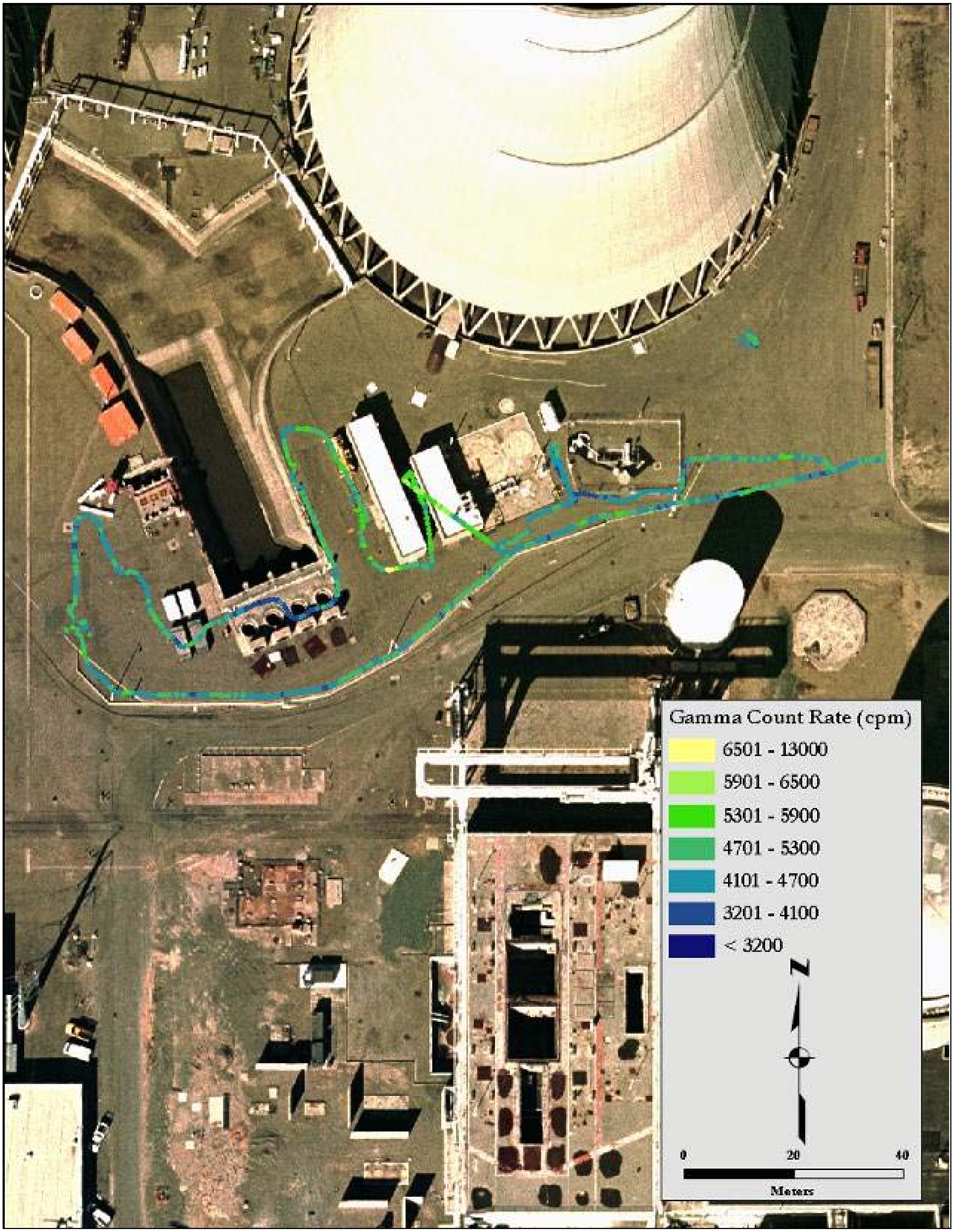

Figure A-4: Survey Unit F8080031, Cooling Tower Buffer, South - Gamma Surface Scans

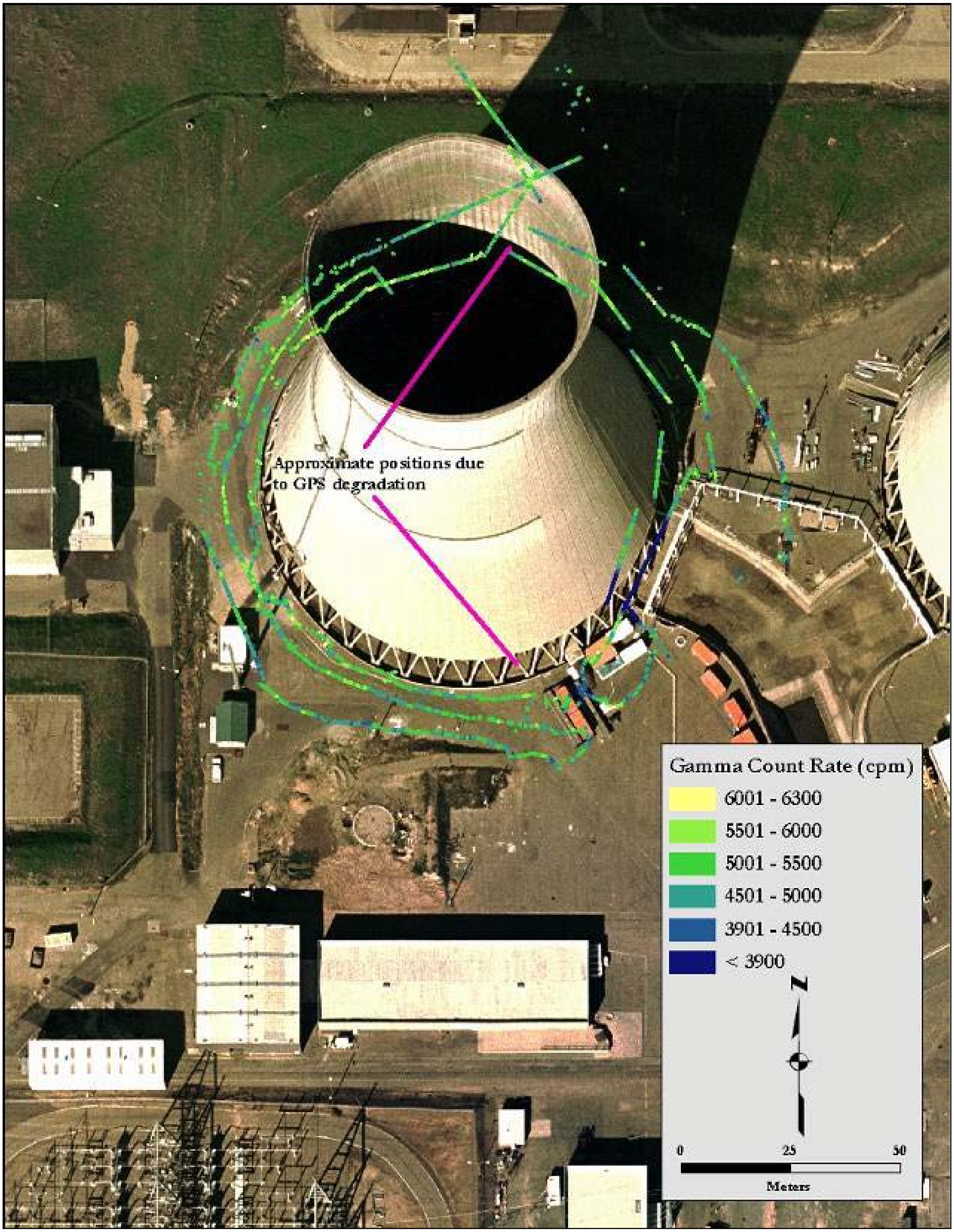

Figure A-5: Survey Unit F8080032, Cooling Tower Buffer, West - Gamma Surface Scans

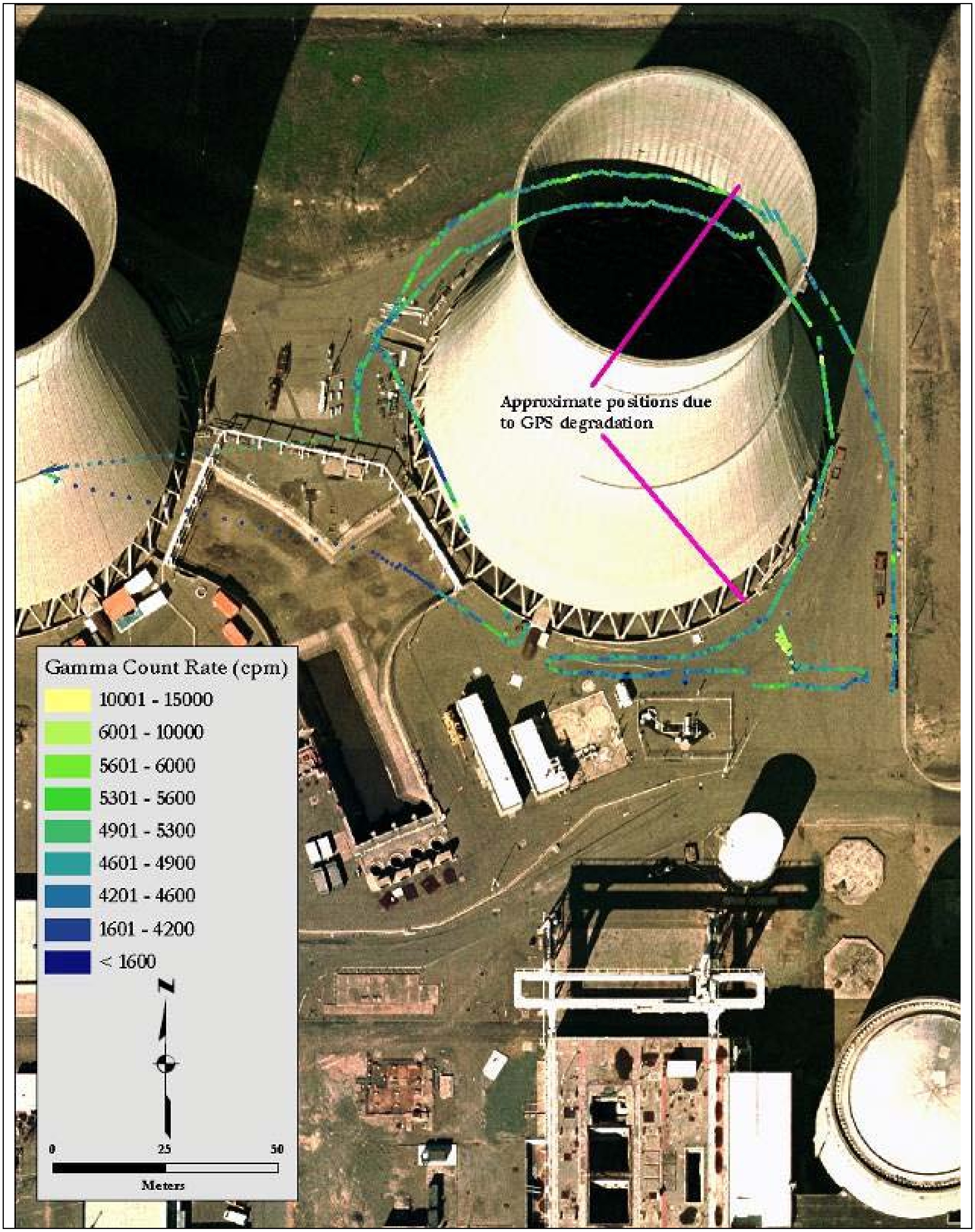

Figure A-6: Survey Unit F8080033, Cooling Tower Buffer, East - Gamma Surface Scans

