APPENDIX A

MAJOR INSTRUMENTATION

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

Gamma

Eberline Pulse Ratemeter Model PRM-6
(Eberline, Santa Fe, NM)
coupled to
Victoreen NaI Scintillation Detector Model 489-55, Crystal: 3.2 cm x 3.8 cm
(Victoreen, 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)

Gamma (Exposure Rate)

Bicron Micro-Rem Meter
(Bicron Corporation, Newburg, OH)

Laboratory Analytical Instrumentation

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

High Purity Extended Range Intrinsic Detectors
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
DEC ALPHA Workstation
(Canberra, Meriden, CT)

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

APPENDIX B

SURVEY AND ANALYTICAL PROCEDURES

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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 (JHAs). Additionally, upon arrival on-site, a walk-down of the site was performed to identify hazards present and a pre-job integrated safety management checklist completed and discussed with field personnel. All survey and laboratory activities were conducted in accordance with ORISE health and safety and radiation protection procedures.

CALIBRATION AND QUALITY ASSURANCE

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

Analytical and field survey activities were conducted in accordance with procedures from the following documents of the Environmental Survey and Site Assessment Program:

- Survey Procedures Manual, (February 2003)
- Laboratory Procedures Manual, (February 2003)
- Quality Assurance Manual, (April 2003)

The procedures contained in these manuals were developed to meet the requirements of Department of Energy (DOE) Order 414.1A 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, ITP, and EML Laboratory Quality Assurance Programs.
- Training and certification of all individuals performing procedures.
- Periodic internal and external audits.

Detectors used for assessing surface activity were calibrated in accordance with ISO-7503[1] recommendations. The total beta efficiency (ε_{total}) was determined for each instrument/detector combination 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 beta calibration ε_i was 0.40 for the gas proportional detector calibrated to Tl-204. The beta calibration source was selected based on the beta energy distribution of the thorium decay chain. ISO-7503[1] recommends an ε_s of 0.25 for beta emitters with a maximum energy of less than 0.4 MeV (400 keV) and an ε_s of 0.5 for maximum beta energies greater than 0.4 MeV. Since the maximum beta energy for the SRUD radionuclides of concern was greater than 0.4 MeV, an ε_s of 0.5 was used to calculate ε_{total}. The total beta efficiency for the gas proportional detector was 0.20.

SURVEY PROCEDURES

Surface Scans

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. A NaI scintillation detector was used to scan for elevated gamma radiation throughout the buildings and site soil surfaces. Building and equipment surfaces were also scanned using small area (126 cm^2) hand-held gas proportional detectors. Identification of elevated levels was based on increases in the audible signal from the recording and/or indicating instrument.

Beta surface scan minimum detectable concentrations (MDCs) were estimated using the calculational approach described in NUREG-1507.[2] The scan MDC is a function of many

[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.
[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.

variables, including the background level. The unshielded beta background levels for the hand-held gas proportional detectors averaged 586 cpm on concrete, 512 cpm on metal, and 537 cpm on wood. Additional parameters selected for the calculation of scan MDCs included a two-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 instrument efficiency (ε_i) for the hand-held gas proportional detector calibrated to Tl-204 was 0.40. To illustrate an example for the hand-held gas proportional detector, the minimum detectable count rate (MDCR) and scan MDC for beta activity can be calculated as follows:

b_i = (586 cpm)(2 s)(1 min/60 s) = 19.5 counts,
MDCR = (2.32)(19.5 counts)$^{1/2}$ [(60 s/min)/(2 s)] = 307 cpm,
$MDCR_{surveyor}$ = 307/(0.5)$^{1/2}$ = 434 cpm

The scan MDC is calculated assuming a source efficiency (ε_s) of 0.5 (for Tl-204):

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

For the given backgrounds, the estimated scan MDC ranged 2,000 to 2,200 dpm/100 cm^2 for the hand-held gas proportional detector.

The scan MDCs for the NaI scintillation detectors were obtained directly from NUREG-1507. The scan MDCs were 28.3 and 115 pCi/g, respectively, for total thorium and total uranium (includes the sum of all radionuclides in the thorium and uranium decay series).

