

APPENDIX D

Accelerated Action Ecological Screening Evaluation

ACRONYMS

AA	accelerated action
CDPHE	Colorado Department of Public Health and Environment
CRA	comprehensive risk assessment
DOE	Department of Energy
EAASP	ecological accelerated action screening procedure
ECOPC	ecological contaminants of potential concern
EPA	U.S. Environmental Protection Agency
ESL	ecological screening level
EU	exposure unit
LOAEL	lowest observable adverse effect level
NOAEL	no observable adverse effect level
PMJM	Preble's Meadow Jumping Mouse
tESL	threshold ecological screening level
UCL	upper confidence limit
USFWS	U.S. Fish and Wildlife Service

Ecological Accelerated Action Screening Procedure

Goal of the Ecological Accelerated Action Screening Procedure (EAASP): To identify areas of the site that may require accelerated actions to reduce risks to ecological receptors.

The Ecological Accelerated Action Screening Process was developed by Kaiser-Hill and the Department of Energy (DOE) in consultation with the U.S. Environmental Protection Agency (EPA), the Colorado Department of Public Health and the Environment (CDPHE), and the U.S. Fish and Wildlife Service (USFWS) to identify areas that may require accelerated actions (AAs) to reduce risks to ecological receptors. The process, based on the ecological risk assessment methodology that is documented in full in the Comprehensive Risk Assessment (CRA) Work Plan and Methodology (DOE 2004), is executed as described in the following outline, using all available Site data.

I. Identification of ecological contaminants of potential concern (ECOPCs) for the EAASP:

- a. Initial screening is identical to the CRA ECOPC identification process.
 - i. For small home range receptors other than the Preble's Meadow Jumping Mouse (PMJM)¹:
 1. Compare maximum detected concentrations in each exposure unit (EU) to no observable adverse effect level (NOAEL) ecological screening levels (ESLs).
 2. If the maximum is above the ESL, then aggregate the data and compare the 95th upper confidence limit (UCL) of the 90th percentile of the ECOPC across the EU to the threshold ESLs (tESL) if available. If the tESL is not available, the NOAEL ESLs will be used in the screening.
 - ii: For large home range receptors²:
 1. Compare maximum detected concentrations in each EU and Site wide to NOAEL ESLs.
 2. If the maximum is above the ESL, then aggregate the data, both Site wide and within each EU, and compare the 95th UCL of the mean of the ECOPC to the tESL (where available) or the NOAEL ESL.
 - iii: For PMJM receptors:
 1. Maximum detected concentrations in each EU that fall within the proposed PMJM habitat will be compared to NOAEL ESLs.
- b. Chemicals identified as ECOPCs will be discussed in an AA Risk Characterization.

II. AA Risk Characterization:

¹ Receptors include the deer mouse, black tailed prairie dog, kestrel, and morning dove.

² Receptors include the coyote and the mule deer.

- a. The AA risk characterization will be conducted in a manner that is directly comparable to the CRA Risk Characterization³, using the most up-to-date database available. The following steps will be taken for all receptors.
 - i. The AA risk characterization will address only current conditions, using all available Site-wide data.
 - ii. Risk calculations will be forward-based dose calculations with comparisons to NOAEL and threshold toxicity reference values.
 - iii. The AA risk characterization will present a range of potential risks from ECOPCs that have concentrations above the ESL values, using a variety of applicable and defensible exposure modifying factors.
 1. Tiered geospatial statistical approach;
 2. Bioavailability;
 3. Site-specific tissue concentrations (where applicable);
 4. Diet variability; and
 5. Other applicable exposure modifying factors.
- b. Non-PMJM receptor-specific:
 - i. Evaluate using a range of lowest observable adverse effect level (LOAEL) TRVs.
 - ii. Present predictions of potential EU and Site wide risk for current conditions.
- c. PMJM-specific evaluations:
 - i. Evaluated on a location by location basis and using the tiered geospatial approach by habitat patch.
 - ii. Present predictions potential risk to the PMJM under current conditions.

III. AA consultative process:

- a. The results of the AA ECOPC identifications and risk characterization will be provided to the regulatory agencies for review and comment.
- b. Cooperative discussions will be held to identify areas of the site that may require AAs.
- c. Decisions will be documented in a Contact Record.
- d. If an AA is deemed necessary, the action will be taken and documented under an appropriate decision document and the results of the confirmation sampling will be included in the CRA
- e. If no AA is deemed necessary and no further samples are collected, the results of the AA risk characterization will be documented in the CRA.

IV. The CRA will present residual risk estimates for all areas of the Site.

³ DOE, 2004, Comprehensive Risk Assessment Work Plan and Methodology

- a. All areas with no ecologically-based AAs.
- b. All areas that have had ecologically-based AAs

APPENDIX E

**Potential Contaminants of Concern, Contaminants of Concern, Method
Detection Limits, and Reporting Limits**

TABLE OF CONTENTS

1.0 ANALYTICAL METHODS1
2.0 CONTAMINANTS DISQUALIFIED FROM FURTHER CONSIDERATION....7
 2.1 Detection Limit/Background Comparison7
 2.2 Comparison with RFCA Action Levels13
3.0 REFERENCES15

LIST OF TABLES

Table E1 Analytical Procedures..... 2
Table E2 Method Detection Limits for Metals in Soil 3
Table E3 Method Detection Limits for Volatile Organic Compounds in Soil 4
Table E4 Method Detection Limits for Semivolatile Organic Compounds in Soil 5
Table E5 Method Detection Limits for Pesticides in Soil 6
Table E6 Method Detection Limits for PCBs in Soil 6
Table E7 Minimum Detectable Limits for Radionuclides in Soil 7
Table E8 Method Detection Limits for Other Methods and Analytes in Soil 7
Table E9 Reporting Limits for Metals in Soil 9
Table E10 Reporting Limits for Volatile Organic Compounds in Soil 10
Table E11 Reporting Limits for Semivolatile Organic Compounds in Soil 11
Table E12 Reporting Limits for Pesticides in Soil 12
Table E13 Reporting Limits for PCBs in Soil 12
Table E14 Reporting Limits for Radionuclides in Soil 12
Table E15 Reporting Limits for Other Analytes in Soil 13
Table E16 Disqualified Analytes 13

ACRONYMS

AL	action level
ALF	Action Levels and Standards Framework for Surface Water, Ground Water, and Soils
ASTM	American Society for Testing and Materials
BZ	Buffer Zone
CAS No.	Chemical Abstract Society Number
COC	contaminant of concern
EPA	U.S. Environmental Protection Agency
IA	Industrial Area
IABZSAP	Industrial Area and Buffer Zone Sampling and Analysis Plan
IHSS	Individual Hazardous Substance Site
MDL	method detection limit
mg/kg	milligrams per kilogram
µg/kg	microgram per kilogram
mm	millimeter
MS	matrix spike
NA	not applicable
NV	no value
PAC	potential area of concern
PCB	polychlorinated biphenyl
pCi/g	picocuries per gram
PCOC	potential contaminant of concern
QC	quality control
RFCA	Rocky Flats Cleanup Agreement
RFETS	Rocky Flats Environmental Technology Site
RL	reporting limit
s	standard deviation
S ²	variance
SAP	Sampling and Analysis Plan
SVOC	semivolatile organic compound
TIC	tentatively identified compound
TCA	trichloroethane
U	undetected
UBC	under building contamination
UWQ4	usable with qualification, result no longer representative, source area remediated
UWQ5	usable with qualification, QC data; do not use for statistics or contaminant characterization
VOC	volatile organic compound
WRW	Wildlife Refuge Worker
XRF	x-ray fluorescence

1.0 ANALYTICAL METHODS

Analytical methods, method detection limits (MDLs), and contaminants of concern (COCs) for the Industrial Area (IA) and Buffer Zone (BZ) Sampling and Analysis Plan (SAP) (IABZSAP) are shown in Tables E1 through E15. The tables present the minimum number of required analytes within each respective suite, as well as the required sensitivity for each analyte. Sensitivities are expressed as MDLs, and are specific to the measurement systems used for samples. A comparison of the MDLs to the Rocky Flats Cleanup Agreement (RFCA) action levels (ALs) is also provided.

Actual upper and lower control limits will be evaluated on a laboratory-by-laboratory basis. All MDLs will be less than or equal to RFCA ALs, where possible. The MDLs listed in the following tables represent values generally attainable by commercial laboratories and field mobile laboratories. The laboratory MDLs will be established using the following three steps:

1. Seven Replicates

Prepare (extract, digest, and so forth) and analyze seven samples of a matrix spike (MS) (American Society for Testing and Materials [ASTM] Type II water for aqueous methods, Ottawa sand for soil methods, and glass beads of 1-millimeter [mm] diameter or smaller for metals) containing the analyte of interest at a concentration three to five times the estimated MDL.

2. Variance and Standard Deviation

Determine the variance (S^2) for each analyte as follows:

$$S^2 = \frac{1}{n-1} \left[\sum_{i=1}^n (x_i - \bar{x})^2 \right]$$

where x_i = the i th measurement of the variable x , and \bar{x} = the average value of x .

Determine \bar{X} as follows:

$$\bar{X} = \frac{1}{n} \sum_{i=1}^n x_i$$

Determine the standard deviation (s) for each analyte as follows:

$$s = (S^2)^{1/2}$$

3. MDL

Determine the MDL for each analyte as follows:

$$MDL = 3.14(s)$$

(Note: 3.14 is the one-sided t-statistic at the 99 percent confidence level appropriate for determining the MDL using seven samples.)

There are no MDLs greater than the existing RFCA Wildlife Refuge Worker (WRW) ALs.

Table E1 presents the analytical procedures for the IABZSAP. Tables E2 through E8 present the MDLs for various analytes.

