Verification Plan for Rocky Flats Sitewide Surface Radiological Characterization

March 3, 2005

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1.0 INTRODUCTION AND SUMMARY

This Verification Plan was developed in response to direction received from the U.S. Department of Energy (DOE) and subsequent discussions with DOE staff and the Oak Ridge Institute for Science and Education (ORISE). (REF: Letter from Frazer Lockhart to Nancy Tuor, dated September 14, 2004) This Verification Plan defines how cleanup at the Rocky Flats Environmental Technology Site (RFETS) will be verified against the goals established under the Rocky Flats Cleanup Agreement (RFCA). This verification is in addition to, but not required by RFCA and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requirements, which include:

1. Characterization and confirmation sampling to statistically demonstrate that cleanup actions were adequate to meet the RFCA radionuclide soil action levels (RSALs) based on 10^{-5} risk to a wildlife refuge worker;
2. Comprehensive Risk Assessment (CRA) to estimate residual risk to a wildlife refuge worker in each exposure unit.

DOE and Kaiser Hill Company, LLC (K-H) are undertaking this effort to provide an additional level of confidence and assurance that the data being used to make decisions regarding cleanup are relevant and reliable.

Sampling goals have also been put forward under the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) guidance. However, in addition to sampling, MARSSIM also uses scanning to provide additional assurance that the cleanup objectives have been achieved. Coupling this Verification Plan (which includes scanning, statistical sampling, historical review, and data review) with the CERCLA requirements provides a high degree of confidence that the cleanup objectives have been achieved. This approach exceeds the requirements of both CERCLA and MARSSIM (CERCLA because no scanning is required under CERCLA, and MARRSIM because no risk assessment is required under MARSSIM). The CERCLA sampling approach clearly meets the intent of MARSSIM statistical sampling because MARSSIM sampling designs are taken directly from CERCLA guidance. However, MARSSIM anticipates sampling after all cleanup activity has been complete. Therefore, the RFETS verification approach will include statistical resampling of previously sampled locations to confirm the validity of existing data.

The RFETS verification approach also exceeds the MARSSIM scanning requirements by providing 100% wide-area scanning where MARSSIM only requires 100% scanning in areas where the highest potential for contamination exists. The RFETS verification approach also includes localized scanning in areas with higher potential for contamination to verify that small areas have not been overlooked.

Key points of the RFCA/CERCLA characterization, remediation, and completion process and the RFETS verification process are shown in Table 1

Table 1 RFETS Completion and Verification Processes

RFCA/CERCLA Characterization, Remediation, and Completion Process	• Extensive preliminary investigation to identify areas where releases may have occurred • Extensive CERCLA-based characterization sampling exceeding 90% confidence • Sampling consistent with the U.S. Environmental Protection Agency (EPA) guidance and approved Sampling and Analysis Plans • In-process sampling to guide remedial actions • Confirmation sampling to verify remediation was complete exceeding 95% confidence • Regulatory review and approval of all remedial action completion reports and no further accelerated action decisions • CRA to estimate the combined risk to the wildlife refuge worker in each exposure unit at the Site for all contaminants, including radionuclides.
RFETS Verification Process	• Additional verification sampling to confirm validity of previous sample results (95% confidence) • 100% wide-area scanning of RFETS with instrumentation sensitive enough to verify that average plutonium contamination does not exceed the RFCA action level of 50 pCi/g for all areas larger than ~80 m^2, and that all areas greater than ~7 m^2 do not pose a risk greater than 10^{-5} to a wildlife refuge worker[1]. • Targeted higher resolution scanning to verify that average plutonium soil contamination does not exceed 50 pCi/g for areas less than 80 m^2. These targeted areas will primarily be around remediated areas where contamination was once known to exist.

The detailed historical information compiled during the preliminary investigation is contained in the Historical Release Report (HRR) and the subsequent updates. Sampling methodology and statistical approaches are outlined in the Industrial Area and Buffer Zone Sampling and Analysis Plan (IABZSAP). RFCA requires that details of further characterization and remedial actions be included in the individual data summary reports and accelerated action closeout reports for each release site or group of release sites. CERCLA requires the preparation of the Remedial Investigation (RI) Report, which will include the CRA, to provide a comprehensive report of site conditions in the absence of additional remediation. All of these reports have been or will be approved by EPA and Colorado Department of Public Health and Environment (CDPHE). All of these reports are or will be available in the Administrative Record. A brief summary of the history of RFETS, its characterization, and remediation is included in Appendix A. Excerpts from the IABZSAP are included in Appendix B.

2.0 VERIFICATION PLAN OBJECTIVES

The objectives of this Verification Plan are to:

[1] The detection limits and areas presented are based on the reported *a priori* minimum detectable activity of the scanning instrumentation. Actual values may vary depending on field conditions.

1. Verify, with reasonable certainty, that all radioactively contaminated surface soil beyond the known and suspected release sites has been identified and appropriately dispositioned under RFCA.[2]

2. Verify, with reasonable certainty, that remedial actions are complete and that no radiological surface contamination above RFCA action levels or allowable elevated measurements per the IABZSAP remains in adjacent areas.

3. Verify, with reasonable certainty, that existing sampling data for radionuclides in the surface soil are valid and remain representative after site cleanup activities.

Objective 1. Verify, with reasonable certainty, that all radioactively contaminated surface soil beyond the known and suspected release sites has been identified and appropriately dispositioned under RFCA. This objective will be achieved primarily by wide-area scanning, which will demonstrate that no significant area (>5 m^2 for Pu-239/240) remains anywhere on site where risk from surface contamination is greater than 10^{-5} to a wildlife refuge worker and no area larger than ~80 m^2 remains anywhere on site with radiological surface contamination exceeding the RFCA action levels. Performance of targeted ground-based scanning, verification sampling, review of historical information, and review of existing data will support the wide-area scanning to achieve this objective. Targeted ground-based scanning in areas with higher potential for remaining contamination will demonstrate that, for areas less than ~80 m^2, radionuclide surface contamination is less than the allowable elevated measurement levels based on the IABZSAP hot spot methodology of no more than three times the RFCA action levels. Statistical verification samples will be collected and analyzed to confirm that existing data remain representative and existing data will be reviewed to ensure no unexpected contaminated areas remain. A final verification review of historical information will be performed, as part of the final (FY2005) update to the HRR, to determine if all historical information related to potential releases has been adequately investigated.

Objective 2. Verify, with reasonable certainty, that remedial actions are complete and that no radiological surface contamination above RFCA action levels or allowable elevated measurements per the IABZSAP remains in adjacent areas. This objective will be achieved primarily by targeted ground-based scanning in areas adjacent to remediated areas, which will demonstrate that for areas of ~80 m^2, average radionuclide surface contamination is less than the RFCA action levels and that smaller areas do not exceed the allowable elevated measurement levels based on the IABZSAP hot spot methodology of no more than three times the RFCA action levels. Performance of wide-area scanning, verification sampling, and review of existing data will support the targeted ground-based scanning to achieve this objective.

Objective 3. Verify, with reasonable certainty, that existing sampling data for radionuclides in the surface soil are valid and remain representative after site cleanup activities. The primary criteria to verify sample validity and representativeness are:

[2] For U-238, verification will be to the RFCA action level regardless of areal extent due to significantly different slope factor used in the calculation of the RFCA action level versus RESRAD 6.0 for the risk calculation shown in Figure 4.

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- Methodology – were the samples collected and analyzed consistent with approved methods?

- Distribution – does the sample distribution adequately represent the potentially contaminated areas?

- Time – are characterization data still valid and representative with changed conditions that have occurred since the samples were collected?

This objective will be achieved by reviewing and verifying that the methodology outlined in the IABZSAP was correct and consistently applied during the characterization process:

- by verifying that sample distribution was compliant with the approved sample plans;

- by collecting statistical samples from the previous locations and comparing the results to confirm that sample results are still representative; and

- by reviewing existing data to ensure all locations with radionuclides in surface soil above RFCA action levels have been remediated.

3.0 VERIFICATION METHODOLOGIES

The verification approach will combine scanning, sampling, historical review and existing data review to provide confidence that all the objectives stated above are achieved. Each of the individual components of the Verification Plan is discussed below.

3.1 Scanning

3.1.1 Wide-Area Scanning

The entire site will be scanned using an aircraft mounted detector system. An array of twelve 2-inch x 4-inch x 16-inch sodium iodide (NaI) detectors will be mounted on a rotary wing aircraft. The survey will be performed at an altitude of 15 meters with a ground speed of 70 knots (81 mph). The aircraft will be equipped with differential global positioning system (GPS) and a radar altimeter. The effective detector footprint is a complex function of detector shape, distance from source, air mass attenuation, aircraft speed, etc. However, for estimation purposes, the footprint radius is approximately the same as the detector distance above the source. Hence, flight lines 30 meters apart across the entire site will establish the flight pattern for wide-area scanning. The detector reports the average activity within its footprint. Thus, for areas larger than the footprint, the reported activity is nominally the surface activity. If the region of activity is smaller than the field of view, the detector activity related to surface activity is approximated by the relationship:

detector activity = (surface activity)(activity area)/(footprint area)*

Tables 2 and 3 list nominal *a priori* Minimum Detectable Activity (MDA) for the proposed Rocky Flats wide-area scanning for selected isotopes and activity areas.

Table 2 Surface Distribution – Wide-Area Scanning

Isotope ID	729 m² area MDA (μCi/m²)	75 m² area MDA (μCi/m²)	7.3 m² area MDA (μCi/m²)	1.2 m² area MDA (μCi/m²)
Am-241	0.065	0.63	6.5	40
U-235	0.054	0.53	5.4	34
U-238 (Th-234)	0.56	5.5	56.	350

Table 3 Soil Concentration – Wide-Area Scanning

Isotope ID	729 m² area MDA (pCi/g)	75 m² area MDA (pCi/g)	7.3 m² area MDA (pCi/g)	1.2 m² area MDA (pCi/g)
Am-241	0.95	9.3	95	590
U-235	0.55	5.4	55	340
U-238 (Th-234)	7.3	71	730	4550

Plutonium-239/240 concentration is determined by multiplying the Am-241 concentration (pCi/g) by 5.7. Uranium-234 is assumed to have the same MDA as U-238. This approximation is reasonable for depleted and natural uranium. However, if enriched uranium is identified, as evidenced by elevated U-235 proportionate to U-238, then the MDA for U-234 is no longer valid. U-238 values are inferred based on Thorium-234.

MDAs in terms of soil concentration versus area from Table 3 for Pu-230/240, Am-241, U-235, and U-238 have been plotted in Figures 1-8 along with constant dose and risk calculations using RESRAD 6.0. Figures 1-4 present contaminant concentration versus area while holding risk values constant for each isotope. The shaded areas represent risk less than 10^{-5} to a wildlife refuge worker. Figures 5-8 present contaminant concentration versus area while holding dose values constant for each isotope. Input parameters for the RESRAD model were the same as those used to calculate the RFETS RSALs. Major assumptions for the RESRAD model were:

- 250 day/yr exposure
- 15.6 m^3 inhalation per day
- 50% of time indoors, 50% of time outdoors
- Default gamma shielding

Note that the RFCA action levels for RFETS were actually computed with an EPA spreadsheet calculation that is largely insensitive to the area/dose relationship. The calculated RSAL for each isotope is shown on the risk curves of Figures 1-4. Also note that for Pu-239/240 the calculated RSAL is 116 pCi/g, however, the RFCA parties agreed to a more conservative RSAL of 50 pCi/g.

3.1.2 Targeted Ground-Based Scanning

The wide-area scanning provides excellent resolution for large areas where point source contamination is not expected and where contaminant distribution mechanisms would lead to

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relatively large, uniform contaminant plumes. These potential contaminant distribution mechanisms are nature-driven mechanisms such as wind dispersion or erosion. The wide-area scanning will also detect small areas of high concentration. However, the wide-area scanning may not adequately detect small areas of low-to-moderate contamination around buildings or release sites. Targeted ground-based scanning will be performed in these areas as well as any anomalous areas identified in the wide-area scanning. Scanning will be performed using a high-purity germanium (HPGe) detector mounted on a tripod 1-meter off the ground. Count time is expected to be ~20 minutes. The field-of-view for the HPGe detector in this configuration is a 10-meter diameter circle.

Table 4 lists the nominal *a priori* MDAs for the targeted ground-based scanning for selected isotopes and activity areas.

Table 4 Soil Concentration – Targeted Ground-Based Scanning

Isotope ID	78 m^2 area MDA (pCi/g)	7.8 m^2 area MDA (pCi/g)	0.78 m^2 area MDA (pCi/g)
Am-241	1.27	12.7	127
U-235	0.28	2.81	28.1
U-238 (Th-234)	4.07	40.68	406.8

Plutonium-239/240 concentration is determined by multiplying the Am-241 concentration (pCi/g) by 5.7. Uranium-234 is assumed to have the same MDA as U-238. This approximation is reasonable for depleted and natural uranium. However, if enriched uranium is identified, as evidenced by elevated U-235 proportionate to U-238, then the MDA for U-234 is no longer valid. U-238 values are inferred based on Thorium-234.

The MDA curves, with a 10-meter field of view and as a function of contaminated area, for each isotope for the targeted ground-based scanning are shown on Figures 1-4. Lower MDAs for smaller areas can be achieved by placing the detector closer to the ground reducing the field of view and/or increasing counting time. Initially, the 10-meter diameter scans will be made along the boundary areas shown on Figure 9 with a 100- or 200-foot spacing (depending on the potential for and type of contamination) and biased around and within the 700- and 900-Areas based on process knowledge and site history. These areas are primarily where buildings with radioactive contamination were demolished or where radioactive release sites required remedial action. Additional scan locations may be identified based on results of the HPGe scan, or the wide-area scan.

3.2 Verification Sampling

Figure 10 shows the location of the existing surface samples for radionuclides. Consistent with the CRA, only validated samples collected after the Rocky Flats Interagency Agreement was signed were used (June 1991). Samples collected in the Buffer Zone in spring of 2004 verified that much of the Buffer Zone remains uncontaminated. EPA also collected independent samples at selected locations for further verification. Based on these results, no further verification samples are required in the buffer zone beyond the anticipated DOE retained lands.

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Because significant building demolition, remediation, and waste handling is continuing at RFETS, existing sample results for anticipated DOE retained lands were divided into two categories. First, samples collected from 1991 to 1995 after most production activity ended but before significant building demolition and remediation work began. Second, samples collected after 1995 during the active cleanup period. Each of these sample sets was assumed to be an independent population and separate statistics were used for each set.

The number of samples required for verification within the Industrial Area and the anticipated DOE retained lands for each of the sample sets was calculated using the computer program "Visual Sample Plan" that is distributed by Pacific Northwest National Laboratory (http://dqo.pnl.gov/vsp/). Visual Sample Plan can calculate an adequate number of samples based on the appropriate statistical inputs. The Wilcoxon Rank Sum Test was chosen as the basis for a random sampling regime to calculate an adequate number of samples.

The characterization results for Pu-239, Am-241, U-234, U-235 and U-238 in the Industrial Area were used as the basis for calculating an adequate number of samples. With an alpha = 1% (false positive error rate) and a beta = 5% (false negative error rate), 90 verification samples for the Industrial Area and the balance of the anticipated DOE retained lands are needed to verify that the existing samples remain representative. Table 5 outlines all the statistical parameters used to calculate the necessary number of verification samples.

Table 5: Statistical Parameters Used and Required Number of Verification Samples

Radionuclide	Mean pCi/g	Standard Deviation pCi/g	Alpha percent	Beta Percent	Number of Verification Samples
Visual Sample Plan Input Parameters and Results for Sample Locations from 1991 through 1995 within the Industrial Area					
Pu-239	1.4	4.9	1	5	24
Am-241	0.9	3.1	1	5	24
U-234	1.5	2.5	1	5	16
U-235	0.2	0.9	1	5	27
U-238	1.8	3.8	1	5	19
Visual Sample Plan Input Parameters and Results for Sample Locations from 1996 through 2005 within the Industrial Area					
Pu-239	3.31	5.86	1	5	17
Am-241	0.86	1.87	1	5	19
U-234	2.57	2.65	1	5	11
U-235	0.15	0.1	1	5	8
U-238	2.6	2.7	1	5	12
Visual Sample Plan Input Parameters and Results for Sample Locations from 1991 through 1995 within the Anticipated DOE Retained Lands outside of the Industrial Area					
Pu-239	1.92	6.3	1	5	24
Am-241	0.96	4	1	5	26
U-234	1.3	2.63	1	5	18
U-235	0.27	2.62	1	5	32
U-238	1.35	1.69	1	5	13
Visual Sample Plan Input Parameters and Results for Sample Locations from 1996 through 2005 within the Anticipated DOE Retained Lands outside of the Industrial Area					

Pu-239	19.55	15.25	1	5	9
Am-241	9.34	9.1	1	5	11
U-234	4.2	1.79	1	5	5
U-235	0.24	0.26	1	5	12
U-238	4.25	1.99	1	5	6

The 90 verification sample locations from the maximum value in each of the 4 populations in Table 5 were randomly selected from the population of sample locations that remain representative. In addition, 10 biased locations were also selected to ensure all areas of the Industrial Area and anticipated DOE retained lands were represented by verification samples. The selected verification sample locations are shown on Figures 10 and 11. Figure 10 shows the locations of planned verification samples in relation to location of all existing surface radionuclide samples and provides approximate boundaries for the Industrial Area and anticipated DOE retained lands. These boundary lines are approximated for purposes of this Verification Plan and are larger than the actual anticipated areas for conservative reasons. Figure 11 is identical to Figure 10, but without the previous sample locations to more clearly show the planned verification sample locations.

Samples will be collected consistent with the methodologies described in the IABZSAP. All samples will be analyzed in approved off-site laboratories with alpha spectrometry. Results will be verified and validated consistent with the IABZSAP.

3.3 Historical Review

The original HRR, as published in 1992, presented a comprehensive review of potential release sites based on review of more than 4,000 documents and hundreds of interviews with employees and former employees. The HRR was updated quarterly until 1996 and then annually thereafter. New information was included in these updates. The final annual update in 2005 will consolidate the information from each potential release site into a single volume as a complete history of the events, actions, and decisions for each potential release site. This review will help ensure that all potential release sites have been evaluated in accordance with RFCA.

3.4 Existing Data Review

The Wilcoxon Rank Sum (WRS) Test will be used to compare the verification data set to the historical data set. The WRS test is a good test for this comparison since the data sets do not need to be normally distributed and non-detect values can be incorporated into the analysis. The WRS test is also being used to compare site and background data sets in the RFETS CRA. In addition, verification sample results will be compared to original sample results for each individual sample location. If the populations fall outside the acceptable statistics of the WRS Test, indicating potential recontamination, additional evaluation will be required to determine the appropriate action. No action will be required if the population statistics are acceptable or if the verification sample results indicate significantly less contamination than the original sample results.

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Once the data have been verified, all remaining valid data will be reviewed to ensure that no sample results exceed the RFCA action levels. This action will be performed by comparing every surface radiological sample result to its associated RFCA action level.

4.0 RESPONSE TO RESULTS ABOVE ACTION LEVELS

Initial response to any results above a RFCA action level will be to confirm results by resampling or scanning. Confirmation samples will be collected and analyzed consistent with the IABZSAP. Additional verification scanning will be performed consistent with this Verification Plan. Any areas identified and confirmed with surface radionuclides exceeding RFCA action levels will be appropriately dispositioned under RFCA.

4.1 Criteria for Verification Success or Failure

Both RFCA and MARSSIM allow for known, small areas with elevated measurements or hot spots to remain after remediation, as well as unknown areas within an acceptable confidence limit. The CERCLA process uses risk assessment to define successful cleanup. At RFETS a risk not to exceed 10^{-5} to a wildlife refuge worker for accelerated actions has been determined to be acceptable. For successful verification, average contamination for all areas larger than ~80 m^2 must not exceed the RFCA action levels, and contamination for smaller areas must not exceed the values determined by the constant 10^{-5} risk curves shown in Figures 1 - 4 (for the wide-area scan, except for U-238 as referenced in footnote 2) or three times the RFCA action levels consistent with the IABZSAP hot spot methodology (for the ground-based scan).

4.2 Actions Based on Verification Results

Objective 1. Verify, with reasonable certainty, that all radioactively contaminated surface soil beyond the known and suspected release sites has been identified and appropriately dispositioned under RFCA.

Required Action: If wide-area scanning identifies no surface radiological contamination posing a risk greater than 10^{-5} to a wildlife refuge worker (for wide-area scanning) or that exceeds RFCA action levels for areas greater than ~80 m^2 (for ground-based scanning), then no further action will be required. If anomalies are identified from the scanning, additional ground-based scanning and sampling may be required to confirm and define the extent of radiological contamination. Based on these results, additional remediation may be required.

Objective 2. Verify, with reasonable certainty, that remedial actions are complete and that no radiological surface contamination above RFCA action levels or allowable elevated measurements per the IABZSAP remains in adjacent areas.

Required Action: If ground-based scanning indicates average surface radiological contamination does not exceed RFCA action levels for areas of ~80 m^2 and radionuclide surface contamination is less than the allowable elevated measurement levels based on the IABZSAP hot

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spot methodology of no more than three times the RFCA action levels for smaller areas adjacent to remediated areas, then no further action will be required. If exceedances of RFCA action levels are identified from the ground-based scanning, additional ground-based scanning and sampling may be required to confirm and define the extent of radiological contamination. Based on these results, additional remediation may be required.

Objective 3. Verify, with reasonable certainty, that existing sampling data for radionuclides in the surface soil are valid and remain representative after site cleanup activities.

Required Action: If the means for the data verification data sets are less than or comparable with the means from the existing data sets, within acceptable statistical uncertainty, and no single verification sample result exceeds the RFCA action level, then no further action will be required. If either the means for the data verification data sets are unacceptably high or if single verification sample results exceed the RFCA action levels, further sampling and analysis may be required to confirm and define the extent of radiological contamination. Based on these results, additional remediation may be required.

5.0 HEALTH AND SAFETY

All field sampling and scanning activities will be conducted consistent with the "Environmental Restoration Program Health and Safety Plan for the Rocky Flats Environmental Technology Site", PRO-1468-HASP-01, Sept, 7, 2001. Specific Job Hazard Analysis and Integrated Work Control Plans will be required.

6.0 VERIFICATION PLAN SCHEDULE

The schedule for implementing this Verification Plan is included in Appendix C.