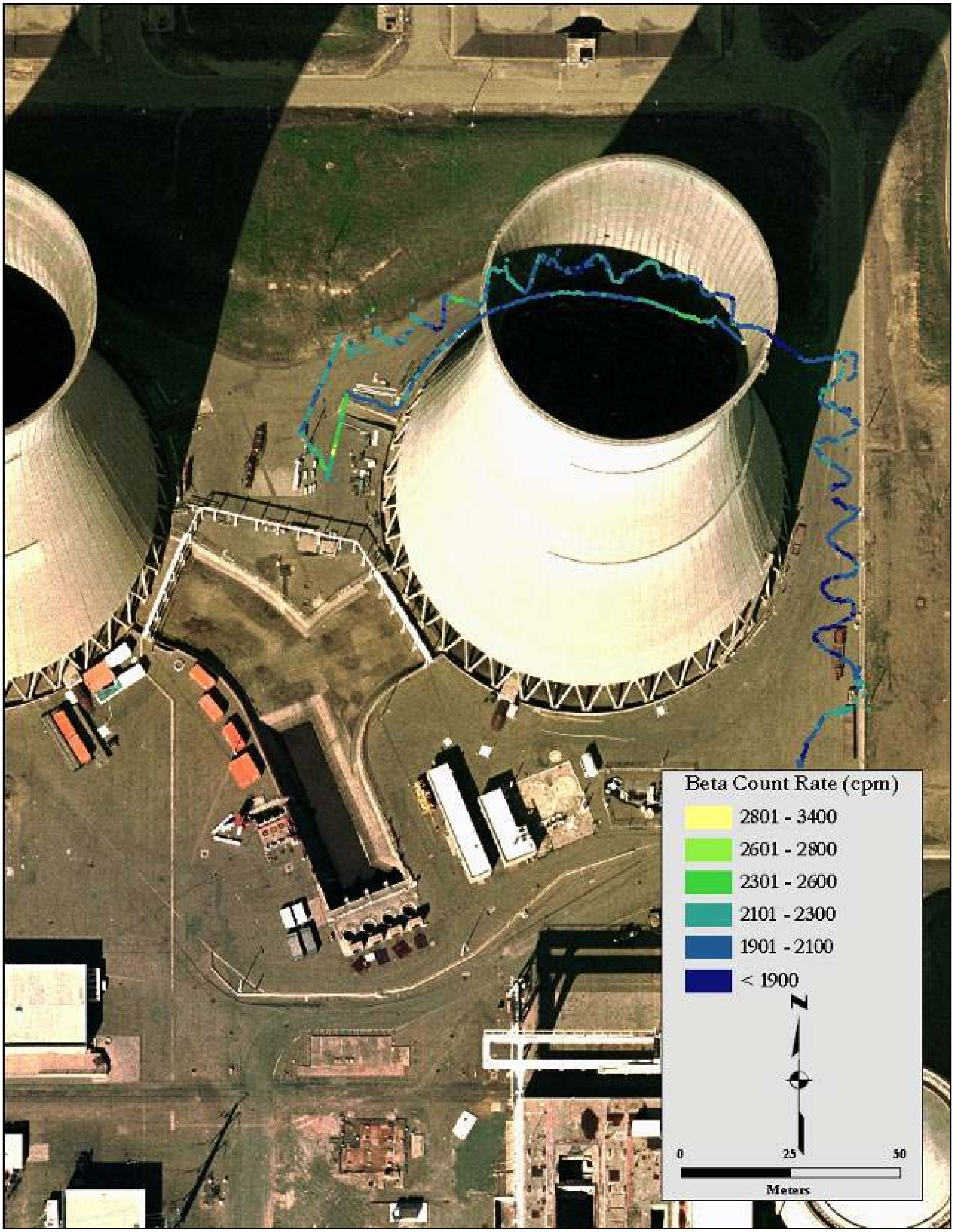

Figure A-7: Survey Unit F8080033, Cooling Tower Buffer, East - Beta Surface Scans