**Table E1
Analytical Procedures**

Analytical Method	Parameter	Preparatory Methods
SW8081A	Organochlorine pesticides (water and soil)	3510C, 3520C, 3540C, 3541, 3545, 3550B
SW8082	Polychlorinated biphenyls (PCBs) (water and soil)	3510C, 3520C, 3540C, 3541
SW8260B	Volatile organic compounds (VOCs) (water and soil)	3585, 5021, 5030B, 5031, 5032, 5035
SW8270C	Semivolatile organic compounds (SVOCs) (water and soil)	3510C, 3520C, 3540C, 3541, 3545, 3550B
SW6010B SW6200 – XRF	Trace metals by ICP-MS (water and soil)	3005A, 3010A, 3015, 3050B, 3051, NA
SW7471A	Mercury (soil)	1311
SW9010B	Cyanide	9010B
SW9056	Common anions	NA
SM4500	Common anions	SM4500
Kaiser-Hill Module RC01 (alpha spec); Gamma Spectroscopy RC03-A.1 ^a In situ ^b	Radionuclides (RFCA standard suite of five isotopes)	NA

^a Containerized samples for field-laboratory analysis

^b In situ measurements; see Appendix G for measurement specifications

NA not applicable

Table E2
Method Detection Limits for Metals in Soil

Analyte	Offsite Laboratory RL (mg/kg)	RFCA WRW AL (mg/kg)
Aluminum	3.E+00	2.28E+05
Antimony	4E+0	4.09E+02
Arsenic	6E+01	2.22E+01
Barium	2.E+01	2.64E+04
Beryllium	2.E-01	9.21E+02
Cadmium	1.E-01	9.62E+02
Chromium III	5.E-01	> 1E+06
Chromium VI	≥2E+00	2.68E+02
Cobalt	1.E+01	1.55E+03
Copper	6.E-01	4.09E+04
Iron	1.E+0	3.07E+05
Lead	4.E-01	1.00E+03
Lithium	2.E+01	2.04E+04
Manganese	3.E+00	3.48E+03
Mercury	2.E-01	2.52E+04
Molybdenum	8E+00	5.11E+03
Nickel	5.E+00	2.04E+04
Selenium	3.E+00	5.11E+03
Silver	7E+00	5.11E+03
Strontium	4.E+01	6.13E+05
Tin	4.E+02	6.13E+05
Uranium (Total)	4.E+02	2.75E+03
Vanadium	8.E+00	7.15E+03
Zinc	4.E+00	3.07E+05

378

Table E3
Method Detection Limits for Volatile Organic Compounds in Soil

Analyte	Offsite Laboratory RL (mg/kg)	RFCA WRWAL (µg/kg)
1,1,1-Trichloroethane	5E+00	7.97E+07
1,1,2,2-Tetrachloroethane	5E+00	1.00E+05
1,1,2-Trichloroethane	5E+00	2.36E+05
1,1-Dichloroethane	5E+00	2.25E+07
1,1-Dichloroethene	5E+00	1.70E+04
1,2-Dichloroethane	5E+00	1.06E+05
1,2-Dichlorobenzene	2E-03	3.12E+07
1,2-Dichloropropane	5E+00	3.45E+05
1,4-Dichlorobenzene	6.60E+02	8.40E+05
2-Butanone	1.0E+02	1.92E+08
Acetone	1.0E+02	1.02E+08
Benzene	5E+00	2.05E+05
Bromodichloromethane	5E+00	6.17E+05
Bromoform	5E+00	3.73E+06
Bromomethane	5E+00	1.93E+05
Carbon disulfide	5E+00	1.51E+07
Carbon tetrachloride	5E+00	8.15E+04
Chlorobenzene	5E+00	6.09E+06
Chloroethane	5E+00	1.32E+07
Chloroform	5E+00	1.92E+04
Chloromethane	5E+00	3.71E+05
Cis-1,3-Dichloropropene	5E+00	6.57E+03
Dibromochloromethane	5E+00	3.29E+05
Ethylbenzene	5E+00	4.25E+06
Methylene chloride	5E+00	2.53E+06
4-Methyl-2-pentanone	2E+01	1.64E+07
Styrene	5E+00	1.23E+08
Trichloroethene	5E+00	1.96E+04
Tetrachloroethene	5E+00	6.15E+05
Toluene	5E+00	3.13E+07
Vinyl acetate	1E+01	9.63E+08
Vinyl chloride	5E+00	4.12E+04
Xylenes (total)	5E+00	2.04E+06

Table E4
Method Detection Limits for Semivolatile Organic Compounds in Soil

Analyte	Offsite Laboratory MDL (µg/kg)	RFGA WRW AL (µg/kg)
Acenaphthene	3.00E+01	4.08E+07
Anthracene	2.30E+01	2.04E+08
Benzo(a)anthracene	2.40E+01	3.49E+04
Benzo(a)pyrene	3.90E+01	3.49E+03
Benzo(b)fluoranthene	2.80E+01	3.49E+04
Benzo(k)fluoranthene	3.10E+01	3.49E+05
Benzoic acid	2.80E+02	> 1E+09
Benzyl alcohol	8.30E+01	3.07E+08
Butylbenzylphthalate	6.40E+01	1.47E+08
4-Chloroaniline	1.10E+02	2.95E+06
Bis(2-chloroethyl)ether	2.40E+01	3.48E+04
Bis(2-chloroisopropyl)ether	2.80E+01	5.47E+05
2-Chloronaphthalene	3.40E+01	8.18E+07
2-Chlorophenol	3.30E+01	5.11E+06
Chrysene	2.70E+01	3.49E+06
Dibenz(a,h)anthracene	2.40E+01	3.49E+03
Dibenzofuran	3.50E+01	2.95E+06
3,3'-Dichlorobenzidine	9.60E+01	6.13E+04
2,4-Dichlorophenol	5.20E+01	3.07E+06
Diethylphthalate	3.00E+01	5.90E+08
2,4-Dimethylphenol	3.60E+01	2.04E+07
Dimethyl phthalate	3.90E+01	> 1E+09
4,6-Dinitro-2-methylphenol	1.60E+02	1.02E+06
2,4-Dinitrophenol	3.70E+02	2.04E+06
2,4-Dinitrotoluene (DNT)	1.60E+02	5.63E+04
2,6-Dinitrotoluene (DNT)	1.60E+02	5.63E+04
Di-n-octylphthalate	5.20E+01	1.47E+07
Bis(2-ethylhexyl)phthalate	7.00E+01	1.97E+06
Fluoranthene	2.20E+01	2.72E+07
Fluorene	3.30E+01	4.08E+07
Hexachlorobenzene	3.50E+01	1.72E+04
Hexachlorobutadiene	4.60E+01	1.47E+05
Hexachlorocyclopentadiene	1.20E+02	3.50E+06
Hexachloroethane	4.30E+01	7.37E+05
Indeno(1,2,3-cd)pyrene	2.20E+01	3.49E+04
Isophorone	3.30E+01	2.91E+07
2-Methylnaphthalene	3.10E+01	2.04E+07
2-Methylphenol	4.00E+01	3.69E+07
4-Methylphenol	5.30E+01	3.69E+06
Naphthalene	3.10E+01	3.09E+06
2-Nitroaniline	3.30E+01	1.67E+07
Nitrobenzene	3.40E+01	3.32E+05
4-Nitrophenol	2.50E+02	8.18E+06
n-Nitrosodiphenylamine	2.70E+01	7.81E+06
n-Nitrosodi-n-propylamine	2.20E+01	5.47E+03
Pentachlorophenol	1.10E+02	1.62E+05
Phenol	3.40E+01	6.13E+08
Pyrene	1.30E+02	2.21E+07
1,2,4-Trichlorobenzene	2.50E+01	9.23E+06
2,4,5-Trichlorophenol	2.70E+01	1.02E+08
2,4,6-Trichlorophenol	3.90E+01	3.47E+06

380

Table E5
Method Detection Limits for Pesticides in Soil

Analyte	Offsite Laboratory MDL (µg/kg)	RFCA WRW AL (µg/kg)
Aldrin	2.7E-01	1.62E+03
α-BHC	2.5E-01	5.24E+03
β-BHC	2.7E-01	1.84E+04
γ-BHC (Lindane)	2.4E-01	2.55E+04
α-Chlordane	2.3E-01	9.44E+04
β-Chlordane	2.5E-01	9.44E+04
γ-Chlordane	5.3E-01	9.44E+04
4,4-DDD	3.5E-01	1.43E+05
4,4-DDE	4.4E-01	1.01E+05
4,4-DDT	4.8E-01	1.00E+05
Dieldrin	2.4E-01	1.72E+03
Endosulfan I	3.7E-01	4.42E+06
Endosulfan II	4.2E-01	4.42E+06
Endosulfan sulfate	4.0E-01	4.42E+06
Endrin	4.1E-01	2.21E+05
Heptachlor	3.1E-01	6.12E+03
Heptachlor epoxide	2.2E-01	3.03E+03
Methoxychlor	7.9E-01	5.11E+06
Toxaphene	1.0E+01	2.50E+04

Table E6
Method Detection Limits for PCBs in Soil

Analyte	Offsite Laboratory MDL (µg/kg)	RFCA WRW AL (µg/kg)
Aroclor-1016	1.90E+00	4.64E+04
Aroclor-1221	2.90E+00	1.24E+04
Aroclor-1232	3.60E+00	1.24E+04
Aroclor-1242	2.90E+00	1.24E+04
Aroclor-1248	1.10E+01	1.24E+04
Aroclor-1254	4.30E+00	1.24E+04
Aroclor-1260	5.90E+00	1.24E+04

381

Table E7
Minimum Detectable Limits for Radionuclides in Soil

Analyte	Onsite Gamma Spectrometer MDL (pCi/g)	Offsite Alpha Spectrometer MDL (pCi/g)	RFCA WRW-AL (pCi/g)
Americium-241	1.0	0.3	7.60E+01
Plutonium-239/240	8a	0.3	5.00E+01/ 1.16E+02
Uranium-233/234	Estimated	1.0	3.00E+02
Uranium-235	0.5	1.0	8.00E+00
Uranium-238	5.0b	1.0	3.51E+02

- a Plutonium-239/240 is estimated based on site-specific decay ratios between americium-241 and plutonium-239/240.
- b Uranium-238 is estimated based on equilibrium with thorium-234 and protactinium-234.