Figure 1
Iso "Risk" of Pu-239/240 as a Function of Area and Soils Concentration

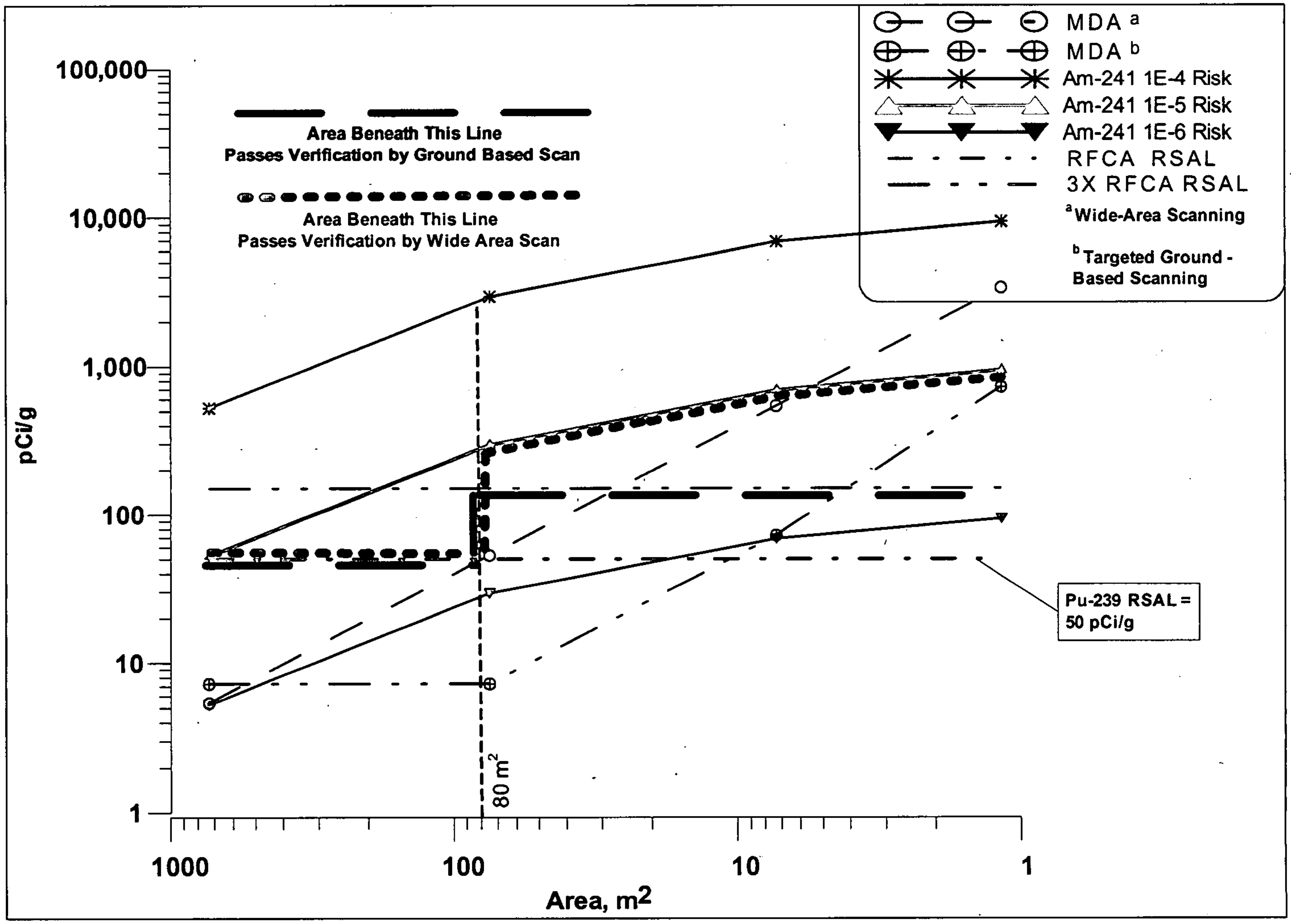


Figure 2
Iso "Risk" of Am-241 as a Function of Area and Soils Concentration

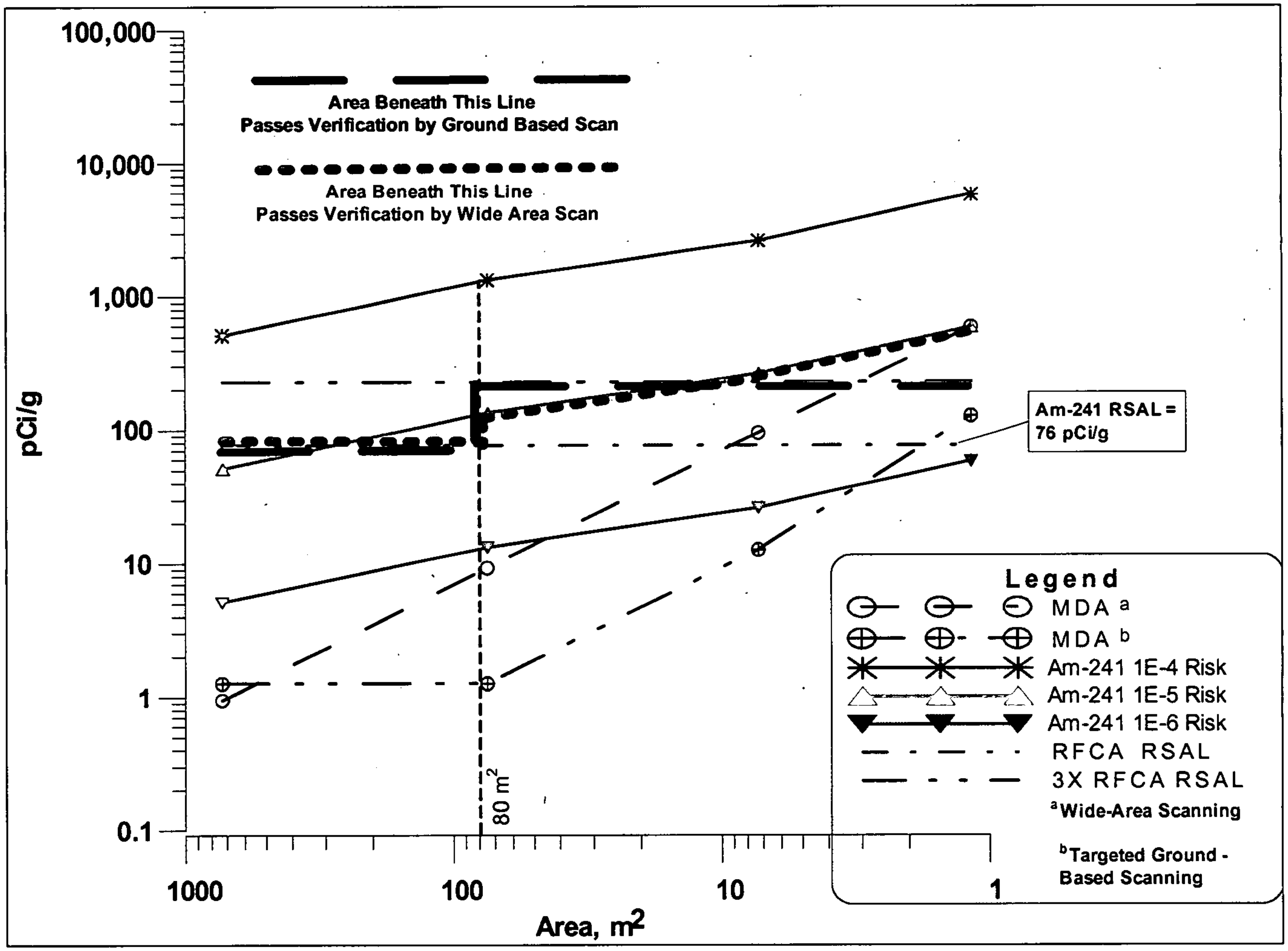


Figure 3
Iso "Risk" of U-235 as a Function of Area and Soils Concentration

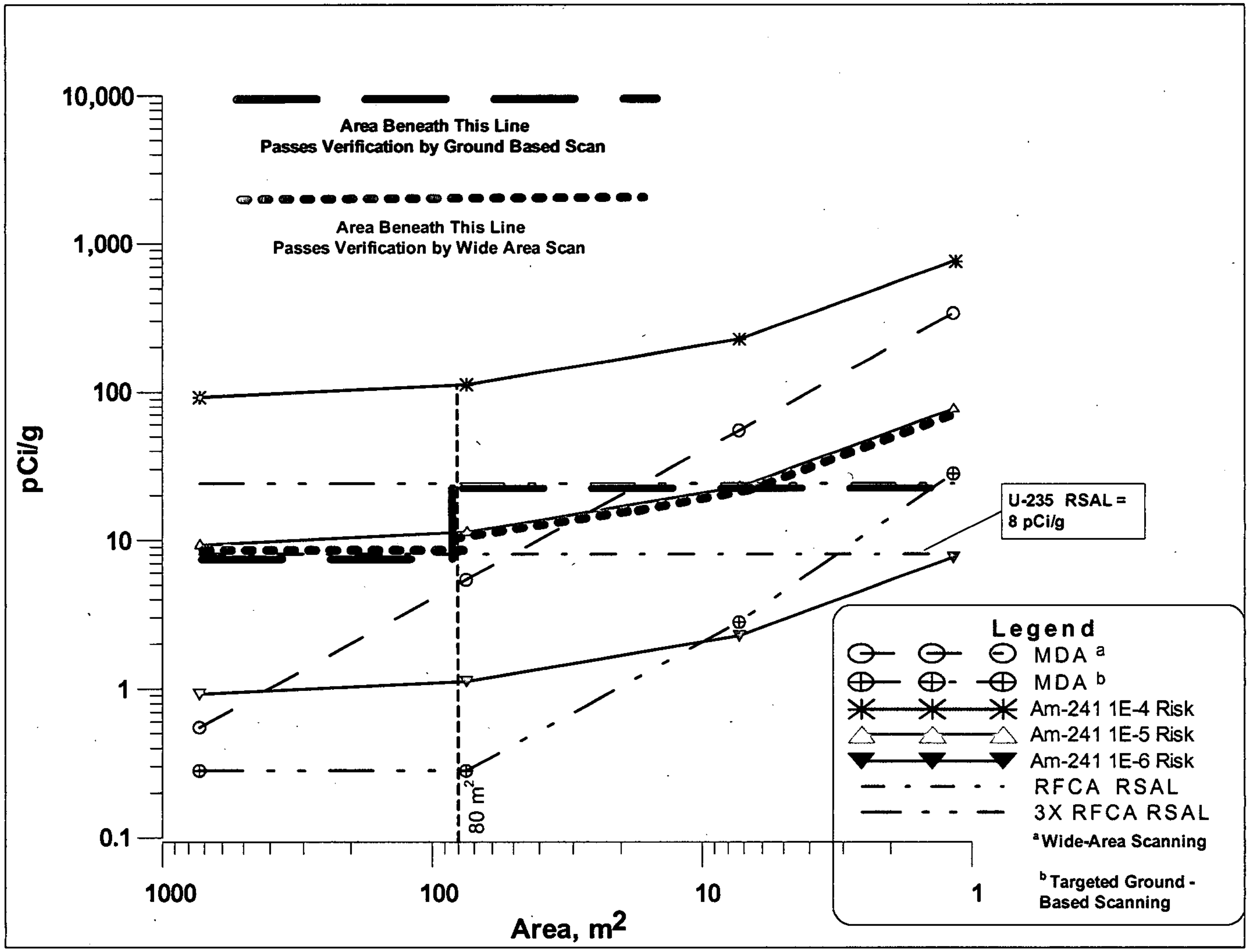


Figure 4
Iso "Risk" of U-238 as a Function of Area and Soils Concentration

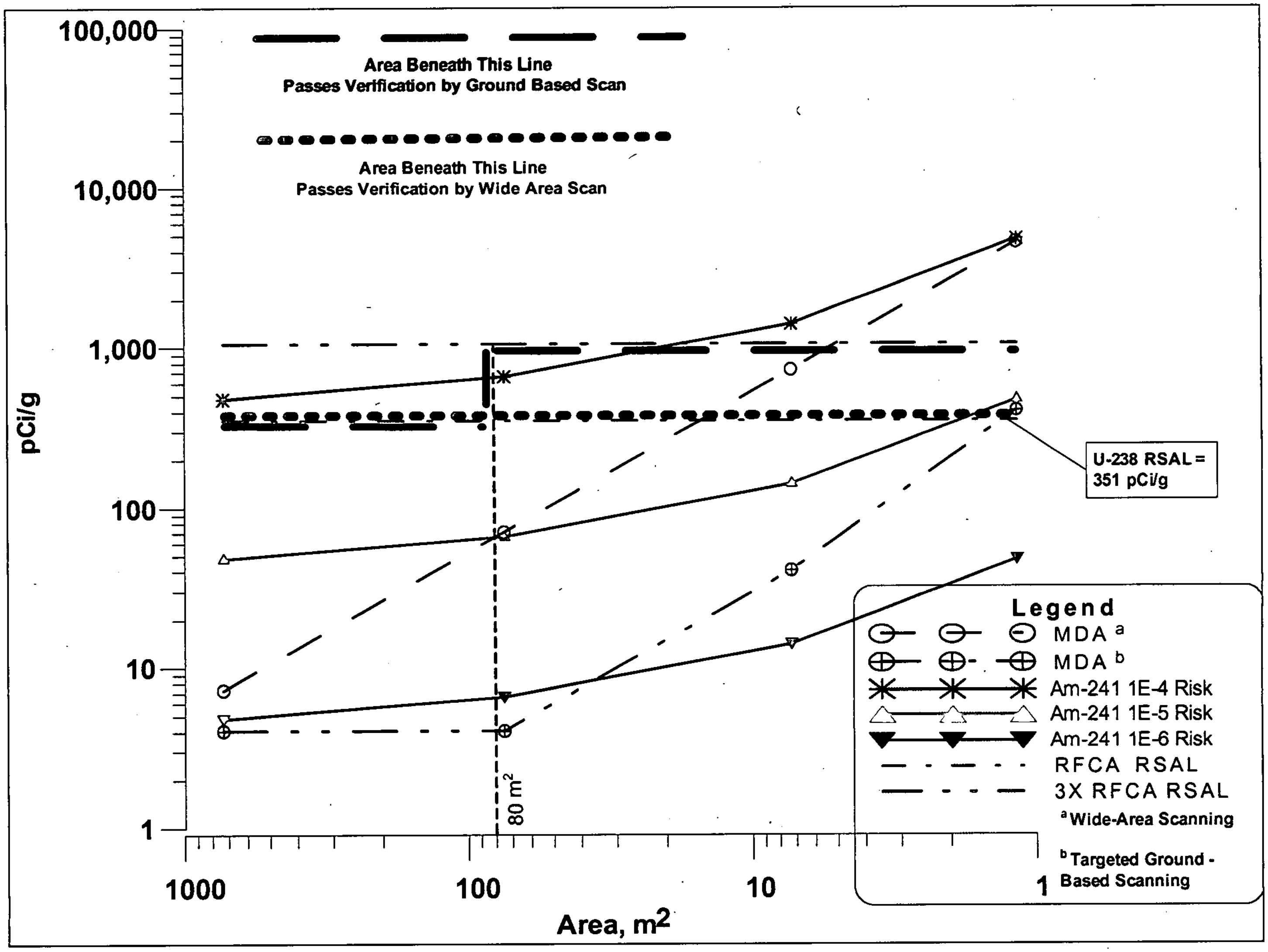


Figure 5
Iso Dose of Pu-239/240 as a Function of Area and Soils Concentration

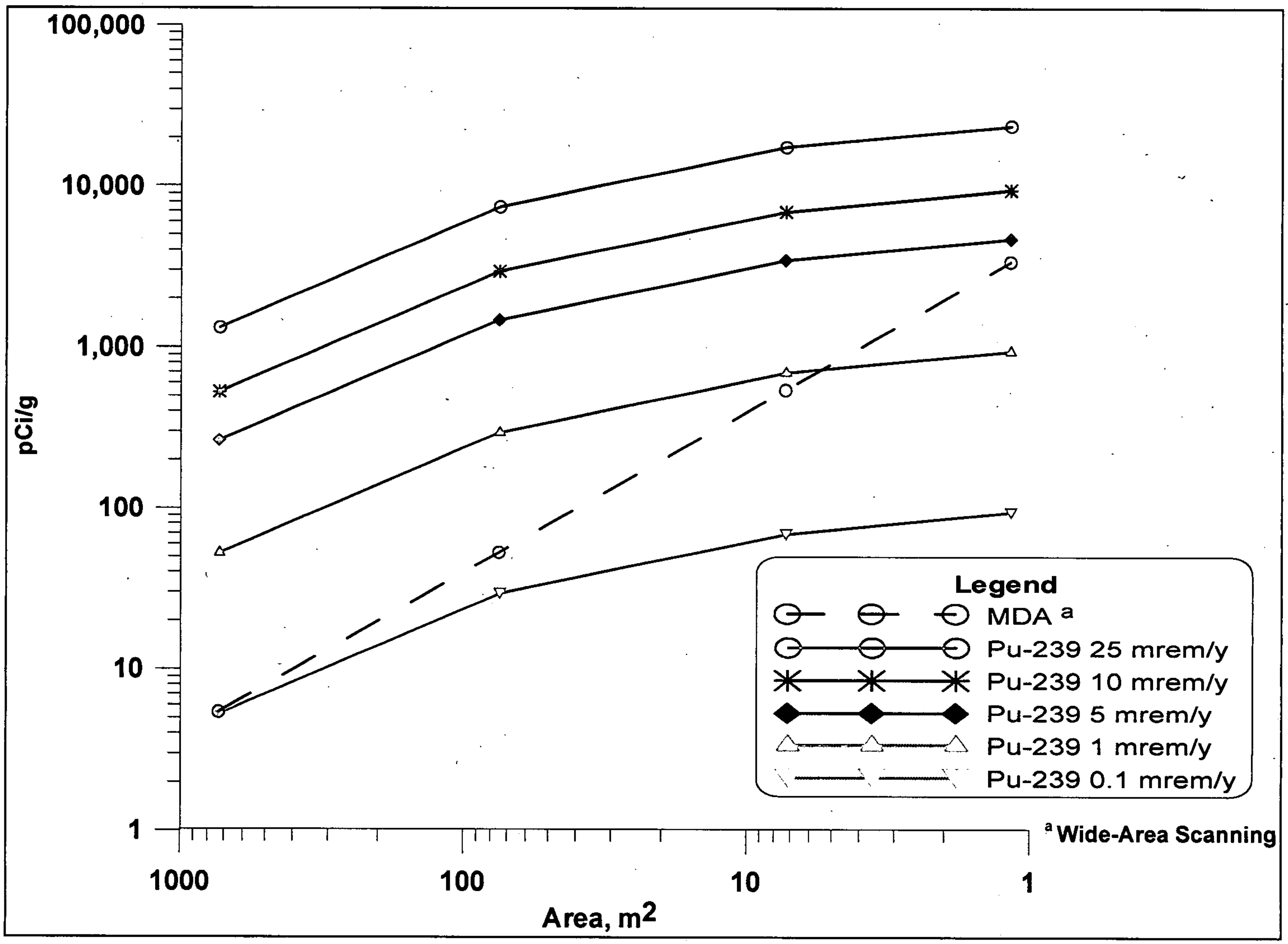


Figure 6
Iso Dose of Am-241 as a Function of Area and Soils Concentration

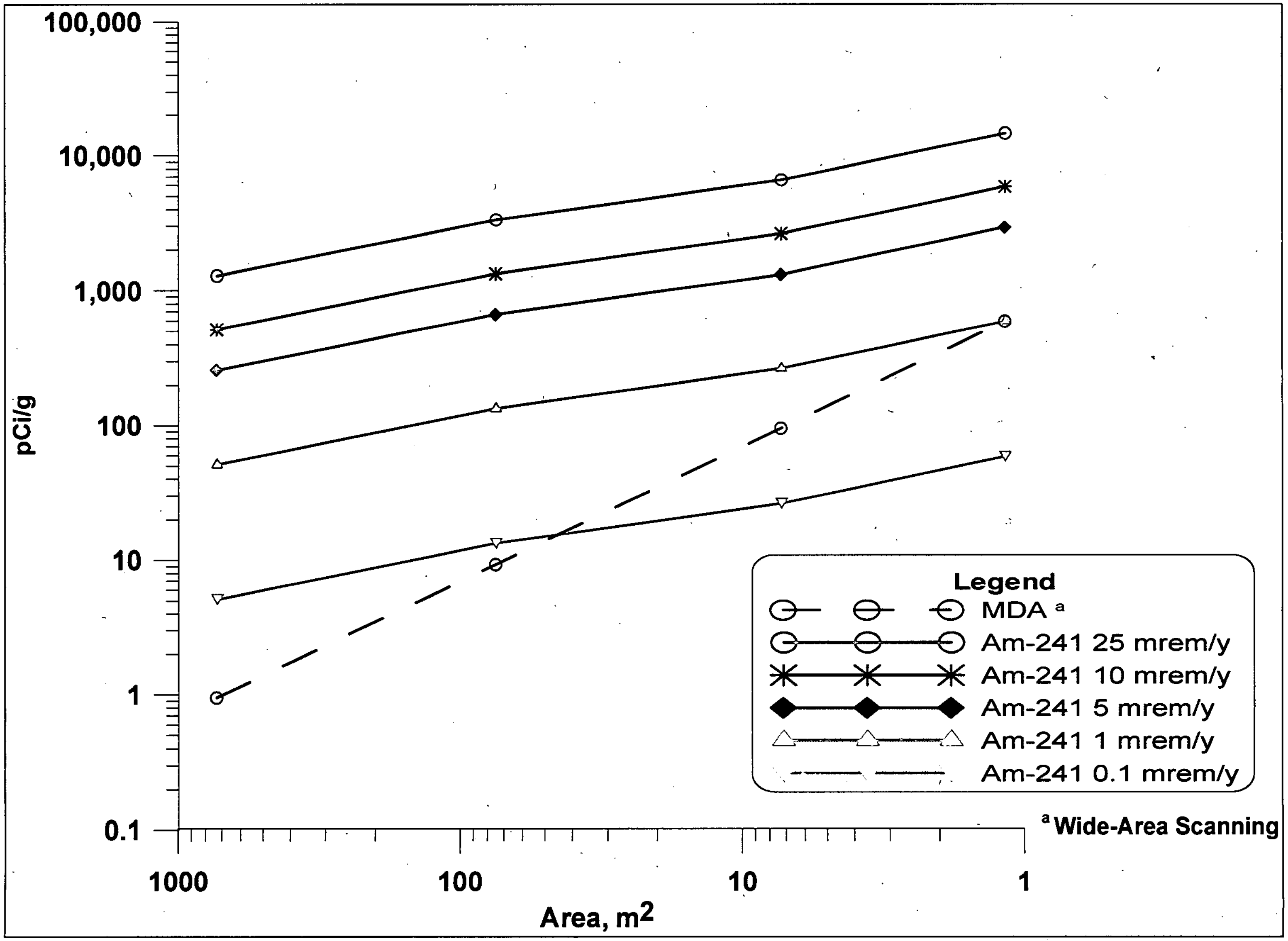


Figure 7
Iso Dose of U-235 as a Function of Area and Soils Concentration

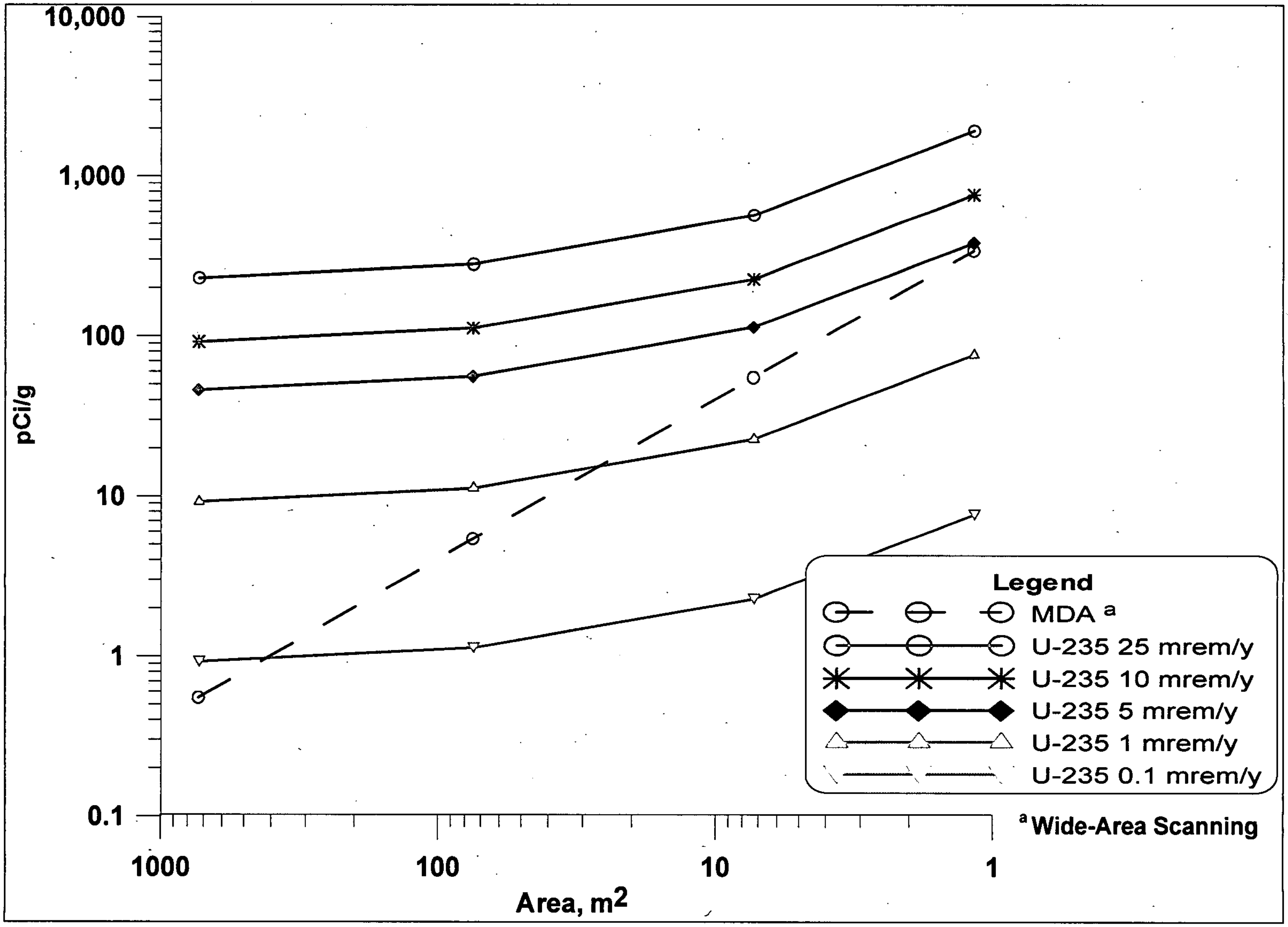


Figure 8
Iso Dose of U-238 as a Function of Area and Soils Concentration

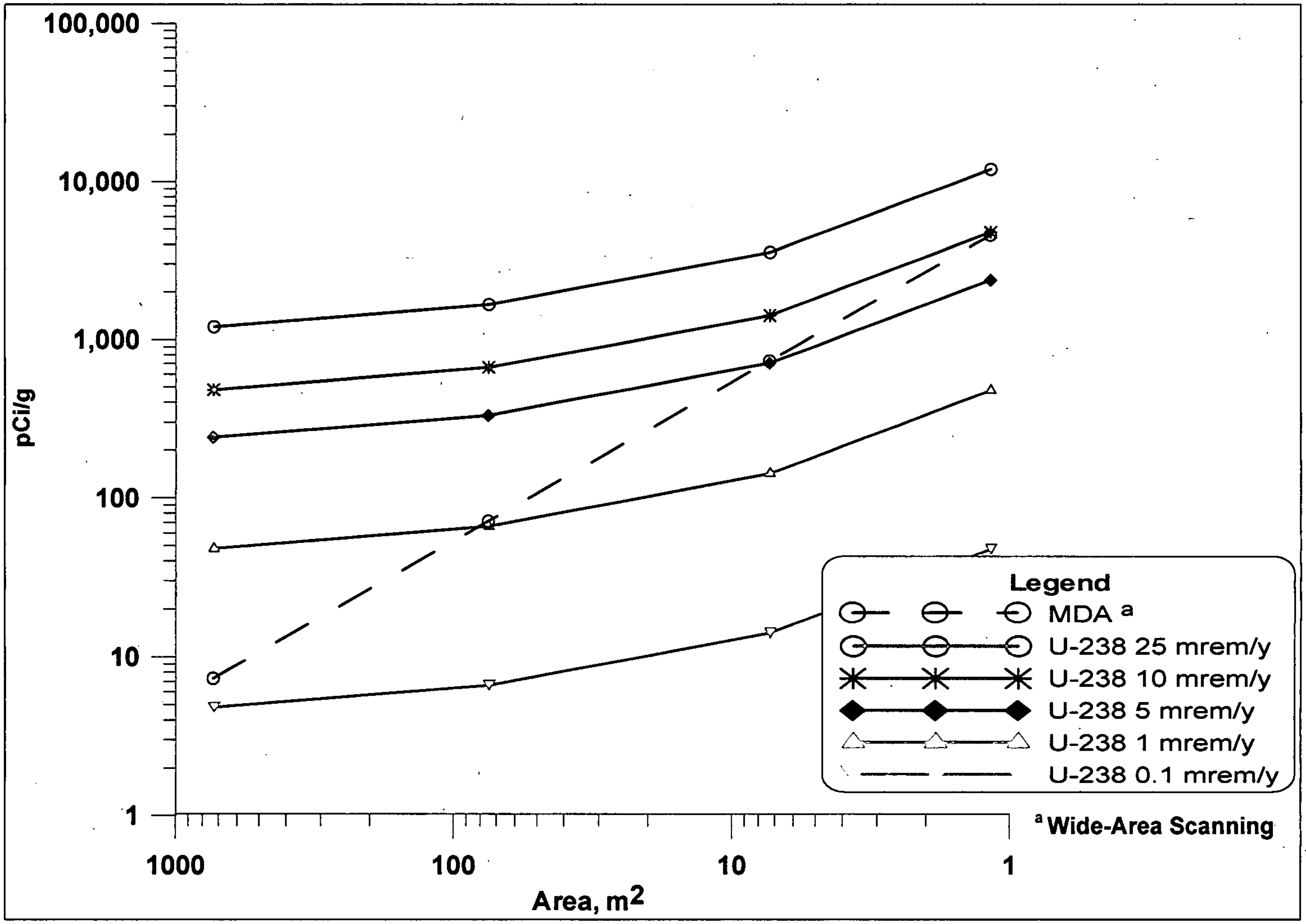
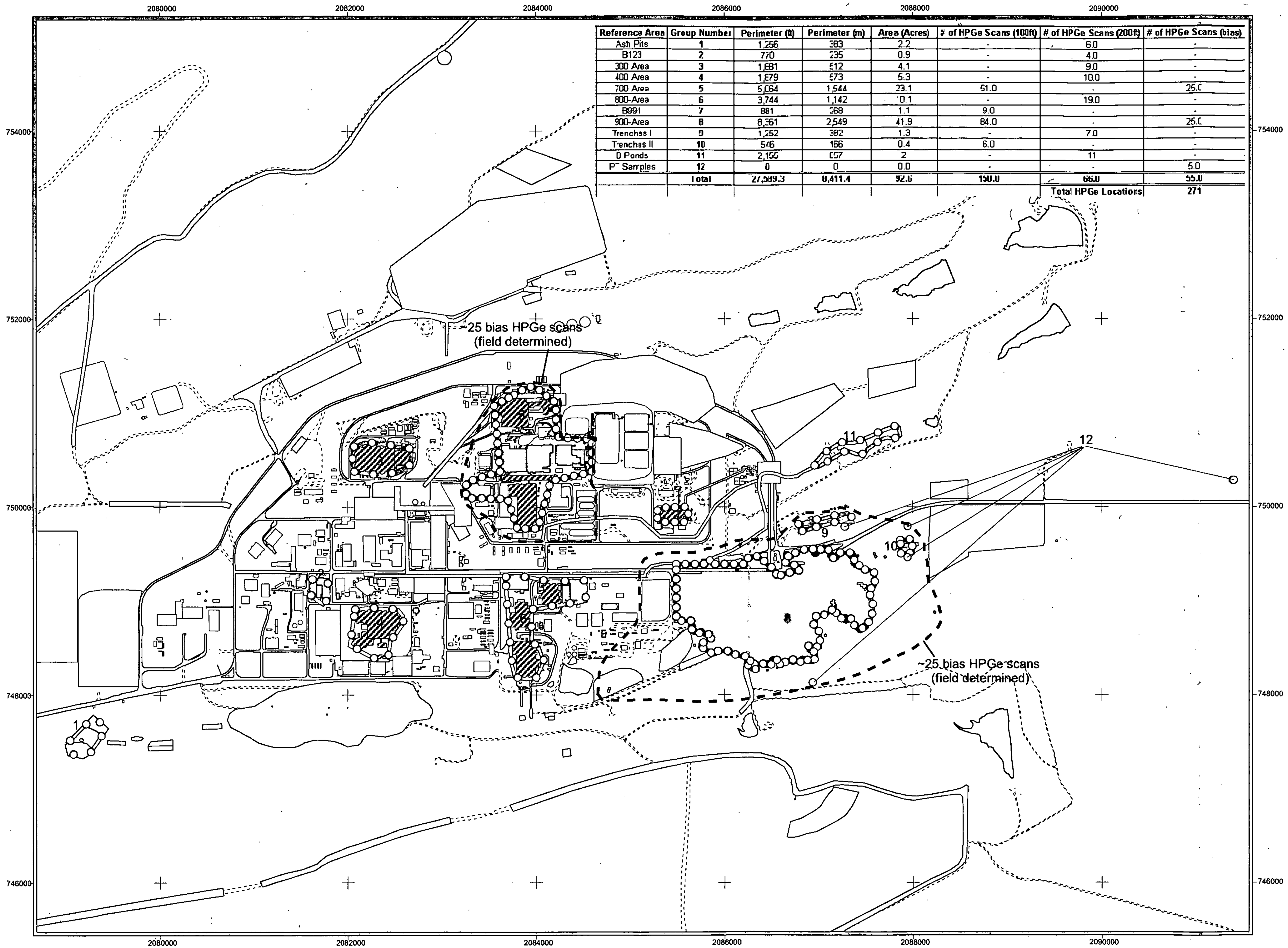


Figure 9
Targeted Ground-Based Scanning Locations for RFETS Verification Plan

Reference Area	Group Number	Perimeter (ft)	Perimeter (m)	Area (Acres)	# of HPGe Scans (100ft)	# of HPGe Scans (200ft)	# of HPGe Scans (bias)
Ash Pits	1	1,256	383	2.2	-	6.0	-
B123	2	770	235	0.9	-	4.0	-
300 Area	3	1,681	512	4.1	-	9.0	-
400 Area	4	1,879	573	5.3	-	10.0	-
700 Area	5	5,064	1,544	23.1	51.0	-	25.0
800-Area	6	3,744	1,142	10.1	-	19.0	-
B991	7	881	268	1.1	9.0	-	-
900-Area	8	8,361	2,549	41.9	84.0	-	25.0
Trenches I	9	1,252	382	1.3	-	7.0	-
Trenches II	10	546	166	0.4	6.0	-	-
0 Ponds	11	2,155	657	2	-	11	-
PT Samples	12	0	0	0.0	-	-	5.0
	Total	27,589.3	8,411.4	92.6	150.0	66.0	55.0
						Total HPGe Locations	271



Scale = 1: 13000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Date: 02.07.05

Prepared by: RADMS

Prepared for: KAISER•HILL COMPANY

W:\Projects\FY2005\Ruthven\site_excvtn_bndrys.apr

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Figure 10
Existing Surface Sample Locations for Radionuclides and Randomly Chosen Verification Surface Sample Locations For Radionuclides

KEY

- Bias Sampling Locations
- Random Samples DOE ICA '91-'95
- Random Samples Industrial Area '91-'95
- Random Samples DOE ICA '96-'05
- Random Samples Industrial Area '96-'05

Radionuclide Surface Sample Locations

- 1988 - 1990
- 1991 - 1995
- 1996 - 2000
- 2001 - 2005
- IA Data Set Boundary
- Site Boundary
- Building Footprints
- PACs
- IHSS
- Estimated DOE Retained Land Data Set Boundary

N
W E
S

600 0 600 1200 1800 Feet

Scale = 1:17,000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

RADMS

Prepared for:

KAISER•HILL COMPANY

Date:02.07.05

W:\Special_projects\Verification-Sampling\radverification.apr

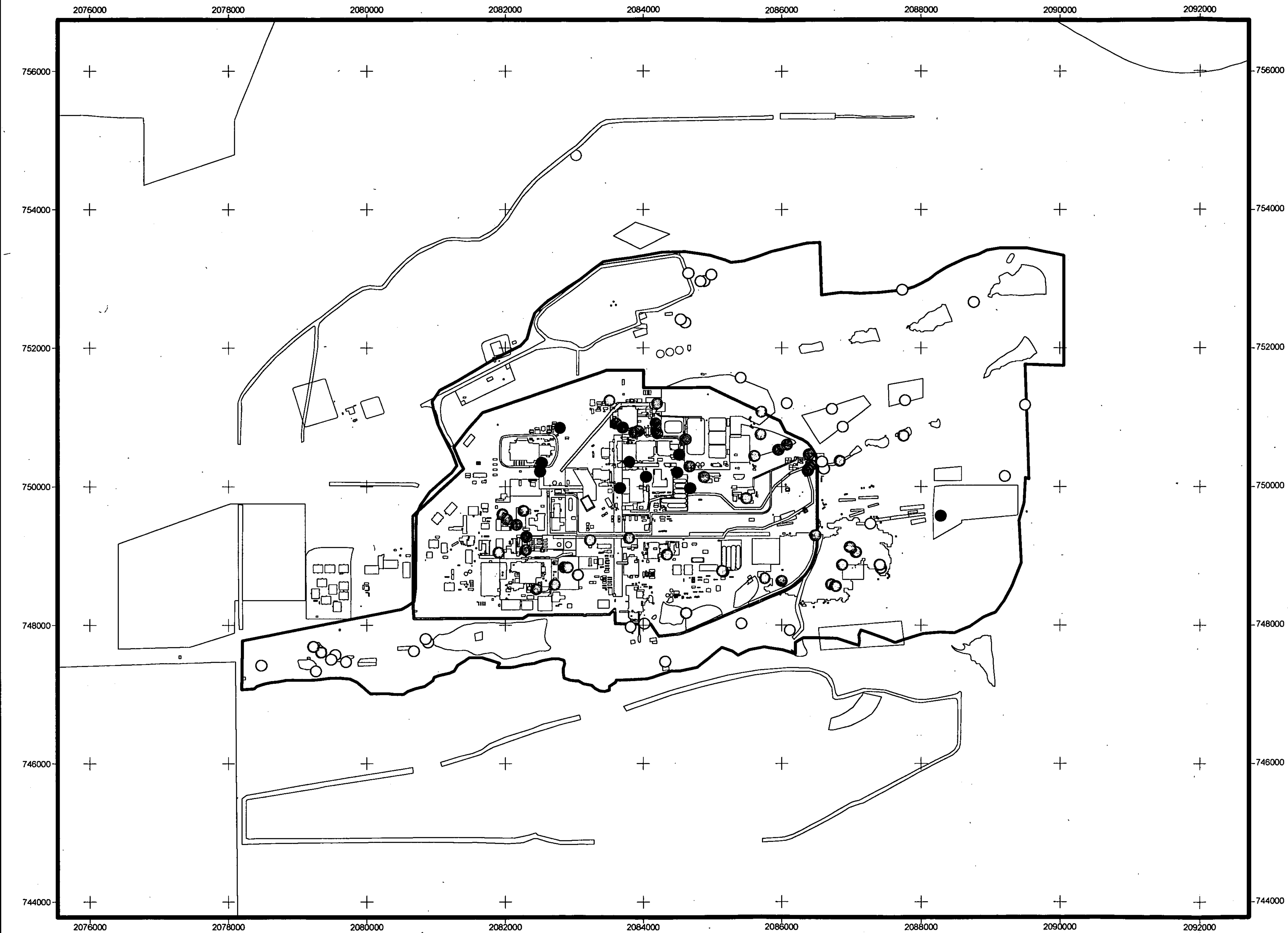

Figure 11
Randomly Chosen Verification Surface Sample Locations For Radionuclides

KEY

- Bias Sampling Locations
- Random Samples DOE ICA '91-'95
- Random Samples Industrial Area '91-'95
- Random Samples DOE ICA '96-'05
- Random Samples Industrial Area '96-'05

- IA Data Set Boundary
- Site Boundary
- Building Footprints
- PACs
- IHSS
- Estimated DOE Retained Land Data Set Boundary

N W E S

500 0 500 1000 1500 2000 Feet

Scale = 1:17,000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

RADMS

Prepared for:

KAISER-HILL COMPANY

Date:02.04.05

W:/Special_Projects/Verification Sampling/radverification.apr

APPENDIX A
RFETS Process Knowledge, Site Investigation, Site Characterization, and Remediation

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RFETS PROCESS KNOWLEDGE, SITE INVESTIGATION, SITE CHARACTERIZATION, AND REMEDIATION

1.0 SITE HISTORY AND EARLY INVESTIGATIONS

The Rocky Flats Environmental Technology Site (RFETS) was part of a nationwide nuclear weapons complex owned by the Department of Energy (DOE) and located northwest of Denver, Colorado. The facility was operated until January 1992 as a nuclear weapons research, development, and production complex. RFETS fabricated components for nuclear weapons from plutonium, uranium, beryllium, and stainless steel. Support activities included chemical recovery and purification of recyclable transuranic radionuclides, and research and development in metallurgy, machining, nondestructive testing, coatings, remote engineering, chemistry, and physics. The RFETS is currently being closed, demolished, and remediated under a DOE Closure Contract.

Construction of the Rocky Flats Plant (RFP) began in 1951 and the first production activities commenced the following year. Operation of the RFP fell under the administration of the U. S. Atomic Energy Commission (USAEC) from 1951 until the USAEC was dissolved in January 1975. Responsibility for the plant was then transferred to the Energy Research and Development Administration (ERDA), which was succeeded in 1977 by DOE. Dow Chemical USA (Dow) was the prime operating contractor of the facility from 1951 until 1975. Rockwell International (Rockwell) succeeded Dow from 1975 through 1989. On January 1, 1990, EG&G assumed RFP operations. The name of the site was changed from RFP to RFETS in July of 1994. Kaiser-Hill was awarded the closure contract for RFETS on July 1, 1995. The Rocky Flats Cleanup Agreement (RFCA) was signed July 19, 1996. RFCA superseded the Interagency Agreement (IAG) and was a legally binding agreement between DOE, the Environmental Protection Agency (EPA), and Colorado Department of Public Health and Environment (CDPHE) to accomplish the required cleanup of radioactive and other hazardous substances contamination at and from RFETS. The cleanup vision for RFETS to be implemented under RFCA was:

- To achieve accelerated cleanup and closure of Rocky Flats in a safe, environmentally protective manner and in compliance with applicable state and federal environmental laws;
- To ensure that Rocky Flats does not pose an unacceptable risk to the citizens of Colorado or to the site's workers from either contamination or an accident; and,
- To work toward the disposition of contamination, wastes, buildings, facilities, and infrastructure from Rocky Flats consistent with community preferences and national goals.

General events of significance have occurred at RFETS that have potentially affected the environment of the entire site and not just one discrete location. A major facility expansion was initiated in 1955 and referred to as Part IV construction. The expansion provided greater process capabilities and many more buildings and facilities. When the buildings went into operation, contaminated liquid and solid waste was produced at a greater rate than before the expansion. Storage and disposal of the wastes became a major concern and several waste management practices were initiated that are now considered to have caused negative impacts on the environment. Some of these waste management practices created several of the areas of concern now being identified and addressed.

In 1957, a fire occurred in Building 771, a plutonium recovery facility that caused the plenum filters to be breached. In addition to airborne releases due to the fire, fire-fighting efforts and clean-up activities contributed to releases to the environment.

A second major plant expansion, Part V construction, was begun in 1967, prompting increased manufacturing capabilities and waste-producing activities. Significant environmental clean-up efforts of waste produced during the 1950s and early 1960s were initiated at the same time.

In 1969, a fire occurred in Building 776 and Building 777 which spread contamination into the buildings, the surrounding asphalt and soil, and the atmosphere. Subsequent clean-up activities produced a significant amount of contaminated fire wastes, which were stored and/or disposed of on-site. Following the fire, waste storage problems increased and concerns were heightened regarding the potential for off-site releases via air, surface water, and groundwater. In addition to contaminated waste clean-up activities, waste management procedures were altered to reduce potential environmental impact. Detention ponds in the drainages were upgraded and additional controls installed to monitor surface water prior to off-site discharge. The DOE purchased additional land surrounding the plant in 1974, 1975, and 1976, which expanded the buffer zone and further isolated the manufacturing area from surrounding communities.

A site-wide radiometric survey was performed from 1977 to 1984 using hand-held FIDLER instruments. The purpose of the survey was to detect extremely contaminated areas of the site. By 1984, over 11 million square feet of the site was surveyed and relative concentrations of plutonium in the surficial materials were mapped. Although arrangements for removal or cleanup of discrete areas were made if the detected contamination was considered an immediate hazard, cleanup was not intended to be an integral part of the survey. The identification of 'hot spots' prompted consideration in the development of subsequent environmental activities.

2.0 PAST ENVIRONMENTAL STUDIES

Many detailed studies of the site environment have been performed. These studies include characterizations of site geology, hydrology, biology, meteorology, and demography, as well as prior efforts to identify and characterize potential hazardous substance sites. These latter studies provide most of the information upon which the current IHSS and OU structure at the RFETS is based, and are of primary importance to the Historical Release Report (HRR) because they were intended to meet many of the same requirements as the HRR. The following paragraphs present brief descriptions of these studies.

A 1973 study was initiated by USAEC and focused on potentially contaminated soils at RFETS. The study was performed through a combination of records/literature review and employee interviews. A draft report was submitted (presumably to the USAEC) in October 1973. The USAEC directive that prompted the study also requested a plan of action for the location and investigation of all contaminated soils on the site, including cost estimates and schedules for remediation.

In May 1975, ERDA (which succeeded USAEC in 1975) initiated an environmental assessment of the site as part of an ongoing program of assessments at various ERDA facilities. The eventual result of the assessment was the Final Environmental Impact Statement (EIS), produced by the DOE in April 1980. The EIS document contains descriptions of the facility, environs, and operations from the viewpoint of environmental impact, but does not include specific descriptions of hazardous substance sites at the Rocky Flats.

In response to the promulgation of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) in 1980, DOE developed an internal program, the Comprehensive Environmental Assessment and Response Program (CEARP). CEARP specified a phased approach to site investigation and remediation which was intended to enable DOE to comply with CERCLA requirements at its facilities, and therefore incorporated many elements of CERCLA. CEARP was later succeeded by the Environmental Restoration (ER) Program. The DOE initiated an assessment of RFETS under Phase 1 of CEARP through their Los Alamos operations office. The CEARP Phase 1 assessment included the identification and characterization of potential CERCLA sites at RFETS (i.e., inactive or former disposal facilities, activities, spills, or leaks), and a ranking of potential hazards and contaminant migration at each site. Sites were identified and characterized based on limited records review and interviews with site employees. The draft CEARP Phase 1 report was produced in April 1986 and was never finalized. The report contains the first systematic descriptions of many of the individual sites, which would later be designated as IHSSs.

CERCLA sites identified in the CEARP Phase 1 report were described, categorized, and supplemented with some additional sites in Table 1 of Appendix 1, RCRA 3004(u) Waste Management Units, of RFETS RCRA Part B Operating Permit Application first in November 1986, and then modified in December 1987. Also included in RCRA 3004(u) were "Inactive Waste Unit Summary Sheets" that provided brief descriptions of most of these sites as well as an evaluation of whether each site was regulated under the RCRA closure regulations, or whether it was strictly a CERCLA site. This document was prepared in response to the requirements of Section 3004(u) of RCRA, and was also specified under a Compliance Agreement of July 1986 between DOE, EPA, and CDPHE. The individual inactive sites from the CEARP Phase 1 report were designated as RCRA Solid Waste Management Units (SWMUs). These SWMUs later were redefined as IHSSs under the IAG. The IAG also presented an extensive list of active and planned waste management units at RFETS. A number of these units were also identified as IHSSs under the IAG, due to their removal from service. The IAG was approved January 22, 1991.

3.0 POST OPERATION STUDIES AND INVESTIGATIONS

The Historical Release Report (HRR), published in 1992, documented an extensive investigation to identify all known and suspected contaminant releases to the environment. The study included reviewing all previous investigation results, incident reports, spills, and other documented releases or incidents with potential for release. More than 4000 documents were reviewed and several hundred interviews were conducted with employees and former employees. The investigation did not end with the publication of the first HRR, but is continuing. Documentation was updated quarterly until 1996 and then annually thereafter, with new information and status changes of the release sites. As a result of this ongoing work, a few new sites have been identified for investigation since the publication of the original HRR, however, no significant areas of contamination have been identified that were previously unknown. The HRR and the updates have been reviewed and accepted by EPA and CDPHE. All sites have been or will be approved by DOE, EPA, and CDPHE as requiring no further accelerated action (NFAA) based on the action levels established in RFCA. The approved NFAA status is achieved when all evidence (characterization samples, confirmation samples, process knowledge, etc.) indicates that the contamination is below the action levels and/or cleanup requirements as set forth in RFCA. NFAA status may be achieved with or without remediation depending on contaminant levels.

CDPHE published the "Spatial and Temporal Analysis of the Rocky Flats Soil Plutonium Data" on September 19, 1994 summarizing more than 20 years of radiation surveys for plutonium in surface soil in the vicinity of Rocky Flats. The report provides contour maps of radiation levels around the site. The radiation level contours are all very low with most estimated contours well below 1 dpm/g for Pu-239/240. As expected, higher concentrations of Pu contamination were found in the area around the 903 Pad.

CDPHE conducted two independent investigations in 1999 and 2003 to verify that all potential release sites and disposal areas in the buffer zone had been identified. The studies consisted of reviewing historic aerial photographs for evidence of soil disturbance or activities associated with site operation, reviewing existing reports, and performing site walkdowns for any observable anomalies in the natural terrain and vegetation. Several potential sites were identified for further investigation. Each of the sites identified were investigated in more detail by Kaiser-Hill and found to require no further action.

The Actinide Migration Evaluation (AME) Program was initiated in 1996 to address the question – how do radioactive elements move in the environment? Specifically, the AME focused on issues of actinide behavior and mobility in surface water, groundwater, air, soil and biota at RFETS. A panel of independent experts was assembled from around the country to perform the AME. This extensive evaluation included thorough review of RFETS operating history and processes, source areas, environmental chemistry, and migration pathways. Results of the AME helped guide characterization and remediation. Their work at the site continues today on building-specific D&D issues and erosional processes.

Numerous other studies and modeling were performed in support of the characterization and remediation work at RFETS. These studies included: development of the Site Conceptual Model; Pathway Analysis Report; Biological Impacts on Actinide Mobility Evaluation; Air Transport Pathway; Dispersion Model; Erosion and Sediment Transport Modeling; Vadose Zone Modeling; Uranium Geochemical Modeling; Uranium Transport Modeling; Uranium Speciation Studies; Soil Aggregation Properties; Concrete Leaching Studies; Actinide Lab Studies/Wetlands Feasibility Evaluation; Site Water Balance; Geostatistical Probability Kriging; RCRA/CERCLA Risk Assessment, and other studies conducted for soil, groundwater, surface water, and air summarized each year in the RFETS Annual Environmental Monitoring reports. These studies were conducted by Kaiser-Hill and others.

4.0 RFETS SAMPLING AND CHARACTERIZATION

Extensive sampling and characterization has been performed at RFETS under numerous sampling plans with various Data Quality Objectives. Samples have been collected for both radioactive contamination and non-radioactive contamination. Most, if not all, samples collected were qualitatively screened for radioactivity as a requirement of site sampling procedure and Department of Transportation (DOT) off-site shipment of samples, providing additional verification of the location of radioactive contamination, even for non-radioactive samples. The Industrial Area (IA)/Buffer Zone (BZ) Sampling and Analysis Plan (SAP) provides QA/QC requirements for all recent samples. Historic sample results have been reviewed and qualified for use prior to making remedial action decisions.

As of October 25, 2004, the RFETS Soil and Water Database (SWD) contained the following data:

- Sample Locations 11,408
- Samples 141,307
- Analyses 434,850
- Analytical Results 6,556,486
- Radiological Results (water)146,946(Pu-239/240, Am-241, U-234, 235, 238)
- Radiological Results (soil)133,960(Pu-239/240, Am-241, U-234, 235, 238)

Some of the data in SWD are no longer representative (NLR) due to soil removal during remediation. The NLR data remain in the database, but confirmation sample results for those locations are now used to represent those areas.

The data at RFETS were primarily collected for CERCLA remedial investigations, for environmental monitoring, and as confirmation sampling following remediation. From 1986 through 1995, 16 Operable Unit (OU) Remedial Investigations (RI) were performed under CERCLA. Most of these RI reports were prepared in draft only and never finalized due to the new accelerated action approach for implementing CERCLA under RFCA, but the data have been qualified and are valid. These OUs were:

1. 881 Hillside
2. 903 Pad with Mound and East Trenches
3. Offsite Areas including Standley Lake
4. Solar Ponds
5. Woman Creek with Original Landfill and Ash Pits
6. Walnut Creek

7. Present Landfill
8. 700 Area
9. OPWL (Outside Tanks)
10. Other Outside Closures
11. West Spray Field
12. 400/800 Areas
13. 100 Area
14. Radioactive Sites
15. Inside Building Closure Sites
16. Low Priority Sites

From 1995 through the present, investigations have been performed under the Rocky Flats Cleanup Agreement (RFCA). Individual sampling and analysis plans were prepared until the IA/BZ SAP consolidated the sampling protocol into a single plan with site specific addenda. Remedial actions were performed using RFCA decision documents. The RFCA decision documents include the requirements for confirmation sampling following remedial actions. Closeout Reports and Data Summary Reports have been published documenting remediation confirmation sample results and characterization sample results where remediation was not required, respectively.

Three hundred and sixty release sites have been identified at RFETS. An additional 61 potential incidents of concern (PICs) without specific release sites have also been identified.

The Rocky Flats Integrated Monitoring Plan (IMP) was established in 1997. Monitoring of environmental media was consolidated under this plan. The IMP establishes the protocols for air monitoring, groundwater monitoring, surface water monitoring, and ecological monitoring. All data collected are verified and validated and entered into SWD. Data are summarized and reported through routine reporting mechanisms to the regulators and the public.

5.0 RADIOLOGICAL SCANNING AND SURVEYING

Several radiological scans/surveys have been performed at RFETS. These scans are in addition to the radiological scans performed on a routine basis by site radiological control for operations, sampling, material handling, incident investigation, decontamination, and worker health and safety.

As previously noted, a site-wide radiometric survey was performed from 1977 to 1984 using hand-held FIDLER instruments. The purpose of the survey was to detect extremely contaminated areas of the site. By 1984, over 11 million square feet of the site was surveyed and relative concentrations of plutonium in the surficial materials were mapped. Although arrangements for

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removal or cleanup of discrete areas were made if the detected contamination was considered an immediate hazard, cleanup was not intended to be an integral part of the survey. The identification of 'hot spots' prompted consideration in the development of subsequent environmental activities.

Two aerial radiological surveys have been performed, one in 1981 and one in 1989. The 1989 aerial scan is assumed to supersede the 1981 aerial scan because it is the most recent, production activities had generally stopped by 1989, and detection technology is assumed to have improved since 1981. The 1989 Survey covered 100% of the site as well as off-site areas. The survey used thallium-activated sodium iodide detectors mounted on a helicopter with an altitude of 46 meters, 76 meter north/south flight lines, and a speed of 30 meters per second. The minimum detectable activity (MDA) reported was 23.8 pCi/g for Am-241 with a field of view of approximately 76 meters. The isopleths generated from the aerial survey indicate several areas of potential contamination within the industrial area. However, these areas, with the exception of the 903 Pad, are associated with waste storage buildings and represent the waste stored in the buildings not environmental releases.

Associated with the 1989 aerial scan, 75 ground measurements were made using a high purity germanium detector (HPGe). At most of the 75 locations the detector was mounted on a vehicle with a boom having extension capability up to 7.4 meter above the ground. Where the terrain prevented vehicle access the detector was mounted on a tripod 1 meter above the ground. Count time was reported at 900 seconds. The MDA was assumed to be approximately 1 pCi/g for Am-241 with the field of views proportional to the height of the detector. The 75 locations of the ground measurements were primarily in the drainages east of the Industrial Area and along Indiana Street.

In 1994, an extensive scan of the site was performed with a HPGe detector mounted on the same vehicle and tripod system as used for the 1989 ground measurements. Approximately 1000 locations were surveyed. Count times were up to one hour per location. The MDA reported varied around 1 pCi/g for Am-241. The survey locations included many areas inside the industrial area, the 903 Pad and Lip Area, the Original Landfill, the PU&D Yard, and the Spray Fields.

In 1998, an extensive scan of the 903 Lip Area was performed with a HPGe detector mounted on the 1-meter tripod system. Over 1100 contiguous locations were surveyed starting at the west and moving to the east until 2 consecutive readings were below 10 pCi/g Am-241. More than 21 acres were surveyed with 78% coverage. The 22% not covered represents the space between the rows where the contiguous field of view circles did not touch (i.e. the corners). Count time was 20 minutes per survey and MDA for Am-241 was between 1 and 2 pCi/g.

In 2004, 30 additional locations were surveyed with HPGe and were used in conjunction with geostatistical kriging of existing data to help better define the area of remediation for the 903 Lip Area. These areas were surveyed using the same configuration as the 1998 surveys.

6.0 RFETS REMEDIAL ACTIONS

As of the end of FY04, all 61 of the PICs have been approved for no further accelerated action, and 285 of the 360 release sites have been approved for no further accelerated action. The NFAA status may be achieved with or without requiring remedial action. At the end of FY04, nearly 70 of the projected 84 sites requiring remedial action had been remediated. Remedial actions are performed to the RFCA action levels and requirements. Completion of remedial actions to the appropriate RFCA action levels are verified and approved by DOE, EPA, and CDPHE. While EPA and CDPHE have the flexibility to collect independent confirmation samples, EPA has collected independent samples only at the 903 Pad and Lip Area. All other verifications were based on the confirmation samples collected by RFETS using approved methods and procedures, analyzed by EPA approved off-site laboratories, and verified and validated consistent with EPA QA/QC guidance.

Under Building Contamination. No contamination above RFCA action levels was found beneath B371/374. No contamination was found beneath B771/774 except for contamination around and beneath the external tanks which was remediated to the RFCA requirements. No contamination above RFCA action levels was found beneath B886, B444, B881, and B991. Contamination beneath and around B779 was remediated to the RFCA requirements. Contamination beneath B776/777 has been identified and will be remediated once the building has been demolished. Contamination beneath B123 and B889 was primarily associated with process lines and has been remediated. A small area of contamination was found and remediated beneath B663. A small area of contamination was found beneath building 442 and was remediated. Generally, no other radioactive contamination was found beneath the many other non-process or waste storage buildings that have been demolished. Following remediation, the sites were graded as necessary to match the existing contour and revegetated. In some cases clean fill from on-site borrow areas was added to match the existing contour of the surrounding area.

Solar Evaporation Ponds. All the sludge was removed from the ponds. Isolated spots around the ponds with radioactively contaminated soil were removed to the RFCA requirements. A groundwater ~~collection~~ and treatment system was installed to collect and treat the contaminated groundwater. The berms were pushed in, the ponds were filled with several feet of clean soil from an on-site borrow source east of the solar ponds, and the area was revegetated.

903 Pad, Lip Area, and Windblown Area. The six-inch thick asphalt pad was removed and disposed. The fill material beneath the asphalt (6 inches) was removed and disposed. The top 3 feet of native soil was remediated to below 50 pCi/g Pu-230/240. Native soil between 3 and 6 feet was remediated to less than 1 nCi/g Pu-239/240. In most cases, all remaining soils after remediation were less than 50 pCi/g Pu-239/240 regardless of depth. The highest confirmation sample result was 296 pCi/g Pu-230/240 at 8 feet deep. All remediation was confirmed with a composite sample of 5 locations within each 25-ft by 25-ft area of the Pad. Clean fill from off-site was added to bring the area back to the grade prior to removal of the asphalt pad (several feet). The area was revegetated and covered with erosion control matting.

The inner lip area was remediated to less than 50 pCi/g Pu-230/240 within the top 3 feet and below 1 nCi/g Pu-239/240 between 3 and 6 feet (if necessary). All remediation was confirmed with a composite sample of 5 locations within each 42-ft by 42-ft area. Clean fill from off-site was added where necessary to bring the grade consistent with surrounding areas. However, where contouring was not required, no fill was added. The area was revegetated and covered with erosion control matting.

The outer lip area or windblown area was remediated to less than 50 pCi/g Pu-230/240. All remediation was confirmed with samples collected on a 50-foot grid. The average confirmation sample results for the entire outer lip area after remediation was ~15 pCi/g Pu-239/240. The area was revegetated and covered with erosion control matting.

Original Process Waste Lines. This remediation is still in progress. Completion of remediation is awaiting demolition of some structures prior to accessing the process waste lines. At the end of FY04, 11,870 feet of 16,938 feet of the process line expected to require removal had been removed. All lines regardless of contamination have been or will be removed to at least 3 feet below grade. Any radioactively contaminated surface soil (0-3 ft) encountered was remediated to less than 50 pCi/g Pu-239/240. Most of the soil encountered was at or near background levels of contamination after remediation was complete. The highest contamination level measured that remained in the subsurface was 225 pCi/g Pu-239/240 at 8 feet deep. All remediated areas were regraded to match the existing contour of the surrounding area and revegetated. Clean fill from on-site borrow areas was only used as necessary to achieve necessary contours.

Buried Waste. The Present Landfill was not intended as a radioactive disposal site. However, a small amount of radioactive material was known to have been placed in the landfill. No evidence exists to indicate there is any radioactive contamination in the surface soil at the landfill. A RCRA cover is currently being placed over the landfill and will consist of several feet of clean material and native vegetation. Most of the underlying fill for the cover was from on-site borrow areas. The final two feet of cover is from an off-site source.

The Original Landfill was primarily a construction debris disposal site. Radioactive material was known to have been placed in the landfill. Sixty kilograms of depleted uranium were placed in the landfill on one occasion and later removed. In 2004, 4 spots where uranium contaminated surface soil was detected were removed. A cover is being planned and designed with a minimum of 2 feet of clean fill material from an off-site source and native vegetation.

Trench 1was used for disposal of drums containing pyrophoric depleted uranium. The drums and associated contaminated soils were removed in 1998. The trench was filled and revegetated. The bottom part of the trench was filled with on-site soil collected from around the site in previous sampling activities that was sampled and found to be statistically uncontaminated above any action level. The top 2-3 feet of the trench was filled with clean soil from off-site.

The Mound area was used for disposal of drums containing used solvents. The drums were removed and the contaminated soil was treated to destroy the organic compounds. Radionuclides were not contaminants of concern. A groundwater collection and treatment system was installed to remediated the Mound plume. The area has been revegetated.

Trench 3 and 4 were used for disposal of uranium contaminated solvents and sanitary sewage sludge. The contaminated media has been removed, the trenches were backfilled with on-site soil, the area has been revegetated, and a groundwater treatment system has been installed to collect and treat the groundwater (for organic contamination).

The East Trenches were used for miscellaneous disposal. Some radioactively contaminated waste was placed in the trenches primarily from sewage sludge and solar evaporation pond planking. Remediation of the contents was not required based on the contamination level, the depth of the waste, and the location of the trenches. However, Pu contaminated surface soil was found on top of some of the trenches. This contaminated soil has been removed to the RFCA requirements of 50 pCi/g Pu-230/240 from 0 – 3 feet and backfilled with clean soil from on-site borrow areas.

The Ash Pits were used for disposal of incinerator ash. The incinerator burned uranium contaminated combustible material, primarily paper. The Ash Pits have been characterized and pass the RFCA risk screen requiring no remediation. Contents of the Ash Pits are covered with clean fill from the original soil excavated from the pits. However, the incinerator and the concrete wash pad were removed and any contaminated surface soil remediated to less than the RFCA action levels. The remediated area has been regraded and revegetated.

7.0 FINAL REMEDIAL INVESTIGATION/FEASIBILITY STUDY (RI/FS) AND COMPREHENSIVE RISK ASSESSMENT (CRA)

CERCLA requires that an RI/FS and a Record of Decision (ROD) be completed prior to final remedial actions. At RFETS, under RFCA, remedial actions are being performed as non-time critical removal actions as allowable under the National Contingency Plan. While the final Record of Decision must be completed prior to selecting the final remedy, it is anticipated that the accelerated actions will be sufficient so that final action will require only the ongoing institutional controls and surveillance and maintenance. The CRA is being prepared as part of the final RI/FS. The purpose of the CRA is to quantify risks posed by residual contamination at RFETS to human and ecological receptors after accelerated actions are completed. The CRA methodology has been prepared and approved by EPA and CDPHE. It describes the site conceptual model for contaminant exposure pathways, the assumptions and parameters to be used in the risk assessment calculations, use of existing data, and identifies the methodology to fill any data gaps to complete the CRA. When completed, the CRA will support the analysis of alternatives developed in the RI/FS. It is anticipated that the CRA will demonstrate with acceptable statistical confidence that the cleanup at RFETS meets or exceeds all remedial action objectives and that the site is safe for its intended future use.

APPENDIX B
Excerpts from the IABZSAP

3.0 DATA QUALITY OBJECTIVES

The RFETS Quality Assurance (QA) staff and Risk Assessment Working Group developed preliminary DQOs for the IABZAP. The Working Group consisted of DOE, the Kaiser-Hill Company, L.L.C. (K-H) Team, CDPHE, and EPA representatives. This section details sampling, analytical, and data analysis DQOs for IA and BZ activities. IA and BZ Group-specific DQOs will be presented in the appropriate IABZSAP Addenda, if required.