Surface Activity Measurements

Measurements of total beta surface activity levels were performed using a hand-held gas proportional detector coupled to a portable ratemeter-scaler. Count rates (cpm), 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 net count rate by the total static efficiency ($\varepsilon_i \times \varepsilon_s$) and correcting for the physical area of the detector.

Surface activity measurements were performed on concrete, metal, and wood. To distinguish between the beta background and the high ambient gamma background that was present in some areas of the site, unshielded and shielded measurements were performed at each background and survey area direct measurement location. A Plexiglas™ shield of sufficient thickness to block the beta particles from the natural thorium and natural uranium series was used to determine the gamma count rate associated with the unshielded count rates. The material-specific beta background count rates used in the calculation for determining net surface activity was calculated using the following:

$R_{rm} = R_u - R_s$

where:

R_{rm}= reference material background count rate (ambient background subtracted out)

R_u= unshielded (gross).

R_s= shielded, background count rate.

The material-specific backgrounds were 159 cpm for concrete, 91 cpm for metal, and 52 cpm for wood. The material-specific background beta count rate was then subtracted from the net count rate determined from the unshielded and shielded direct measurements to provide a true beta-only direct measurement on surfaces.

The following equation was used to determine the beta net count rate when correcting surface activity measurements in the survey areas for ambient gamma background differences:

$N = (R_{u,\,su} - R_{s,\,su}) - R_{rm}$

where:

N = net counts

$R_{u,\,su}$ = unshielded survey unit count rate

$R_{s,\,su}$ = shielded survey unit count rate

R_{rm} = reference material count rate

The static beta MDC—calculated using the background materials unshielded average count rates—ranged from 430 to 460 dpm/100 cm^2. The physical surface area assessed by the gas proportional detector used was 126 cm^2.

Removable Activity Measurements

Smear samples for removable gross alpha and gross beta contamination were obtained from most measurement locations. 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.

Exposure Rate Measurements

Measurements of dose equivalent rates (μrem/h) were performed at 1 m above the surface using a Bicron microrem meter. Although the instrument displays data in μrem/h, the μrem/h to μR/h conversion is essentially unity.

Soil and Miscellaneous Material Sampling

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

Miscellaneous material samples were collected and placed in specimen cups or other appropriate container, sealed, and labeled in accordance with ESSAP survey procedures. The quantity collected varied from 0.02 to 0.15 kg.

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 9 dpm/100 cm^2 and 15 dpm/100 cm^2 for a 2-minute count-time for gross alpha and gross beta, respectively.

Gamma Spectroscopy

Soil samples were counted directly in the sample container without processing, due to the anticipated contamination levels. The arid conditions at the site alleviated the necessity to dry samples. As an assurance, representative samples were dried and the wet weight percent determined to be less than 1 %. Residue samples were transferred to other appropriate containers to reproduce as closely as possible the calibrated counting geometry. However, there was not an adequate volume of most of the miscellaneous samples to completely fill the counting containers. Therefore, results are qualified as semi-quantitative. Net material weights were determined and the samples counted using intrinsic germanium detectors coupled to a pulse height analyzer system. Background and Compton stripping, peak search, peak identification, and concentration calculations were performed using the computer capabilities inherent in the analyzer system. All photopeaks associated with the radionuclides of concern were reviewed for consistency of activity. Photopeaks used for determining the activities of radionuclides of concern and the average associated MDCs for a 15-minute count time were:

Radionuclide	Photopeak	MDC soil (pCi/g)
Th-228	0.239 MeV from Pb-212	1.0
Th-232	0.911 MeV from Ac-228*	1.5
U-235	0.143 MeV	3.6
U-238	0.063 MeV from Th-234*	12.6
Ra-226	0.352 Mev from Pb-214*	1.3

*Secular equilibrium assumed.

Spectra were also reviewed for other identifiable photopeaks.

UNCERTAINTIES AND DETECTION LIMITS

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, referred to as minimum detectable concentration (MDC), were based on 3 plus 4.65 times the standard deviation of the background count $[3 + (4.65\sqrt{BKG})]$. 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.