Table E8
Method Detection Limits for Other Methods and Analytes in Soil

Analyte	Method	Offsite Laboratory MDL (mg/kg)	RFCA WRW-AL (mg/kg)
Ammonium	SM4500	NV	>1E+09
Fluoride	SM4500	1E+00	6.13E+07
Nitrate	SW9056	5E-01	>1E+06
Nitrite	SW9056	5E-01	1.02E+05
Total cyanide	SW9010B	9.9E-02	2.04E+04

2.0 CONTAMINANTS DISQUALIFIED FROM FURTHER CONSIDERATION

The contaminants disqualified from further sampling and analysis in the IA and BZ are based on the (data) filter criteria listed below. All data related to these contaminants were passed through the "Data Quality Filter", as referenced in Section 3.1 of the IABZSAP.

The data comparisons described below were performed for two separate subsets of data, specifically the two matrix types of interest: surface soil and subsurface soil.

2.1 DETECTION LIMIT/BACKGROUND COMPARISON

Results are disqualified from further consideration based on the following Data Quality Filter criteria:

1. The analyte was not detected (specifically, the result was flagged with laboratory qualifier "U"), not remediated after detection ("UWQ4"), or was not a laboratory quality control (QC) sample ("UWQ5");
2. The analyte does not exceed published background values (Appendix F) plus two standard deviations;
3. The analyte exists as a tentatively identified compound (TIC) only;

382

4. The analyte was rejected through the formal data validation process (“R”);
5. The analyte did not have a published RFCA AL (RFCA Attachment 5) (DOE et al. 2003); or
6. For preaccelerated action data, Rocky Flats Environmental Technology Site (RFETS) Laboratory Contract GR04 Reporting Limits (RLs) will be used instead of MDLs because these data were collected over a period of 10 years under the requirements of several different types of contracts. Comparison to GR03 RLs will provide a consistent and conservative method for determining PCOCs. GR03 RLs are listed in Tables E9 through E15.

PCOCs will be re-evaluated on an Individual Hazardous Substance Site (IHSS), Potential Area of Concern (PAC), or Under Building Contamination (UBC) site basis during the IABZSAP Addendum development process to ensure that potential contaminants are not overlooked during sampling and analysis.

Disqualified analytes are listed in Table E16.

383

Table E9
Reporting Limits for Metals in Soil

Analyte	Offsite Laboratory MDL (mg/kg)	Onsite XRF MDL (mg/kg)	RFCA WRW AL (mg/kg)
Aluminum	4.5E+00	NV	2.28E+05
Antimony	2.6E-01	4E+00	4.09E+02
Arsenic	7.5E-01	4E+00	2.22E+01
Barium	3.4E-01	104E+00	2.64E+04
Beryllium	9.4E-02	NV	9.21E+02
Cadmium	6.0E-02	1E+00	9.62E+02
Chromium III	NV	NV	> 1E+06
Chromium VI	3.8E-02	9E+00	2.68E+02
Cobalt	1.7E-01	90E+00	1.55E+03
Copper	4.2E-02	6E+00	4.09E+04
Iron	1.3E+00	778E+00	3.07E+05
Lead	2.5E-01	0E+00	1.00E+03
Lithium	4.5E-01	NV	2.04E+04
Manganese	1.6E-01	20E+00	3.48E+03
Mercury	6.4E+00	1E+00	2.52E+04
Molybdenum	2.7E-01	50E+00	5.11E+03
Nickel	1.8E-01	7E+00	2.04E+04
Selenium	7.4E-01	2E+00	5.11E+03
Silver	7.2E-02	2E+00	5.11E+03
Strontium	5.4E-02	14E+00	6.13E+05
Tin	7.8E-01	3E+00	6.13E+05
Uranium (Total)	1.3E+00	NV	2.75E+03
Vanadium	4.3E-01	19E+00	7.15E+03
Zinc	4.2E-01	3E+00	3.07E+05

NV no value

384

Table E10
Reporting Limits for Volatile Organic Compounds in Soil

Analyte	Offsite Laboratory MDL (µg/kg)	Onsite Laboratory MDL (µg/kg)	RFCAL WRW AL (µg/kg)
Acetone	4.6E+00	2.22E+01	1.02E+08
Benzene	8.9E-01	8.20E-01	2.05E+05
Bromodichloromethane	9.2E-01	6.55E-01	6.17E+05
Bromoform	9.1E-01	1.06E+00	3.73E+06
Bromomethane	1.2E+00	1.53E+00	1.93E+05
2-Butanone	4.7E+00	9.55E+00	1.92E+08
Carbon disulfide	9.2E-01	2.64E+00	1.51E+07
Carbon tetrachloride	1.2E+00	1.12E+00	8.15E+04
Chlorobenzene	7.5E-01	9.44E-01	6.09E+06
Chloroethane	1.3E+00	3.72E+00	1.32E+07
Chloroform	9.0E-01	8.55E-01	1.92E+04
Chloromethane	1.5E+00	1.33E+00	3.71E+05
Dibromochloromethane	9.0E-01	9.55E-01	3.29E+05
1,2-Dichlorobenzene	1.1E+00	1.23E+00	3.12E+07
1,4-Dichlorobenzene	1.4E+00	1.06E+00	8.40E+05
1,1-Dichloroethane	9.8E-01	9.44E-01	2.25E+07
1,2-Dichloroethane	9.9E-01	1.08E+00	1.06E+05
1,1-Dichloroethene	1.1E+00	1.42E+00	1.70E+04
1,2-Dichloroethene (total)	1.5E+00	NV	9.02E+06
1,2-Dichloropropane	1.2E+00	8.70E-01	3.45E+05
Cis-1,3-Dichloropropene	9.6E-01	8.33E-01	6.57E+03
Trans-1,3-Dichloropropene	1.0E+00	9.34E-01	6.57E+03
Ethylbenzene	1.2E+00	8.25E-01	4.25E+06
Methylene chloride	8.0E-01	1.23E+00	2.53E+06
4-Methyl-2-pentanone	3.9E-01	6.47E+00	1.64E+07
Styrene	6.6E-01	9.97E-01	1.23E+08
1,1,2,2-Tetrachloroethane	1.1E+00	1.09E+00	1.00E+05
Tetrachloroethene	9.9E-01	1.30E+00	6.15E+05
Toluene	7.8E-01	1.25E+00	3.13E+07
1,1,1-Trichloroethane	9.8E-01	1.05E+00	7.97E+07
1,1,2-Trichloroethane	1.5E+00	8.89E-01	2.36E+05
Trichloroethene	8.7E-01	7.07E-01	1.96E+04
Vinyl acetate	2.4E+00	NV	9.63E+08
Vinyl chloride	1.1E+00	2.80E+00	4.12E+04
Xylenes (total)	2.8E+00	2.49E+00	2.04E+06

NV No value

385

Table E11
Reporting Limits for Semivolatile Organic Compounds in Soil

Analyte	Offsite Laboratory RL (µg/mg)	RFCA WRW AL (µg/mg)
1,2,4-Trichlorobenzene	6.60E+02	9.23E+06
1,2-Dichlorobenzene	6.60E+02	3.12E+07
1,4-Dichlorobenzene	6.60E+02	8.40E+05
2,4-Dinitrotoluene	6.60E+02	5.63E+04
2,6-Dinitrotoluene	6.60E+02	5.63E+04
2-Chloronaphthalene	6.60E+02	8.18E+07
2-Methylnaphthalene	6.60E+02	2.04E+07
2-Nitroaniline	3.30E+00	1.67E+07
3,3'-Dichlorobenzidine	1.30E+00	6.13E+04
4-Chloroaniline	1.30E+00	2.95E+06
Acenaphthene	6.60E+02	4.08E+07
Anthracene	6.60E+02	2.04E+08
Benzo(a)anthracene	6.60E+02	3.49E+04
Benzo(a)pyrene	6.60E+02	3.49E+03
Benzo(b)fluoranthene	6.60E+02	3.49E+04
Benzo(k)fluoranthene	6.60E+02	3.49E+05
Benzoic acid	3.30E+03	> 1E+09
Benzyl alcohol	1.30E+03	3.07E+08
Bis(2-chloroethyl)ether	6.60E+02	3.48E+04
Bis(2-chloroisopropyl)ether	6.60E+02	5.47E+05
Bis(2-ethylhexyl)phthalate	6.60E+02	1.97E+06
Butylbenzylphthalate	6.60E+02	1.47E+08
Chrysene	6.60E+02	3.49E+06
Di-n-octylphthalate	6.60E+02	1.47E+07
Dibenz(a,h)anthracene	6.60E+02	3.49E+03
Dibenzofuran	6.60E+02	2.95E+06
Diethylphthalate	6.60E+02	5.90E+08
Dimethylphthalate	6.60E+02	> 1E+09
Fluoranthene	6.60E+02	2.72E+07
Fluorene	6.60E+02	4.08E+07
Hexachlorobenzene	6.60E+02	1.72E+04
Hexachlorobutadiene	6.60E+02	1.47E+05
Hexachlorocyclopentadiene	6.60E+02	3.50E+06
Hexachloroethane	6.60E+02	7.37E+05
Indeno(1,2,3-cd)pyrene	6.60E+02	3.49E+04
Isophorone	6.60E+02	2.91E+07
n-Nitrosodiphenylamine	7.E+02	7.81E+06
n-Nitrosodi-n-propylamine	7.E+02	5.47E+03
Naphthalene	6.60E+02	3.09E+06
Nitrobenzene	7.E+02	3.32E+05
Pyrene	6.60E+02	2.21E+07
Isophorone	6.60E+02	2.91E+07
2,4,5-Trichlorophenol	6.60E+02	1.02E+08
2,4,6-Trichlorophenol	6.60E+02	3.47E+06
2,4-Dichlorophenol	6.60E+02	3.07E+06
2,4-Dimethylphenol	6.60E+02	2.04E+07
2,4-Dinitrophenol	3.30E+03	2.04E+06
2-Chlorophenol	6.60E+02	5.11E+06
2-Methylphenol	6.60E+02	3.69E+07
4,6-Dinitro-2-methylphenol	3.30E+03	1.02E+06
4-Methylphenol	6.60E+02	3.69E+06
4-Nitrophenol	3.30E+03	8.18E+06
Pentachlorophenol	3.30E+03	1.62E+05
Phenol	6.60E+02	6.13E+08