Figure A-8: Survey Unit F8100041, Tank Farm, CST Pad – Beta Surface Scans

Figure A-9: Survey Unit F8100042, Tank Farm, DRCST Pad – Beta Surface Scans

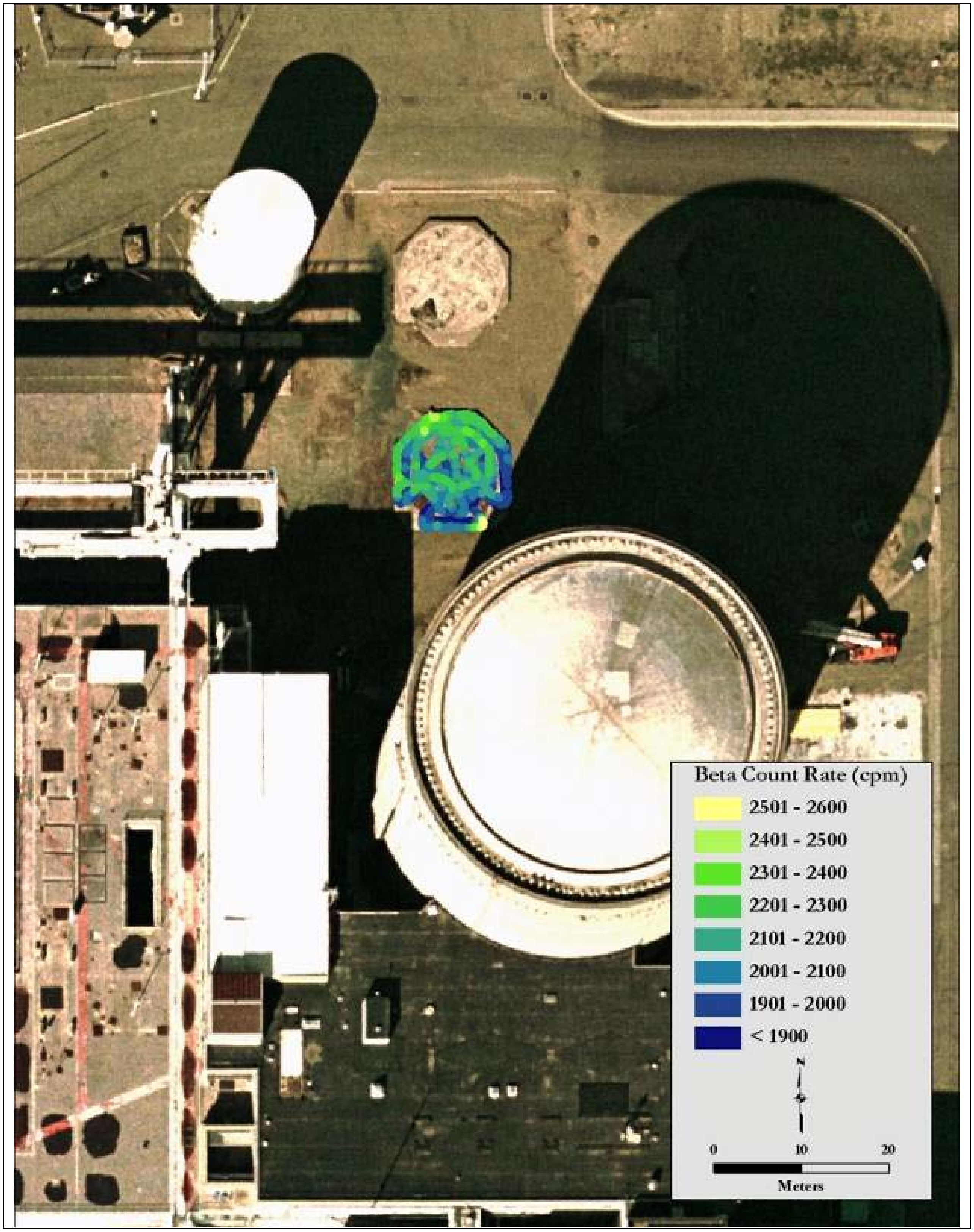

Figure A-10: Survey Unit F8100043, Tank Farm, BWST Pad – Beta Surface Scans

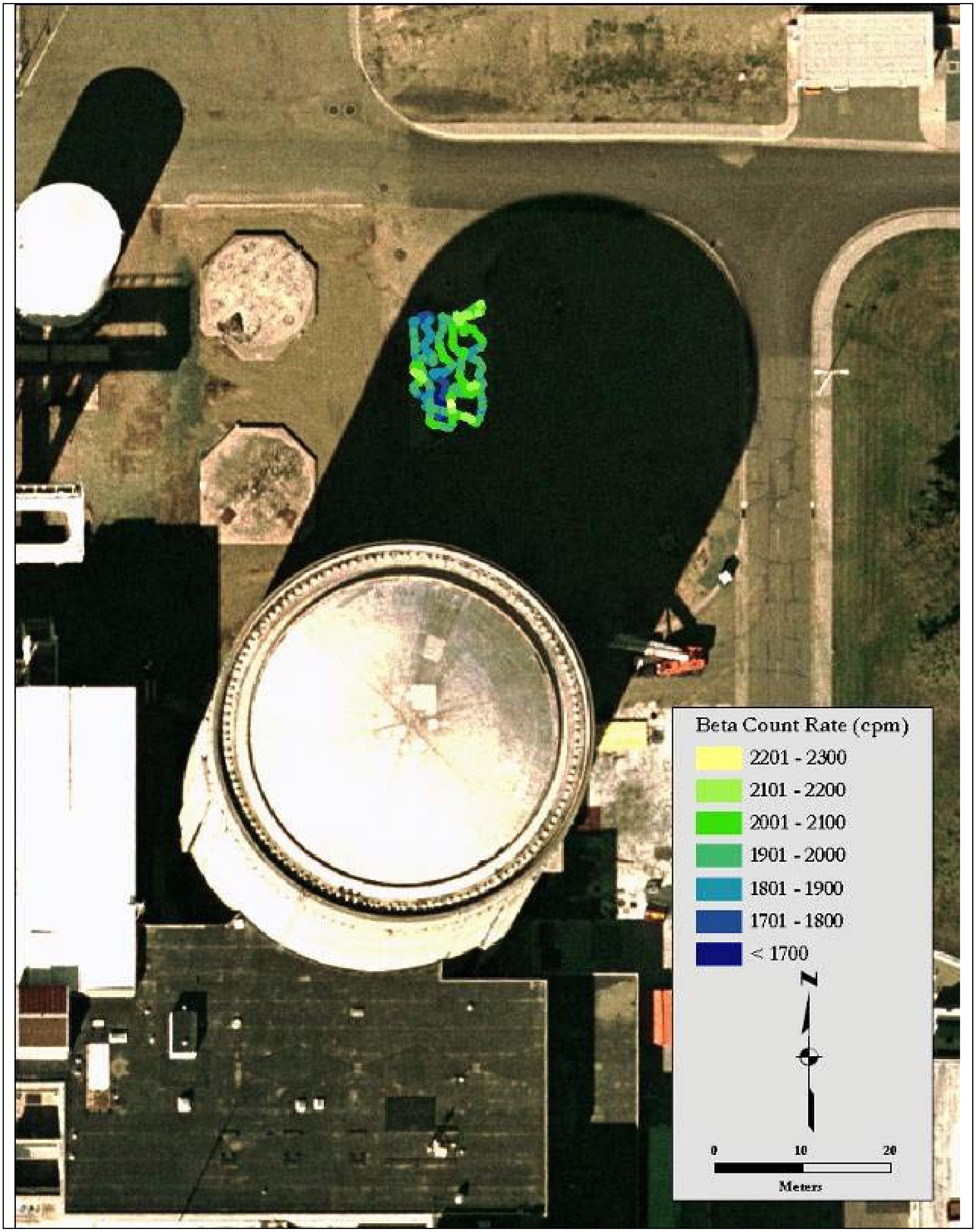

Figure A-11: Survey Unit F8100044, Tank Farm, Tritium Evaporation Pad – Beta Surface Scans