3.1 DQO Process for the IABZSAP

The DQO process is a series of planning steps designed to ensure that the type, quantity, and quality of environmental data used in decision making are appropriate for the intended purpose. EPA has issued guidelines to help data users develop site- and project-specific DQOs (EPA 1994). The DQO process is intended to:

- Clarify the study objective;
- Define the most appropriate types of data to collect;
- Determine the most appropriate conditions under which to collect the data; and
- Specify acceptable levels of decision errors that will be used as the basis for establishing the quantity and quality of data needed to support decisions.

The DQO process specifies project decisions, the data quality required to support those decisions, specific data types needed, data collection requirements, and analytical techniques necessary to generate the specified data quality. The DQO process consists of seven steps. Each step influences choices that will be made later in the process. These steps are as follows:

- Step 1 - State the Problem;
- Step 2 - Identify the Decision;
- Step 3 - Identify the Inputs to the Decision;
- Step 4 - Define the Study Boundaries;
- Step 5 - Develop a Decision Rule;
- Step 6 - Specify Tolerable Limits on Decision Errors; and
- Step 7 - Optimize the Design.

During the first six steps of the DQO process, the planning team develops decision performance criteria (that is, DQOs) for the data collection design. DQOs for the IABZSAP provide key IA and BZ characterization decision rules. All decision rules need to be considered, as appropriate. The final step of the process involves developing the data collection design based on the DQOs. The data collection design is presented in

Section 4.0. These DQOs are based on EPA Guidance for the Data Quality Objective Process (EPA 1994). Data developed under these DQOs will be used to:

1. Establish the nature and extent of contamination within IHSSs, PACs, and UBC Sites, including where RFCA ALs are exceeded;
2. Support final remedy selection analysis; and
3. Confirm that remediation within IHSSs, PACs, and UBC Sites was successful.

The IABZSAP DQOs apply to surface and subsurface soil characterization (Section 3.1.1) and post-remediation confirmation sampling (Section 3.1.2). CRA DQOs are presented in the CRA Methodology ecological evaluation presented in Appendix D.

The IABZSAP DQOs complement those used in the RFETS Integrated Monitoring Plan (IMP) (DOE 1999b). The IMP and associated DQOs focus on air, surface water, groundwater, and ecology, and will be used to support remediation decisions and the CRA. Project-specific air, surface water, and groundwater performance monitoring data from stations surrounding remediation project locations will be used to identify additional areas that may require evaluation.

3.1.1 Characterization of IHSSs, PACs, and UBC Sites

The Problem

The nature and extent of contamination must be known with adequate confidence to make accelerated action decisions. Data of sufficient quality and quantity must be available to conduct an AL comparison, as specified in the RFCA Implementation Guidance Document (IGD), and assess whether an IHSS, PAC, or UBC Site requires remediation or management.

Identification of Decisions

The decisions that will be made are as follows:

1. Determine whether the nature and extent of PCOCs in an IHSS, PAC, or UBC Site are known with adequate confidence; and
2. Characterize an IHSS, PAC, or UBC Site to determine whether sampling and analysis results are greater than RFCA ALs.

Inputs to the Decisions

Information needed to make the characterization decisions specified above include the following:

1. PCOCs

   PCOCs include all analytes detected during previous studies in the IA and BZ and generally include the following analytical suites:

   - Target Compound List (Organics)

VOCs
SVOCs
Pesticides
Aroclors (PCBs)
Herbicides

- Target Analyte List

Metals
Cyanide

- Radionuclides (RFETS-specific)

PCOCs will be evaluated for each IHSS Group during preparation of the IABZSAP Addenda. At that time, the PCOC list may be expanded or abbreviated depending on site-specific analytical data and process knowledge.

2. Method detection limits (MDLs)/reporting limits (RLs)

RLs for accelerated action data and MDLs for existing data for IA and BZ PCOCs and analytical methods are presented in Appendix E. Analytical methods are organized in tables by general analytical suite. The tables present the minimum required analytes within each respective suite, as well as the required analytical sensitivity for each analyte. Sensitivities are expressed as RLs or MDLs, and are specific to the measurement systems used for IA and BZ sample analysis.

3. Background levels for each inorganic and radionuclide PCOC, included in Appendix F.

4. RFCA wildlife refuge worker (WRW) ALs for soil, as listed in ALF (Attachment 5, RFCA [DOE et al. 2003]). Comparison criteria include the following:

a) Soil PCOC concentrations for inorganics will be compared to the background means plus two standard deviations. Soil PCOC concentrations for organics will be compared to MDLs for existing data or RLs for accelerated action data.

b) Each soil PCOC concentration greater than background means plus two standard deviations or MDLs/RLs will be compared to the appropriate AL.

c) RFCA radionuclide AL exceedance occurs when:

- The ratio of each soil PCOC concentration to the RFCA AL is greater than 1; or
- The sum of the ratios (SOR) for radionuclides is greater than 1.

d) RFCA nonradionuclide AL exceedance is defined as:

- The ratio of each soil PCOC concentration to the RFCA AL is greater than 1; or

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- The SOR for surface soil nonradionuclides is greater than 1.

e) A PCOC concentration is considered to be below the RFCA AL when:

- The ratio of each PCOC concentration value to the AL is less than 1; or
- The SOR for radionuclides is less than 1.

f) The SOR for surface soil nonradionuclides is defined as:

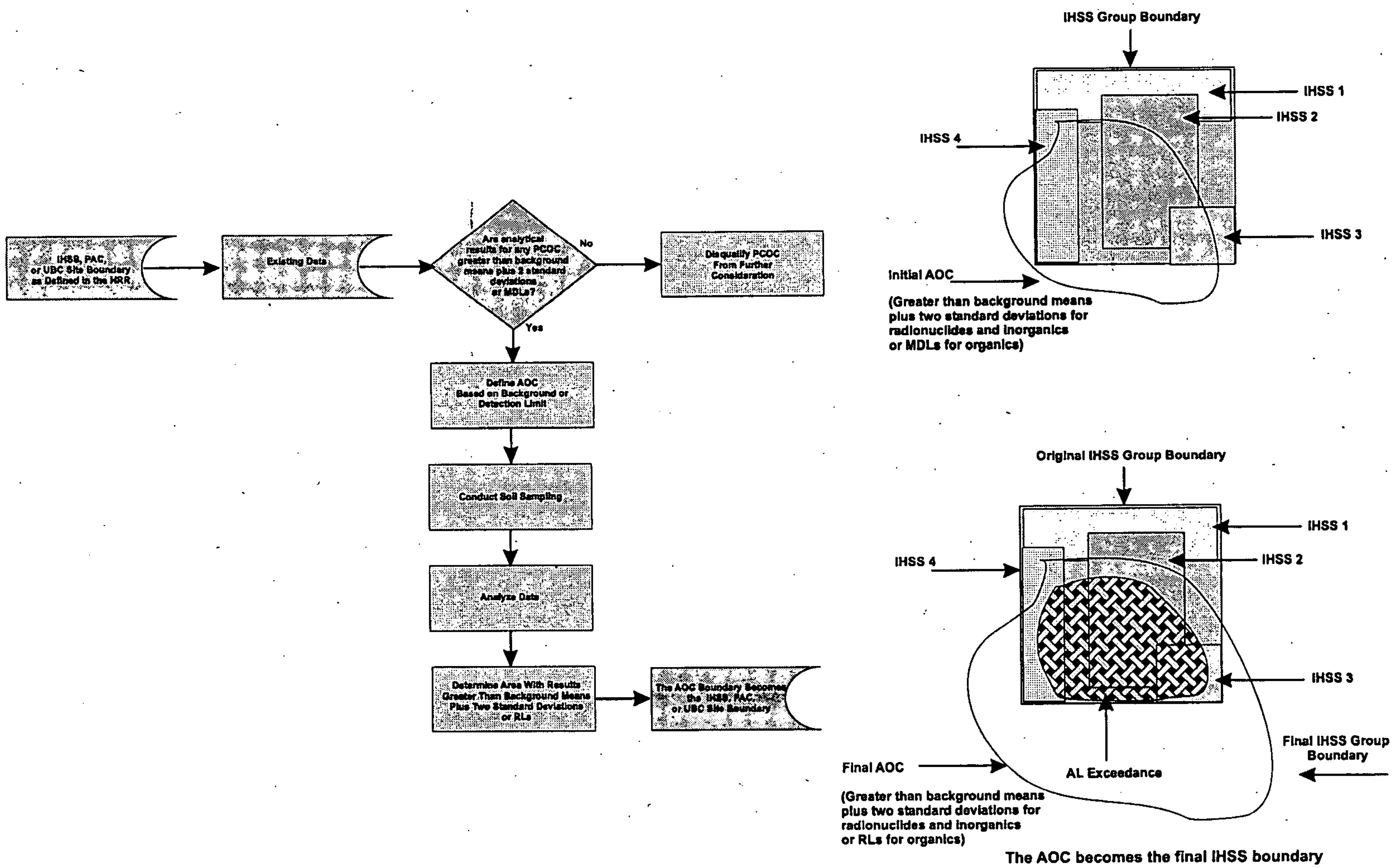
- The SOR of analytes with concentrations greater than RLs or background means plus two standard deviations, and greater than 10 percent of the RFCA AL; with the exception of aluminum, arsenic, iron, manganese, and polyaromatic hydrocarbons (PAHs).

g) For sites with soil PCOC or COC concentrations exceeding RFCA ALs, the spatial extent of the AOC will be established by delineating PCOC or COC concentrations greater than the background means plus two standard deviations for inorganics and radionuclides, and PCOC concentrations greater than MDLs for existing data or RLs for accelerated action data for organics. PCOC or COC concentrations greater than RFCA ALs will be delineated. There is no lower limit on the size of an AOC; however, no single AOC will exceed 10 acres or an approved AOC size. The AOC will initially consist of an IHSS Group, which, in turn, may consist of one or more IHSS, PAC, or UBC Sites. Data will be collected within each IHSS, PAC, and UBC Site, so that each site can be individually dispositioned as an NFAA Site. However, data aggregation will be conducted over the AOC, rather than over individual IHSSs, PACs, or UBC Sites. Because the AOC only considers data results greater than background means plus two standard deviations or RLs, data aggregation over the AOC is more conservative than averaging over all locations (aggregating nondetections and results less than background). The process for determining the extent of the AOC is shown on Figure 19 and described below:

- Compare data for inorganics and radionuclides to the background means plus two standard deviations; compare data for organics to RLs.
- Establish AOCs based on the spatial distribution of data.
- Aggregate data over the AOC according to decision rules.
- Compare the 95% upper confidence limit (UCL) of the mean for each nonradionuclide PCOC or COC to the RFCA ALs.
- When evaluation of a RFCA exceedance indicates an area of very limited extent (that is, a hot spot), data aggregation may not be appropriate. The methodology for determining potential localized areas of elevated PCOC concentration (hot spots) is described in Section 5.2.

5. Process knowledge and historical data, including information and data contained in technical memoranda, RFI/RI reports, remedial action reports, IMP reports, the Historical Release Report (HRR) (DOE 1992d), and other relevant documents.

Figure 19
Initial and Final AOC Determinations



6. Existing and IABZSAP-generated characterization data, which meet usability criteria and pass the Data Quality Filter (Figure 20) (DOE 2000a). These data will be used to assess the variability of PCOC and COC concentrations.
7. Ecological information developed as part of the Accelerated Action Ecological Screening Evaluation (AAESE) (Appendix D).

Study Boundaries

Characterization decision boundaries that define when and where data will be collected are listed below. IHSSs, PACs, and UBC Sites are listed in Table 2 and shown on Figures 1 and 2. The actual boundary of an AOC will be determined from the spatial distribution of the sampling data. The study boundaries are as follows:

1. The decisions will be applied to each IHSS, PAC, and UBC Site located in the IA and BZ.
2. Soil will be considered from the land surface to the top of the saturated zone or top of bedrock, as appropriate.
3. Temporal boundaries will be consistent with project schedules. These boundaries will be refined in the IABZSAP Addenda.
4. Surface soil includes nonradionuclide- and uranium-contaminated soil from 0 to 6 inches in depth and americium-241- or plutonium-239/240-contaminated soil from 0 to 3 ft. All other soil is considered subsurface soil.

Decision Rules

The characterization decision rules that describe how the data will be aggregated and evaluated are listed below. Decision rules are complex and must be applied in a systematic way. Figure 21 illustrates the decision sequence, and Figure 22 illustrates how PCOCs become COCs. The decision rules are as follows:

1. If all analytical results for organic PCOCs or COCs are nondetections, the compounds will be disqualified from further consideration; otherwise, the compounds will be retained. AOCs will be determined based on organic PCOC or COC concentrations above MDLs for existing data or RLs for accelerated action data.
2. If all data values for inorganic and radionuclide PCOCs or COCs are less than background means plus two standard deviations, the inorganic or radionuclide PCOC or COC will be disqualified from further consideration. Some inorganic and radionuclide concentrations may be below background levels but greater than RFCA ALs. Data values less than background will not be carried over for further evaluation. AOCs will be determined based on inorganic and radionuclide PCOC concentrations detected above background.

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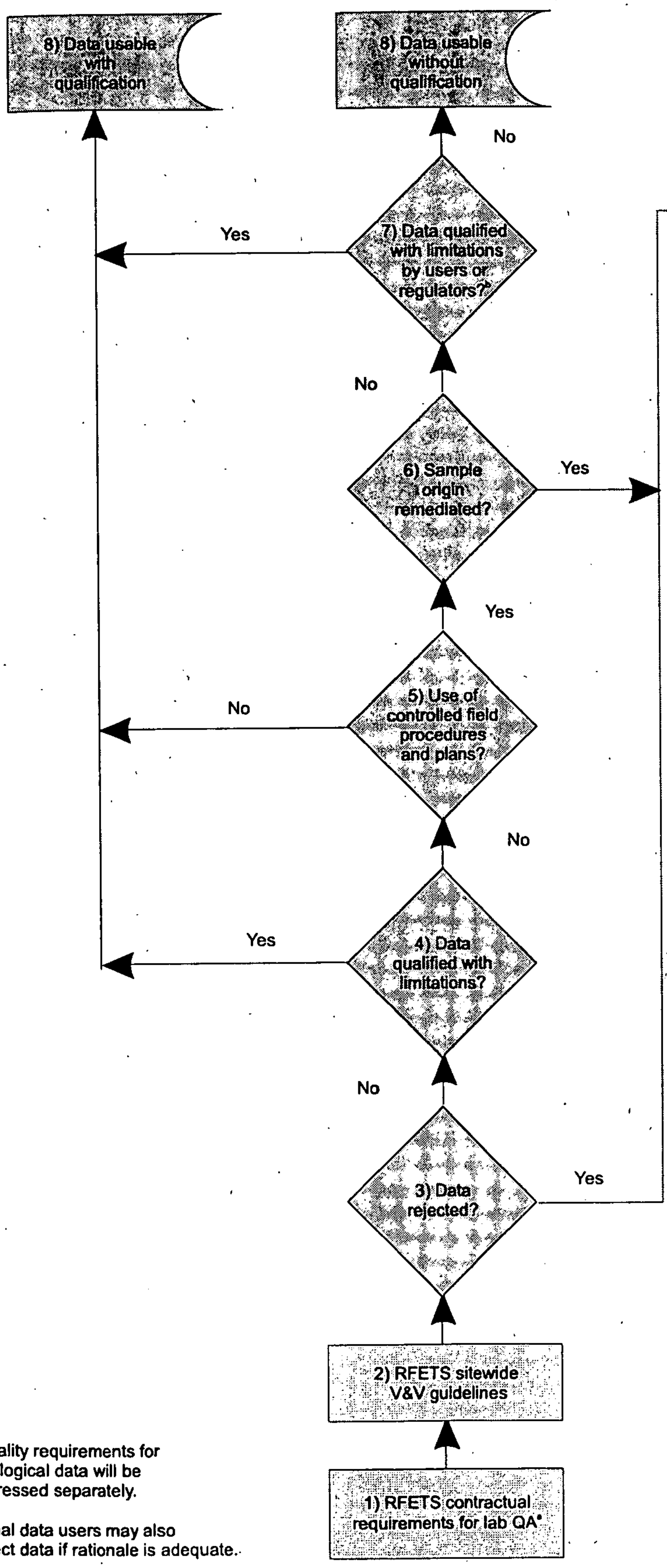
Figure 20
Data Quality Filter for the Industrial Area and Buffer Zone Sampling and Analysis Plan



8) One or more critical quality requirements have not been met.

7) This step will be documented in the IABZSAP.

6) If the source area has been remediated, the contaminated bulk material represented by the sample no longer exists.

5) Checks for intact chain-of-custody:

- Sample traceability
- Representative samples
- Programmatic control of procedures and documents
- Technical and QC reviews
- Independent assessments of work

4) If data are qualified, based on V&V criteria, they have not met all quality (V&V) requirements, but may be usable depending on how they are to be used and whether the added uncertainty is tolerable within the project's decision framework. All data will be flagged relative to the quality status, and will be discussed in the SAP.

3) Data are rejected if critical quality criteria are not met relative to sampling or analysis.

2) Checks for lab accuracy (LCS/MS/tracers)
Lab precision (MSD/replicates)
Lab cross-contamination (blanks)
Quality records intact/traceable

1) Requires documented lab procedure/use of standard methods
Documented lab QA program
Passage of annual QA/technical audits

[a] Quality requirements for ecological data will be addressed separately.

[b] Final data users may also reject data if rationale is adequate.

Figure 21
Characterization Sampling Data Quality Assessment Logic Flow Diagram

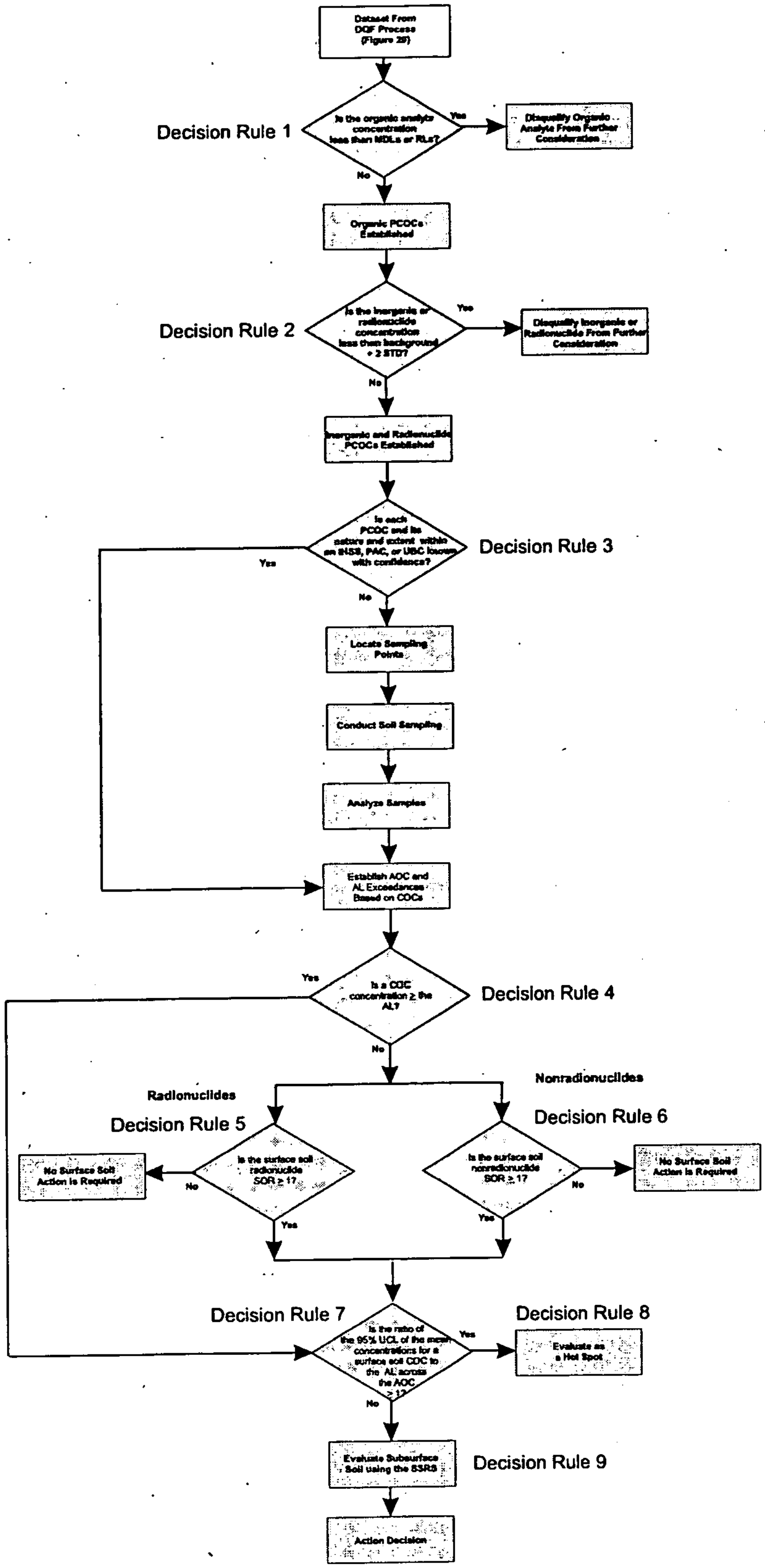
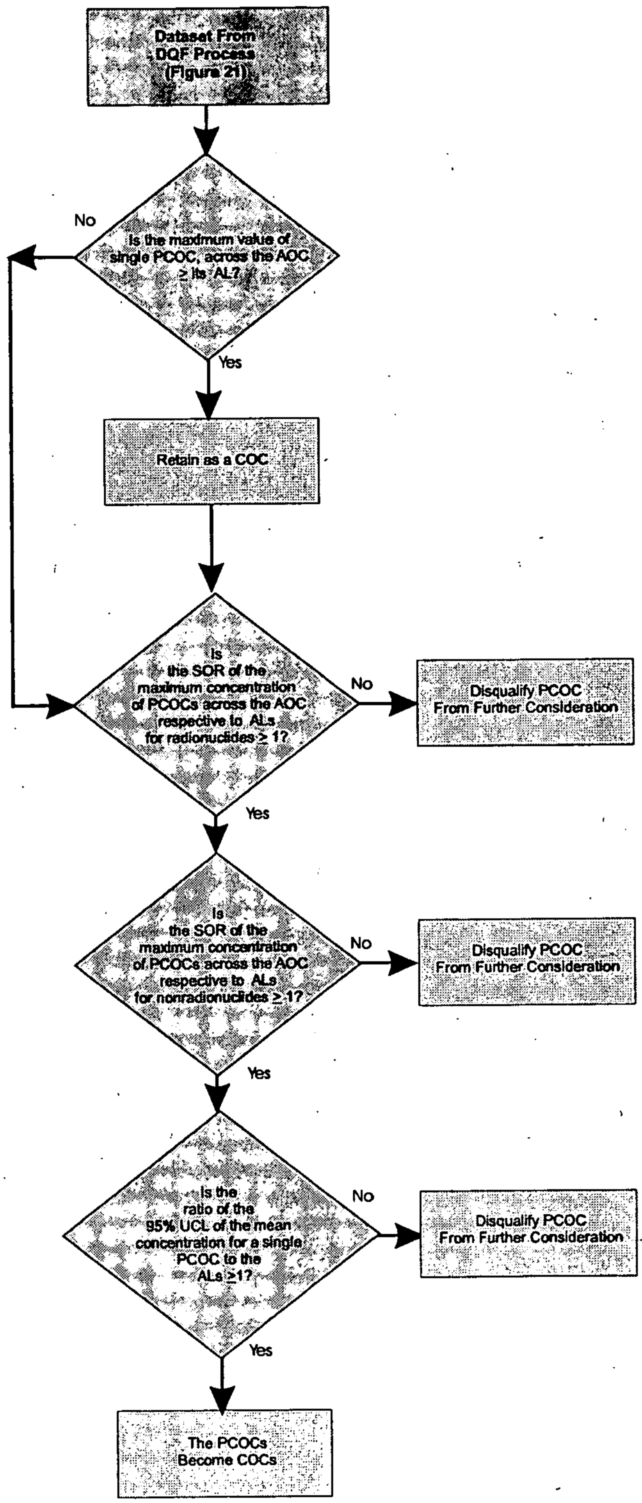


Figure 22
PCOC to COC Transition



3. If each PCOC or COC has been documented with respect to concentrations and three-dimensional locations for IHSSs, PACs, or UBC Sites, the nature and extent are defined. Otherwise, PCOCs or COCs have not been adequately characterized, and additional sampling and analysis are necessary.

4. If a PCOC concentration is greater than or equal to its RFCA AL, the PCOC is considered a COC.

5. If a single maximum surface soil PCOC or COC concentration is equal to or greater than the RFCA AL, aggregation and evaluation as described in Decision Rules 6, 7, and 8 are necessary in accordance with RFCA requirements.

6. If the surface soil SOR at a given location for radionuclides is greater than or equal to 1, a remedial action decision will be made in accordance with RFCA requirements. Otherwise, the PCOC or COC concentrations are less than RFCA ALs and the soil does not need to be further evaluated in accordance with RFCA requirements.

7. If more than one nonradiological surface soil contaminant concentration is detected above RLs for organics or background means plus two standard deviations for inorganics and exceeds 10 percent of the respective WRW AL, then a SOR at a given location will be calculated for those contaminants that exceed 10 percent of their WRW AL. If a SOR exceeds 1, the nonradiological carcinogenic contaminants and nonradiological noncarcinogenic contaminants may each be summed separately. Data will be aggregated and evaluated as described in Decision Rule 8 in accordance with RFCA requirements. Otherwise, the soil does not need to be further evaluated or remediated in accordance with RFCA requirements. If further evaluation is necessary, the data may also be summed by target organ.

8. If the ratio of the 95% UCL of the mean concentration for a surface soil COC to its respective RFCA AL across the AOC is greater than or equal to 1, a remedial action decision will be made in accordance with RFCA requirements. Otherwise, the COC concentrations are less than RFCA ALs and the soil does not need to be further evaluated in accordance with RFCA requirements.

9. If a single maximum surface soil COC concentration is equal to or greater than the RFCA AL and the ratio of the 95% UCL of the mean concentration to its respective RFCA AL is greater than or equal to 1, additional evaluation as a potential localized area of elevated PCOC concentration (hot spot) will be necessary.

10. If a single subsurface soil COC concentration is equal to or greater than the RFCA AL, evaluation as described in the RFCA Subsurface Soil Risk Screen (SSRS) is necessary.

Tolerable Limits on Decision Errors

Sample data requirements will be based on uncertainties of 10 percent or less for alpha (false positive) errors and 20 percent or less for beta (false negative) errors. The null hypothesis (Ho) is that the AOC is contaminated. The Ho and alternative hypothesis (Ha) are stated as follows:

Ho = AOC concentrations greater than or equal to ALs

Ha = AOC concentrations greater than or equal to ALs

Characterization of data, including the minimum detectable relative differences and data variability, will be evaluated for each AOC.

Optimization of Plan Design

The IABZSAP sampling design will be optimized through the IABZSAP Addenda. Sampling locations, sampling depth, and PCOCs will be described in the IABZSAP Addenda for each IHSS, PAC, and UBC Site. Optimization will be conducted in consultation with CDPHE and EPA through a shared access data and mapping system (Section 6.2). This will allow RFETS and regulatory agency staffs to communicate and view data and maps concurrently so that potential sampling design issues are resolved.

Existing data and process knowledge will be reviewed and analyzed to determine:

- Type of sampling methods (geostatistical, standard statistical, biased, or a combination of methods) appropriate for each site;
- Specific PCOC lists for each IHSS, PAC, and UBC Site through comparison to background for inorganics and radionuclides, and MDLs or RLs for organics; and
- Sampling depth.

Consistent with the iterative approach of the DQO process, decisions without adequate confidence will be revisited until enough data are gathered to make a decision. Existing data sets may be checked for sampling adequacy based on comparison with the EPA QA/G-4 model (EPA 1994) or Gilbert's methods (Gilbert 1987). Sampling requirements and densities will be based on the AOC. The following documents will be used as guidance in optimizing sampling and analysis requirements:

- DOE, 1999a, Industrial Area Characterization and Remediation Strategy, September.
- EPA, 1989, Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A), EPA/540/1-89/002, December.
- EPA, 1992, Guidance for Data Usability in Risk Assessment (Parts A & B), EPA Publication 9285.7-09A & B, April/May.
- EPA, 1994, Guidance for the Data Quality Objective Process, QA/G-4, EPA/600/R-96/055, September.
- EPA, 1996, Soil Screening Guidance: Technical Background Document, EPA/540/R-95/128, May.

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- EPA, 1997, Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), NUREG-1575, EPA 402-R-97-016, December.
- EPA, 1998, Guidance for the Data Quality Assessment Process: Practical Methods for Data Analysis, QA/G-9, EPA/600/R-96/084, January.
- EPA, 1999, Guidance on Environmental Data Verification and Validation, Peer Review Draft, QA/G-8, August.
- EPA, 2000, Data Quality Objectives Process for Hazardous Waste Site Investigations, EPA QA/G-4HW, EPA/600/R-00/007, January.

3.1.2 Confirmation Sampling and Analysis

The Problem

Following accelerated action at any contaminated area, the concentrations of remaining contaminants, if any, are not known with adequate confidence to conclude that remediation was complete and successful.