386

Table E12
Reporting Limits for Pesticides in Soil

Analyte	Offsite Laboratory RL (µg/kg)	RFCA WRW AL (µg/kg)
Aldrin	2.7E+01	1.62E+03
α-BHC	2.E+01	5.24E+03
β-BHC	4.E+01	1.84E+04
γ-BHC (Lindane)	6.E+01	2.55E+04
α-Chlordane	1E+03	9.44E+04
β-Chlordane	1E+03	9.44E+04
γ-Chlordane	1E+03	9.44E+04
4,4-DDD	7.5E+01	1.43E+05
4,4-DDE	2.7E+01	1.01E+05
4,4-DDT	8.E+01	1.00E+05
Dieldrin	1.4E+01	1.72E+03
Endosulfan I	1.4E+01	4.42E+06
Endosulfan II	2.7E+01	4.42E+06
Endosulfan sulfate	4.5E+02	4.42E+06
Endrin	4.E+01	2.21E+05
Heptachlor	2.E+01	6.12E+03
Heptachlor Epoxide	5.4E+01	3.03E+03
Methoxychlor	1.2E+03	5.11E+06
Toxaphene	1.7E+03	2.50E+04

Table E13
Reporting Limits for PCBs in Soil

Analyte	Offsite Laboratory RL (µg/kg)	RFCA WRW AL (µg/kg)
Aroclor-1016	3.50E+2	4.64E+04
Aroclor-1221	3.50E+2	1.24E+04
Aroclor-1232	3.50E+2	1.24E+04
Aroclor-1242	3.50E+2	1.24E+04
Aroclor-1248	3.50E+2	1.24E+04
Aroclor-1254	3.50E+2	1.24E+04
Aroclor-1260	3.50E+2	1.24E+04

Table E14
Reporting Limits for Radionuclides in Soil

Analyte	Offsite Laboratory RL (pCi/g)	RFCA WRW AL (pCi/g)
Americium-241	0.3	7.60E+01
Plutonium-239/240	0.3	5.00E+01/ 1.16E+02
Uranium-233/234	1.0	3.00E+02
Uranium-235	1.0	8.00E+00
Uranium-238	1.0	3.51E+02

387

Table E15
Reporting Limits for Other Analytes in Soil

Analyte	Offsite Laboratory RL (mg/kg)	RFCA WRW AL (mg/kg)
Nitrate	1.0	>1E+06
Nitrite	1.0	1.02E+05
Total Cyanide	0.25	2.04E+04

2.2 COMPARISON WITH RFCA ACTION LEVELS

If a RFCA AL is not published for the analyte of interest (RFCA Attachment 5), the analyte is disqualified from further consideration as a potential contaminant, consistent with the RFCA Action Levels and Standards Framework for Surface Water, Ground Water, and Soils (ALF) (DOE et al. 2003)

Those analytes exceeding detection limits, but without associated RFCA ALs, will be addressed on an IHSS-by-IHSS basis.

Table E16
Disqualified Analytes

Analyte	CAS No	Number of Samples Collected in the IA	Max RESULT (mg/kg or pCi/g)	Max DL
1,1,1,2-Tetrachloroethane	630-20-6	149	129	20
1,1,2-Trichlorotrifluoroethane	76-13-1	122	150000	11
1,1-Dichloropropene	563-58-6	149	88	20
1,2 Dichloroethane-D4	17060-07-0	620	121	10
1,2,3-Trichlorobenzene	87-61-6	149	135	20
1,2,3-Trichloropropane	96-18-4	149	154	20
1,2-Dibromoethane	106-93-4	149	144	20
1,2-Dichlorobenzene-D4	2199-69-1	35	128	0.5
1,2-Dichloroethene (total)	544-59-2	11	620	620
1,3-Dichlorobenzene	541-73-1	1465	38000	12000
1,3-Dichloropropane	142-28-9	149	146	20
2,2-Dichloropropane	594-20-7	149	86	20
2,2-Dichloropropionic Acid	75-99-0	4	100	200
2,4,5-Trichlorophenoxyacetic Acid	93-76-5	4	100	200
2,4,6-Tribromophenol	118-79-6	714	106	10
2,4-DB	94-82-6	4	100	200
2,4-Dichlorophenoxyacetic Acid, Salts and Esters	94-75-7	42	112	200
2-Chloroethyl (Vinyl Ether)	110-75-8	33	50	26
2-Fluorobiphenyl	321-60-8	702	131	10
2-Hexanone	591-78-6	2011	13000000	13000000
2-Nitrophenol	88-75-5	1269	38000	12000
3-Nitroaniline	99-09-2	1314	190000	31000
4-Chloro-3-Methylphenol	59-50-7	1323	38000	12000
4-Chlorophenyl (Phenyl Ether)	7005-72-3	1314	38000	12000
4-Isopropyltoluene	99-87-6	149	116	20
4-Nitroaniline	100-01-6	1314	190000	31000
Acenaphthylene	208-96-8	1315	38000	12000
Acetic Acid, Dichloro-	79-43-6	4	95	1
Alkalinity as CaCO3	10-09-3	1	513.9	10
Benzenamine	62-53-3	6	1800	1800
Benzene, 1,2,4-Trimethyl	95-63-6	149	129	20
Benzene, 1,3,5-Trimethyl-	108-67-8	149	124	20
Benzidine	92-87-5	28	1800	1800
Benzo(ghi)Perylene	191-24-2	1315	28000	12000

388

Industrial Area and Buffer Zone Sampling and Analysis Plan Modification 1 – Appendix E

Analyte	CAS No	Number of Samples Collected in the IA	MaxRESULT (mg/kg or pCi/g)	MaxDL
Bicarbonate as CaCO ₃	71-52-3	26	624	10
Bis(2-Chloroethoxy) Methane	111-91-1	1314	38000	12000
Bromobenzene	108-86-1	149	141	20
Bromochloromethane	74-97-5	149	88	20
Bromofluorobenzene	460-00-4	1126	161	10
Calcium	7440-70-2	2221	3490000	5000
Carbazole	86-74-8	336	12000	12000
Carbonate as CaCO ₃	3812-32-6	93	101	52.2
Cesium	7440-46-2	2099	5170	1900
Cesium-134	13967-70-9	498	1.119	3.09
Cesium-137	10045-97-3	626	10	29.4
Chemical Oxygen Demand	C-004	23	121.8	20
Chlordane	57-74-9	17	20	20
Chloride	16887-00-6	53	996	250
cis-1,2-Dichloroethene	156-59-2	162	630	630
Corrosivity for Liquid Waste	261.22-A-1	2	7.1	0.01
Curium-244	13981-15-2	42	0.4618	0.0671
delta-BHC	319-86-8	863	500	500
Dibromomethane	74-95-3	149	132	20
Di-Butylchloroethane	1770-80-5	282	510	16
Dicamba	1918-00-9	4	150	200
Dichlorodifluoromethane	75-71-8	149	104	20
Dichloroprop	120-36-5	4	107	200
Diesel Fuel	68334-30-5	20	194	25
Endrin	72-20-8	900	920	990
Endrin Aldehyde	7421-93-4	151	990	990
Endrin Ketone	53494-70-5	806	920	190
Fluoride	16984-48-8	55	119.9	2.5
Gamma-BHC [Lindane]	58-89-9	898	500	500
Gasoline	8006-61-9	27	560	100
Gross Alpha	10-78-6	2	320	14
Gross Alpha	12587-46-1	2372	6300	897
Gross Beta	12587-47-2	2376	6053	560
Isopropylbenzene	98-82-8	149	120	20
m,p-Xylene	000-00-0	20	28.813	6
m+pCresol	65794-96-9	1	10	10
m+p Xylene	136777-61-2	14	140	0.3
Magnesium	7439-95-4	2235	353000	5000
MCPA	94-74-6	2	100000	100000
MCPP	93-65-2	2	100000	100000
n-Butylbenzene	104-51-8	149	107	20
Neptunium-237	13994-20-2	31	0.05457	0.199
Nitrobenzene-D5	4165-60-0	744	128	10
N-Nitrosodimethylamine	62-75-9	6	730	730
n-Propylbenzene	103-65-1	150	120	20
o-Chlorotoluene	95-49-8	149	119	20
o-Fluorophenol	367-12-4	707	1200	10
Oil and Grease	10-30-0	1	0.163	0.05
Orthophosphate	14265-44-2	16	98	0.05
o-Xylene	95-47-6	46	133	13
p-Bromodiphenyl Ether	101-55-3	1314	38000	12000
p-Chlorotoluene	106-43-4	149	145	20
Petroleum Hydrocarbons Total Recoverable	10-90-2	33	91	30
pH	10-29-7	359	10.5	0.1
Phenanthrene	85-01-8	1314	220000	12000
Phenol, 2-(1-Methylpropyl)-4,6-Dinitro-	88-85-7	4	100	200
Phenol-D5	4165-62-2	714	131	10
Plutonium-238	13981-16-3	213	0.3131	0.727
Plutonium-242	13982-10-0	42	0.0848	0.2547
Potassium	7440-09-7	2221	12000000	121000
Propane, 1,2-Dibromo-3-Chloro-	96-12-8	407	387	20
Propanoic Acid, 2-(2,4,5-Trichlorophenoxy)-	93-72-1	42	111	200
Radium-226	13982-63-3	534	150	8