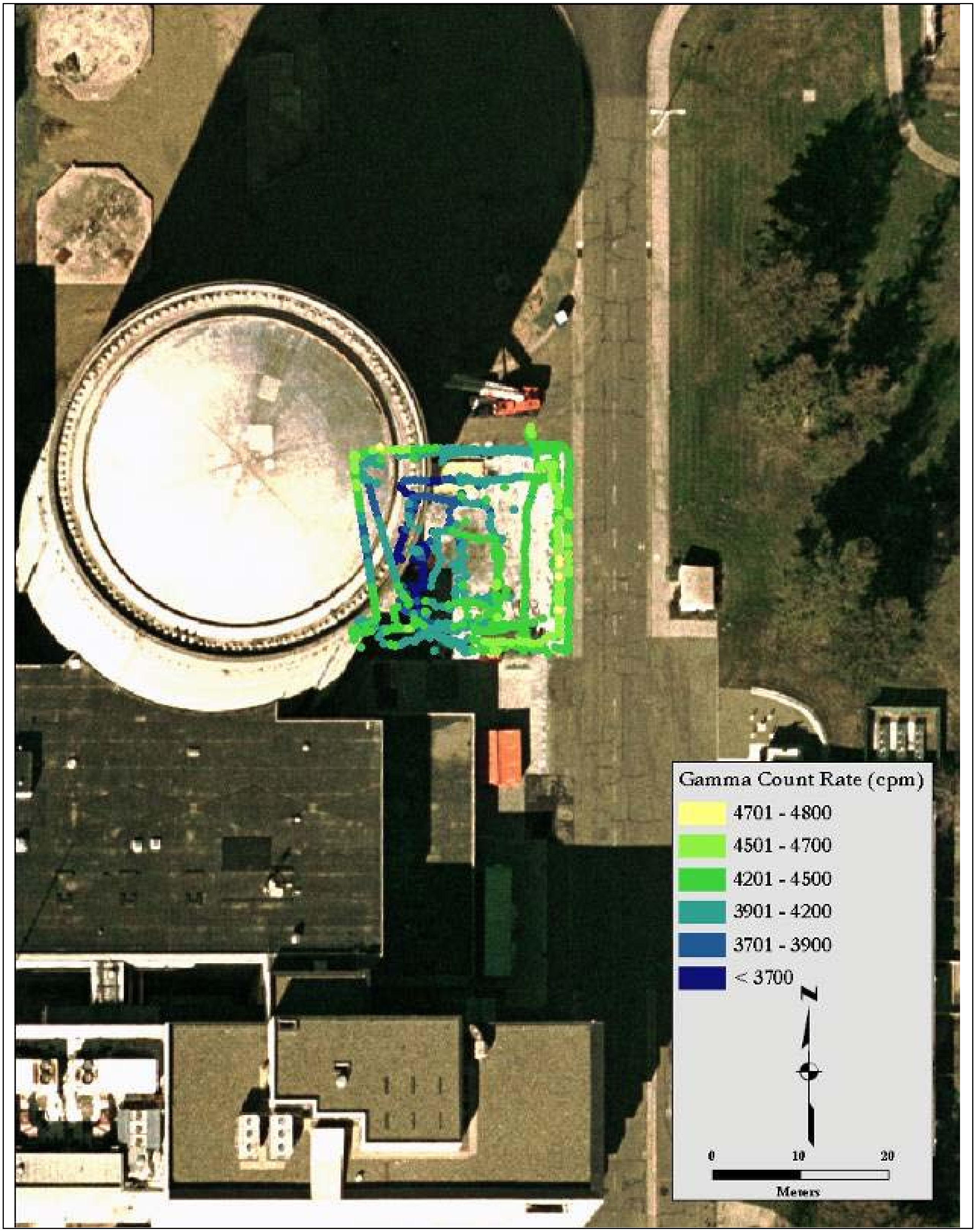

Figure A-12: Survey Unit F8100052, Trench 1, East Surface – Gamma Surface Scans

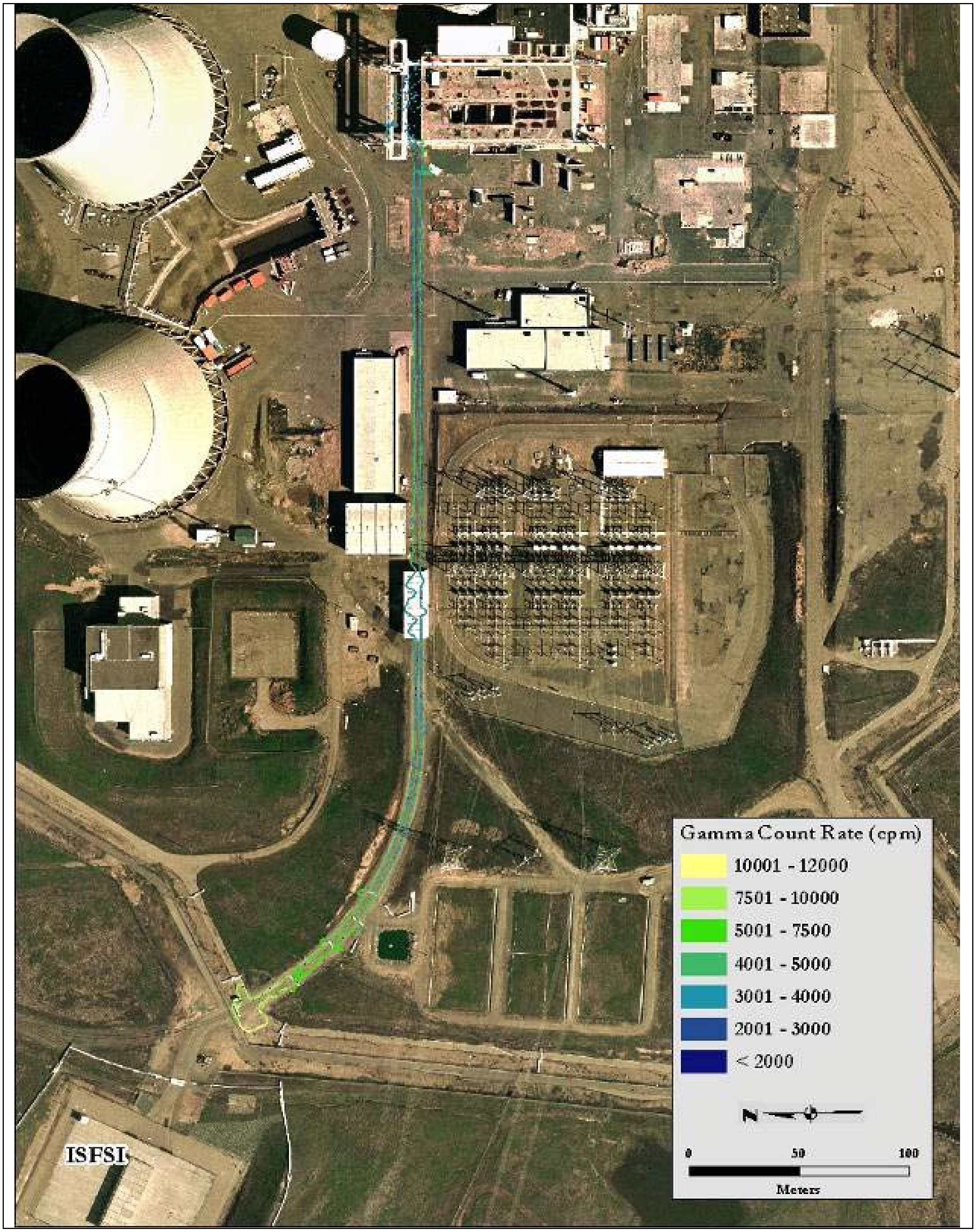

Figure A-13: Survey Unit F8340012, Industrial Area Railway – Gamma Surface Scans

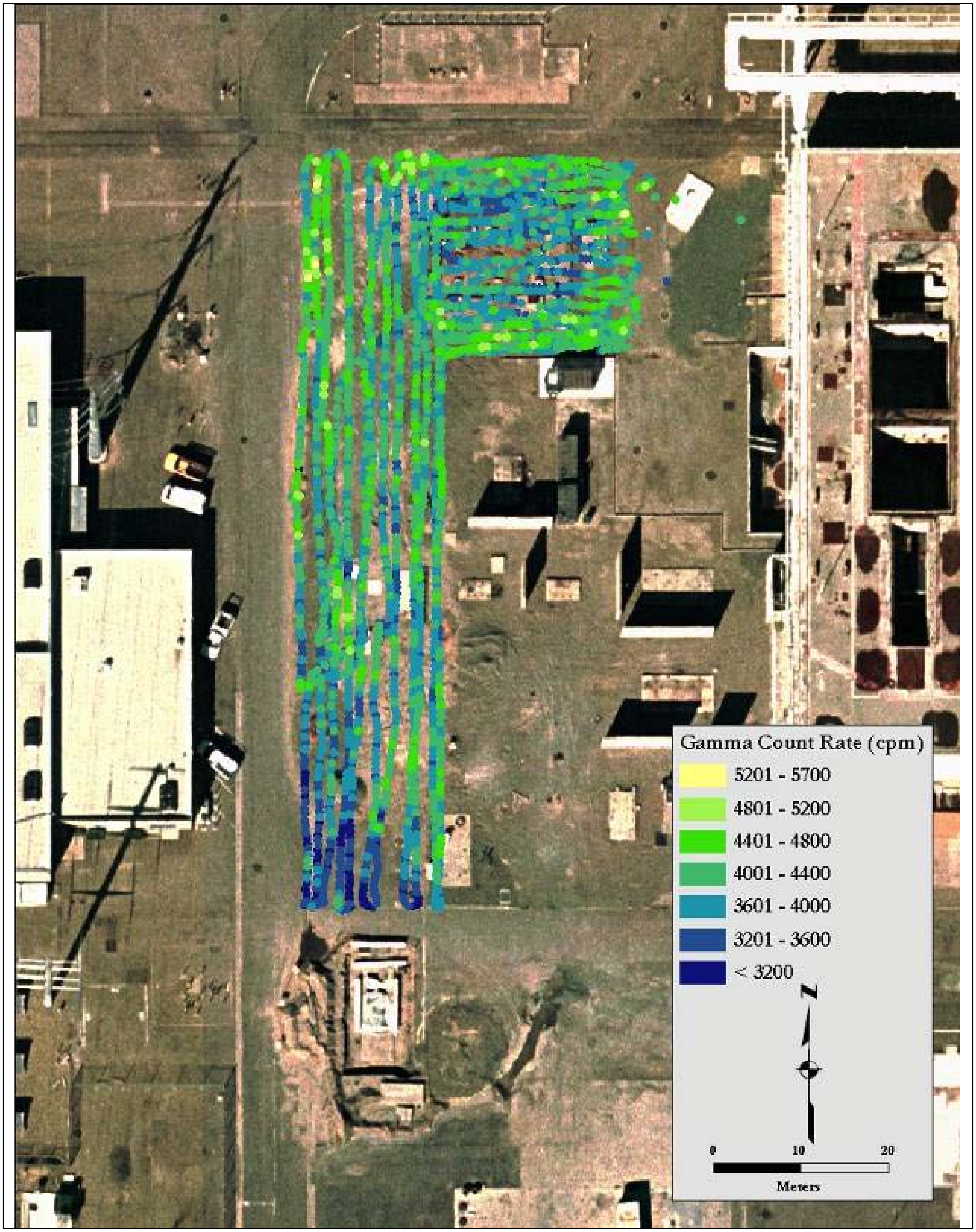

Figure A-14: Survey Unit F8370001, Auxiliary Boiler Pad and RHUT Land Areas – Gamma Surface Scans

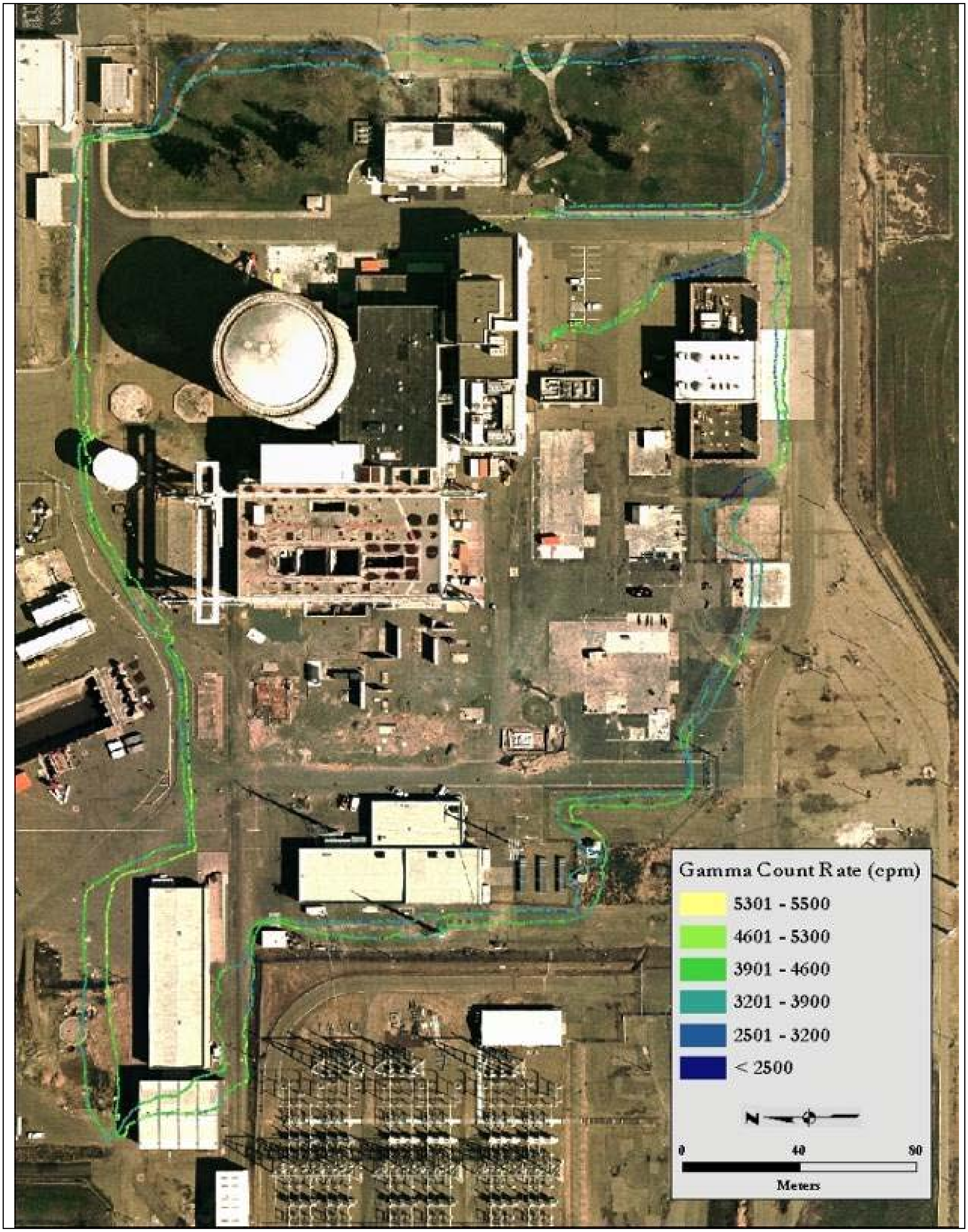

Figure A-15: Rancho Seco Nuclear Generating Station – Judgmental Gamma Surface Scans

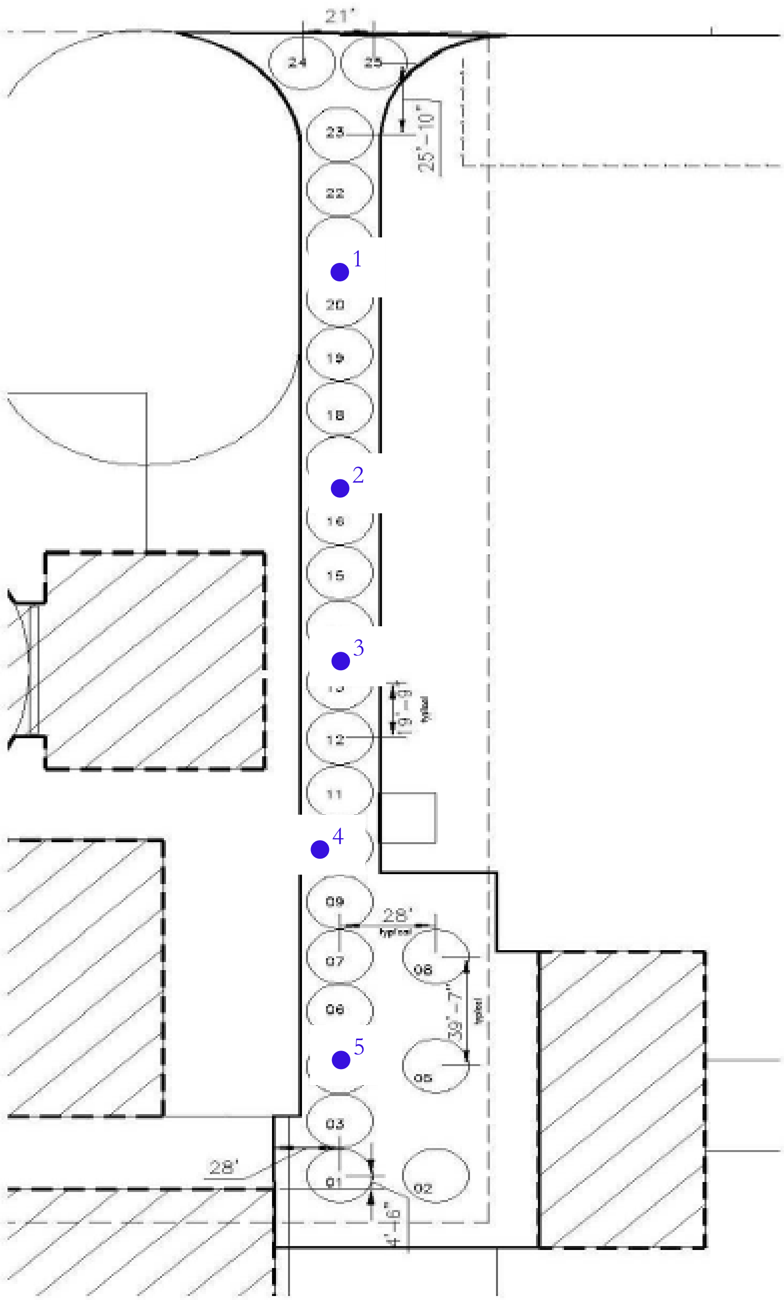

Figure provided by SMUD

MEASUREMENT LOCATION

● # SINGLE POINT

N

NOT TO SCALE

Figure A-16: Survey Unit F8000105, Industrial Area Central Yard – Direct Measurement Locations