Due to the nature of some remediation technologies, such as soil excavation and hauling with heavy equipment, the possibility exists that limited contaminated media could be released outside the remediation boundaries during field activities.

Identification of Decisions

The confirmation sampling and analysis questions that will be resolved include the following:

1. Has contamination within an AOC been successfully remediated based on RFCA ALs and other mutually agreed-upon cleanup criteria?
2. Did any releases of contamination occur outside the remediation activity boundaries during the remediation activity (based on compliance and project-specific performance monitoring)?

Inputs to the Decisions

Information needed to resolve the confirmation sampling and analysis questions are as follows:

1. COCs as determined by the RFCA AL screen.
2. Post-remediation sampling locations based on RFCA and CRA requirements.
3. Compliance monitoring results concurrent with remediation.
4. RLs/MDLs

   RLs for accelerated action data and MDLs for existing data for IA and BZ COCs and analytical methods are presented in Appendix E. Analytical methods are organized in tables by general analytical suite. The tables present the minimum required analytes within each respective suite, as well as the required analytical sensitivity for each analyte. Sensitivities are expressed as RLs or MDLs, and are specific to the measurement systems used for IA and BZ sample analysis. RLs for off-site analytical laboratories are those established by the Analytical Services Division (ASD) and are listed in Appendix E.

5. Confirmation sample results (post-remediation concentrations).

6. RFCA WRW ALs for soil as listed in ALF (Attachment 5, RFCA). Comparison criteria include the following:

   a) Each soil COC concentration for inorganics and radionuclides will be compared to the background means plus two standard deviations. COC concentrations for organics will be compared to MDLs for existing data or RLs for accelerated action data.

   b) Each soil COC concentration greater than background means plus two standard deviations or MDLs/RLs will be compared to the appropriate RFCA AL.

   c) A RFCA radionuclide AL exceedance occurs when:

      - The ratio of each soil COC concentration to the RFCA AL is greater than to 1; or
      - The SOR for radionuclides is greater than 1.

   d) A RFCA nonradionuclide AL exceedance is defined as:

      - The ratio of each soil COC concentration to the RFCA AL is greater than 1; or
      - The SOR for surface soil nonradionuclides is greater than 1.

   e) A PCOC concentration is considered to be below the RFCA AL when:

      - The ratio of each soil COC concentration to the RFCA AL is less than 1; or
      - The SOR for radionuclides at a sampling location is less than 1.

   f) The SOR for surface soil nonradionuclides is defined as:

      - The SOR of detected analytes or those with concentrations greater than background means plus two standard deviations, and greater than 10 percent of the RFCA AL, with the exception of aluminum, arsenic, iron, manganese, and PAHs.

7. Ecological information developed as part of the AAESE (Appendix D).

8. Other mutually agreed-upon cleanup criteria.

Data will be reviewed and evaluated against usability criteria and must pass the Data Quality Filter (DOE 2000a).

Study Boundaries

Decision boundaries that determine when and where data will be collected are listed below:

1. Identified IHSS, PAC, and UBC Sites are listed in Table 2 and shown on Figures 1 and 2. The actual boundary of an AOC will be determined from the spatial distribution of the sampling data, as specified in the IGD. The AOCs will be used as areas for confirmation sampling and analysis immediately after remediation.

2. Other areas will be sampled and addressed when monitoring data indicate contamination was spread during remediation of adjacent sites. Otherwise, they will be addressed as part of the CRA.

3. COCs determined for each AOC in accordance with Section 3.1.1 will be compared to ALs or other mutually agreed-upon cleanup criteria.

4. Confirmation sampling will cover the area remediated.

5. Surface soil includes nonradionuclide- and uranium-contaminated soil from 0 to 6 inches in depth and americium-241- or plutonium-239/240-contaminated soil from 0 to 3 ft. All other soil is considered subsurface soil.

6. Soil will be considered from the land surface to the top of the saturated zone or top of bedrock, as appropriate.

7. Temporal boundaries will be consistent with project schedules. These boundaries will be refined as remediation proceeds. Confirmation sampling will be conducted after remediation. Data from confirmation sampling will be used to support the CRA.

Decision Rules

The confirmation sampling and analysis decision rules that describe how the data will be aggregated and evaluated are illustrated on Figure 23 and listed below:

1. If all analytical results for organic COCs are less than RLs, the compounds will be disqualified from further consideration; otherwise, the compounds will be retained. AOCs will be determined based on organic COC concentrations above RLs.

2. If all analytical results for inorganic and radionuclide COCs are less than the background means plus two standard deviations, the inorganic or radionuclide COC will be disqualified from further consideration. Some inorganic and radionuclide concentrations may be below background levels but greater than RFCA ALs. Analytical results less than background will not be carried over for further evaluation. AOCs will be determined based on inorganic and radionuclide COC concentrations detected above background.

3. If each COC has been documented with respect to concentrations and three-dimensional locations for IHSSs, PACs, or UBC Sites, the nature and extent are defined. Otherwise, COCs have not been adequately characterized, and additional sampling and analysis are necessary.

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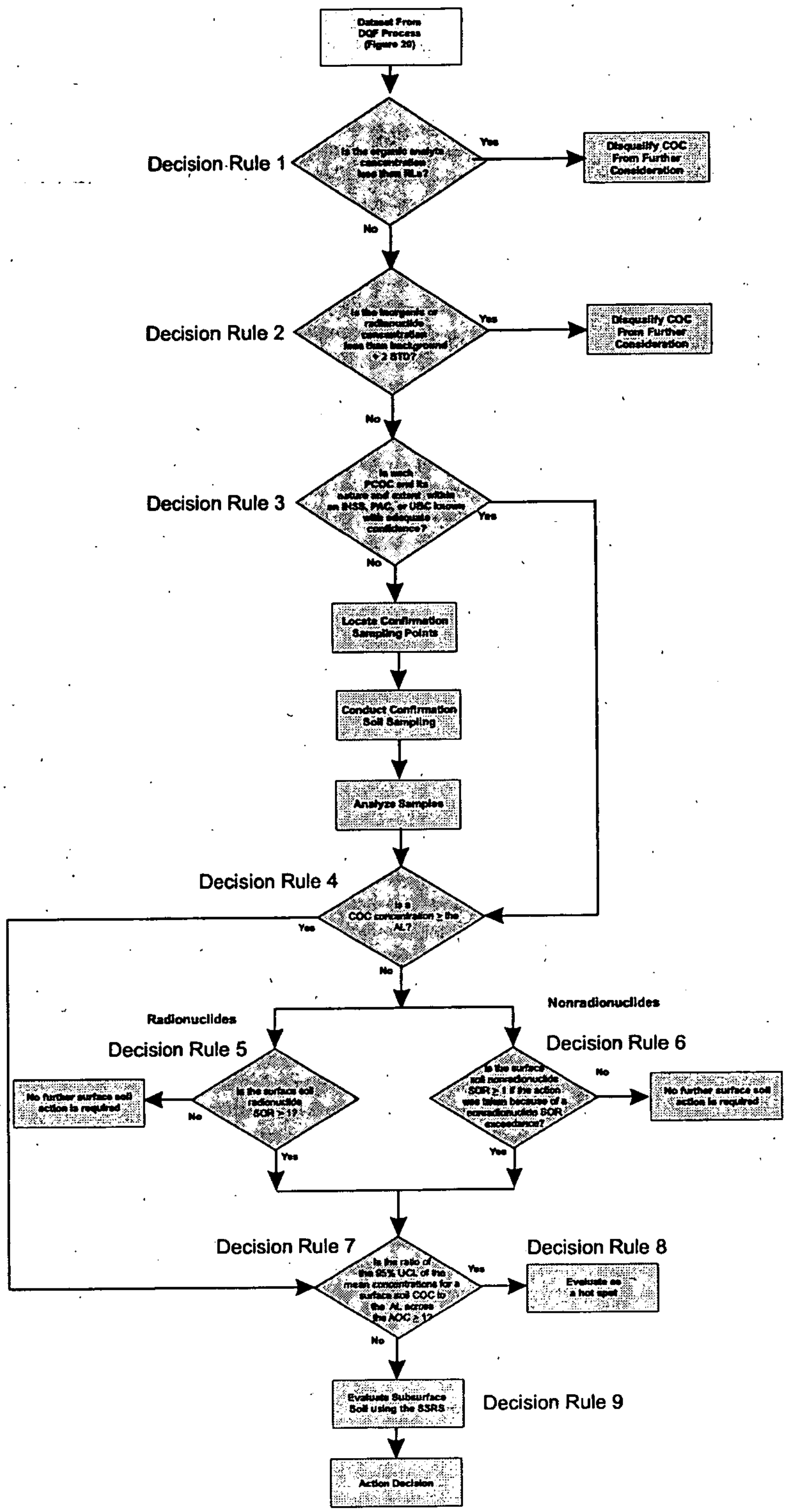
Figure 23
Confirmation Sampling Data Quality Assessment Logic Flow Diagram



4. If a single maximum surface soil COC concentration is equal to or greater than the RFCA AL, aggregation and evaluation as described in Decision Rules 5, 6, and 7 are necessary in accordance with RFCA requirements. If the SOR for surface soil radionuclides at a given location is greater than or equal to 1, a remedial action decision will be made in accordance with RFCA requirements. Otherwise, the COC concentrations are less than RFCA ALs and the soil does not need to be further evaluated or managed in accordance with RFCA requirements.

5. If an action was required at a given location based on a nonradiological surface soil SOR and if more than one nonradiological contaminant concentration is detected above RLs for organics or background means plus two standard deviations for inorganics and exceeds 10 percent of the respective WRW AL, then SOR at a given location will be calculated for those contaminants that exceed 10 percent of their WRW AL. If the SOR exceeds 1, the nonradiological carcinogenic contaminants and nonradiological noncarcinogenic contaminants may each be summed separately. Data will be aggregated and evaluated as described in Decision Rule 7 in accordance with RFCA requirements. Otherwise, the soil does not need to be further evaluated or remediated in accordance with RFCA requirements. If further evaluation is necessary, the data may also be summed by target organ.

6. If the ratio of the 95% UCL of the mean concentration for a surface soil COC to its respective RFCA AL across the AOC is greater than or equal to 1, a remedial action decision will be made in accordance with RFCA requirements. Otherwise, the COC concentrations are less than RFCA ALs and the soil does not need to be further evaluated or managed in accordance with RFCA requirements.

7. If a single maximum surface soil COC concentration is equal to or greater than the RFCA AL and the ratio of the 95% UCL of the mean concentration to its respective RFCA AL is greater than or equal to 1, additional evaluation as a potential localized area of elevated COC concentration (hot spot) will be necessary.

8. If a subsurface soil COC concentration is equal to or greater than the RFCA AL, evaluation as described in the RFCA SSRS is necessary.

9. If compliance or project-specific performance monitoring (for example, air or surface water monitoring) corresponding with the remediation activity produces results that exceed ALs stated in RFCA, then the potential release of contaminants resulting from the respective remediation activity will be evaluated. Otherwise, the remediation activity was adequately controlled to prevent release of contaminants outside the immediate remediation boundaries.

Tolerable Limits on Decision Errors

Areas and associated COCs disqualified from further characterization or remediation based on process knowledge have no associated quantifiable decision error. Sample data requirements will be based on uncertainties of 10 percent or less for alpha errors and 20 percent or less for beta errors. The null hypothesis is that the AOC is contaminated. Characterization of data, including the minimum detectable relative differences and data variability, will be evaluated for each AOC.

Optimization of Plan Design

Optimization of the post-remediation data collection process will be based on statistical or geostatistical analysis where possible. Consistent with the iterative approach of the DQO process, decisions without adequate confidence will be revisited until enough data are gathered to make a decision. Existing data sets may be checked for sampling adequacy by comparison with the EPA QA/G-4 model (1994), Gilbert's methods (Gilbert 1987), or MARSSIM (EPA 1997A). Sampling requirements and densities will be based on the remediation area considerations.

The following documents will be used as guidance to optimize sampling and analysis requirements in support of remediation activities:

- DOE, 1999a, Industrial Area Characterization and Remediation Strategy, September.
- EPA, 1989, Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A), EPA/540/1-89/002, December.
- EPA, 1992, Guidance for Data Usability in Risk Assessment (Parts A & B), EPA Publication 9285.7-09A & B, April/May.
- EPA, 1994, Guidance for the Data Quality Objective Process, QA/G-4, EPA/600/R-96/055, September.
- EPA, 1996, Soil Screening Guidance: Technical Background Document, EPA/540/R-95/128, May.
- EPA, 1997, MARSSIM, NUREG-1575, EPA 402-R-97-016, December.
- EPA, 1998, Guidance for the Data Quality Assessment Process: Practical Methods for Data Analysis, QA/G-9, EPA/600/R-96/084, January.
- EPA, 1999, Guidance on Environmental Data Verification and Validation, Peer Review Draft, QA/G-8, August.
- EPA, 2000, Data Quality Objectives Process for Hazardous Waste Site Investigations, EPA QA/G-4-HW, EPA/600/R-00/007, January.

3.1.3 Final Characterization of the IA and BZ for the CRA

The IA and BZ will be assessed in the CRA to quantify and report risks posed by residual contamination at the Site to human and ecological receptors after accelerated actions are complete. The CRA will address all media with exposure pathways listed as significant in the Site conceptual model. Other media will be sampled and evaluated as part of the compliance monitoring or other RFETS programs. The nature and extent of soil contamination remaining in accelerated action areas within the IA and BZ must be determined with adequate confidence to support the CRA. Detailed DQOs for the CRA are presented in the CRA Methodology.

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4.0 SAMPLING STRATEGY

The IA sampling strategy specifies soil sampling and analysis methodologies that will streamline characterization and remediation processes and maintain appropriate QA. The sampling strategy will:

- Provide a consistent process for characterizing IHSSs, PACs, and UBC Sites shown on Figures 1 and 2;
- Provide characterization focused on identifying areas that require remediation;
- Diminish reliance on off-site analytical laboratories to reduce cost and accelerate schedules; and
- Provide defensible quality data for the CRA.

The IA and BZ sampling strategy includes the following key elements:

- In-process characterization and remediation sampling at IHSSs, PACs, and UBC Sites;
- Post-remediation confirmation sampling at IHSSs, PACs, and UBC Sites;
- Sampling in other areas, as needed, for risk assessment or screening; and
- Samples, in addition to those in support of the CRA, identified for other purposes.

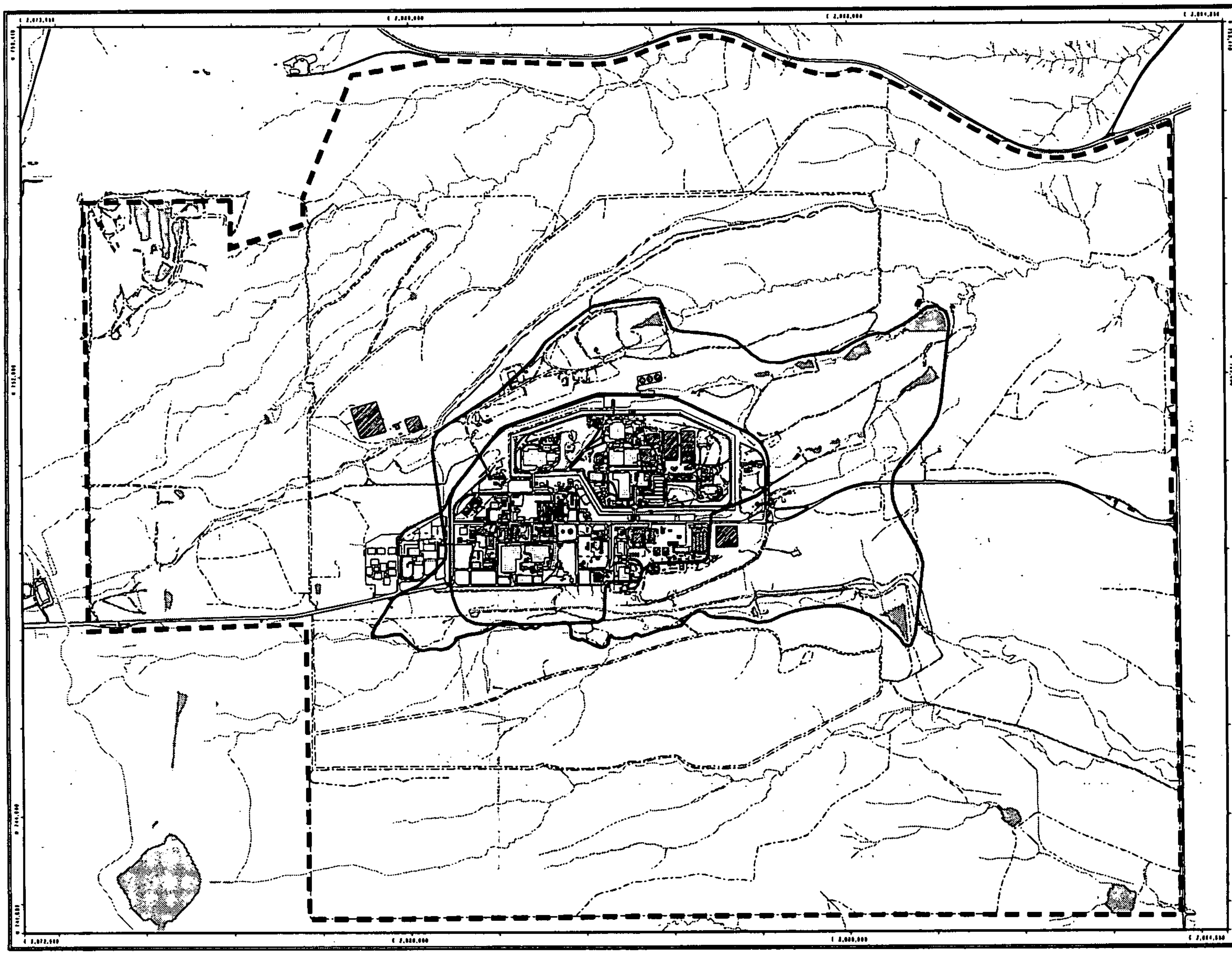
Areas in the IA and inner BZ outside of AOCs that are within or extend from IHSSs, PACs, and UBC Sites, as shown on Figure 24, are not expected to have contamination above ALs. To support the CRA, data sufficiency analyses will be performed to confirm that concentrations within the accelerated action AOCs have been adequately delineated against background or RLs as appropriate (DOE 2003a).

4.1 In-Process Sampling

The K-H characterization team will implement an in-process sampling approach that combines a statistical or biased approach to determine sampling locations and remediation areas with the use of field analytical equipment. Existing data and historical process information will be used to determine the statistical approach needed to determine characterization sampling locations in IHSSs, PACs, UBC Sites, and other areas. After the sampling locations have been identified, samples will be collected and analyzed using field analytical instrumentation. The data will be evaluated using a geostatistical or standard statistical approach to delineate the AOC and areas that require remediation.

Figure 24

Industrial Area White Space and Inner Buffer Zone



EXPLANATION

- Inner Buffer Zone
- Industrial Area

Standard Map Features

- Buildings and other structures
- Demolished buildings and Other Structures
- Solar Evaporation Ponds (SEPs)
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Rocky Flats Environmental Technology Site boundary
- Paved roads
- Dirt roads

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95
Data Source:
Boundary data source unknown, please reference RFCA Report.

Scale = 1 : 21330
1 inch represents approximately 1778 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: CH2MHILL

Prepared for: KAISER-HILL

March 16, 2004

After the areas have been remediated, samples will be collected and analyzed using field analytical instrumentation to immediately determine whether remediation goals have been achieved. Soil will be removed in "lifts." After a lift is removed, the remaining soil will be analyzed with field instrumentation. This process will continue until remedial objectives have been achieved. When field analytical results indicate remediation has been achieved, post-remediation confirmation samples will be collected and analyzed on site if appropriate data quality can be demonstrated, or sent to an off-site laboratory for analysis. Off-site laboratory results will be validated according to ASD requirements.

If remediation is not required at specific IHSSs, PACs, or UBC Sites based on the results of field analysis, confirmation samples will be collected to support an NFAA recommendation and the CRA. An off-site or on-site laboratory will perform the confirmation sample analysis. Field analytical instrument data will be used for the CRA if appropriate data quality can be demonstrated. Off-site laboratory results will be validated according to DQO requirements. Figure 25 illustrates the overall in-process sampling technique for IHSSs, PACs, and UBC Sites.

4.2 Sampling Approaches

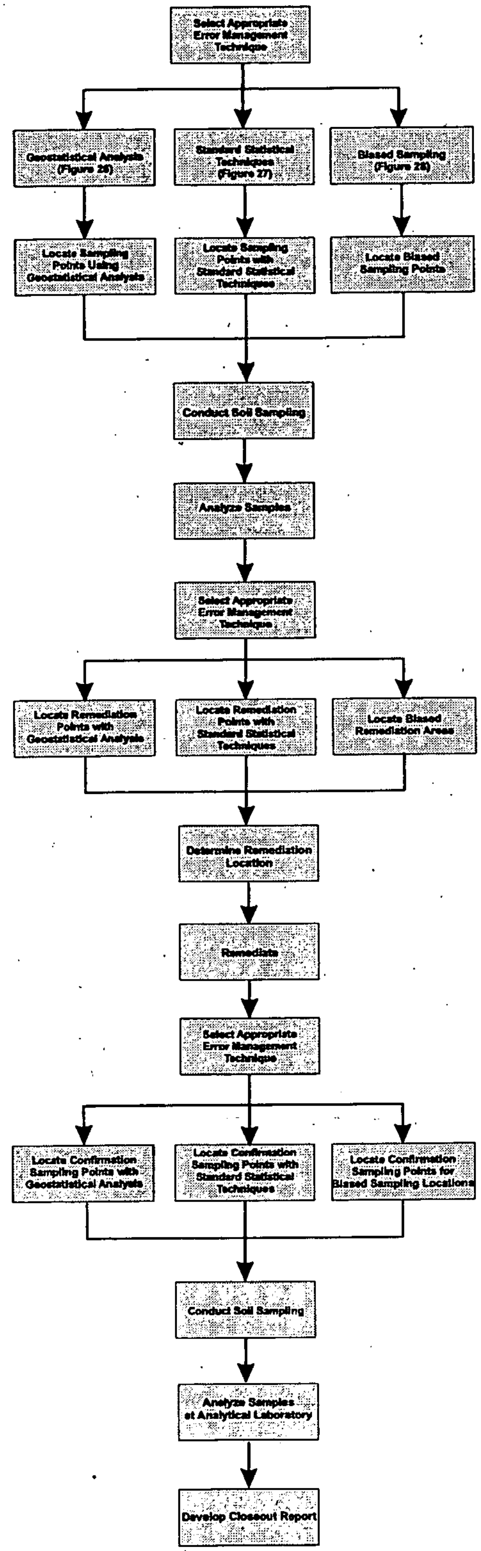
Characterization sampling locations will be determined for each IHSS, PAC, and UBC Site using geostatistical, standard statistical, or biased sample selection methods. Table 3 generally describes when each method will be used. Using existing data, a decision as to whether the data define a contaminant distribution (apply geostatistical approach) or a localized area of elevated PCOC concentration (hot spot) (apply standard or biased approach) will be made. The method for determining sampling locations will be specified in the appropriate IABZSAP Addenda. In some cases, a combination of techniques may be used. For example, if process knowledge or existing data indicate discrete spill areas in a large IHSS, both standard statistical and biased sampling may be appropriate.

Table 3
Sampling Decision Matrix for IHSSs, PACs, and UBC Sites

Method	Condition
Geostatistical	Existing analytical data Existing data indicating a contaminant distribution
Standard Statistical	No existing analytical data Limited analytical data Process knowledge
Biased	Process knowledge Limited analytical data Analytical data indicating localized contamination or point sources

In-process sampling will use a variety of statistical error management approaches to meet the decision error limits specified in the DQOs. The specific approach will be customized to meet the uncertainty, time, and health and safety (H&S) constraints of each IHSS, PAC, and UBC Site characterization.

Figure 25
Sampling Process for IHSSs, PACs, and UBC Sites



Each component of the sampling design is based on the project DQOs presented in Section 3.0. The sampling strategies described in this section are the basis for IHSS, PAC, and UBC Site characterization. However, these strategies are flexible and will be modified, as needed, to fit actual field conditions. Statistical methods are described in the following sections.

4.2.1 Geostatistical Approach

SmartSampling, a geostatistical approach developed at Sandia National Laboratories (SNL) and used at several DOE sites, is the basis for the geostatistical approach that will be used to determine the optimum number and location of samples needed to characterize IHSSs, PACs, and UBC Sites for remediation.

The geostatistical approach will be used to:

- Optimize the number and locations of characterization samples;
- Develop maps of the areas with concentrations or activities exceeding RFCA ALs at a given level of probability;
- Optimize the number and location of post-remediation confirmation samples;
- Achieve DQO-specified limits on decision errors; and
- Link on-site analysis with sampling to allow near-real-time remediation decisions.

Geostatistics uses an iterative process based on remediating a site to required ALs at a specified level of confidence. Geostatistics will be applied using existing data to generate maps showing the probability of exceeding RFCA ALs in IHSSs, PACs, UBC Sites, and other areas. Based on the probability of exceedance, two types of maps can be developed:

1. Maps showing areas requiring additional sampling; and
2. Maps showing RFCA AL exceedances at a specified level of reliability.

Existing data will be analyzed, and a decision to collect more samples will be based on an analysis of sampling locations, analytical results, and the chosen reliability level. After characterization of individual IHSSs, PACs, and UBC Sites, geostatistical or standard statistical techniques will be used to define AOCs and areas with concentrations above RFCA ALs. Sampling necessary to define the extent of contamination will be iterative: as sample data are received, they will be evaluated using geostatistics. The results will be used to determine the optimal number and locations of samples to be collected in the next iteration, if necessary. This iterative updating will be conducted in near real-time (on the order of several hours turnaround for incorporating the new sample information).

Geostatistics are not designed for developing a characterization plan around a single localized area of elevated PCOC concentration. Sampling to identify localized areas of elevated PCOC concentrations will generally be more focused on defining contaminants in a single location, and may not provide the necessary areal coverage to define the extent of contamination across an entire IHSS. However, depending on the size of the IHSS, the same sampling grid spacing used for finding a localized area of elevated PCOC concentration may provide the necessary information for the geostatistical approach. Figure 26 illustrates how geostatistics will be used at the IHSSs, PACs, and UBC Sites. A more detailed description of geostatistical procedures is provided in Section 5.1.4.

4.2.2 Standard Statistical Approach

The geostatistical approach is not suitable for IHSSs, PACs, or UBC Sites that have relatively few or no observations. Therefore, a separate sampling methodology is necessary to adequately characterize soil contamination in these areas. An efficient sampling strategy for delineating the spatial distribution and total amount of contamination encompassing "poorly" defined areas is a statistical grid design. This type of design is best suited for detecting potential localized areas of elevated PCOC concentration of unknown spatial distribution(s).

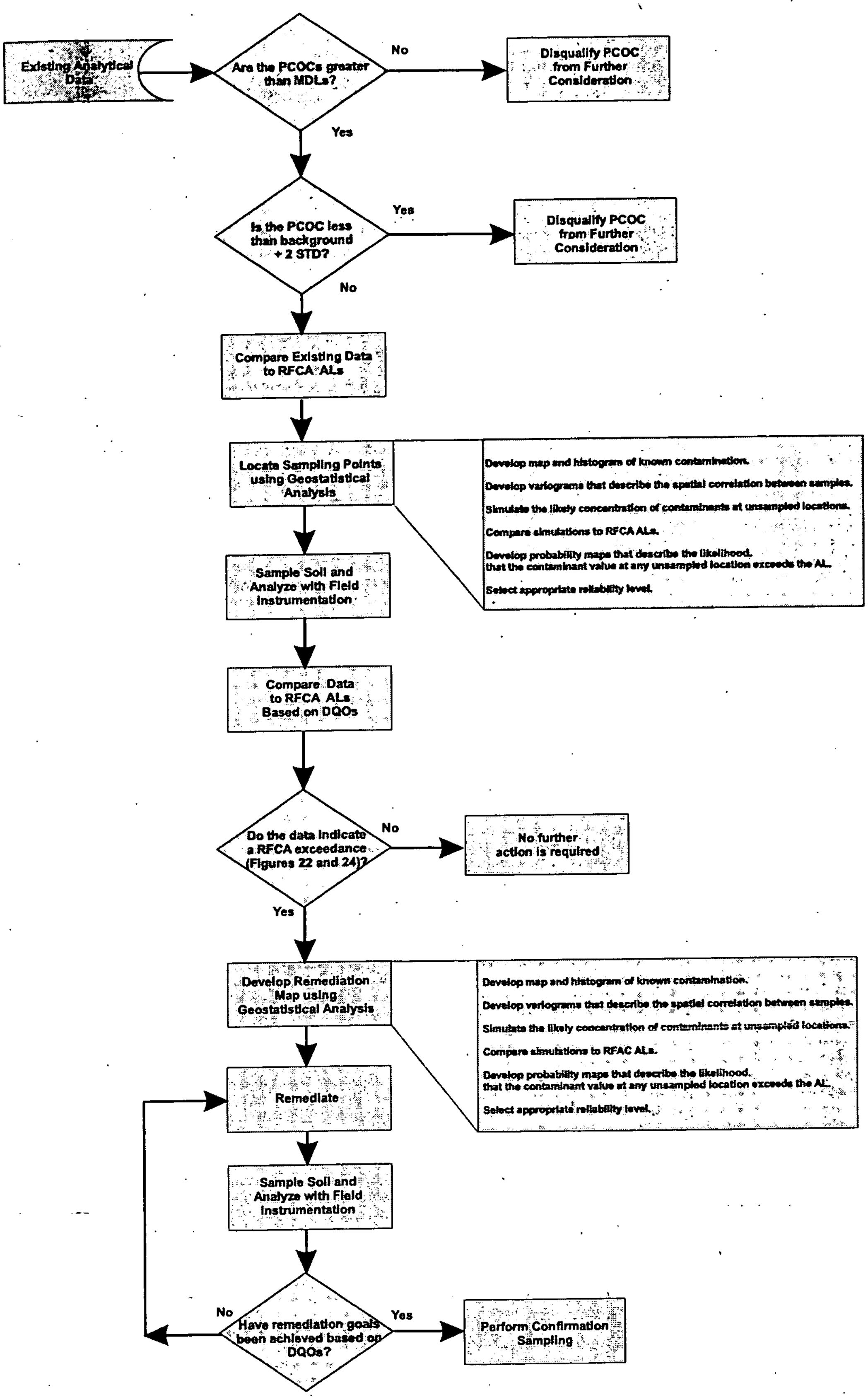
A localized area of elevated PCOC concentration is a relative term used to denote an area that has a significantly higher contaminant concentration than the surrounding area. Localized areas of elevated PCOC concentration are quantified by their size and contaminant concentration. The statistical grid design is based on the ability to determine whether these areas are present. A method for measuring localized areas of elevated PCOC concentration is needed to:

- Determine areas of limited extent that require remediation;
- Statistically evaluate the extent of contamination in localized areas; and
- Determine the size of the sampling grid.