389

Analyte	CAS No	Number of Samples Collected in the IA	MaxRESULT (mg/kg or pCi/g)	MaxDL
Radium-228	15262-20-1	479	28	38
sec-Butylbenzene	135-98-8	149	111	20
Silicon	7440-21-3	574	288000	500
Sodium	7440-23-5	2221	3080000	140000
Specific Conductivity	10-34-4	114	15900	10
Strontium-89	14158-27-1	30	0.5	0.7
Strontium-89,90	11-10-9	796	68.9	6.1785
Strontium-90	10098-97-2	33	13	0.65
Sulfate	14808-79-8	60	1800	250
Sulfide	18496-25-8	344	203	10.7
Tantalum	7440-25-7	84	89.3	500
Terphenyl-D14	1718-51-0	715	232	10
tert-Butylbenzene	98-06-6	149	117	20
Thallium	7440-28-0	2343	157	15
TNT	118-96-7	3	0.23	0.23
Toluene – D8	2037-26-5	1099	143	10
Total Dissolved Solids	10-33-3	27	15631.03	50
Total Organic Carbon	10-35-5	259	24700	50
Total Radiocesium	13-00-0	68	136	200
Total Suspended Solids	10-32-2	27	1218	6.8
trans-1,2-Dichloroethene	156-60-5	193	630	630
Tributyl Phosphate	126-73-8	50	440	440
Trichlorofluoromethane	75-69-4	149	93	20
Tritium	10028-17-8	953	329000	4490
Uranium-232	14158-29-3	42	0.0562	0.0644

3.0 REFERENCES

DOE, CDPHE, and EAP, 2003, Modifications to the Rocky Flats Cleanup Agreement, Rocky Flats Environmental Technology Site, Golden, Colorado, June.

APPENDIX F

**Background Levels for Inorganic and Radionuclide
Potential Contaminants of Concern**

LIST OF TABLES

Table F1	Summary Statistics for BSCP Metals (mg/kg) and Naturally-Occurring Radionuclides (pCi/g).....	1
Table F2	Summary Statistics for BSCP Fallout Radionuclides and Supporting Data.....	2
Table F3	Summary Statistics for Inorganics (mg/kg).....	2
Table F4	Subsurface Background Soils - Inorganics	3
Table F5	Subsurface Background Soils - Radionuclides	3

392

ACRONYMS

BSCP	Background Soils Characterization Plan
DOE	U.S. Department of Energy
g/cm ³	grams per cubic centimeter
IDL	instrument detection limit
mg/kg	milligrams per kilogram
n	number of samples
NC	not calculated
nd	non-detect
pCi/g	picocuries per gram
RFETS	Rocky Flats Environmental Technology Site
U	undetected
UTL	upper tolerance limit

Background levels for inorganic and radionuclide potential contaminants of concern in soil at the Industrial Area and Buffer Zone are listed in Tables F1, F2, F3, F4, and F5.

Table F1
Summary Statistics and Background Values for Metals (mg/kg) and Naturally-Occurring Radionuclides (pCi/g) in Surface Soil

Analyte	Distribution	Count (n)	% Non-detection	Minimum (mg/kg)	Maximum (mg/kg)	Mean	Standard Deviation	M+2SD (mg/kg)
ALUMINUM	Normal	20	0	4050	17100	10244	3329	16902
ANTIMONY*	NA	20	96	.19U	0.47	NC	NC	0.47
ARSENIC	Normal	20	0	2.3	9.6	6.09	2	10.09
BARIUM	Normal	20	0	45.7	134	102.4	19.43	141.26
BERYLLIUM	Normal	20	0	0.24	0.9	0.66	0.153	0.966
CADMIUM	Non-parametric	20	39	.295U	2.3	0.714	0.449	1.612
CALCIUM	Normal	20	0	1450	4550	2969	749	4467
CESIUM*	NA	20	100	6.05U	7U	NC	NC	7
CHROMIUM	Normal	20	0	5.5	16.9	11.29	2.85	16.99
COBALT	Normal	20	0	3.4	11.2	7.29	1.81	10.91
COPPER	Non-parametric	20	0	5.2	15.85	12.94	2.56	18.06
IRON	Normal	20	0	7390	18100	12549	2744	18037
LEAD	Normal	20	0	8.6	53.3	33.6	10.51	54.62
LITHIUM	Lognormal	20	0	4.8	11.6	7.69	1.93	11.55
MAGNESIUM	Lognormal	20	0	1310	2800	1913.1	468.1	2849.3
MANGANESE	Normal	20	0	129	357	237.3	63.89	365.08
MERCURY	Lognormal	20	65	.04U	0.12	0.072	0.031	0.134
MOLYBDENUM*	NA	20	91	.29U	0.9U	NC	NC	0.9
NICKEL	Normal	20	0	3.8	14	9.63	2.64	14.91
POTASSIUM	Normal	20	0	1110	2830	2061.2	453	2967.2
SELENIUM	Nonparametric	20	39	.29U	1.4	0.634	0.295	1.224
SILICON	Normal	20	0	934	1650	1383.5	179	1741.5
SILVER*	NA	20	100	.19U	.22U	NC	NC	.22
SODIUM	Lognormal	20	0	43.8	105	62.16	14.84	91.84
STRONTIUM	Lognormal	20	0	9.6	45.2	28.44	10.25	48.94
THALLIUM*	NA	14	100	.385U	.445U	NC	NC	.445
TIN*	NA	20	91	1.35U	2.9	NC	NC	2.9
VANADIUM	Normal	20	0	10.8	45.8	27.85	8.87	45.59
ZINC	Normal	20	0	21.1	75.9	49.56	12.1	73.76
URANIUM Total				2.21	7.7	3.26	1.36	5.98
				pCi/g	pCi/g			pCi/g
RADIUM-226	Lognormal	20	0	0.1	0.805	0.619	0.153	0.925
RADIUM-228	Normal	20	0	0.2	2.3	1.35	0.48	2.31
URANIUM-233,-234	Lognormal	20	0	0.6	3.1	1.097	0.578	2.253
URANIUM-235	Lognormal	20	0	0.033	0.11	0.0539	0.02	0.0939
URANIUM-238	Lognormal	20	0	0.74	2.6	1.09	0.455	2

* Background mean plus two standard deviations is equal to maximum value
 NA = not applicable because > 80% of data were non-detects
 % Non-detects (nds) are calculated from all accepted valid data except equipment rinsates
 Min and Max values: highest/lowest detected value or, if no detected values, 1/2 IDL (notated with "U")
 IDL = instrument detection limit
 Uranium-238 had 2 outliers removed for calculation of upper tolerance limit (UTL); outliers retained for summary statistics
 Normal* : Distribution assumed to be normal for summary statistics of supporting data
 NC = Not calculated

DOE, 1995. *Geochemical Characterization of Background Surface Soils: Background Soils Characterization Program, Table E-1, RFETS, May 1995.*

394

Table F2
Summary Statistics and Background Values for BSCP Fallout Radionuclides in Surface Soil

Analyte	Distribution	Count (n)	% Non-detection	Minimum	Maximum	Mean	Standard Deviation	M+2SD	Units
AMERICIUM-241	Nonparametric	50	0	0.001	0.025	0.0107	0.006	0.0227	pCi/g
CESIUM-134	Nonparametric	50	0	0.05	0.3	0.2	0.056	0.312	pCi/g
CESIUM-137	Lognormal	50	0	0.3	1.7	0.941	0.372	1.685	pCi/g
PLUTONIUM-239/240	Lognormal	50	0	0.017	0.072	0.038	0.014	0.066	pCi/g
STRONTIUM-89-90	Lognormal	50	0	0.065	0.64	0.254	0.128	0.51	pCi/g
% Clay	Normal*	50	0	1	34	11.58	6.37		%
% Sand	Normal*	50	0	24	78	53.29	11.97		%
% Silt	Normal*	50	0	20	51	35.21	7.49		%
Soil density	Normal*	50	0	0.8	1.2	0.944	0.78		g/cm ³
Total Organic Carbon	Normal*	50	0	1.4	6.05	3.66	1.24		%

Normal*: Distribution assumed normal for summary statistics of supporting data
 DOE, 1995. Geochemical Characterization of Background Surface Soils: Background Soils Characterization Program, Table E-3, RFETS, May 1995.

Table F3
Summary Statistics for Inorganics (mg/kg) in Surface Soil

Analyte	Distribution	Count (n)	% Non-detection	Minimum	Maximum	Mean	Standard Deviation	M+2SD
AMMONIA	Normal*	20	39	0.5U	7	2.033333333	1.897674785	5.8
CARBONATE	Normal*	20	100	5U	5.5U	X	X	X
NITRATE/NITRITE	Normal*	20	0	2	7	4	1.685854461	7.4
OIL&GREASE	Normal*	20	0	52	130	94.575	19.32497362	133.2
pH	Normal*	20	0	6	6.8	6.3575	0.242397564	6.8
SPECIFIC COND.	Normal*	20	0	0.1	0.53	0.20825	0.089593747	0.4
T.O.C.	Normal*	20	0	4920	17600	16132.66667	2696.900452	21526.5
% CLAY	Normal*	20	0	7	36	20.45	8.62	37.7
% SAND	Normal*	20	0	22	76	43.93	15.27	74.5
% SILT	Normal*	20	0	18	45.5	35.76	7.52	50.8
SOIL DENSITY	Normal*	20	0	0.9	1.2	0.923	0.07	1.1

Normal*: Distribution assumed to be normal for summary statistics of supporting data
 NC = Not calculated
 DOE, 1995. Geochemical Characterization of Background Surface Soils: Background Soils Characterization Program, Table E-2, RFETS, May 1995.