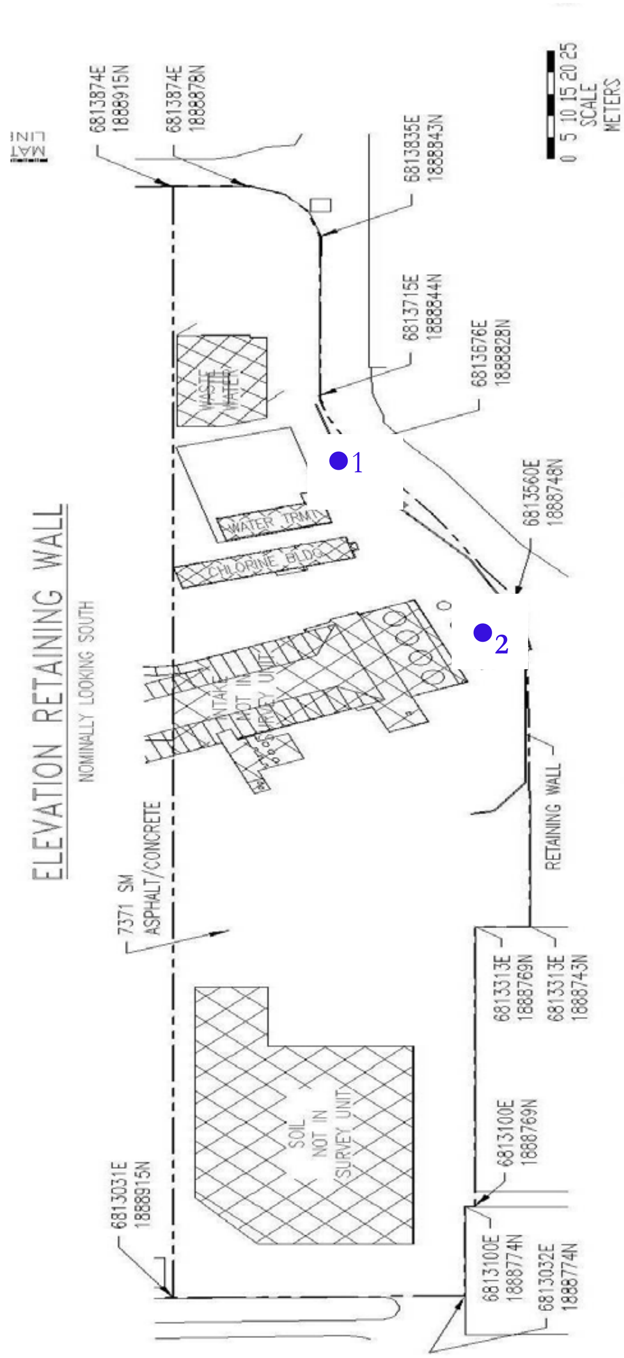

Figure provided by SMUD

MEASUREMENT LOCATION

● # SINGLE POINT

N

NOT TO SCALE

Figure A-17: Survey Unit F81080031, Cooling Tower Buffer – Direct Measurement Locations

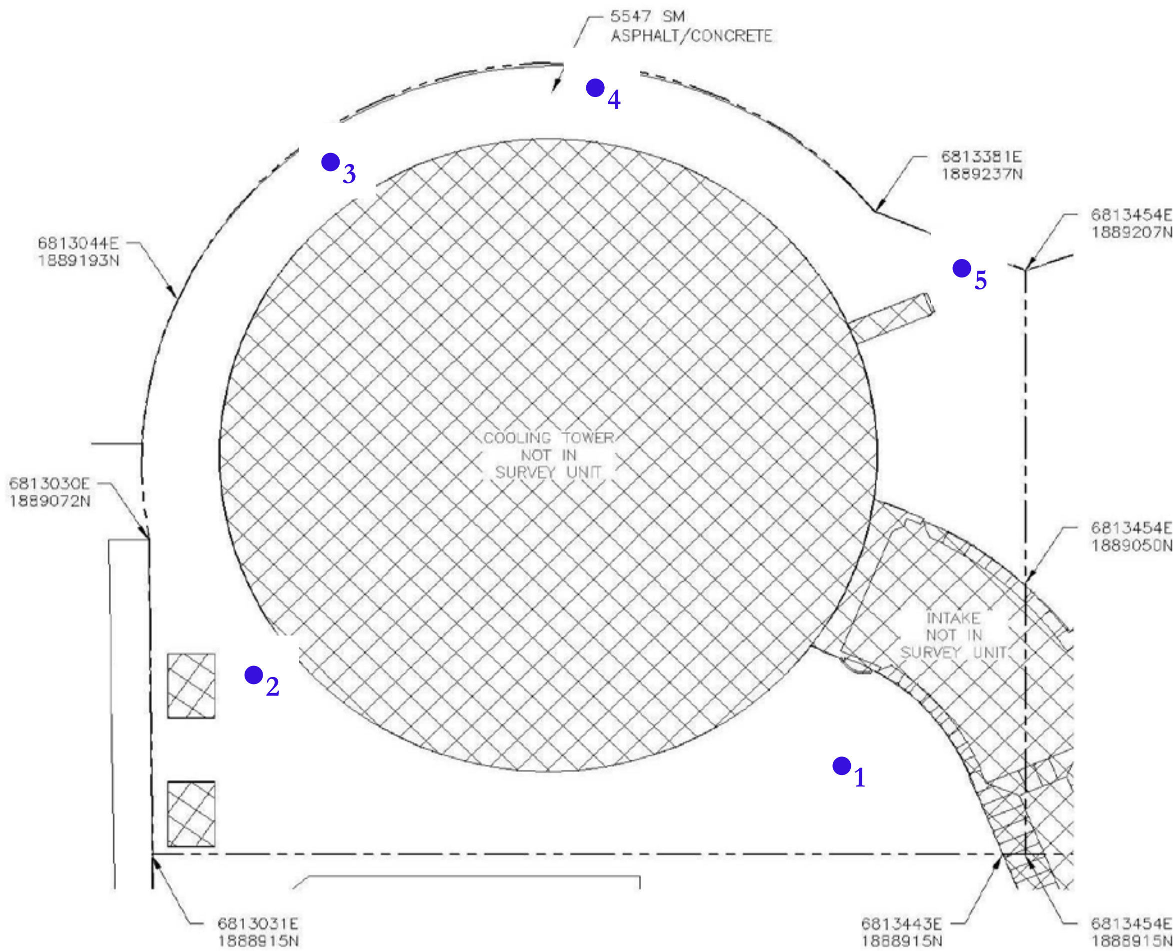

Figure provided by SMUD

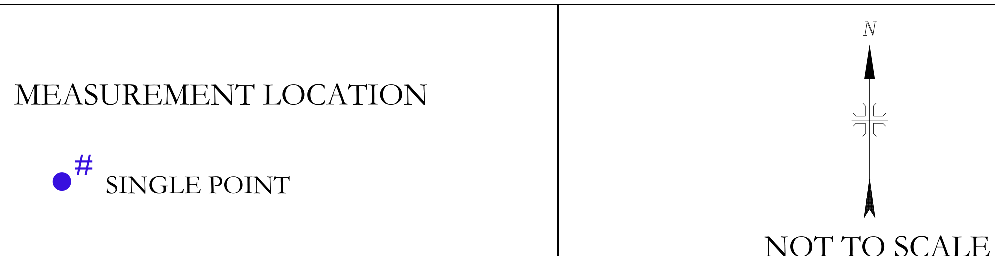

Figure A-18: Survey Unit F8080032, Cooling Tower Buffer, West – Direct Measurement Locations

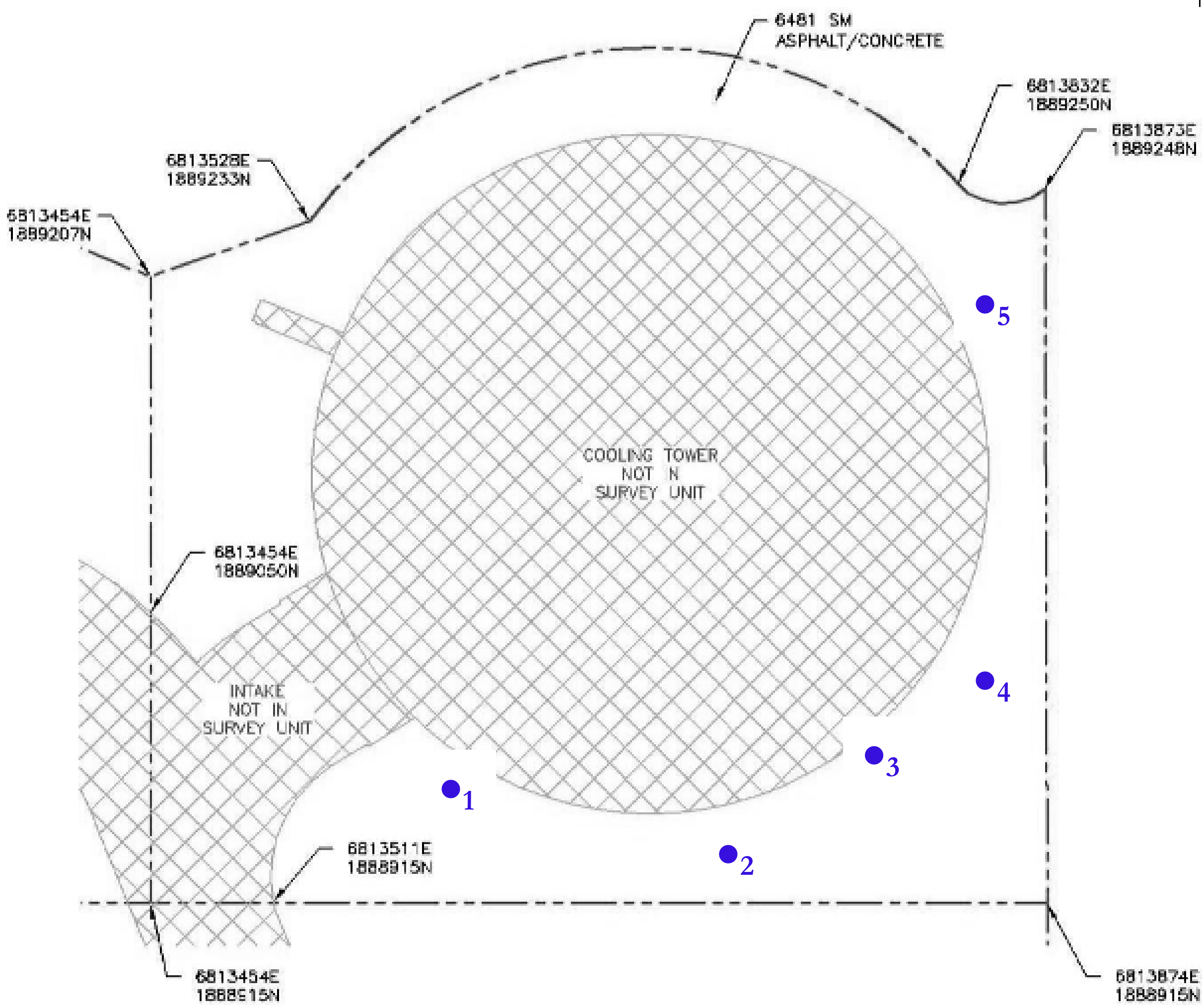

Figure provided by SMUD

MEASUREMENT LOCATION

● # SINGLE POINT

N

NOT TO SCALE

Figure A-19: Survey Unit F8080033, Cooling Tower Buffer – Direct Measurement Locations