This method is described in two steps:

1. Evaluate existing analytical data to determine whether there are data to constrain the size of a potential localized area of elevated PCOC concentration in an IHSS, PAC, or UBC Site. If data exist that provide information on potential localized areas of elevated PCOC concentration size (or sizes), these data will be used. For example, knowledge of the size of hazardous waste storage units, such as drum pallets, storage tanks, and crates, or the size of spills, will dictate the likely localized area of elevated PCOC concentration dimension(s) in a given area. If there is more than one potential localized area of elevated PCOC concentration in a given area, an average localized area of elevated PCOC concentration size will be determined. The grid size used for sampling and the number of samples required will be based on the defined localized area of elevated PCOC concentration and level of probability (90 percent) of finding a localized area of elevated PCOC concentration (Gilbert 1987). Biased sampling may also be used to augment the grid design.

Figure 26
Geostatistical Process for IHSSs, PACs, and UBC Sites



2. If there are no data available that can constrain the size of a localized area of elevated PCOC concentration in IHSSs and PACs, the statistical approach will be based on the sampling grid that was used to characterize radiologically contaminated surface soil within the 903 Pad Area. The 903 Pad Area was characterized using an HPGe detector on an 11-meter (m) (36-ft) triangular grid. Based on this grid dimension, there is a 90 percent probability of detecting a localized area of elevated PCOC concentration using Gilbert's (1987) methodology. The localized area of elevated PCOC concentration size is assumed to be circular with a diameter of 36 ft. (The field of view of the HPGe detector was 10 m [or 33 ft], which was based on the instrumentation, not a specified localized area of elevated PCOC concentration size.) The 36-ft triangular grid spacing is conservative for characterizing radionuclides and nonradionuclides, provides a consistent approach, and is small enough to detect most localized areas of elevated PCOC concentrations not targeted by biased sampling. This methodology will provide a consistent sample density for most IHSSs and PACs in the IA and BZ and provide data for subsequent geostatistical analysis, if needed.

   At UBC Sites and IHSSs or PACs that were covered by asphalt or concrete before the leaks or spills may have occurred, a larger grid size (22 m) may be used. This larger grid size is justified based on sampling at UBC Sites (UBCs 881 [DOE 2003b], 886 [DOE 2003c], and 889 [DOE 2003d]) that indicated COCs were not present beneath the slabs at concentrations greater than ALs. Biased sampling that specifically targets source terms and increases the probability of finding potential contamination will augment the larger grid size. This method provides 90 percent confidence that enough samples will be collected to adequately characterize the site.

There are IHSSs and PACs that are smaller than the proposed grid size of 11 m across. If no data are available to constrain a localized area of elevated PCOC concentration in these IHSSs and PACs, biased sampling methods will be used.

Areas with contaminant concentrations greater than RFCA ALs will be evaluated, according to IABZSAP DQOs and methods described in Section 5.0, to determine whether a localized area of elevated PCOC concentration is present. The localized area of elevated PCOC concentration, along with grid spacing and number of samples required for individual IHSSs, PACs, and UBC Sites, will be described in the IABZSAP Addenda.

Appropriate grid designs will be developed based on project DQOs and may include, but not be limited to, triangular and random stratified grids. Sampling IHSSs, PACs, and UBC Sites on a triangular grid will result in a spatial configuration of data that can be used for geostatistical analysis. This approach is conducive to determining the spatial correlation structure of the data set, which can be used in the geostatistical analysis to define areas above RFCA ALs.

A systematic sampling scheme will be used to identify and delineate the localized area of elevated PCOC concentration within the areas of interest following procedures outlined in Gilbert (1987). Sampling locations will be positioned into equilateral grids, such as triangular grids, following the methods presented in Gilbert (1987), Gilbert and Simpson (1992), and Section 4.2. Triangular grid sampling provides uniform coverage of a sampling area and increases the chances of identifying an elliptical or circular localized area of elevated PCOC concentration (Gilbert 1987). The following assumptions apply to the proposed sampling design:

- Samples will be collected on a statistical grid.
- The sampling area is much smaller than the grid spacing.
- Localized areas of elevated PCOC concentrations are circular or elliptical.
- Localized areas of elevated PCOC concentrations will be defined.
- After the grid interval is calculated for the specified area, a random-start grid overlay will be superimposed on a map of the IHSS, PAC, or UBC Site. In some cases, biased sampling will supplement the grid interval. This methodology provides grid coverage with a 90 percent confidence of finding a localized area of elevated radionuclide PCOC activity, as well as provides statistical confidence for other constituents consistent with DQO error rates of 10 percent (alpha) and 20 percent (beta) for both radionuclides and nonradionuclides. Confidence limits are also consistent with EPA specifications (EPA 1992).
- Soil samples will be collected at the intersection of each grid according to the sample collection methods described in Section 4.9. Additional samples will be collected, as needed, to determine the size of the AOC. Sampling methods for each IHSS, PAC, and UBC Site will be specified in the appropriate IABZSAP Addendum.

In summary, standard statistical techniques, outlined in Gilbert (1987) (and incorporated in a number of available software programs [for example, Visual Sampling Plan]), will be used to determine sampling locations in areas where:

- No existing analytical data are available;
- Limited analytical data are available;
- Process knowledge does not indicate biased sampling is appropriate; and
- Uniform contamination is indicated.

Figures 27 and 28 illustrate how standard statistical techniques and standard statistical techniques combined with a biased sampling approach, respectively, will be used at IHSSs, PACs, and UBC Sites.

4.2.3 Biased Approach

In addition to the systematic sampling design, some areas may require judgment or biased sampling where process knowledge or analytical data suggest there is a high probability of contamination in a limited area. This approach will provide targeted sampling of potential problem areas and result in the following:

- Additional sampling between the standard grid, if necessary; and

Figure 27
Standard Statistical Sampling Process for IHSSs, PACs, and UBC Sites

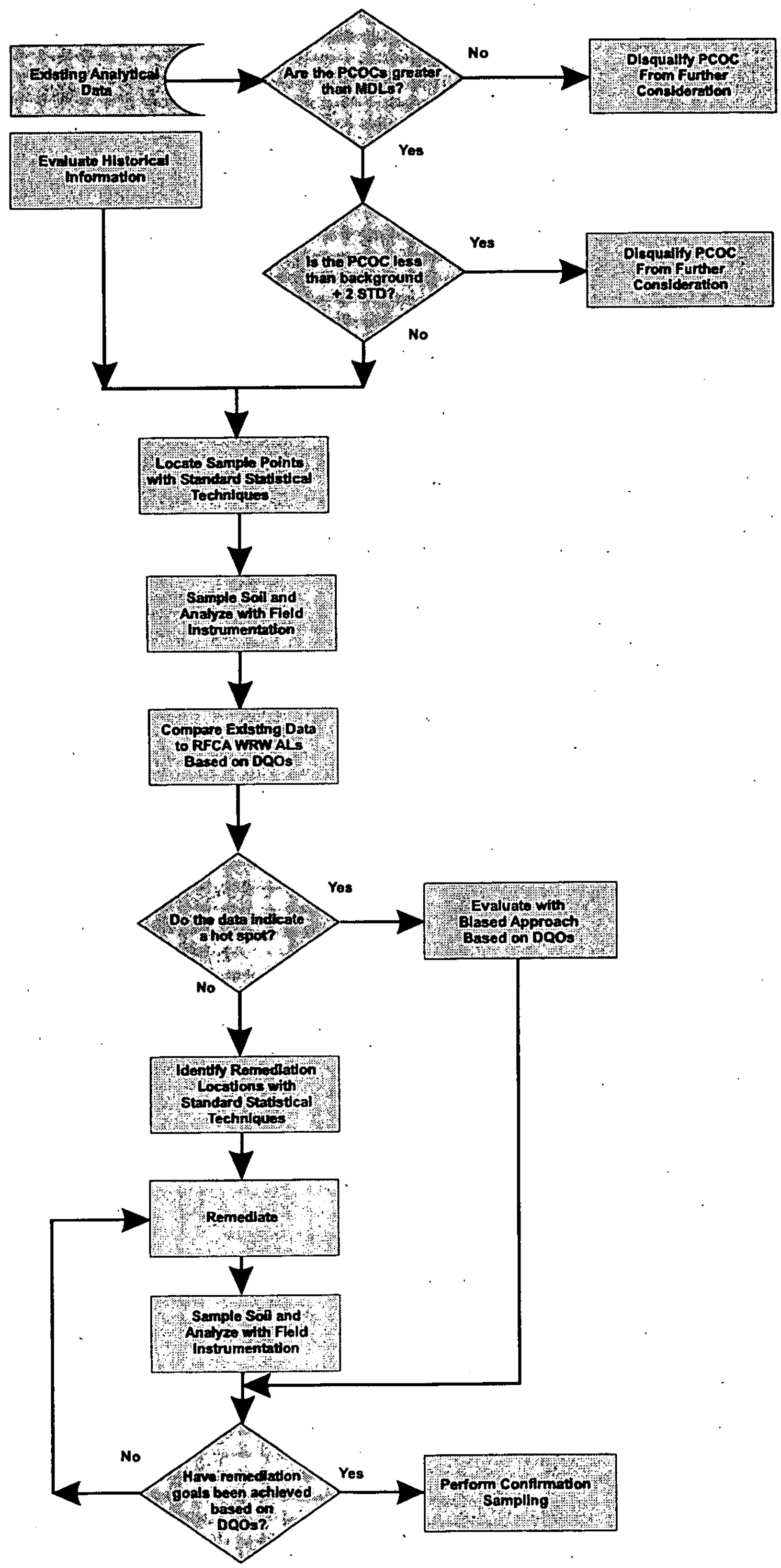
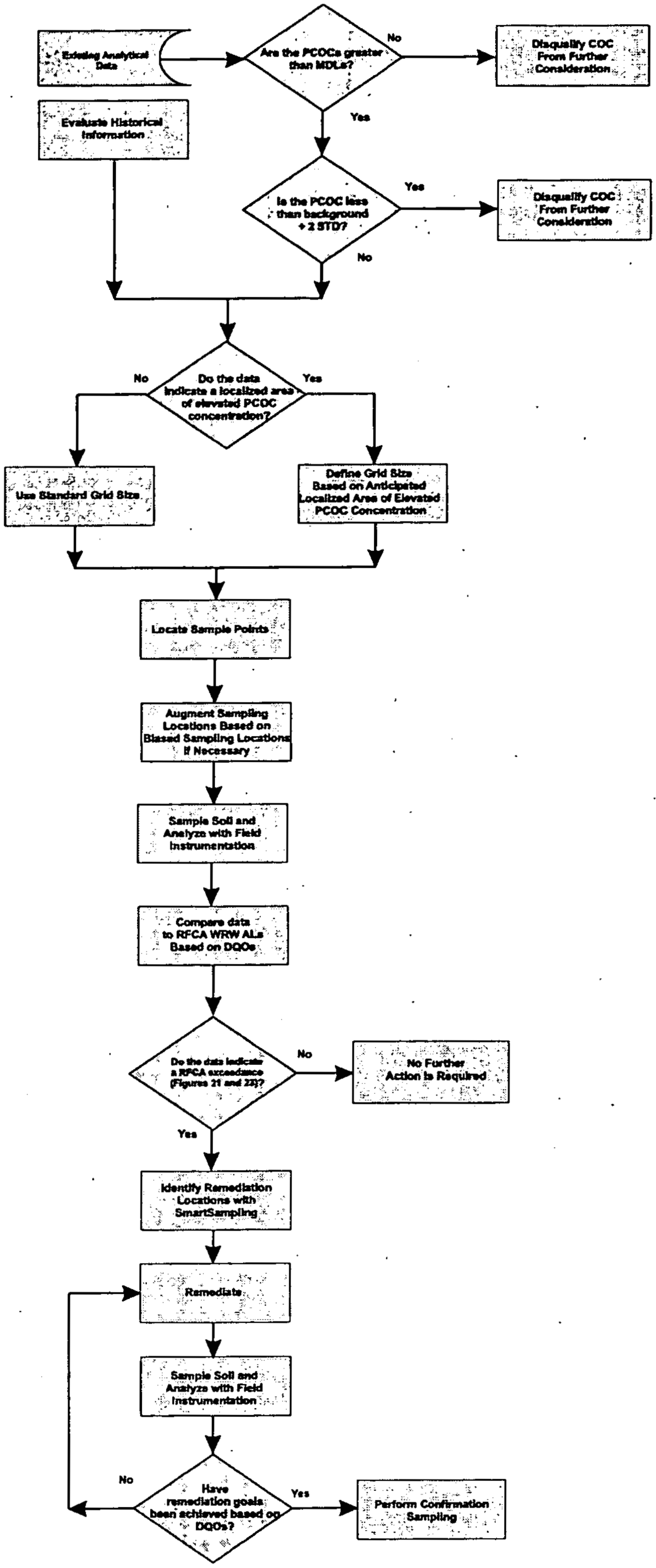


Figure 28
Standard Statistical and Biased Sampling Process for IHSSs, PACs, and UBC Sites



- Limited sampling of some IHSSs, PACs, or UBC Sites.

Biased sampling locations might include areas of deposition where contaminants have a tendency to accumulate. Other physical features that may warrant biased sampling include confluences, outfall points, and apparent discoloration of the soil, sediment, or vegetation. These features and the applicability of biased locations will be assessed during characterization planning. Figure 29 illustrates how biased sampling will be used at IHSSs, PACs, and UBC Sites.

In summary, a biased sampling approach will be used when:

- Process knowledge indicates discrete spills or releases; or

- Limited analytical data indicate hot spots or other discrete areas of interest.

4.3 Characterization Sampling Strategy for IHSSs, PACs, and UBC Sites

Existing analytical and historical information will be evaluated for each IHSS, PAC, and UBC Site to establish the appropriate statistical method (Section 4.2) for determining characterization sampling locations, PCOCs, and sampling methods for the site. A list of IHSSs, PACs, and UBC Sites, and a preliminary assessment of the statistical method that will be used, is provided in Table 4. PCOCs for the IA and BZ are listed in Section 3.0 and Appendix F. Sampling locations for IHSSs, PACs, and UBC Sites will be detailed in the appropriate IABZSAP Addendum.

4.3.1 Soil Sampling

The characterization team will sample surface soil in accordance with Standard Operating Procedure (SOP)-OPS-GT-08 and as described in Section 4.9. Surface soil samples will be analyzed with field instruments for radionuclides, metals, SVOCs, and, if existing historical or analytical data suggest, other analytes (pesticides, PCBs, and so forth). In some cases where existing data suggest a restricted PCOC list, soil samples will be analyzed for the specific PCOCs only. An example of this could be PAC 300-700, Pesticide Shed. Historical information indicates a small number of pesticides were used at RFETS and there is no evidence of any other compounds stored or used at PAC 300-700. In this case, surface soil samples will only be analyzed for pesticides. A list of PCOCs will be included in the appropriate IABZSAP Addendum.

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Figure 29
Biased Sampling Process for IHSSs, PACs, and UBC Sites

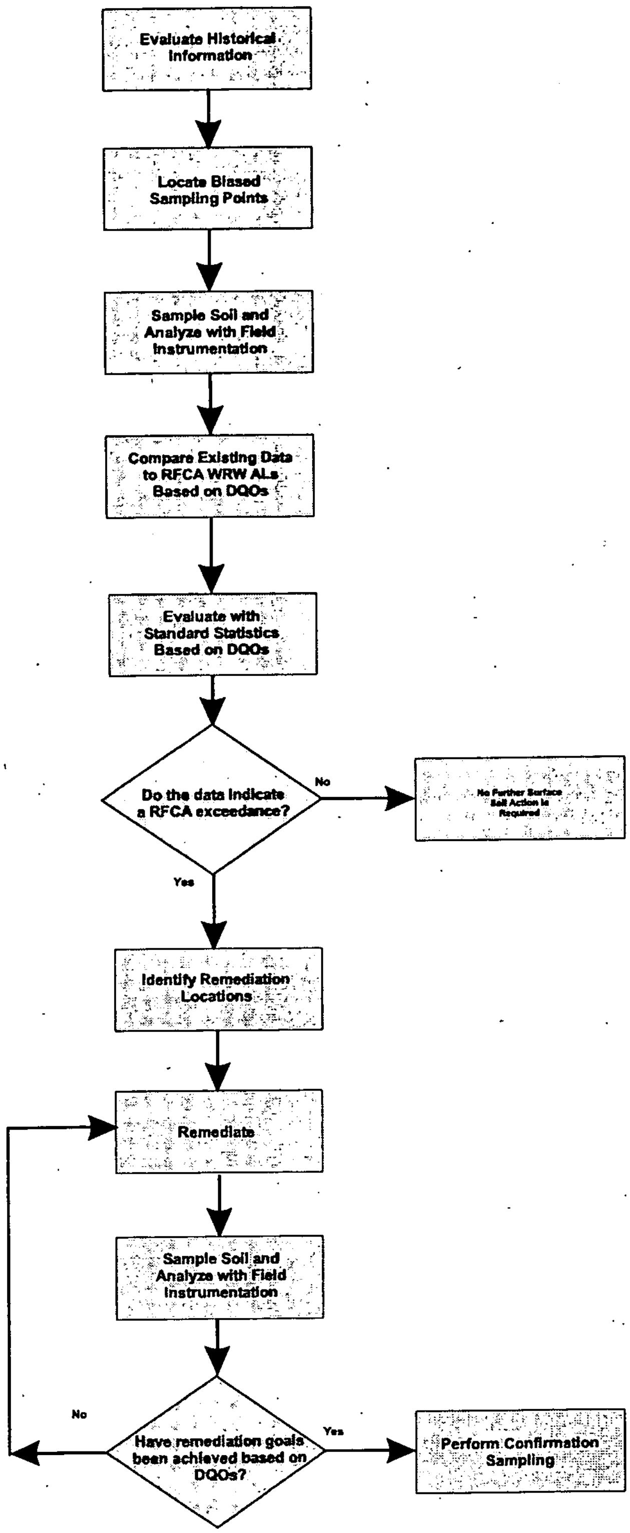

Table 4
Preliminary Sampling Location Statistical Techniques

IHSS Group	Description	IHSS/PAC/ UBC Site	Area (ft^2)	Number of Existing Sampling Locations			Historical Notes	Sampling Location Technique
				Rads	Metals	Organics		
000-1	SEP	000-101	2,500	110	110	62	Waste disposal ponds	Sampling Completed
	Effluent Line	700-149.1	10,260				PVC transfer pipes w/multiple breaks; large outfall footprint	Biased Sampling
	Effluent Line	700-149.2	9,770	3	3	3	PVC transfer pipes w/ multiple breaks; large outfall footprint	Biased Sampling
	Triangle Area	900-165	242,269	23	42	34	Leaking drums, windblown contamination, plutonium soil and scrap stockpiles	Geostatistical
	S&W Contractor Yard	000-176	113,839	13	31	30	Windblown SEP spray and drum storage area	Geostatistical
	ITS Water Spill (formerly 000-502)	900-1310	4,031				ITS line separation (approx 500 gals released)	Standard Statistical
000-2	OPWL	000-121					Underground network pipes/tanks; multiple breaks and leaks	Biased Sampling
	Valve Vault West of Building 707	700-123.2	2,476				Process waste migration along containment pipe and into ditch	Biased Sampling
	Building 123 Process Waste Line Break	100-602	14,514				Line, valve vault, bedding material (conduit) between Buildings 123 and 443	Biased Sampling
	Tank 29 - OPWL	000-121		6	6	6	Aboveground waste process tank; possible leaks	Biased Sampling
	Tank 31 - OPWL	000-121					Belowgrade, open-top sewage tank	Biased Sampling
	Low-Level Radioactive Waste Leak	700-127	2,500				Multiple line breaks and leaks	Biased Sampling
	Process Waste Line Leaks	700-147.1	16,427	1			Multiple line breaks and leaks; diverse release paths	Biased Sampling
	Radioactive Site 700 Area	700-162	141,294	13	4	3	Residual hot spots along 8th Street	Biased Sampling
000-3	Sanitary Sewer System	000-500					Routine and incidental waste discharges to sinks, sumps, lines	Biased Sampling
	Storm Drains	000-505					May have received contaminated runoff	Biased Sampling
	Old Outfall - Building 771	700-143	6,167	6	6	6	Contaminated wastewater outfall area; one hot spot in nearby culvert	Biased Sampling
	Central Avenue Ditch Caustic Leak	000-190	186,016	31	8		Caustic release to Central Ave. Ditch, Walnut Creek, and Pond B-1	Biased Sampling
000-4	NPWL	000-504					Underground pipe system	Biased Sampling
000-5	Present Landfill	114	1,644,510	188	196	104	Disposal of uncontaminated solid waste	Geostatistical/Biased
100-1	UBC 122 - Medical Facility	UBC 122	9,768				Drum leaks and possible line leaks	Standard Statistical
	Tank 1 - OPWL - Underground Stainless Steel Waste Storage Tank	000-121		3	3	3	Overflows and leaks from underground tank	Biased Sampling
100-2	UBC 125 - Standards Laboratory	UBC 125	17,736				Possible spills from calibration lab (mercury)	Standard Statistical

IHSS Group	Description	IHSS/PAC/ UBC Site	Area (ft²)	Number of Existing Sampling Locations			Historical Notes	Sampling Location Technique
				Rads	Metals	Organics		
100-3	Building 111 Transformer PCB Leak	100-607	356				Transformer leak	Standard Statistical/Biased Sampling
100-4	UBC 123 - Health Physics Laboratory	UBC 123	18,885				Disposal out windows and waste line leaks	Standard Statistical
	Waste Leaks	100-148	14,143	4	4		Unlocated waste spills, OPWL leaks	Standard Statistical/Biased Sampling
	Building 123 Bioassay Waste Spill	100-603	356				OPWL leaks	Standard Statistical/Biased Sampling
	Building 123 Scrubber Solution Spill	100-611	294				Process waste leak	Standard Statistical/Biased Sampling
100-5	Building 121 Security Incinerator	100-609	599				Incinerator accepted PCB-laden paper	Standard Statistical
300-1	Oil Burn Pit #1	300-128	914				Burn and airborne contamination area	Standard Statistical
	Lithium Metal Site	300-134(N)	7,126	3	3		Burn area	Standard Statistical
	Solvent Burning Grounds	300-171	11,412	4	4		Burn area	Standard Statistical
300-2	UBC 331 - Maintenance	UBC 331	4,986				Possible spills from maintenance activities	Standard Statistical
	Lithium Metal Destruction Site	300-134(S)	23,728	9	9		Lithium burn areas (2)	Standard Statistical
300-3	UBC 371 - Plutonium Recovery	UBC 371	114,147				Known spills of wastewater and process solutions	Standard Statistical
	North Firing Range	NW-1505	117,748				Firing range currently in use	Standard Statistical/ Biased Sampling
300-4	UBC 374 - Waste Treatment Facility	UBC 374	27,131				Multiple spills and potential leaks from waste lines	Standard Statistical
300-5	Inactive D-836 HW Tank	300-206	627	8	8	8	Condensate water spill from line to tank	Biased Sampling
300-6	Pesticide Shed	300-702	4,380				Herbicide/pesticide spills/leaks in shed and surrounding area	Standard Statistical/Biased Sampling
400-1	UBC 439 - Radiological Survey	UBC 439	5,107				Possible spills from machining operations	Standard Statistical
400-2	UBC 440 - Modification Center	UBC 440	40,166				Possible spills from machining operations	Standard Statistical
400-3	UBC 444 - Fabrication Facility	UBC 444	123,113				Overflows and leaks of process solutions	Standard Statistical
	UBC 447 - Fabrication Facility	UBC 447	19,182				Possible spills and leaks from ongoing processes	Standard Statistical
	West Loading Dock Building 447	400-116.1	2,009	7	7	7	Spills and leaks impacted soil and groundwater beneath dock	Geostatistical/Biased Sampling
	Cooling Tower Pond West of Building 444	400-136.1	7,654	2	2		Evaporation holding pond	Geostatistical/Biased Sampling
	Cooling Tower Pond East of Building 444	400-136.2	7,097	10	10		Cooling tower blowdown pond	Standard Statistical/Biased Sampling
	Buildings 444/453 Drum Storage	400-182	3,465				Leaking drums and oil spills	Standard Statistical
	Inactive Building 444 Acid Dumpster	400-207	1,288				Known spills to containment berm (possible leakage)	Standard Statistical/Biased Sampling
	Inactive Buildings 444/447 Waste Storage Site	400-208	864	1			Possible leakage from drum storage	Standard Statistical

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IHSS Group	Description	IHSS/PAC/ UBC Site	Area (ft²)	Number of Existing Sampling Locations			Historical Notes	Sampling Location Technique
				Rads	Metals	Organics		
	Transformer, Roof of Building 447	400-801	1,597				Transformer leakage via downspouts possibly to storm drain	Standard Statistical/Biased Sampling
	Beryllium Fire - Building 444	400-810	15,073				Drainage, holding basin, and airborne contamination from fire	Standard Statistical/Biased Sampling
	Tank 4 - OPWL Process Waste Pits	000-121					Potential leaks and overflows	Biased Sampling
	Tank 5 - OPWL Process Waste Tanks	000-121					Potential leaks and overflows	Biased Sampling
	Tank 6 - OPWL Process Waste Floor Sump and Foundation Drain Floor	000-121					Potential leaks and overflows	Biased Sampling
	South Loading Dock Building 444	400-116.2	1,113	4	4	4	Windblown, drum leakage, dumping	Standard Statistical
400-4	Miscellaneous Dumping, Building 460 Storm Drain	400-803	18,932				Dumping to storm drain, extends along open ditch	Standard Statistical/Biased Sampling
	Road North of Building 460	400-804	1,393				Hot spots covered w/asphalt from falling ingots	Standard Statistical
400-5	Sump #3 Acid Site (Southeast of Building 460)	400-205	1,693				Leakage from container overflows in berm area	Biased Sampling
	RCRA Tank Leak in Building 460	400-813	356				Pipe leakage beneath building	Standard Statistical/Biased Sampling
	RCRA Tank Leak in Building 460	400-815	356				Possible leakage from spills to secondary containment	Standard Statistical/Biased Sampling
400-6	Radioactive Site South Area	400-157.2	438,409	52	52	52	Dumping, surface runoff, air releases, open surface storage	Geostatistical
400-7	UBC 442 - Filter Test Facility	UBC 442	2,583				Leaking barrels, discharges	Standard Statistical/Biased Sampling
	Radioactive Site North Area	400-157.1	51,169	7	7	7	Leaking drums, drainage to ditches	Standard Statistical
	Building 443 Oil Leak	400-129	6,434	11	11	11	Leaks and spills from underground tanks (6)	Geostatistical/Biased Sampling
	Sulfuric Acid Spill Building 443	400-187	20,206	2	2	2	Multiple leaks and sprays from storage tank	Geostatistical/Biased Sampling
400-8	UBC 441- Office Building	UBC 441						Standard Statistical
	Underground Concrete Tank	400-122					Overflows and leaking from tanks	Biased Sampling
	Tank 2 - Concrete Waste Storage Tank	000-121		2	2	2	Potential leaks and overflows	Biased Sampling
	Tank 3 - Concrete Waste and Steel Waste Storage Tanks.	000-121	-	8	8	8	Potential leaks and overflows	Biased Sampling
400-10	Sandblasting Area	400-807	9,583				Open air sandblasting	Standard Statistical
	Fiberglass Area West of Building 664	600-120.2	5,449	12	14	3	Multiple spills around work area (resin and solvents)	Geostatistical
	Radioactive Site West of Building 664	600-161	53,346	30	10	2	Punctured and leaking drums, hydraulic leaks	Standard Statistical
500-1	Valve Vaults 11, 12, 13	300-186	48,345		8		Leaks and discharges from transfer pipes and vaults	Standard Statistical
	Scrap Metal Storage Site	500-197	89,320	5	5	5	Residual contamination from removal of process and building scrap	Standard Statistical
	North Site Chemical Storage Site	500-117.1	115,489	1	1		Surface storage of contaminated material,	Standard Statistical