Table F4
Subsurface Background Soils - Inorganics

Analyte	Flow System	Sample Size (n)	Percent Detects	Mean	Standard Deviation	M+2SD	Units
ALUMINUM	UPPER	98	100	12,752.03	11,310.57	35373.17	mg/kg
ANTIMONY	UPPER	66	3	4.71	6.13	16.97	mg/kg
ARSENIC	UPPER	99	75	3.88	4.63	13.14	mg/kg
BARIUM	UPPER	99	89	96.46	96.46	289.38	mg/kg
BERYLLIUM	UPPER	99	91	4.78	4.71	14.2	mg/kg
CADMIUM	UPPER	81	48	0.82	0.44	1.7	mg/kg
CALCIUM	UPPER	99	86	6,951.09	16,215.59	39382.27	mg/kg
CESIUM	UPPER	95	78	230.46	273.51	777.48	mg/kg
CHROMIUM	UPPER	99	100	19.61	24.33	68.27	mg/kg
COBALT	UPPER	99	30	7.5	10.77	29.04	mg/kg
COPPER	UPPER	99	91	12.57	12.82	38.21	mg/kg
IRON	UPPER	99	100	14,531.98	13,257.27	41046.52	mg/kg
LEAD	UPPER	99	100	10.87	7.05	24.97	mg/kg
LITHIUM	UPPER	99	45	11.76	11.45	34.66	mg/kg
MAGNESIUM	UPPER	99	64	2,584.42	3,365.51	9315.44	mg/kg
MANGANESE	UPPER	99	100	217.64	341.96	901.56	mg/kg
MERCURY	UPPER	86	34	0.24	0.64	1.52	mg/kg
MOLYBDENUM	UPPER	99	14	8.93	8.34	25.61	mg/kg
NICKEL	UPPER	96	91	20.73	20.74	62.21	mg/kg
POTASSIUM	UPPER	98	29	1,311.57	2,442.62	6196.81	mg/kg
SELENIUM	UPPER	82	26	1.22	1.79	4.8	mg/kg
SILVER	UPPER	83	41	5.62	9.46	24.54	mg/kg
SODIUM	UPPER	99	9	300.66	475.29	1251.24	mg/kg
STRONTIUM	UPPER	99	43	65.62	72.88	211.38	mg/kg
THALLIUM	UPPER	75	3	0.52	0.66	1.84	mg/kg
TIN	UPPER	92	23	61.75	112.28	286.31	mg/kg
VANADIUM	UPPER	99	98	31.49	28.50	88.49	mg/kg
ZINC	UPPER	98	96	36.86	51.12	139.1	mg/kg
URANIUM TOTAL	UPPER	99	100	1.46	0.79	3.04	mg/kg

DOE, 1993, Background Geochemical report, Table D-16, RFETS, September, 1993

Table F5
Subsurface Background Soils - Radionuclides

Analyte	Flow System	Sample Size (n)	Percent Detects	Mean	Standard Deviation	M+2SD	Units
AMERICIUM-241	UPPER	28	100	0.00	0.01	0.02	pCi/g
CESIUM-137	UPPER	99	100	0.01	0.04	0.09	pCi/g
GROSS ALPHA	UPPER	99	100	24.91	9.28	43.47	pCi/g
GROSS BETA	UPPER	99	100	24.72	6.06	36.84	pCi/g
PLUTONIUM-239,240	UPPER	99	100	0.00	0.01	0.02	pCi/g
RADIUM-226	UPPER	83	100	0.75	0.23	1.21	pCi/g
RADIUM-228	UPPER	83	100	1.40	0.32	2.04	pCi/g
STRONTIUM-89,90	UPPER	99	100	0.03	0.36	0.75	pCi/g
TRITIUM	UPPER	99	100	141.72	126.75	395.22	pCi/g
URANIUM-244,234	UPPER	99	100	0.78	0.93	2.64	pCi/g
URANIUM-235	UPPER	99	100	0.02	0.05	0.12	pCi/g
URANIUM-238	UPPER	99	100	0.73	0.38	1.49	pCi/g

DOE, 1993, Background Geochemical Report, Table D-17, RFETS, September.

APPENDIX G

**Industrial Area and Buffer Zone Sampling and Analysis Plan
Quality Assurance Project Plan**

TABLE OF CONTENTS

1.0 QUALITY ASSURANCE CRITERIA 1

2.0 MANAGEMENT 3

 2.1 Program..... 3

 2.2 Personnel Training and Qualification 3

 2.3 Quality Improvement 5

 2.4 Documents and Records 5

3.0 PERFORMANCE..... 6

 3.1 Work Processes..... 6

 3.1.1 Workforce..... 6

 3.1.2 Sampling and Analysis 7

 3.1.3 Radiological Surveys..... 8

 3.1.4 Radiochemistry..... 9

 3.1.5 Analytical Chemistry..... 9

 3.2 Design 10

 3.2.1 Data Quality Objectives 10

 3.2.2 Computerized Systems (Software/Hardware) 10

 3.2.3 Data Quality Assessment..... 30

 3.3 Procurement 34

 3.4 Inspection and Acceptance Testing..... 35

4.0 ASSESSMENTS 35

 4.1 Management Assessment..... 35

 4.2 Independent Assessment..... 35

5.0 REFERENCES 35

LIST OF TABLES

Table G1 Crosswalk Between EPA QA/R-5 and DOE Order 414.1A 2

Table G2 QA/QC Implementation Matrix for the IABZSAP 4

Table G3 Validation Qualifier Codes 14

Table G4 Data Quality Filter Validation Reason Codes..... 15

Table G5 Result Type Codes 22

Table G6 Validation Reason Codes 28

Table G7 Validation Qualifiers..... 30

398

LIST OF FIGURES

Figure G1 Data Quality Filter for the Industrial Area and Buffer Zone Sampling and Analysis
Plan and Comprehensive Risk Assessment 12

Figure G2 Industrial Area Data Quality Filter –Subsurface Soil 13

Figure G3 Industrial Area Data Quality Filter – Surface Soil..... 14

Figure G4 Buffer Zone Data Quality Filter – Subsurface Soil..... 15

Figure G5 Buffer Zone Data Quality Filter – Surface Soil 16

ACRONYM LIST

%D	percent difference
%R	percent recovery
%RSD	relative standard deviation
AL	action level
ANSI	American National Standards Institute
AR	Administrative Record
ASD	Analytical Services Division
ASQC	American Society of Quality Control
BZ	Buffer Zone
CAS	Chemical Abstract Service
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	contaminant of concern
CRA	Comprehensive Risk Assessment
CRDL	Contract Required Detection Limit
DER	duplicate error ratio
DMP	Decision Management Plan
DOE	U.S. Department of Energy
DQA	Data Quality Assessment
DQO	data quality objective
DRC	Data Review Checklist
EDD	electronic data deliverable
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
GC	gas chromatography
GC/MS	gas chromatography/mass spectrometry
GIS	Geographic Information System
GPS	global positioning system
H&S	Health and Safety
HASP	Health and Safety Plan
IA	Industrial Area
IABZSAP	Industrial Area and Buffer Zone Sampling and Analysis Plan
ICP	inductively coupled plasma
IDL	Instrument Detection Limit
IMP	Integrated Monitoring Plan
IWCP	Integrated Work Control Package
K-H	Kaiser Hill Company, LLC
LCS	Laboratory control sample
LIBS	laser-induced breakdown spectroscopy
M&TE	measurement and test equipment
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDA	minimum detectable activity

MDL	method detection limit
MS	matrix spike
MSD	matrix spike duplicate
NIST	National Institute of Standards Technology
PARCC	precision, accuracy, representativeness, completeness, and comparability
PATS	plant action tracking system
PCB	polychlorinated biphenyl
PE	performance evaluation
QA	quality assurance
QAPjP	Quality Assurance Project Plan
QC	quality control
RDL	required detection limit
RFCA	Rocky Flats Cleanup Agreement
RFEDS	Rocky Flats Environmental Database System
RFETS	Rocky Flats Environmental Technology Site
RPD	relative percent difference
RSP	Radiological Safety Practices
RWP	Radiological Work Permit
SAP	Sampling and Analysis Plan
SDP	standard data package
SOP	standard operating procedure
SOW	Statement of Work
STD	standard
SWD	Soil/Water Database
TBD	to be decided
TCLP	Toxicity Characteristic Leaching Procedure
TIC	tentatively identified compound
TPU	total propagated uncertainty
TSR	Training, Scheduling, and Records
UWQ1	usable with qualification, unable to associate with validated Laboratory batch
UWQ2	usable with qualification, potential low bias may exist per validation qualifier
UWQ3	usable with qualification, samples taken without controlling documents
UWQ4	usable with qualification, source material has been remediated
UWQ5	usable with qualification, QC data
V&V	verification and validation
XRF	x-ray fluorescence

401

1.0 QUALITY ASSURANCE CRITERIA

Quality assurance (QA) criteria presented in this Quality Assurance Project Plan (QAPjP) are consistent with quality requirements as defined by both the U.S. Department of Energy (DOE) (Order 414.1A, *Quality Assurance*) and the U.S. Environmental Protection Agency (EPA) (QA/R-5, *EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations*, 1997a). Table G1 provides a “crosswalk” between these requirements, illustrating the overlap between them. The application and implementation of these criteria into items and services will be consistent with the graded approach.

The graded approach is a “process of basing the level of application of managerial controls applied to an item or work according to the intended use of the results and the degree of confidence needed in the quality of the results” (E-4, ANSI/ASQC, 1994). The graded approach is also a function of safety (risk) and security required to accomplish program objectives (10 Code of Federal Regulations [CFR] 830.3). In practical terms, the graded approach requires selective application of QA requirements and control to items and services commensurate with their impact on risks posed to workers, the public, and the environment. EPA states that “Environmental data operations encompass diverse and complex activities, and they represent efforts pertaining to rulemaking, compliance with regulations, and research. Consequently, any plan that is developed to represent how QA/quality control (QC) should be applied to environmental activities must contain considerable flexibility...” (EPA 1994a). The content and level of detail in this QAPjP is tailored to the nature of the work and associated risk with the Industrial Area (IA) and Buffer Zone (BZ) Project.