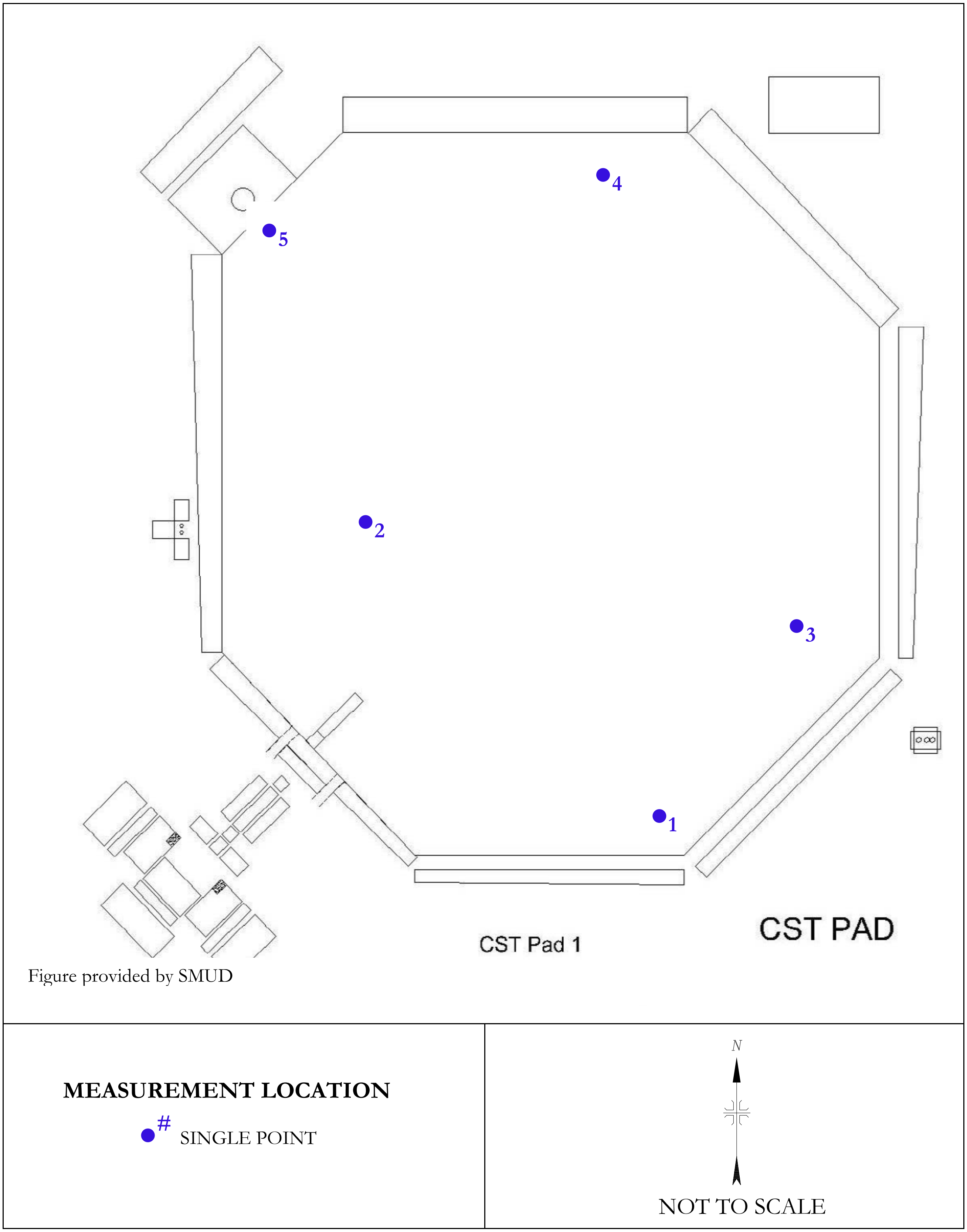

Figure A-20: Survey Unit F8100041, Tank Farm, CST Pad – Direct Measurement Locations

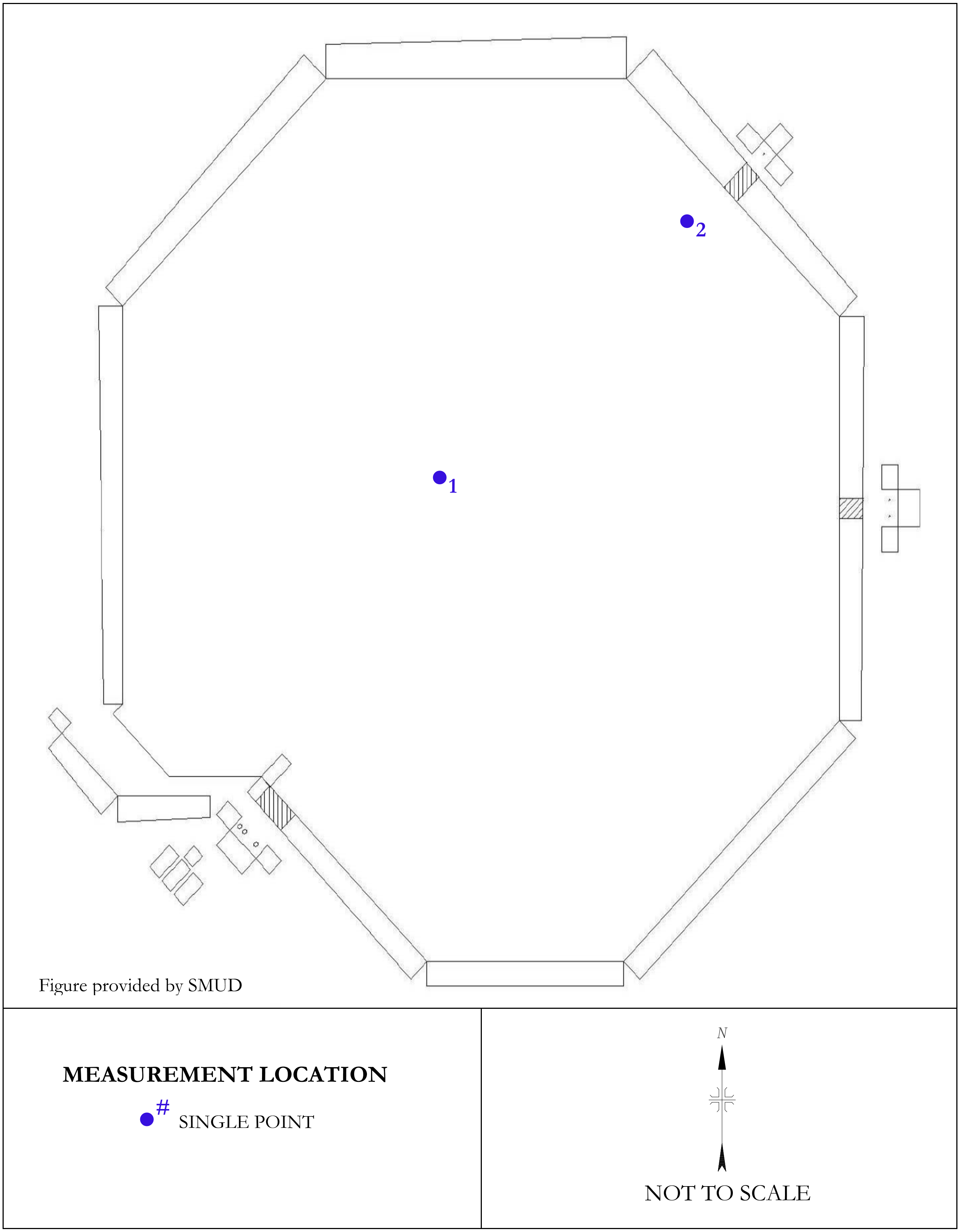

Figure A-21: Survey Unit F8100042, Tank Farm, DRCST Pad – Direct Measurement Locations

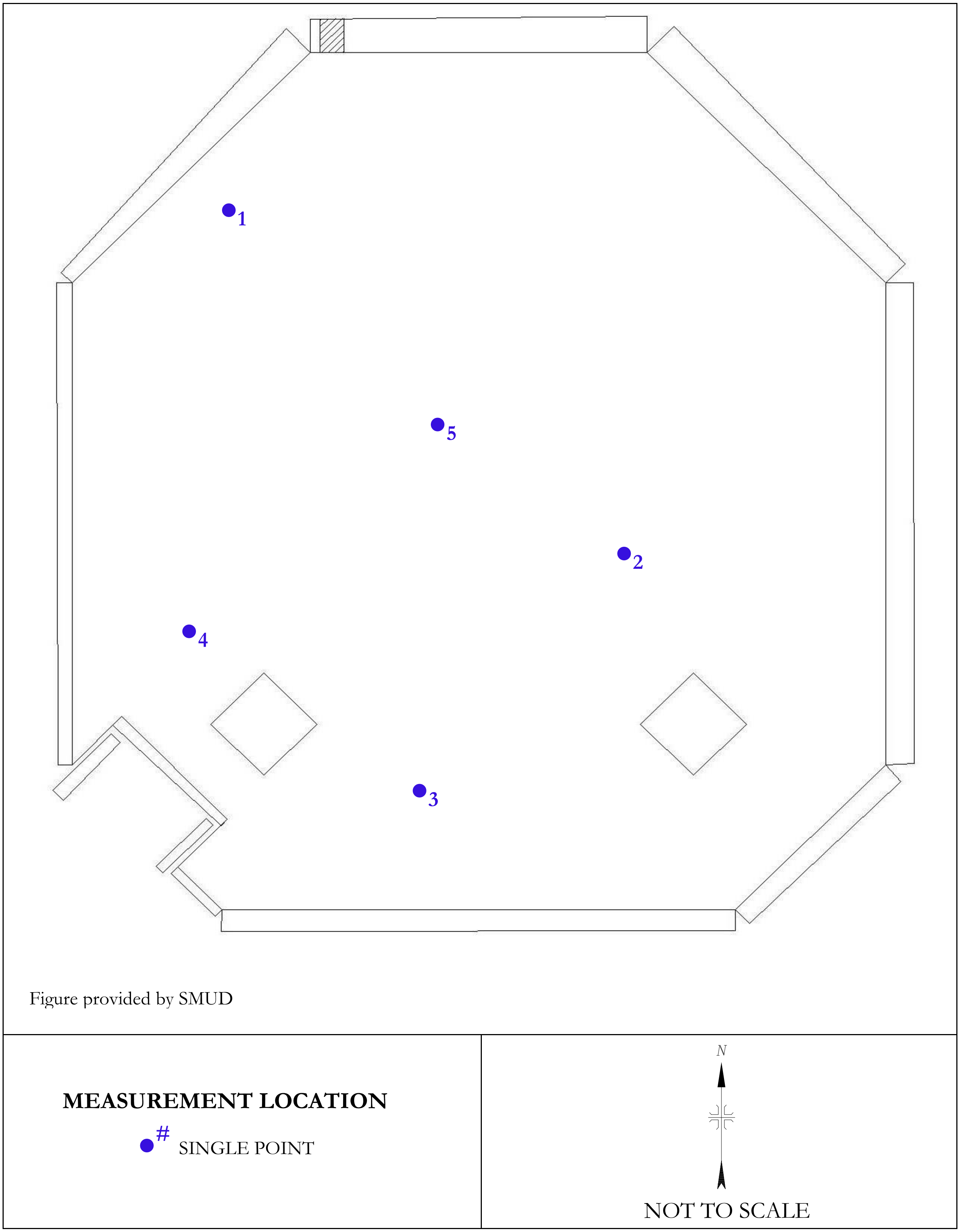

Figure A-22: Survey Unit F8100043, Tank Farm, BWST Pad – Direct Measurement Locations