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IHSS Group	Description	IHSS/PAC/ UBC Site	Area (ft^2)	Number of Existing Sampling Locations			Historical Notes	Sampling Location Technique
				Rads	Metals	Organics		
							uranium chips	
500-2	Radioactive Site Building 551	500-158	62,166	7	7		Wastebox leakage, exterior contaminated drums transferred	Standard Statistical
500-3	UBC 559 - Service Analytical Laboratory	UBC 559	34,544				Plutonium waste line leaks and breaks	Standard Statistical/Biased Sampling
	UBC 528 - Temporary Waste Holding Building	UBC 528	432				OPWL leaks/valve vault overflows	Standard Statistical/Biased Sampling
	Radioactive Site Building 559	500-159	5,363				Broken process waste lines	Standard Statistical
	Tank 7 - OPWL - Active Process Waste Pit	000-121		3	3	3	Potential leaks and overflows	Biased Sampling
	Tank 33 - OPWL - Process Waste Tank	000-121					Potential leaks and overflows	Biased Sampling
	Tank 34 - OPWL - Process Waste Tank	000-121					Potential leaks and overflows	Biased Sampling
	Tank 35 - OPWL - Building 561 Concrete Floor Sump	000-121					Potential leaks and overflows	Biased Sampling
500-4	Middle Site Chemical Storage	500-117.2	91,616	5	5		Minor leaks and spills, partial asphalt cover	Geostatistical/Standard Statistical
500-5	Transformer Leak - 558-1	500-904	356				PCB-oil leaks to concrete pad	Standard Statistical/ Biased Sampling
500-6	Asphalt Surface Near Building 559	500-906	356				1-gal F001 spill from liquid hose transfer	Standard Statistical
500-7	Tanker Truck Release of Hazardous Waste from Tank 231B	500-907	859				Liquid and solid sludge release to soil	Standard Statistical/ Biased Sampling
600-1	Temporary Waste Storage - Building 663	600-1001	42,803				Leaking, punctured, and spilled drums (concrete pad)	Standard Statistical
600-2	Storage Shed South of Building 334	400-802	63,641				Leaking and spilled drums to concrete pad	Standard Statistical
600-3	Fiberglass Area North of Building 664	600-120.1	4,650	9	9		Multiple spills around work area	Geostatistical/Standard Statistical
600-4	Radioactive Site Building 444 Parking Lot	600-160	143,752	99	36	4	Releases from drums and boxes stored on ground	Geostatistical
600-5	Central Avenue Ditch Cleaning	600-1004	14,885				Soil spreading from ditch to area around tanks	Biased Sampling
600-6	Former Pesticide Storage Area	600-1005	356				Pesticide spills to dirt floor	Standard Statistical
700-1	Identification of Diesel Fuel in Subsurface Soil	700-1115					Subsurface fuel leak	Standard Statistical
700-2	UBC 707 - Plutonium Fabrication and Assembly	UBC 707	107,710				Process line leaks/breaks	Standard Statistical
	UBC 731 - Building 707 Process Waste	UBC 731	4,000				Process spills/OPWL leaks and breaks	Standard Statistical
	Tank 11 - OPWL - Building 731	000-121		3	3	3	Potential leaks and overflows	Biased Sampling
	Tank 30 - OPWL - Building 731	000-121		3	3	3	Potential leaks and overflows	Biased Sampling
700-3	UBC 776 - Original Plutonium Foundry	UBC 776	142,889				Airborne/tracked contamination fires and explosions/liquid waste spills	Standard Statistical/Biased Sampling
	UBC 777 - General Plutonium Research and Development	UBC 777					Process spills/OPWL leaks/fire contamination	Standard Statistical/Biased Sampling

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IHSS Group	Description	IHSS/PAC/ UBC Site	Area (ft²)	Number of Existing Sampling Locations			Historical Notes	Sampling Location Technique
				Rads	Metals	Organics		
	UBC 778 - Plant Laundry Facility	UBC 778	26,609				Laundry water spills/OPWL leaks and breaks	Standard Statistical/Biased Sampling
	UBC 701 - Waste Treatment Research and Development	UBC 701	5,645				Possible spills from R&D lab	Standard Statistical/Biased Sampling
	Solvent Spills West of Building 730	700-118.1	246				Carbon tet overflows and line leaks	Standard Statistical/Biased Sampling
	Radioactive Site 700 Area No.1	700-131	7,072	17	17	17	Fire and explosion resulting in soil contamination	Geostatistical/Standard Statistical
	Radioactive Site West of Building 771/776	700-150.2(S)	27,113	4			Airborne and tracked contamination from fire, cleanup, and rain	Standard Statistical
	Radioactive Site South of Building 776	700-150.7	18,589	3	3		Airborne and tracked contamination from fire, cleanup, and rain	Standard Statistical
	French Drain North of Building 776/777	700-1100	1,567				Possible pathway for contamination from explosion and fire	Biased Sampling
	Tank 9 - OPWL - Two 22,500-Gallon Concrete Laundry Tanks	000-121		2	2	2	Potential leaks and overflows	Biased Sampling
	Tank 10 - OPWL - Two 4,500-Gallon Process Waste Tanks	000-121		2	2	2	Potential leaks and overflows	Biased Sampling
	Tank 18 - OPWL - Concrete Laundry Waste Lift Sump	000-121					Potential leaks and overflows	Biased Sampling
	Solvent Spills North of Building 707	700-118.2	633				Tank leaks and rupture	Standard Statistical/ Biased Sampling
	Sewer Line Overflow	700-144(N)	1,710	6	6	6	Pressurized sewer line breaks and overflows	Geostatistical/ Biased Sampling
	Sewer Line Overflow	700-144(S)	2,330	7	7	7	Pressurized sewer line breaks and overflows	Biased Sampling
	Transformer Leak South of Building 776	700-1116	356				Dielectric fluid leak to pad, gravel, and soil	Standard Statistical/ Biased Sampling
	Radioactive Site Northwest of Building 750	700-150.4	394	5	5	5	Leaks and backups of stored decon fluid	Standard Statistical
700-4	UBC 771 - Plutonium and Americium Recovery Operations	UBC 771	97,553				Fire, sewer line breaks, process waste line leaks	Standard Statistical/ Biased Sampling
	UBC 774 - Liquid Process Waste Treatment	UBC 774	15,776				Tank overflows, drain breaks	Standard Statistical/Biased Sampling
	Radioactive Site West of Buildings 771/776	700-150.2(N)	27,113	1	6	6	Fire, explosion, tank overflows	Standard Statistical
	Radioactive Site 700 North of Building 774 (Area 3) Wash Area	700-163.1	18,613	9	9	9	Contaminated equipment wash area	Geostatistical/Standard Statistical
	Radioactive Site 700 Area 3 Americium Slab	700-163.2	2,270				Buried contaminated (Am) slab 8'x8'x10"	Standard Statistical
	Abandoned Sump Near Building 774 Unit 55.13 T-40	700-215	960				Mixed waste storage tank	Biased Sampling
	Hydroxide Tank, KOH, NaOH Condensate	700-139(N)(b)	342				Overflows/spills from aboveground KOH/NaOH tanks	Standard Statistical/ Biased Sampling
	30,000-Gallon Tank (68)	700-124.1	1,133				Overflows/leaks from tank	Standard Statistical/ Biased Sampling
	14,000-Gallon Tank (66)	700-124.2					Overflows/leaks from tank	Biased Sampling

IHSS Group	Description	IHSS/PAC/ UBC Site	Area (ft²)	Number of Existing Sampling Locations			Historical Notes	Sampling Location Technique
				Rads	Metals	Organics		
	14,000-Gallon Tank (67)	700-124.3					Overflows/leaks from tank	Biased Sampling
	Holding Tank	700-125					Tank overflows	Biased Sampling
	Westernmost Out-of-Service Process Waste Tank	700-126.1	383				Belowgrade leaks/overflows	Biased Sampling
	Easternmost Out-of-Service Process Waste Tank	700-126.2	370				Belowgrade leaks/overflows	Biased Sampling
	Tank 8 - OPWL - East and West Process Tanks	000-121		2	2	2	Potential leaks and overflows	Biased Sampling
	Tank 12 - OPWL - Two Abandoned 20,000-Gallon Underground Concrete Tanks	000-121					Potential leaks and overflows	Biased Sampling
	Tank 13 - OPWL - Abandoned Sump - 600 Gallons	000-121					Potential leaks and overflows	Biased Sampling
	Tank 14 - OPWL - 30,000-Gallon Concrete Underground Storage Tank (68)	000-121		3	3	3	Potential leaks and overflows	Biased Sampling
	Tank 15 - OPWL - Two 7,500-Gallon Process Waste Tanks (34W, 34E)	000-121					Potential leaks and overflows	Biased Sampling
	Tank 16 - OPWL - Two 14,000-Gallon Concrete Underground Storage Tanks (66, 67)	000-121		2	2	2	Potential leaks and overflows	Biased Sampling
	Tank 17 - OPWL - Four Concrete Process Waste Tanks (30, 31, 32, 33)	000-121					Potential leaks and overflows	Biased Sampling
	Tank 36 - OPWL - Steel Carbon Tetrachloride Sump	000-121					Potential leaks and overflows	Biased Sampling
	Tank 37 - OPWL - Steel-Lined Concrete Sump	000-121					Potential leaks and overflows	Biased Sampling
	Caustic/Acid Spills Hydrofluoric Tank	700-139.2	918				Spills and leaks infiltrated surrounding soil	Standard Statistical/Biased Sampling
	Concrete Process 7,500-Gallon Waste Tank (31)	700-146.1	1,507				Frequent tank overflows and leakage	Standard Statistical/Biased Sampling
	Concrete Process 7,500-Gallon Waste Tank (32)	700-146.2					Frequent tank overflows and leakage	Standard Statistical/Biased Sampling
	Concrete Process 7,500-Gallon Waste Tank (34W)	700-146.3					Frequent tank overflows and leakage	Standard Statistical/Biased Sampling
	Concrete Process 7,500-Gallon Waste Tank (34E)	700-146.4					Frequent tank overflows and leakage	Standard Statistical/Biased Sampling
	Concrete Process 7,500-Gallon Waste Tank (30)	700-146.5					Frequent tank overflows and leakage	Standard Statistical/Biased Sampling
	Concrete Process 7,500-Gallon Waste Tank (33)	700-146.6					Frequent tank overflows and leakage	Standard Statistical/Biased Sampling
	Radioactive Site North of Building 771	700-150.1	24,779	9	9	9	Airborne, leaking drums, tracked contamination	Geostatistical/Biased Sampling
	Radioactive Site Between Buildings 771 and 774	700-150.3	5,037	3	3	3	Broken process waste line	Geostatistical/Biased Sampling
700-5	UBC 770 - Waste Storage Facility	UBC 770	3,111				Possible leakage from stored waste containers	Standard Statistical/ Biased Sampling
700-6	Buildings 712/713 Cooling Tower Blowdown	700-137	14,962	5	5	5	Ground placement of tower sludge/blowdown water leaks	Geostatistical/Standard Statistical

IHSS Group	Description	IHSS/PAC/ UBC Site	Area (ft²)	Number of Existing Sampling Locations			Historical Notes	Sampling Location Technique
				Rads	Metals	Organics		
	Caustic/Acid Spills Hydroxide Tank Area	700-139.1(S)	923	2	2	2	Multiple spills and leaks	Standard Statistical/ Biased Sampling
700-7	UBC 779 - Main Plutonium Components Production Facility	UBC 779	43,360				Building over original Solar Pond/water spills and leaks	Standard Statistical/ Biased Sampling
	Building 779 Cooling Tower Blowdown	700-138	14,962	9	9	9	Underground cooling tower water line break	Geostatistical/Standard Statistical
	Radioactive Site South of Building 779	700-150.6	4,435	3	3	3	Tracked contamination	Standard Statistical
	Radioactive Site Northeast of Building B779	700-150.8	13,054	2	1	1	Tracked contamination	Standard Statistical
	Transformer Leak - 779-1/779-2	700-1105	712				PCB oil released from transformer	Standard Statistical/ Biased Sampling
	Tank 19 - OPWL - Two 1,000-Gallon Concrete Sumps	000-121					Potential leaks and overflows	Biased Sampling
	Tank 20 - OPWL - Two 8,000-Gallon Concrete Sumps	000-121					Potential leaks and overflows	Biased Sampling
	Tank 38 - OPWL - 1,000-Gallon Steel Tanks	000-121					Potential leaks and overflows	Biased Sampling
700-8	750 Pad - Pondcrete/Saltcrete Storage	700-214	139,658				Pondcrete/saltcrete spills/pad runoff not contained	Standard Statistical
700-10	Laundry Tank Overflow - Building 732	700-1101	1,856				Wastewater tank overflow	Standard Statistical/ Biased Sampling
700-11	Bowman's Pond	700-1108	4,741				Tanks/process line leaks/footing drain accumulation area	Standard Statistical/ Biased Sampling
	Hydroxide Tank, KOH, NaOH Condensate	700-139.1(N) (a)	2,520	7	7	2	Multiple spills and leaks	Standard Statistical/ Biased Sampling
700-12	Process Waste Spill - Portal 1	700-1106	356				Valve vault water spilled onto street	Biased Sampling
800-1	UBC 865 - Materials Process Building	UBC 865	41,558				OPWL leaks/spills from coating ops and R&D activities	Standard Statistical
	Building 866 Spills	800-1204	2,623				Vent pipe and tank overflows	Standard Statistical/ Biased Sampling
	Building 866 Sump Spill	800-1212	364				Leak from sump pump	Standard Statistical/ Biased Sampling
	Tank 23 - OPWL	000-121					Potential leaks and overflows	Biased Sampling
800-2	UBC 881 - Laboratory and Office	UBC 881	79,222				Multiple leaks/broken waste lines	Standard Statistical
	Building 881, East Dock	800-1205	2,426				Possible unknown contamination/condensate spill	Standard Statistical
	Tank 24 - OPWL - Seven 2,700-Gallon Steel Process Waste Tanks	000-121		1	1	1	Potential leaks and overflows	Biased Sampling
	Tank 32 - OPWL - 131,160-Gallon Underground Concrete Secondary Containment Sump	000-121		2	2	2	Potential leaks and overflows	Biased Sampling
	Tank 39 - OPWL - Four 250-Gallon Steel Process Waste Tanks	000-121					Potential leaks and overflows	Biased Sampling
800-3	UBC 883 - Roll and Form Building	UBC 883	49,325				Process waste water leaks and overflows	Standard Statistical/ Biased Sampling
	Valve Vault 2	800-1200	4,541				Transfer line leak	Biased Sampling

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IHSS Group	Description	IHSS/PAC/ UBC Site	Area (ft²)	Number of Existing Sampling Locations			Historical Notes	Sampling Location Technique
				Rads	Metals	Organics		
	Tank 25 - OPWL - 750-Gallon Steel Tanks (18, 19)	000-121					Potential leaks and overflows	Biased Sampling
	Tank 26 - OPWL - 750-Gallon Steel Tanks (24, 25, 26)	000-121					Potential leaks and overflows	Biased Sampling
	Radioactive Site South of Building 883	800-1201	1,500				Multiple areas of contamination from Plant operations	Standard Statistical
800-4	UBC 886 - Critical Mass Laboratory	UBC 886	13,517				Leaks and spills from criticality experiments	Standard Statistical/ Biased Sampling
	Tank 21 - OPWL - 250-Gallon Concrete Sump	000-121		2	2	2	Potential leaks and overflows	Biased Sampling
	Tank 22 - OPWL - Two 250-Gallon Steel Tanks	000-121		3	3	3	Potential leaks and overflows	Biased Sampling
	Tank 27 - OPWL - 500-Gallon Portable Steel Tank	000-121	31,400	2	2	2	Potential leaks and overflows	Standard Statistical/Biased Sampling
	Radioactive Site #2 800 Area, Building 886 Spill	800-164.2	31,400	57	57	57	Tank leak	Geostatistical
800-5	UBC 887 - Process and Sanitary Waste Tanks	UBC 887	378				Leaks and breaks in process waste lines	Standard Statistical/Biased Sampling
	Building 885 Drum Storage	800-177	1,064	9	9	9	Possible releases from waste storage	Geostatistical/Standard Statistical
800-6	UBC 889 - Decontamination and Waste Reduction	UBC 889	2,603				Radiological car wash area/OPWL leaks/waste tank breaches	Standard Statistical/ Biased Sampling
	Radioactive Site 800 Area Site #2 Building 889 Storage Pad	800-164.3	28,944	34			Leaks/spills/rainwater transport from storage area	Standard Statistical
	Tank 28 - Two 1,000-Gallon Concrete Sumps	000-121					Potential leaks and overflows	Biased Sampling
	Tank 40 - Two 400-Gallon Underground Concrete Tanks	000-121		4	4	4	Potential leaks and overflows	Biased Sampling
900-1	UBC 991 - Weapons Assembly and R&D	UBC 991	59,849				Potential line leaks/valve vault breaches and overflows	Standard Statistical/ Biased Sampling
	Radioactive Site Building 991	900-173	5,970	3	3	3	Small spills and equipment wash area	Standard Statistical
	Radioactive Site 991 Steam Cleaning Area	900-184	4,125				Equipment cleaning area	Standard Statistical
	Building 991 Enclosed Area	900-1301	3,939				Possible leaks from waste containers/material storage	Standard Statistical
900-2	Oil Burn Pit No. 2	153	6,403				Disposal and burning of uranium-contaminated coolant and waste oils	Biased/Stratified Statistical Grid
	Pallet Burn Site	154	3,152	4	4	12	Burning of wooden pallets	Biased/Stratified Statistical Grid
900-3	904 Pad, Pondcrete Storage	900-213	127,334	1			Spillage and rainwater runoff of stored pondcrete/saltcrete	Standard Statistical
900-4&5	S&W Building 980 Contractor Storage Facility	900-175	5,819	10	10	10	Leaks and spills from drum storage	Geostatistical/Standard Statistical
	Gasoline Spill Outside Building 980	900-1308	356				Gas overflow during filling	Standard Statistical/Biased Sampling
900-11	East Firing Range and Target Area	SE-1602	465,173				Lead bullets in Firing Range berm; armor-piercing bullet fragments made of depleted uranium in Target Area	Biased/Stratified Statistical Grid

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IHSS Group	Description	IHSS/PAC/ UBC Site	Area (ft^2)	Number of Existing Sampling Locations			Historical Notes	Sampling Location Technique
				Rads	Metals	Organics		
	903 Pad	112	146,727	52	12	73	Leaks and spills from drum storage	Geostatistical/ Biased Sampling
	Hazardous Disposal Area	140	65,498	14	12	48	Reactive metal destruction and disposal site	Biased/Stratified Statistical Grid
	903 Lip Area	155	1,009,572	1,173	16	73	Wind dispersal contamination from the 903 Pad	Geostatistical/ Biased Sampling
900-12	Trench T-6	111.3	4,089	2		2	Received sludge, asphalt planking, miscellaneous material	Biased Sampling
	Trench T-8	111.5	13,135	2	2	2	Received sludge, asphalt planking, miscellaneous material	Biased Sampling
	Trench T-9	111.6	21,061	5	5	5	Received sludge, asphalt planking, miscellaneous material	Biased Sampling
NE-1	Pond A-1	142.1	39,294	4	4	4	Received wastewater effluent from the Industrial Area; spill control	Biased/Stratified Statistical Grid
	Pond A-2	142.2	61,373	1	4	4	Received wastewater effluent from the Industrial Area; spill control	Biased/Stratified Statistical Grid
	Pond A-3	142.3	122,909	4	5	4	Received wastewater effluent from the Industrial Area	Biased/Stratified Statistical Grid
	Pond A-4	142.4	254,102	4	4	4	Received wastewater effluent from the Industrial Area	Biased/Stratified Statistical Grid
	Pond A-5	142.12	12,256	5	5	5	Received wastewater effluent from the Industrial Area	Biased/Stratified Statistical Grid
	Pond B-1	142.5	11,396	5	4	5	Flow-through retention pond; received treated sanitary effluent and process waste	Biased/Stratified Statistical Grid
	Pond B-2	142.6	33,761	5	5	5	Flow-through retention pond; received treated sanitary effluent and process waste	Biased/Stratified Statistical Grid
	Pond B-3	142.7	18,422	4	4	4	Flow-through retention pond; received treated sanitary wastewater effluent discharge	Biased/Stratified Statistical Grid
	Pond B-4	142.8	11,731	5	5	5	Flow-through retention pond; received treated sanitary wastewater effluent discharge	Biased/Stratified Statistical Grid
	Pond B-5	142.9	129,515	5	5	7	Flow-through retention pond; received treated sanitary wastewater effluent discharge	Biased/Stratified Statistical Grid
	Pond C-1	142.10	33,975	2	2	2	Retention and monitoring pond; received sanitary sewage discharge and runoff from the 903 Pad Area	Biased/Stratified Statistical Grid
	Pond C-2	142.11	168,524	3	4	4	Received discharge from the SID	Biased/Stratified Statistical Grid
NE-2	Trench T-7	111.4	15,565	9	9	27	Disposal of sanitary waste sludge and debris	Biased/Stratified Statistical Grid
	Ryan's Pit (Trench 2)	109	261	2	2	6	Disposal of VOCs and drum carcasses	Biased/Stratified Statistical Grid
NE/NW	East Spray Field-Center Area	216.2	73,458	1	1	8	Spray irrigation from Pond B-3	Biased/Stratified Statistical Grid

IHSS Group	Description	IHSS/PAC/ UBC Site	Area (ft^2)	Number of Existing Sampling Locations			Historical Notes	Sampling Location Technique
				Rads	Metals	Organics		
	East Spray Field-South Area	216.3	651,580	10	13	27	Spray irrigation from Pond B-3	Biased/Stratified Statistical Grid
	Trench T-12 Located at OU 2 East Trenches	NE-1412	7,449				Disposal of sanitary waste sludge and flattened drums	Biased/Stratified Statistical Grid
	Trench T-13 Located at OU 2 East Trenches	NE-1413	5,090				Disposal of sanitary waste sludge and flattened drums	Biased/Stratified Statistical Grid
	PU&D Yard - Drum Storage	174a	4,342		21	93	Leaks and spills from RCRA drum storage	Geostatistical/Biased Sampling
	OU 2 Treatment Facility	NE-1407	356				Leaks and spills from process operations	Biased/Stratified Statistical Grid
SW-1	Recently Identified Ash Pit	SW-1702	5,588				Disposal of combustible waste ash, depleted uranium, and metallic debris	Biased/Stratified Statistical Grid
	Ash Pit 1	133.1	13,960	4	4		Disposal of combustible waste ash and noncombustible trash	Biased/Stratified Statistical Grid
	Ash Pit 2	133.2	26,624	7	7		Disposal of combustible waste ash and noncombustible trash	Biased/Stratified Statistical Grid
	Ash Pit 4	133.4	10,749	3	3		Disposal of combustible waste ash and noncombustible trash	Biased/Stratified Statistical Grid
	Incinerator	133.5	45,495	2	2	1	Area backfilled with ash potentially contaminated with depleted uranium	Biased/Stratified Statistical Grid
	Concrete Wash Pad	133.6	35,274	1	1	4	Deposition of potentially contaminated ash	Biased/Stratified Statistical Grid
SW-2	Original Landfill	SW-115		68	71	68	General Plant waste disposal/burning pits/depleted uranium disposal	Sampling Completed
	Water Treatment Plant Backwash	SW-196		3	3	3	Sandfilter backflushing	Sampling Completed

Subsurface soil will be sampled where historical information and analytical data suggest contamination may be present below a depth of 6 inches. The characterization team will collect subsurface soil samples with a Geoprobe® (or other appropriate method) to the top of the saturated zone or top of bedrock. The characterization team will use concrete drills (for UBC Sites, concrete slabs, and other foundation areas) where necessary. The types of Geoprobe® and other sampling methods that may be used are described in Section 4.9. The COCs for each IHSS, PAC, and UBC Site will be specified in the appropriate IABZSAP Addendum.

Soil sample analytical results will be compared to RFCA ALs. Data from each IHSS, PAC, and UBC Site will be evaluated according to DQOs (Section 3.0).

4.4 Post-Remediation Confirmation Sampling

Post-remediation confirmation sampling will be conducted at AOCs associated with IHSSs, PACs, and UBC Sites in the IA and BZ. In-process confirmation soil samples will be collected and analyzed during remediation to verify cleanup below remediation goals. In-process samples will be analyzed with field analytical instruments. Post-remediation confirmation samples will also be collected and analyzed. The combination of in-process and confirmation samples will ensure that residual contamination levels are below remediation goals.

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4.4.1 Confirmation Sampling and Analysis

Confirmation samples are defined as those samples collected following a remedial action. The characterization team will conduct confirmation sampling and analysis on remediated areas to verify that the site has met remedial objectives. The confirmation sampling and analysis will provide a representative assessment of the magnitude and spatial configuration of the COC(s) after remediation. The number and distribution of confirmation samples will be based on the probability of detecting residual contamination (90 percent) and the size and spatial variability of the remediated site. Statistical sampling strategies will ensure that the appropriate numbers of samples are collected from unbiased locations.

The characterization team will collect soil from the remediated areas before the areas are covered with clean fill. Confirmation sampling locations will be determined using geostatistical methods or the approaches described in Section 4.4.2. Soil samples will be analyzed on site if appropriate data quality is achieved, or sent to off-site analytical laboratories for analysis, and analytical data will be validated in accordance with ASD requirements. If adequate correlation is demonstrated between field analytical and laboratory analysis data, field instrumentation may also be used for confirmation analysis.

The characterization team will conduct confirmation sampling at all IA and BZ IHSS Group remediations. They will compile and evaluate confirmation sampling data generated during that time to determine whether field analytical data are of sufficient quality to be used for CRA analyses. If the regulatory agencies concur that the field analytical data are of sufficient quality, remediation confirmation samples will be analyzed with field analytical instruments rather than sent to off-site laboratories.

4.4.2 Sampling Locations

Confirmation sampling locations will be determined based on the configuration of the remediated area or as determined through the consultative process. The following sampling location methods may be used:

- Biased sampling will be used at sites with known or suspected discrete spills or leaks and to supplement statistical sampling if necessary. Exact locations of biased sampling points will be based on site-specific and physical characteristics of the soil. Some characteristics that may require biased sampling may include, but are not limited to, the following:
  - Preferential migration pathways (for example, burrows, fractures, bedding planes, and sandstone lenses);
  - Source areas (for example, outfalls, storage areas, and historical spill sites);
  - Stained soil;
  - Changes in soil characteristics (for example, sand/clay interfaces); and
  - Depressions and ditches.
- At remediated areas smaller than 0.06 acre (2,614 ft^2), a minimum of five locations will be sampled. Locations will include the walls and floor of the remediated area.

- Confirmation sampling in trenches will consist of biased sampling. This will include sampling every 100 ft, depending on the length of the pipeline or trench, along the bottom of the pipeline or trench. If residual contamination is found along the bottom of the trench, sidewall sampling may also be necessary.

- Composite or grab samples may be used as confirmation samples within a remediation grid as determined through the consultative process.

- For remediated areas that were contaminated with radionuclides, 90 percent of the area may be scanned using in-situ HPGe techniques within a triangular grid system. Considering that an HPGe detector has an 11-m-diameter field of view with the detector placed 1 m above the soil surface, a grid interval of 11 m (36 ft) will be used to achieve 90-percent coverage. This grid spacing is consistent with the characterization sampling approach.

- For remediated areas where nonradiologically-contaminated soil was remediated, the grid density for confirmation sampling in nonradiologically-contaminated areas may be based on the size of the remediated area (Michigan DNR 1994). This approach is based on a 95% confidence level of determining any hot spot concentrations on a site. Incorporating confirmation sampling will allow for a reduction in the Type I error rate from 0.1 to 0.05, which will reduce the probability of residual contamination after remediation. This approach is designed to delineate nonuniform areas of residual contamination, and is therefore appropriate for reliable characterization of the entire remedial area. Grid density is proportional to the size of the area and can be determined using one of the following equations (Michigan DNR 1994):

Small Remediation Site (0.06 to 0.25 acre): $$GI = \frac{\sqrt{A/\pi}}{2}$$ (Equation 4-1)

Medium Remediation Site (0.25 to 3.0 acres): $$GI = \frac{\sqrt{A/\pi}}{4}$$ (Equation 4-2)

Large Remediation Site (> 3.0 acres): $$GI = \sqrt{(A*\pi)/SF}$$ (Equation 4-3)

Where:

GI = grid size (L)
A = size of area of interest (L^2)
SF = site factor, length of grid area (dimensionless)

As shown above, the grid equations apply to three different size areas. The grid densities vary according to the size of the area of interest.

Table 5 presents several examples of the calculations.

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Table 5
Calculation of Confirmation Sampling Location Grids

Equation 4-1	Area (ft^2)	A/π	Sq Root	Grid Size (ft^2)
Small Site - 0.06 to 0.25 acre (2,614 to 10,890 ft^2)	2,614	832	28	14
	5,000	1,592	39	20
	10,890	3,468	58	29
Equation 4-2				
Medium Site - 0.25 to 3.0 acres (10,890 to 130,680 ft^2)	50,000	15,923	126	32
	100,000	31,847	178	45
	130,680	41,617	204	51
Equation 4-3	**Area (ft^2)**	**A*π**	**SF**	**Grid Size (ft^2)**
Large Site - >3.0 acres (>130,680 ft^2)	1,000,000	3,140,000	1,000	56

Both the sidewalls and bottom areas will be included in the determination of the confirmation samples. A minimum of five confirmation samples will be collected, including one sample for each sidewall and the floor or as determined through the consultative process. Sidewall samples will be located in biased areas, if possible.