Hazardous and radiological risks to project personnel are addressed in the project’s Health and Safety Plan (HASP). 10 CFR 830.120 QA does not apply to activities controlled by the IABZ Sampling and Analysis Plan (SAP) (IABZSAP), unless inventories of materials, under direct control of the project, become nuclear facilities as defined in DOE Standard 1027-92.

References cited in this appendix are provided in Section 5.0, References, whereas Rocky Flats Environmental Technology Site (RFETS) internal documents are referenced throughout this QAPjP by control numbers maintained at RFETS by Kaiser-Hill Company, L.L.C. (K-H).

QA will also be consistent with the following guidance and regulatory documents:

- ANSI/ASQC E4-1994; American National Standard, Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs;
- DOE Order 414.1, Quality Assurance;
- DOE Order 5400.1, General Environmental Protection Program;
- EPA, 1994a, Guidance for the Data Quality Objectives Process; QA/G-4;

403

Table G1
Crosswalk Between EPA QA/R-5 and DOE Order 414.1A

EPA QA/R-5 Elements	DOE Order 414.1A Requirements									
	Program	Personnel Training & Qualification	Quality Improvement	Documents & Records	Work Processes	Design	Procurement	Inspection/Acceptance Testing	Management Assessment	Independent Assessment
A1 Title and Approval Sheet										
A2 Table of Contents										
A3 Distribution List										
A4 Project/Task Organization										
A5 Problem Definition & Background										
A6 Project/Task Description										
A7 Quality Objectives & Criteria for Measurement Data										
A8 Special Training Requirements										
A9 Documentation & Records										
B1 Sampling Process and Design										
B2 Sampling Methods Requirements										
B3 Sample Handling and Custody Requirements										
B4 Analytical Methods Requirements										
B5 Quality Control Requirements										
B6 Instrument/Equipment Testing, Inspect. & Maintenance Req.										
B7 Instrument Calibration & Frequency										
B8 Inspection/Acceptance Requirements - Supplies/Consumables										
B9 Data Acquisition Requirements										
B10 Data Management										
C1 Assessments & Response Actions										
C2 Reports to Management										
D1 Data Review, Validation, & Verification Requirements										
D2 Validation & Verification Methods										
D3 Reconciliation w/ User Requirements										

- EPA, 1994b, USEPA Contract Laboratory Program National Function Guidelines for Inorganic Data Review;
- EPA, 1997b, 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; and
- EPA, 1999, Guidance on Environmental Data Verification and Validation, QA/G-8.

2.0 MANAGEMENT

2.1 PROGRAM

The IA and BZ quality program implements requirements set forth in Order 414.1A, which is “flowed-down” through the RFETS-specific quality documents of K-H (K-H-QAPD-001, *Quality Assurance Program Description*).

The documents listed in Section 1.0 and the QA/QC Implementation Matrix (Table G2) provide a general perspective of the documents establishing the engineering and administrative controls in place for the IA and BZ Project. Specific document and record control numbers may be obtained through review of the IA and BZ Project Files, K-H Records Center, or K-H Document Control.

2.2 PERSONNEL TRAINING AND QUALIFICATION

Personnel will be qualified to perform their respective tasks based on a combination of education, training, and experience. Education and professional experience will constitute the primary means of qualification for activities that emphasize management and problem-solving strategies. Training will be the primary means of qualification where:

- Consistency and team coordination constitutes a major component of the overall quality (or safety) of the process or item; and
- The process is well established, proven, and perfunctory.

In addition, a project-specific QA briefing will be given during the pre-evolution briefing before project start-up in the field. New personnel will also receive a QA briefing prior to their participation on the project. The QA briefing will cover the requirements stated in this QAPjP and will be documented via an attendance roster.

**Table G2
QA/QC Implementation Matrix for the IABZSAP**

DOE Quality Requirement		Implementing Documents and Quality Records
Management	Program	RFCA K-H Team Quality Assurance Program IA/BZ QAPjP (this section of the IABZSAP) Stop Work Action (1-V10-ADM-15.02)
	Training/Qualification	HASP K-H Human Resources (Personnel Files) Subcontractor (various) Human Resources (Personnel Files) Readiness Review (verifies personnel training) Statements of Work (SOWs)/Contracts (for subcontractors)
	Quality Improvement	Plant Action Tracking System (PATS) Corrective Actions Process (3X31-CAP-001) K-H Assessment Reports (Independent & Management)
	Controlling Documents	Document Control Program Manual (MAN-063-DC) Site Documents Requirements Manual (MAN-001-SDRM) Records Management Guidance for Records Sources (1V41-RM-001) Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Administrative Record Program (1F18-ER-ARP.001) SOWs
	Records	Various maps (esp. from GIS/SmartSampling applications) K-H QA Assessment Reports Analytical/radiochemistry data packages, incl. electronic data deliverables (EDDs) IA/BZ Final Reports/Technical Memoranda Health and Safety (H&S) Quality Records, per HASP Radiological Quality Records, incl. routine monitoring Administrative Record (AR) Daily Shift Reports Field Logbooks (controlled) ER GIS Database (ARC/INFO; land surveys/GPS)
Performance	Work Processes	Control of Processes (1C20-QAP-09.01) Industrial Area and Buffer Zone Sampling & Analysis Plan (IABZSAP) Integrated Work Control Manual (MAN-071-IWCP) Integrated Work Control Packages (IWCPs) - TBD (RFETS Radiological Control Manual (Radcon Manual) Radiological Safety Practices (RSPs) Site Design Control Manual (1W56-COEM-AMN-101) Conduct of Operations Manual (MAN-066-COOP) Subcontractor Statements of Work (incl. Gamma Spec) Gamma Spectroscopy Kaiser-Hill Analytical Services Field Laboratory – Organics RFETS Integrated Monitoring Plan (MP) Radiological Work Permits (RWPs) Standard Operating Procedures (SOPs)
	Design	IWCPs (listed above) Industrial Area and Buffer Zone Sampling & Analysis Plan (IABZSAP) IABZSAP Addenda Data Management Plans (TBD)
	Procurement	Procurement Quality Assurance Requirements (PRO-572-PQR-001)
	Inspection and Acceptance Testing	Calibration/maintenance records for M&TE Identification and Control of Items (1-A67-QAP-08.01) Inspection and Acceptance Test Program (1-PRO-072-001)
Assessments	Management	K-H Mgmt Assessment Program (3W24-MA-002)
	Independent	Site Integrated Oversight Manual (MAN-013-SIOM)

405

Fundamental education and experience are captured by transcripts and resumes, which are maintained by K-H Human Resources or K-H subcontractors, as applicable. Site-specific and project-specific training records are managed within the IA and BZ Project Files and the K-H Training, Scheduling, and Records (TSR) database. Qualification requirements and records may also be maintained through the project manager, individual staff, procurement (within contractual agreements), and/or the centralized training group within K-H.

2.3 QUALITY IMPROVEMENT

Quality improvement will be realized through use of a systematic means of identifying, tracking, and correcting problems (deficiencies, nonconformances, issues, etc.). Problems may be identified by any project personnel, at any time, through formal documentation of issues as stated in 3-X31-CAP-001, *Corrective Actions Process*. Management and independent assessments will also be used to identify, track, and correct issues (see subsections below). The extent of causal analysis and corrective action will be commensurate with the significance (potential risk) of the failure or problem. "Lessons learned" will be communicated to staff by management where appropriate.

2.4 DOCUMENTS AND RECORDS

Work-controlling documents, such as work plans (including IWCPs, SOPs, HASPs, etc.), will be controlled, where "control" is constituted by the following criteria:

- The documents are uniquely identified for reference purposes.
- The required reviews and approvals are accomplished.
- The personnel who need the documents to perform work use the latest approved versions of the document(s).

The document control process is described in MAN-063-DC-06.01, *Document Control Program Manual*, and MAN-001-SDRM, *Site Document Requirements Manual*. Essential policies, plans, procedures, decisions, data, and transactions of the project will be documented to an appropriate level of detail. The objective will be to maximize the utility of records and data for accomplishment of performance objectives while minimizing the cost of information management and paperwork for the project (K-H) and its subcontractors. The documents controlling this project are summarized in Table G2.

All documents that constitute contractual deliverables to DOE, such as work plans or final reports, will undergo a minimum of three reviews to ensure that minimum quality requirements are met:

- Management review (level of management higher than originating author[s]);
- Technical/peer review (subject matter experts as determined by management); and
- QA review.

The project manager may assign other technical reviewers, as applicable, to cover the technical disciplines represented within the document.

Quality records, including digital data stored on computerized media, will be managed to ensure that information is retained, retrievable, and legible. Active records will be maintained by project personnel, including K-H subcontractors, in an organized and retrievable fashion, until such time that the records have served their purpose and become inactive. Quality records are considered active until the final peer reviews are conducted and are not subject to the 30-day limit on turnover to the Records Center until final peer reviews are conducted. Peer reviews of records must be conducted on records completed by the originator within 2 weeks of completion. Records at the job site will be stored and protected in standard filing cabinets, consistent with 1-V41-RM-001, *Records Management Guidance for Records Sources*, and ultimately with 1-F18-ER-ARP.001, *Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Administrative Record Program*. Quality records managed by subcontractors will be consistent with K-H requirements.

Quality records resulting from direct measurements or technical sampling activities will be authenticated by the originator and subsequently authenticated by a peer reviewer ("QC checked"). For data uploaded to computer from the quality records described above, final data entry (as portrayed on hardcopy output or electronic file) must be reviewed by someone other than the data entry person. Errors and changes on completed quality records will be maintained as follows:

- Hardcopy - By striking through the original entry with a line, and incorporation of the correct data and authentication adjacent to the strikeout; and
- Electronic files - By incorporating configuration/change control in each applicable document, where all changes and additions (e.g., QC checks) are dated with electronic signatures.

K-H Analytical Services Division (ASD) is responsible for archiving all original hardcopy records produced by offsite laboratories. The K-H Soil/Water Database (SWD) will archive the complete EDDs provided by the laboratories via K-H ASD. The IA and BZ Project will manage, in real time, all data critical for decision making in the field, and will be responsible for summarizing the data into usable formats for reporting purposes. Reporting purposes include primarily, decisions relative to contaminant characterization, remediation, and comprehensive risk assessment. A data flow/data management diagram will be appended to the IABZSAP prior to fieldwork.