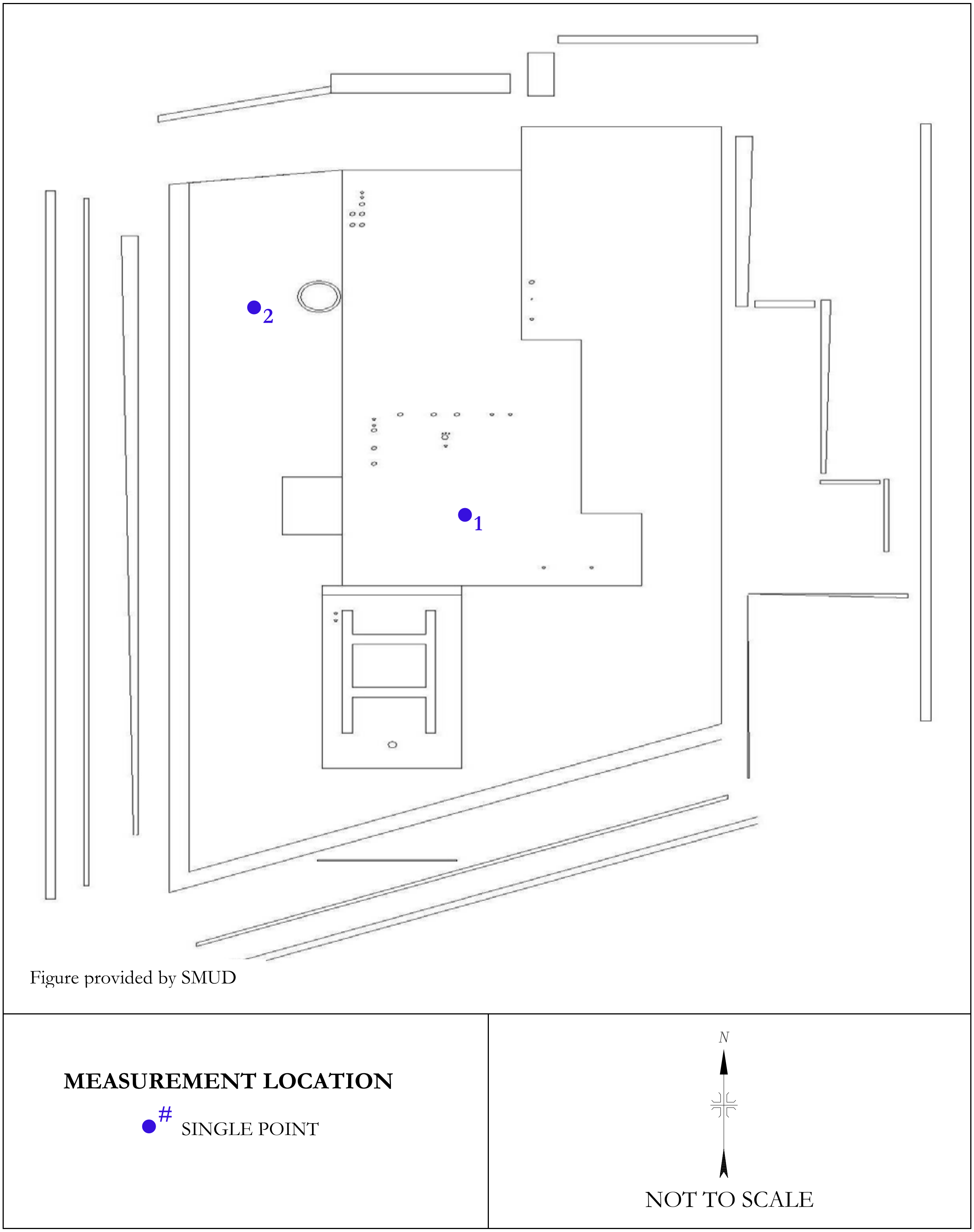

Figure A-23: Survey Unit F8100044, Tank Farm, Tritium Evaporation Pad – Direct Measurement Locations

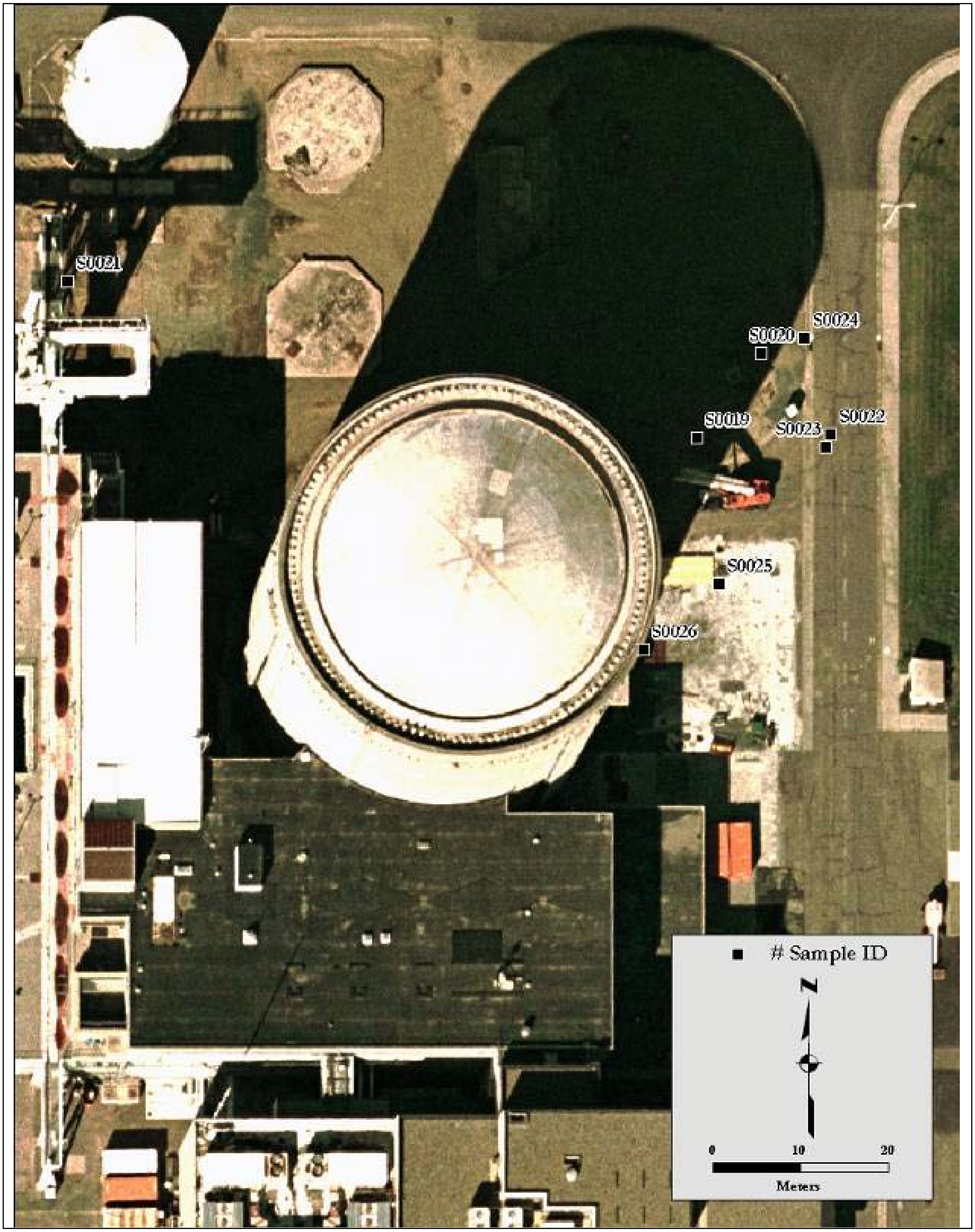

Figure A-24: Rancho Seco Nuclear Generating Station – ORISE Soil Sample Locations

APPENDIX B

TABLES

TABLE B-1
DERIVED CONCENTRATION GUIDELINE LEVELS AND ELEVATED MEASUREMENT COMPARISONS FOR THE EXTERIOR AREAS
RANCHO SECO NUCLEAR GENERATING STATION
HERALD, CALIFORNIA

Survey Unit[a]	Class	Gross Beta Activity DCGL[b] (dpm/100 cm^2)	Design $DCGL_{EMC}$[c] (dpm/100 cm^2)/ Area Factor	Soil DCGL[d] (pCi/g)	Soil $DCGL_{EMC}$ (pCi/g)/ Area Factor
F8000105, Industrial Area, North/South Roadway	2	NA[e]	NA	51.2	NA
F8080031, Cooling Tower Buffer	2	NA	NA	51.2	NA
F8080032, Cooling Tower Buffer	2	NA	NA	51.2	NA
F8080033, Cooling Tower Buffer	2	NA	NA	51.2	NA
F8100011, Southwest Tank Farm	1	NA	NA	51.2	74.2/1.45
F8100012, Southwest Tank Farm Subsurface	1	NA	NA	51.2	NA
F8100021, Northwest Tank Farm	1	NA	NA	51.2	62.97/1.23
F8100022, Northwest Tank Farm Subsurface	1	NA	NA	51.2	NA
F8100031, Northeast Tank Farm	1	NA	NA	51.2	61.5/1.2
F8100032, Northeast Tank Farm Subsurface	1	NA	NA	51.2	61.5/1.2
F8100041, Tank Farm, Condensate Storage Tank (CST) Pad	1	43,000	152,901/3.56	NA	NA
F8100042, Tank Farm, Demin RC Storage Tank (DRCST) Pad	2	43,000	NA	NA	NA

TABLE B-1 DERIVED CONCENTRATION GUIDELINE LEVELS AND ELEVATED MEASUREMENT COMPARISONS FOR THE EXTERIOR AREAS RANCHO SECO NUCLEAR GENERATING STATION HERALD, CALIFORNIA					
Survey Unit[a]	**Class**	**Gross Beta Activity DCGL[b] (dpm/100 cm^2)**	**Design $DCGL_{EMC}$[c] (dpm/100 cm^2)/ Area Factor**	**Soil DCGL[d] (pCi/g)**	**Soil $DCGL_{EMC}$ (pCi/g)/ Area Factor**
F8100043, Tank Farm, Borated Water Storage Tank (BWST) Pad	1	43,000	152,901/3.56	NA	NA
F8100044, Tank Farm, Tritium Evaporator Pad	2	43,000	NA	NA	NA
F8100052, Trench 1 East Surface	1	NA	NA	52.6	79/1.5
F8100053, Trench 1 East Subsurface	1	NA	NA	52.6	NA
F8340012, Industrial Area Railway	2	NA	NA	51.2	NA
F8370001, Auxiliary Boiler Pad and RHUT Land Areas	1	NA	NA	51.2	61.95/1.21

[a]Refer to Figures A-3 through A-24.
[b]Gross beta DCGL accounts for radionuclide fractions and hard to detects as specified in the DTBD-05-15 (SMUD 2006b).
[c]$DCGL_{EMC}$ (DCGL Elevated Measurement Comparison) provided by SMUD and accounted for area factors (also provided by SMUD) determined for each specific survey unit.
[d]Unless otherwise stated, as specified in DTBD 05-014, Cs-137 was used as the surrogate radionuclide for surface soils in determining the surface soil DCGL.
[e]Not applicable.