4.5 Characterization Sampling Strategy for Surface Soil in Areas Outside of IHSSs, PACs, and UBC Sites

Surface soil in areas outside of IHSSs, PACs, and UBC Sites in the IA and BZ will be sampled and analyzed to provide data for risk assessment or screening. The SOR data for COCs from existing data and IA and BZ characterization data will be compared to RFCA ALs through geostatistical analysis, and the resulting simulation will be used to determine optimal sampling areas within these areas.

Sampling grid spacing and the number of required samples will be calculated based on Gilbert's method (1987). Specific sampling locations will be described in the appropriate CRA sampling addendum.

Soil samples will be collected at the specified locations and depths according to the sample collection methods described in Section 4.9. These samples will be analyzed in accordance with CRA requirements. Data will be evaluated according to CRA DQOs.

4.6 UBC Sites

There are 31 designated UBC Sites in the IA OU. Past and current operations in these buildings have included production and waste management activities. These buildings were designated as UBC Sites because of documented spills or releases in the buildings or routine operations that may have resulted in contamination (DOE 1992d). Issues associated with characterization of these UBC Sites include the following:

- Potentially unknown spills, releases, and contamination;
- OPWL and other utilities beneath buildings;

5.0 DATA ANALYSIS PROCEDURES

The characterization team will aggregate and evaluate data generated as part of IABZSAP activities in accordance with the IABZSAP DQOs. This will include the following:

- Aggregation according to IABZSAP DQOs for comparison to RFCA ALs;
- Use of geostatistical or standard statistical techniques to determine whether additional sampling is required to reach specified confidence levels that an IHSS, PAC, or UBC Site has been adequately characterized;
- Use of verification sampling techniques to ensure the accuracy of data generated from field instrumentation;
- Use of geostatistical or standard statistical techniques to determine whether RFCA ALs have been exceeded;
- Aggregation of remediation confirmation data according to IABZSAP DQOs for comparison to RFCA ALs to determine whether remediation was successful; and
- Aggregation and evaluation according to IABZSAP DQOs for use in the CRA.

5.1 RFCA ALs and Data Evaluation

In accordance with the IABZSAP DQOs, the extent of contamination must be delineated by comparison to RFCA ALs. Designation of hot spots and subsequent remediation and/or closure decisions will be based on comparisons to RFCA ALs. A phased statistical evaluation will be conducted that consists of the following steps:

1. Data aggregation;
2. Comparison of data to RFCA ALs;
3. Geostatistical analyses if appropriate data are available; and
4. Elevated Measurement Comparison (EMC) (hot spot methodology) if necessary.

The flow chart presented on Figure 33 displays the steps and decision points used for this phased statistical evaluation. The null (Ho) and alternative (Ha) hypotheses used during the statistical analyses are as follows:

Ho: Analyte concentrations/activities within the AOC are significantly greater than the RFCA ALs.

Ha: Analyte concentrations/activities within the AOC are not significantly greater than the RFCA ALs.

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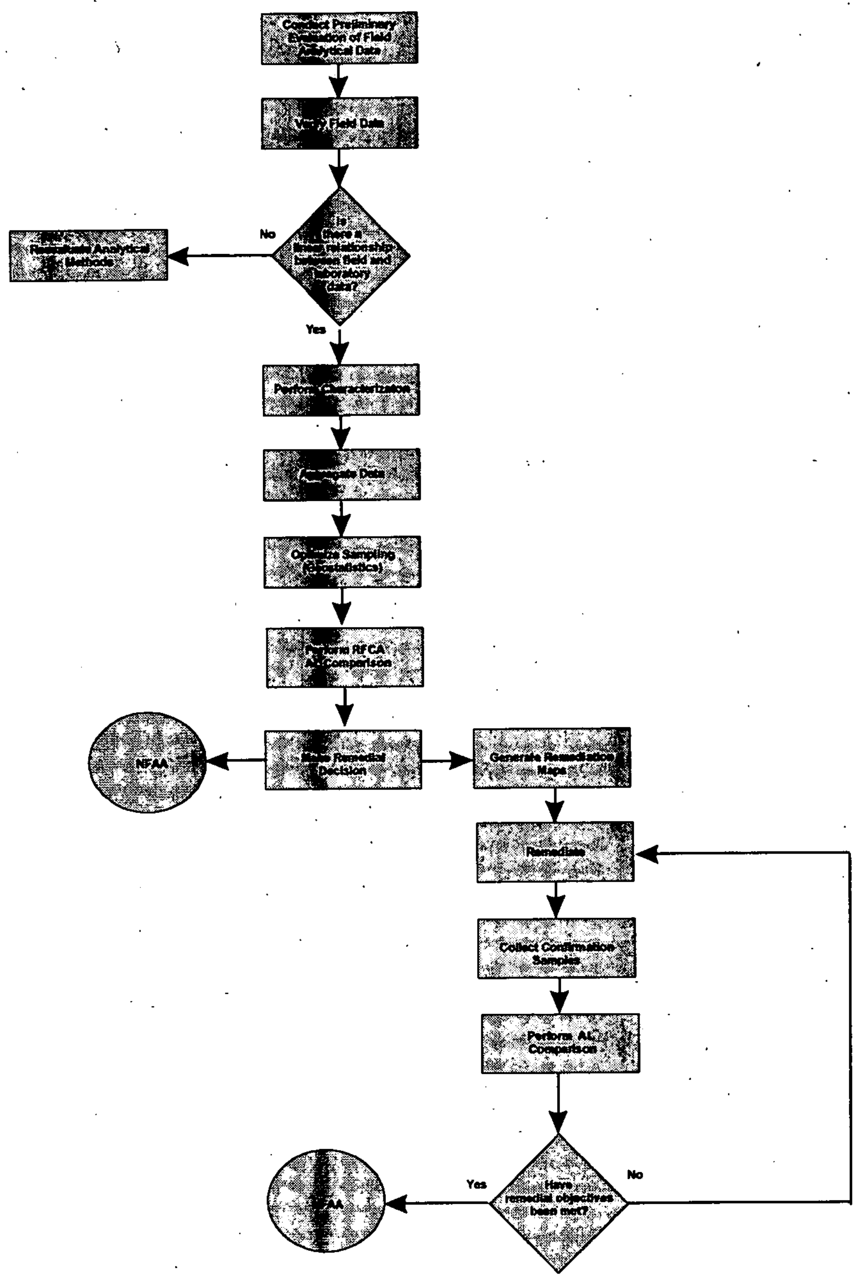
Figure 33
Data Evaluation Flow Chart



5.1.1 Data Aggregation

Data aggregation will be based on media type (for example, surface or subsurface soil), AOC, and purpose of evaluation (for example, characterization, confirmation, or CRA). To perform a valid statistical evaluation, data must meet the criteria that all observations are independent but comparable (that is, collected and analyzed using similar methods). Furthermore, data from various soil horizons need to be aggregated by subgroups before conducting statistical comparisons. These aggregated subgroups must represent a single population characterized by a fixed population mean and variance. Table 8 summarizes the data aggregation and appropriate subdivisions of each group.

Table 8
Data Aggregation Framework

Soil Horizon	Depth Interval (ft)[1]	Subgroups		
		Characterization[2]	Confirmation (Excavation Remedy)	CRA
Surface Soil	0.0 to 0.5	AOC		
	0.5 to 2.5	AOC		
	2.5 to 4.5	AOC		
Subsurface Soil	4.5 to 6.5	AOC	Floor and Sidewalls	Exposure Unit
	6.5 to 8.5	AOC		
	8.5 to Bedrock	AOC		

[1] Actual depth intervals will be based on the depth to bedrock contact or depth to water.
[2] The AOC is initially based on IHSS, PAC, and UBC Site boundaries as defined by the project team.

The first step in the data evaluation process is to group the data by soil horizons. For example, surface soil samples collected from 0 to 6 inches bgs will be grouped as a single soil horizon, and subsurface soil samples from 6 to 30 and 30 to 54 inches bgs will be grouped into second and third horizons, respectively, so that each depth interval is grouped as a unique sample population. Although different subsurface soil horizons may have similar geologic and physical properties, the aggregation of distinct soil horizons will conform to remediation excavation techniques.

Data aggregation for remediation confirmation will be based on samples collected within the excavated or remediated area. For excavations, samples from the floor and sidewalls of the excavation will be consolidated into a single subgroup.

5.1.2 Comparison of Data to RFCA ALs

Characterization results will be compared to RFCA ALs in accordance with IABZSAP DQOs using the following steps:

1. Results will be compared on a point-by-point basis to RFCA ALs.
2. The surface soil radionuclide SOR will be determined.
3. The surface soil nonradionuclide SOR will be determined.
4. If the point-by-point comparison indicates that a surface soil radionuclide analyte exceeds its RFCA AL or the radionuclide SOR exceeds 1, then the 95% UCL for that analyte will be calculated across the AOC.

5. If the point-by-point comparison indicates that a surface soil nonradionuclide analyte exceeds its RFCA AL or the nonradionuclide SOR exceeds 1, then the SOR will be calculated for carcinogenic and noncarcinogenic nonradionuclide analytes.
6. If the surface soil carcinogenic or noncarcinogenic nonradionuclide SOR exceeds 1, then the 95% UCL for that analyte will be calculated across the AOC.
7. If the 95% UCL divided by the RFCA AL exceedance is greater than 1 in surface soil, the EMC (Section 5.2, hot spot analysis) may be used to determine whether a hot spot is present.
8. Subsurface soil will be evaluated using the SSRS.

5.1.3 Confirmation Samples

The characterization team will evaluate confirmation sampling measurements to determine whether residual soil is clean with respect to remediation goals. Measurements of a given analyte that exceed remediation goals may require additional evaluation. Flexibility in the decision process includes statistically comparing means of populations to the corresponding ALs.

5.1.4 Spatial Evaluation - Geostatistics

In addition to defining optimal sampling locations for characterization purposes, the characterization team will also use geostatistical analysis to define areas with concentrations above RFCA ALs. The geostatistical approach incorporates probabilistic and risk-based outcomes relative to the AL thresholds and decision error rates. The geostatistical methodology is an unbiased geostatistical tool that will be used to optimize characterization and remediation within the IA. Specifically, geostatistical analysis will be used to:

- Optimize the number and locations of characterization samples;
- Develop maps of the areas with concentrations above RFCA ALs at a given level of probability;
- Optimize the number and locations of confirmation samples; and
- Link on-site analysis with sampling to allow near-real-time remedial decisions.

Geostatistical Procedures

Geostatistical analysis is a spatial correlation modeling approach that uses several evaluative steps. Descriptions and applications of the SmartSampling geostatistical technique are presented in reports published by SNL (1998), Rautman (1996), and McKenna (1997). The following steps describe the ordered process of the geostatistical approach:

1. Exploratory Analysis - The first step in the geostatistical evaluation is to determine the distribution of the data set by evaluating descriptive statistics and plotting the data on a histogram. Data found to depart from the normal distribution function should be normalized prior to performing the geostatistical evaluation.

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2. Structural Analysis - Variograms (Myers 1997), which describe the geostatistical spatial correlation between samples, are generated. This procedure defines the spatial variance between data points. Three important parameters defined by the variogram include (1) the range (distance at which samples are spatially correlated), (2) sill (similar to the variance of the data set), and (3) nugget effect (departure from the origin, which indicates microscale sampling variability or imprecision of the data set).
3. Kriging - The spatial correlation model derived from the variogram analysis is used in the kriging simulation. Kriging is the process of simulating predicted values in unsampled areas by calculating a weighted least-squares mean of the surrounding data points. The weighted values account for not only the distance between known observations and points of predicted values, but also the correlation of clustered observations. For example, clustered data may provide redundancy and are weighted less than a single observation at an equal distance in a different direction. The kriging simulations are processed to produce maps defining the spatial distribution of the contaminants and uncertainty in the spatial distribution.
4. Probability Kriging - Probability maps that describe the likelihood a contaminant value at any unsampled location exceeds the AL are generated. Probability kriging is based on multiple simulations of the contaminant concentration. The outcome of each simulation reflects the actual observations within the area. The multiple simulations of the concentrations provide the basis for determining the relative uncertainty so that the probability of exceeding a specified threshold value (for example, RFCA ALs) at any point within the area can be estimated. The simulations are processed to produce maps defining the spatial distribution of the contaminants and the inherent uncertainty in spatial distribution.
5. Probability Calculation - The probabilities are calculated from the estimated value for each realization and a cumulative distribution function at each point of estimation is developed. For example, assume 100 realizations are performed for the area of interest. If the threshold value is 10 pCi/g and 20 of the 100 realizations exceed the threshold value at a given point, the probability of exceedance is 20 percent at that point.
6. Uncertainty Mapping - A map with optimal locations for additional sampling is developed. These locations are optimized to produce the greatest decrease in the spatial uncertainty of the contaminant distribution with respect to ALs. That is, areas with the greatest uncertainty of exceeding the ALs are identified and targeted for additional sampling and analysis.
7. Sample Optimization - Data are collected and added to the geostatistical program.
8. Steps 2 through 5 are repeated as necessary.
9. Excavation Mapping - Excavation maps are developed from the probability kriging. These maps are based on the probability of exceeding a specified AL as described in Step 4. An excavation map requires that an acceptable reliability of remediation is determined. This is similar to the process of specifying an acceptable level of false positive errors in the traditional DQO procedure. For example, if the Type I error rate

is specified at 10 percent, then all remediation units exceeding 10 percent would be targeted for remediation.

5.2 Elevated Measurement Comparison

The EMC (MYAPC 1999) comparison, illustrated on Figure 34, includes an equation that depends on several variables: AL, measured value, size of the hot spot, and size of the AOC. The EMC is consistent with MARSSIM (EPA 1997A), and is applicable to all sample results or hot spots with concentrations above RFCA ALs. In AOCs where all sample results are less than ALs, the EMC is not required. The EMC for nonradionuclides is shown in Equation 5-1. If the EMC is greater than or equal to 1, action is indicated.

(Equation 5-1)

$$If: \sum_{i=1}^{n}\left[\frac{95\%UCL_{AOC}}{AL}\right]_i + \sum_{j=1}^{n}\left[\frac{\left(SampleResult_{hs} - 95\%UCL_{AOC}\right)}{\left(\frac{AL * Area_{AOC}}{Area_{hs}}\right)}\right]_j \geq 1, \text{ Then : Action is Indicated}$$

Where:

$(95\%UCL)_{AOC}$	=	95% UCL of the mean concentration in the AOC
AL	=	RFCA soil AL
$(Sample\ Result)_{hs}$	=	hot spot sample result
$(Area)_{AOC}$	=	area of the AOC
$(Area)_{hs}$	=	hot spot area (based on the area surrounding the elevated sample result)
i	=	number of COCs
j	=	number of hot spots for a particular COC

The first term "i" of Equation 5-1 will be applied to each COC separately. This term will be used for all observations less than RFCA ALs within the AOC. As shown in Equation 5-1, the first term is defined as the ratio of the 95% UCL of the mean to the RFCA AL for the AOC. Observations greater than the ALs will be excluded from the 95% UCL calculations, because this type of censorship will ensure the data set complies with normality assumptions required for calculating the 95% UCL.

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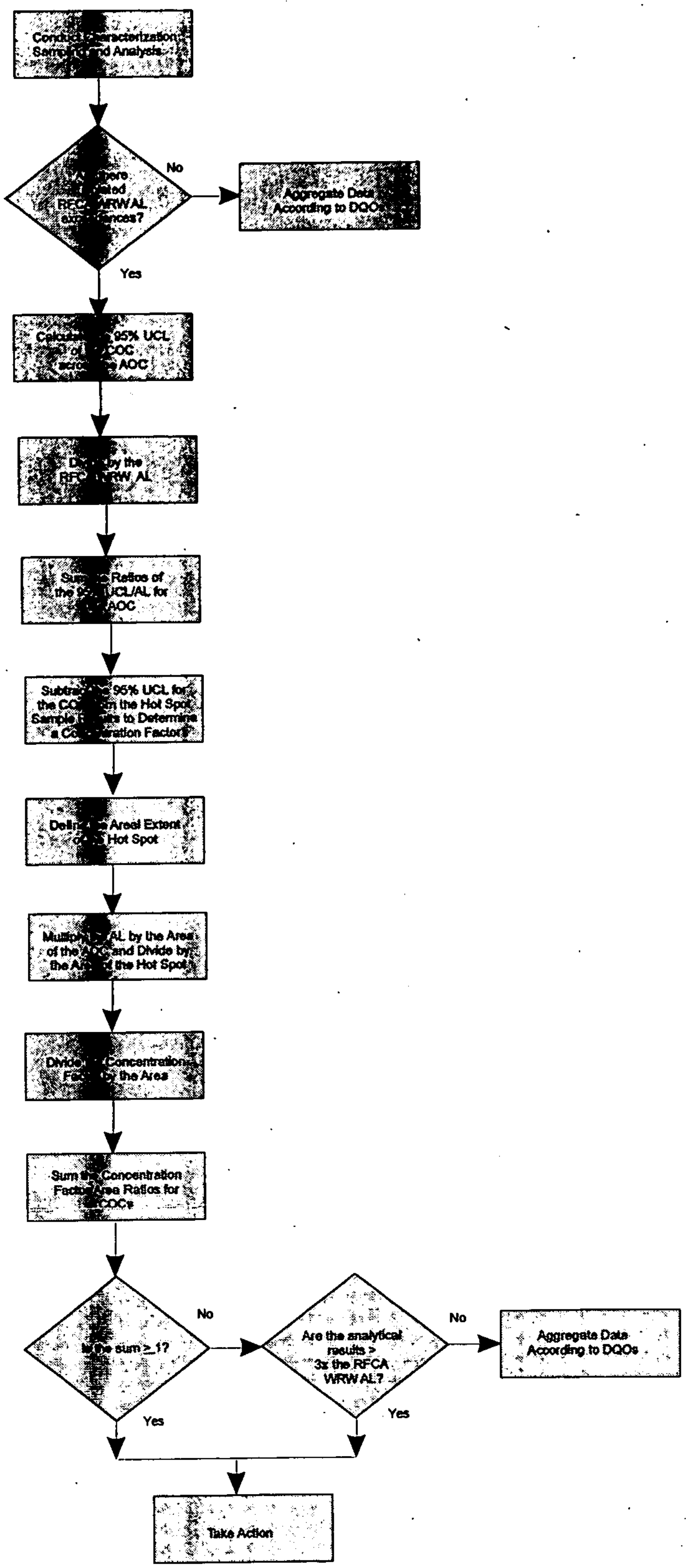
Figure 34
Elevated Measurement Flow Chart



The second term "j" of Equation 5-1 will be applied to each sample result that exceeds the RFCA AL separately, so that these results can be evaluated as a function of the hot spot size relative to the AOC and magnitude of the AL. Because human health risks are based on an individual's exposure across an area, the incremental risk due to a small, elevated COC sample result (hot spot) needs to be determined. The second term of Equation 5-1 is defined as the difference between the 95% UCL of the mean concentration and the sample result divided by the RFCA AL for a given COC. The AL is area-weighted, which is appropriate because exposure to contamination is random across an area.

For radionuclides, an area factor consistent with MARSSIM (EPA 1997A) guidance is applied to the AL as shown in Equation 5-2. Radionuclide-specific area factors are based on exposure pathway models, which can be estimated from Residual Radioactivity Computer Code (RESRAD) simulations.

(Equation 5-2)

$$If: \sum_{i=1}^{n}\left[\frac{95\%UCL_{AOC}}{AL}\right]_i + \sum_{j=1}^{n}\left[\frac{(SampleResult_{hs} - 95\%UCL_{AOC})}{(AL * AF)}\right]_j \geq 1, Then: action\ is\ indicated$$

Where:

$(95\%UCL)_{AOC}$	=	95% UCL of the mean concentration in the AOC
AL	=	RFCA soil AL
$(Sample\ Result)_{hs}$	=	hot spot sample result
AF	=	area factor (for radionuclides)
i	=	number of COCs
j	=	number of hot spots for a particular COC

The product of Equations 5-1 and 5-2 is the summation of EMCs for all COCs and each hot spot within a given AOC. Results of the equation greater than 1 indicate action may be necessary and results less than 1 indicate action is not necessary. Because the EMC includes an area-weighting component, results for very small hot spots may indicate action is not necessary for very high contaminant concentrations. To reduce this effect, when the concentration of the contaminant at a hot spot is three times the RFCA AL, action is indicated. If the hot spot is remediated, the confirmation sample values will be used in the equation. Using a value of three times the AL as an upper limit for re-evaluation is consistent with RESRAD's release criteria. The "three times the AL" concept will not apply to ALs that are based on acute toxicity. An example data set (Appendix H) shows how the EMC is applied.

5.3 Verification of Field Analytical Data

Data generated from field instrumentation will be correlated with analytical laboratory data. The following techniques will verify the accuracy of field analytical data:

- Evaluation of linear regression based on data developed during the 903 Pad characterization for HPGe correlation (Appendix I);

- Initial verification study to compare new field analytical instruments to laboratory analytical data;

- Ongoing verification sampling of field analytical results at a rate of 5 to 10 percent (that is, 5 to 10 laboratory analytical samples for every 100 field analytical samples); and

- Confirmation sampling.

5.3.1 Linear Regression Analysis

The QA staff will evaluate the accuracy of HPGe and other field instrument methods, not only through standard, periodic QC specifications (such as daily source checks and annual full-scale calibrations), but also by regressing field measurements against associated laboratory measurements. Regression analysis provides a means of "normalizing," or standardizing, field measurements to laboratory measurements. The general linear model that relates a response to a set of indefinite variables will be used.

Successful regression analyses of HPGe data have been performed at RFETS and other DOE sites (DOE 2000b). Regression analysis has also been successfully used in the quantification of metals (Sackett and Martin 1998), and is recommended by EPA to correct for low biases inherent in the field methods.

Optimization of sample homogeneity is a key factor in producing usable field/laboratory correlations (Sackett and Martin 1998), where relatively large and variable grain sizes are thought to cause a low bias (in field methods). Samples will be homogenized and sieved, and each sample will be split for field and laboratory analysis.

A general linear model (Equation 5-3) that relates a response to a set of indefinite variables may be used as follows:

$$y = B_0 + B_1x_1 + B_2x_2 + ...B_kx_k + E \qquad \text{(Equation 5-3)}$$

Where:

$x_1, x_2 ... x_k$	=	independent variables
$B_1, B_2 ... B_k$	=	unknown parameters
E	=	random error term

Consistent with calibration curves constructed for laboratory analytical methodologies (EPA SW-846), where full-range curves are constituted by four (for example, metals, SW-6010) to five (for example, VOCs, SW-8260) sequentially increasing values, regression analyses will be initiated with a minimum of five values through the measurement range of interest. Additional values will be added to the curves as the project progresses.

Based on previous experience and related publications (Sackett and Martin 1998), a linear relationship is expected between field and laboratory results. Acceptability of a linear regression will be based on a correlation coefficient (R2) of greater than 0.90, and use of an Analysis of Variance (ANOVA) and corresponding F Test to determine both "goodness-of-fit" and appropriateness of the model. The regression will be rejected if the measurements are too variable or the model is incorrect. If a linear model is inappropriate, a curvilinear regression may be evaluated (including confidence intervals or limits), and if used, will be evaluated using an ANOVA to determine the significance of adding terms to the regression. Polynomial expansion beyond a quadratic is not anticipated for correlating field results with laboratory results.

5.3.2 Initial Verification Study

An initial verification study will be conducted to confirm the accuracy of field analytical equipment. Soil samples will be collocated with field analytical readings and sent to an off-site analytical laboratory for analysis.

The underlying assumption for the verification study is that a linear relationship exists between the laboratory analytical data and field analytical data. The field analytical data may be standardized using the following equation (Gilbert 1987):

$$\bar{x}_{lr} = \bar{x}_A + b(\bar{x}_{n'} - \bar{x}_F) \qquad \text{(Equation 5-4)}$$

Where:

$\bar{x}_{lr}$ = standardized estimate of μ
$\bar{x}_A$ = mean of the n laboratory measurements
b = slope of the estimated linear regression
$\bar{x}_{n'}$ = mean of the n' field measurements
$\bar{x}_F$ = mean of the n field measurements

5.3.3 Ongoing Verification

As stated previously, accuracy of several field methods will be evaluated, not only through standard, periodic QC specifications (such as daily source checks and annual full-scale calibrations), but also by regressing field measurements against associated laboratory measurements. Regression analysis provides a means of normalizing, or standardizing, field measurements to laboratory measurements.

Verification of field analytical methods will continue throughout IA and BZ characterization and remediation activities. The frequency of split samples for the ongoing field analytical equipment verification sampling will be based on the following:

- Initial verification study;
- Results of previous verification; and
- Field duplicate frequency (5 to 10 percent), as discussed in Section 5.3.4.

5.3.4 Confirmation Sampling

Environmental projects may use a variety of QC samples, depending on the needs and goals of the project. The QC samples could include blanks (for example, preparation blanks and trip blanks), duplicates, splits, blind performance evaluation (PE) samples, and so forth. Typically, each type of QC sample has only one use; for example, field duplicates are used to evaluate sampling precision. The QC samples required for the IA and BZ sampling and analysis efforts are presented in Appendix G.

To increase the efficiency and reliability of the project, one type of QC sample, the duplicate, will serve several purposes:

- To evaluate sampling precision (its typical use);
- To confirm that methods are sufficiently comparable with laboratory methods; and
- As "confirmation samples," to confirm the results in the AOC.

This approach will eliminate the time and cost of performing a separate phase of verification sampling and will be performed in parallel with field sampling and analysis. This approach will be implemented by sending a duplicate sample, after it is analyzed for its first purpose, to the laboratory for verification analysis. The duplicate sample, initially used for field precision purposes, effectively becomes a replicate when used for verification purposes. Acceptable verification will be determined through use of a percent difference value; specifically, this is the laboratory value compared with the normalized field value (that is, field value based on the regression analysis).

In certain cases where field analytical methods (or on-site laboratories) do not provide adequate quality, such as unacceptable detection limits or field/laboratory correlations, verification sampling must be more aggressive than described above. More rigor could include the original grid spacing and number of samples used for characterization purposes, which considers hot spot size and contaminant boundaries. The term "verification sample," in the context of the IABZSAP, is reserved for those specific samples whose sole purpose is to confirm (or contradict) results of samples already collected. Because of this narrow purpose, the number of samples needed is much less than the previous number of samples required to characterize the site of interest. If an aggressive design for verification sampling is required, it indicates that characterization sampling (and field analysis), relative to a specific COC and applicable ALs, was inadequate for cleanup decisions.

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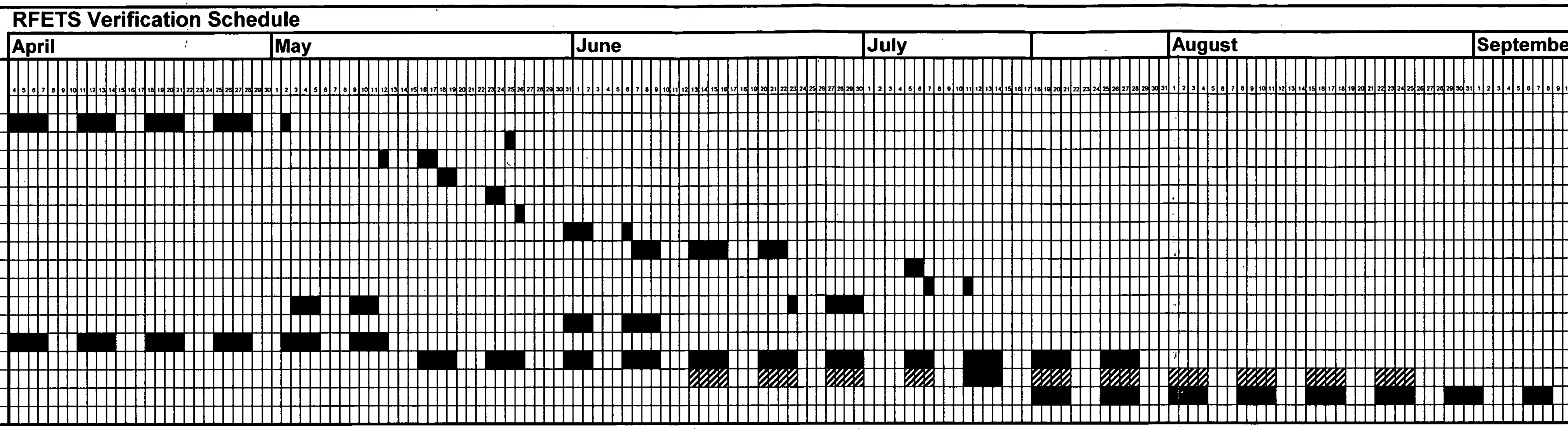
APPENDIX C
RFETS Verification Schedule

RFETS Verification Schedule

	No.	Duration (days)
Localized Scanning		
903 Pad Area	84	17
Ash Pits	6	1
East Trenches	13	3
B 991	9	2
B-Ponds	11	2
B 123	4	1
800 Area	19	4
700 Area	51	10
400 Area	10	2
300 Area	9	2
Follow-on Areas	55	11
Wide-Area Scanning	1	8
Verification Sampling	110	24
Data V&V & Eval [1]		42
WA Scanning Rpt [2]		43
Verification Report [3]		31



1 Data Verification, Validation, and Evaluation will begin immediately after data is avaliable and will continue as needed until all data is received. This is not full time, but must be done when data is available to facilitate quick action if necessary.
2 The Wide-Area Scanning Report will be provided by Bechtel Nevada. Details of the schedule are provided in Appendix C. The cross-hatched areas represent scheduled activities outside Kaiser-Hill control.
3 The Verification Report will begin immediately after sampling results and target-scanning results are available, and the draft Wide-Area Scanning Report is received from Bechtel Nevada, but cannot be finalized until after the final report is received from Bechtel Nevada.

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