TABLE B-2 SURVEY UNIT CLASSIFICATION AND CONFIRMATORY SCAN COVERAGE RANCHO SECO NUCLEAR GENERATING STATION HERALD, CALIFORNIA			
Survey Unit[a]	**Class**	**Percent Scan Coverage**	
		Gamma	**Beta**
F8000105, Industrial Area, North/South Roadway	2	100	---[b]
F8080031, Cooling Tower Buffer	2	30	---
F8080032, Cooling Tower Buffer	2	65	---
F8080033, Cooling Tower Buffer	2	25	25
F8100011, Southwest Tank Farm	1	100	---
F8100021, Northwest Tank Farm	1	100	---
F8100031, Northeast Tank Farm	1	100	---
F8100041, Tank Farm, Condensate Storage Tank (CST) Pad	1	100	50
F8100042, Tank Farm, Demin RC Storage Tank (DRCST) Pad	2	100	25
F8100043, Tank Farm, Borated Water Storage Tank (BWST) Pad	1	100	100
F8100044, Tank Farm, Tritium Evaporator Pad	2	100	20
F8100052, Trench 1 East Surface	1	100	---
F8340012, Industrial Area Railway	2	50	---
F8370001, Auxiliary Boiler Pad and RHUT Land Areas	1	100	---

[a]Refer to Figures A-3 through A-15.
[b]Scan not performed.

TABLE B-3 SURFACE ACTIVITY LEVELS RANCHO SECO NUCLEAR GENERATING STATION HERALD, CALIFORNIA			
Survey Unit /Location[a]	**Surface**	**Gross Beta Activity (dpm/100 cm^2)[b]**	**Activity Meets Gross Beta DCGL/DCGL$_{EMC}$[c]**
F8000105, Industrial Area Central Yard			
1	Asphalt	1,400	YES/NA
2	Asphalt	840	YES/NA
3	Asphalt	1,900	YES/NA
4	Asphalt	1,800	YES/NA
5	Asphalt	4,400	YES/NA
F8080031, Cooling Tower Buffer South			
1	Asphalt	1,200	YES/NA
2	Asphalt	1,000	YES/NA
F8080032, Cooling Tower Buffer West			
1	Asphalt	720	YES/NA
2	Asphalt	830	YES/NA
3	Asphalt	910	YES/NA
4	Asphalt	720	YES/NA
5	Asphalt	890	YES/NA
F8080033, Cooling Tower Buffer East			
1	Asphalt	890	YES/NA
2	Asphalt	1,600	YES/NA
3	Asphalt	2,100	YES/NA
4	Asphalt	2,400	YES/NA
5	Asphalt	2,200	YES/NA
F8100041, Tank Farm CST Pad			
1	Concrete	2,100	YES/YES
2	Concrete	500	YES/YES
3	Concrete	540	YES/YES
4	Concrete	470	YES/YES
5	Concrete	760	YES/YES

TABLE B-3 SURFACE ACTIVITY LEVELS RANCHO SECO NUCLEAR GENERATING STATION HERALD, CALIFORNIA			
Survey Unit /Location[a]	**Surface**	**Gross Beta Activity (dpm/100 cm^2)[b]**	**Activity Meets Gross Beta $DCGL/DCGL_{EMC}$[c]**
F8100042, Tank Farm DRCST Pad			
1	Concrete	580	YES/NA
2	Concrete	630	YES/NA
F8100043, Tank Farm BWST Pad			
1	Concrete	350	YES/YES
2	Concrete	580	YES/YES
3	Concrete	480	YES/YES
4	Concrete	500	YES/YES
5	Concrete	410	YES/YES
F8100044, Tank Farm Tritium Evaporation Pad			
1	Concrete	440	YES/NA
2	Concrete	600	YES/NA

[a]Refer to Figures A-16 through A-23.
[b]Direct measurement results rounded to two significant digits.
[c]DCGL values are provided in Table B-1. NA indicates that the survey unit was classified as Class 2 or Class 3 and a $DCGL_{EMC}$ was not required.

TABLE B-4
RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
RANCHO SECO NUCLEAR GENERATING STATION
HERALD, CALIFORNIA

ORISE ID	SMUD ID[a]	Co-60	Cs-137
Soil Samples Collected by ORISE[b]			
1695S0019	NA[c]	0.28 ± 0.04[d]	0.19 ± 0.03
1695S0020	NA	0.05 ± 0.02	1.64 ± 0.16
1695S0021	NA	0.05 ± 0.03	6.41 ± 0.60
1695S0022	NA	0.05 ± 0.04	0.00[e] ± 0.03
1695S0023	NA	-0.03 ± 0.05	0.00 ± 0.03
1695S0024	NA	0.07 ± 0.04	0.27 ± 0.05
1695S0025	NA	0.02 ± 0.03	0.14 ± 0.03
1695S0026	NA	0.02 ± 0.04	0.03 ± 0.01
Subsurface Soil Samples Collected by SMUD and Analyzed by ORISE[c]			
1695S0027	F8100012S0202SS	0.01 ± 0.05	0.01 ± 0.04
1695S0028	F8100012S0081SS	0.00 ± 0.03	0.75 ± 0.07
1695S0029	F8100022S0091SS	-0.01 ± 0.03	0.59 ± 0.07
1695S0030	F8100022S0141SS	0.43 ± 0.05	39.4 ± 3.8
1695S0031	F8100031S0002SS	0.04 ± 0.02	1.05 ± 0.09
1695S0032	F8100031S0006SS	0.00 ± 0.00	1.49 ± 0.14
1695S0033	F8100032S0071SS	0.04 ± 0.03	0.05 ± 0.02
1695S0034	F8100053S0008SS	0.05 ± 0.04	0.08 ± 0.02
1695S0035	F8100011SS0001SS	0.04 ± 0.01	1.21 ± 0.12
1695S0036	F8100011S0005SS	0.18 ± 0.03	1.55 ± 0.15

[a]SMUD sample identification numbers provided by SMUD. These samples were judgmentally selected by ORISE from FSS preliminary data results for SMUD subsurface soil sampling in the surveyed areas.
[b]Refer to Figure A-24.
[c]Not applicable. ORISE collected these samples based on gamma surface scan results.
[d]Uncertainties are total propagated uncertainties, based on the 95% confidence interval.
[e]Zero values due to rounding.

APPENDIX C

MAJOR INSTRUMENTATION

APPENDIX C

MAJOR INSTRUMENTATION

The display of a specific product is not to be construed as an endorsement of the product or its manufacturer by the author or 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)
coupled to:
Trimble GeoXH Receiver and Data Logger
(Trimble Navigation Limited, Sunnyvale, CA)

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

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)
coupled to:
Trimble GeoXH Receiver and Data Logger
(Trimble Navigation Limited, Sunnyvale, CA)

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)

LABORATORY ANALYTICAL INSTRUMENTATION

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

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

High-Purity Germanium Detector
Model GMX-30-P4, 30% Eff.
(AMETEK/ORTEC, Oak Ridge, TN)
Used in conjunction with:
Lead Shield Model G-16
(Gamma Products, Palos Hills, IL) and
Multichannel Analyzer
Dell Workstation
(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 (April 2009)
- Quality Program Manual (May 2009)

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 Mixed-Analyte Performance Evaluation Program (MAPEP), NIST Radiochemistry Intercomparison Testing Program (NRIP), and Intercomparison Testing Program (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 of the Containment Building walls and sumps were calibrated in accordance with ISO-7503[2] 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): $\varepsilon_{total} = \varepsilon_i \times \varepsilon_s$.

Tc-99 was selected as the beta calibration source. The 2π beta ε_i factor for the gas proportional detector used to collect direct measurements was 0.44. ISO-7503 recommends an ε_s of 0.25 for maximum beta energies less than 0.4 MeV (the maximum beta energy of Co-60 is 0.314 MeV). Since RSNGS provided a ratio (mentioned above) for Cs-137 and Co-60, ORISE determined a weighted total beta efficiency using an ε_s of 0.5 for the Cs-137 and an ε_s of 0.25 for the Co-60. The resulting total beta efficiency was 0.21.

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 (126 cm^2) multipoint total efficiency (ε_{total}): 0.21
- Background (BKG): 250cpm
- Time (T): 1 minute count time

[2]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.

- G = geometry = $\frac{Physical\ Detector\ Area\ cm^2}{100}$

Determine Action Level

- Action Level (cpm) = (SRC * ε_{total} * G * T) + (BKG * T)
- Action Level = 11,627 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) and/or a small area (126 cm^2) hand-held gas proportional 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.[3] 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 index of sensitivity *(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 and floor monitor detectors in the same fashion as above for the static hand-held gas proportional detectors except typical scanning efficiencies for the detectors were used rather than

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

specific calibrations for this survey. The scanning ε_{total} value for a hand-held gas proportional detector was 0.18.

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

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 floor monitor detector was 6,367 dpm/100 cm^2.

Surface Activity Measurements

Measurements of total beta surface activity levels were performed using hand-held gas proportional 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:

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

Where:

BKG = 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 290 dpm/100 cm^2 using the total efficiency of 0.21 and an instrument background of 250 cpm. The physical surface area assessed by the gas proportional detector used was 126 cm^2.

Soil Sampling

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

RADIOLOGICAL ANALYSIS

Gamma Spectroscopy

Samples of soil were dried, mixed, crushed, and/or homogenized as necessary, and a portion sealed in a 0.5-liter Marinelli beaker or other appropriate container. The quantity placed in the beaker was chosen to reproduce the calibrated counting geometry. Water samples were filtered and acidified as needed. Net material weights and volumes were determined and the samples counted using intrinsic germanium detectors coupled to a pulse height analyzer system. Background and Compton stripping, peak search, peak identification, and concentration calculations were performed using the computer capabilities inherent in the analyzer system. All total absorption peaks (TAP) associated with the radionuclides of concern were reviewed for consistency of activity. TAPs used for determining the activities of radionuclides of concern and the typical associated MDCs for a one-hour soil gamma spectroscopy count time and a 16-hour water gamma spectroscopy count time were:

RADIONUCLIDE	TAP (MeV)	SOIL MDC (pCi/g)
Co-60	1.173	0.06
Cs-137	0.661	0.11

Uncertainties

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

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.