3.0 PERFORMANCE

3.1 WORK PROCESSES

3.1.1 Workforce

Management will hire and maintain a workforce capable of performing the project objectives as set forth in the IABZSAP. Establishment and maintenance of the workforce for this project will be within budgetary constraints as defined by K-H.

Individual workers are responsible for the quality of their work. Management will provide the workforce with the tools, materials, and resources (including training) necessary for successful accomplishment of their assigned tasks. Performance criteria for personnel are established and

clearly communicated to project personnel through the SAP, associated procedures, and briefings, including “pre-evolution” meetings, readiness reviews, and daily “tool-box” meetings.

3.1.2 Sample Collection

Controlling Documents

All sampling events will be controlled through documented procedures. These procedures, specific to the type of sampling implemented, are referenced throughout the IABZSAP, within the context of sampling discussions, as applicable. Quality controls required for all chemical and radiological services will be further specified in contractual requirements with the applicable vendors (i.e., within SOWs, in progress).

A combination of sampling strategies is planned for the IA and BZ. Both statistical (EPA 1994a, QA/G-4, and EPA 1998, QA/G-9) and geostatistical methods will be adopted. Use of these two general approaches is consistent with use of the EPA data quality objective (DQO) process, which determines the types, quality, and quantity of data needed for environmental decisionmaking, while optimizing time and cost considerations.

QC Requirements

QC checks of both field sampling and laboratory sample analyses will be used to assess and document data quality and to identify discrepancies in the measurement process that need correction. QC samples such as equipment decontamination rinsates, field duplicates, and performance evaluation (PE) samples will be collected and analyzed.

QC samples will be employed to assess various data quality parameters such as representativeness of the environmental samples, the precision of sample collection and handling procedures, the thoroughness of the field equipment decontamination procedures, and the accuracy of laboratory analysis. To evaluate bias and contamination from field collection procedures, blanks will be prepared from distilled or dionized water. In addition, all sample containers, preservation methods, and holding times will be in accordance with Site SOPs. The quantities and types of control samples for each data collection activity are presented and described below.

In addition to the control samples identified below, the analytical laboratories will use a series of QC samples as identified in the laboratory quality control plan and specified in the standard analytical methods and laboratory standard operating procedures. These types of samples are method blank, laboratory control standard, matrix spike, and laboratory duplicate.

The following sections describe field QC samples that will be collected.

Equipment Blanks

Equipment blanks (equipment decontamination rinsates) will be used to assess the adequacy of practices to prevent cross-contamination between sampling locations and samples. Rinsate samples will be collected at a frequency of one rinsate for every 20 environmental samples and only for sampling equipment used repetitively to collect environmental samples. Rinsate samples will be collected and analyzed for the same parameters as the samples. Rinsate water will be collected following the final decontamination rinse of sampling equipment and then dispensed into sample containers. The equipment decontamination rinsates will be handled and analyzed in the same manner as all environmental samples.

Field Duplicates and Verification Samples

A field duplicate sample is a split of a homogenized sample. Homogenization is performed in a stainless steel mixing bowl. For VOC analysis, the field duplicate is a second sample collected at the same location/depth as the original sample, and is collected immediately after the parent sample. Field duplicates will be collected at selected locations at a frequency of 1 in 20 sample locations to provide estimates of the precision of the sample collection process. If the selected field duplicate location is a borehole, a field duplicate sample will be prepared for all sampling intervals. Field duplicates are sent to the onsite laboratory for analysis.

A verification sample is collected as described for field duplicates. Sample locations are designated for collection of verification split samples prior to the beginning of a sampling event. The verification samples will be analyzed by an independent offsite laboratory to assess the accuracy of the on-site laboratory.

Field Blanks

Field blanks will be used to indicate the presence of external contaminants that may have been introduced into the VOC samples during collection. Field blanks will be analyzed only for VOCs. Because these blanks may also become contaminated during transport, trip blanks, as discussed below, will also be used. Field blanks will be prepared on site during the sampling event by pouring solvent-grade water into randomly selected sample containers. At least one field blank sample will be analyzed for each group of samples that will be analyzed for VOCs. Appropriate sample containers will be filled to yield an appropriate sample volume for VOC analysis. The field blanks will be handled and analyzed in the same manner as all environmental samples.

Trip Blanks

Trip blanks will be used to assess contamination introduced into the sample containers by VOC diffusion during sample storage and transport. One trip blank will be included in each shipping container containing samples scheduled for analysis of VOCs. Trip blanks will be prepared at the onsite laboratory using solvent-grade water, transported to the sampling site with the other sample containers, and then returned to the onsite laboratory for analysis along with the samples collected during the sampling event. The trip blanks will remain unopened throughout the transportation and storage processes and will be analyzed in the same manner as all environmental samples.

Performance Evaluation Samples

PE samples will be used to assess the accuracy of the specified analytical methods. These samples will be prepared by an independent laboratory or supplier with known composition and submitted to the analytical laboratory as unknown samples. The PE samples will be analyzed in the same manner as all environmental samples. PE samples will be analyzed at a frequency of one per year for all analyses for which PE samples are commercially available. DOE-provided PE samples will be analyzed semi-annually or as provided. PE sample acceptance criteria will be specified by the PE sample supplier or manufacturer.

3.1.3 Radiological Surveys

Radiological surveys and monitoring will be routinely performed, primarily for purposes of ensuring contamination control and general H&S purposes. All surveys for removable and fixed

contamination, as well as monitoring for airborne contamination, will be performed and reported consistent with RFETS RSPs. Those RSPs planned for implementation in the IA Project are listed and controlled on the RFETS intranet.

3.1.4 Radiochemistry

Gamma spectroscopy is the primary means by which the type and quantity of radionuclides will be determined. In general, gamma spectroscopy will be used in lieu of alpha spectroscopy, because gamma spectroscopy provides data of comparable quality and sensitivity. Limited alpha spectroscopy analyses may be performed for verification/validation of the gamma spectroscopy methods, consistent with the fielding of this technology in other major projects at RFETS (e.g., Trench-1 and 903 Pad). Alpha spectrometry methods are defined in the following controlling documents:

- K-H Module RC01, *Isotopic Determinations by Alpha Spectrometry*; and
- K-H Module GR04, *General Laboratory Requirements*.

Gamma spectroscopy methods for the project may be used in at least two configurations: in-situ and field laboratories. In situ methods are measurements acquired in the field for two-dimensional measurements (areal), or three-dimensional measurements with limited thickness. field laboratory methods will count containerized samples with distinct 3D configurations. An initial draft of QC specifications for the in situ techniques is given in Attachment G1. Field laboratory specifications are addressed in K-H Module RC11, *Determination of Radionuclides by Gamma Spectrometry*. These controls will be contractually required of the gamma spectroscopy vendor. The attachment will be revised before requests for proposals are released to vendors.

3.1.5 Analytical Chemistry

Analytical chemistry generally consists of two types: organic and inorganic, both of which are addressed separately with respect to QC.

Summarized below are variances to the referenced protocols, which allow for mobile methods that will be faster and less expensive than traditional methods, while concurrently providing sufficient quality in the data for making project decisions (including risk assessment). More specific variances will be provided in the final SOW for the vendor ultimately providing analytical services. Generally, the variances reside in the following areas:

- Abbreviated analytical suites, based on IA and BZ contaminants of concern (COCs) only;
- Generalized accuracy specifications, especially percent recoveries;
- Sensitivity specifications, as detailed below; and
- Reporting requirements for abbreviated data packages, with emphasis on EDD specifications designed for use in the field.

Organic chemical analysis will be accomplished through use of a mobile gas chromatography (GC) or gas chromatography/mass spectrometry (GC/MS), preceded by the appropriate extraction/digestion method. Preparation and analytical methods will consist of SW-846 methodology, and will generally be consistent with existing K-H ASD contractual requirements, as referenced below:

- K-H Module SS01, *Volatile Organics*;
- K-H Module SS02, *Semivolatile Organics*; and
- K-H Module SS03, *Polychlorinated Biphenyls (PCBs)/Pesticides*.

Inorganic chemistry, primarily metals, will be accomplished through use of both field and laboratory methods. Field methods will implement EPA Method 6200, *Field Portable XRF Spectrometry*, and manufacturer's instructions for a LIBS system. The required analytical suites, sensitivities, and general QC requirements are given in Appendix E of the IABZSAP.

The minimum quality requirements specific to use of field/portable metals analysis are summarized below:

1. SOPs - The manufacturer's operating instructions will be used. Any deviations or modifications to the instructions provided with the instrumentation will be documented and dispositioned by both the manufacturer/vendor and the project. Use of SOPs will also include full-range calibrations, periodic performance checks, and maintenance of equipment.
2. Sample Preparation/Measurements - Bulk samples will be composited and homogenized for the purpose of optimizing sample precision. A procedure for sample preparation to homogenize samples before analysis will be produced and controlled as a prerequisite to field analysis, consistent with EPA guidance (EPA 1995). Specific sampling geometries may also be considered, such as compositing samples about a point via a symmetrical, triangular pattern.

3.2 DESIGN

Sound engineering/scientific principles and appropriate technical standards will be incorporated into designs to ensure that they perform as intended, including use of the RFETS Conduct of Engineering Manual.

Final designs, as documents, quality records, or computerized data, will undergo validation through peer review. Peer reviews will be commensurate with the scale, cost, specialty, and hazards of the item or activity in question. Management approval, in addition to peer and quality reviews of designs, will be obtained prior to procurement, manufacture, construction, or field implementation. Peer and quality reviews are corroborated through authentication of the design reviews.

3.2.1 Data Quality Objectives

DQOs are addressed, in detail, in IABZSAP Section 3.0.

3.2.2 Computerized Systems (Software/Hardware)

Design control of computerized systems will be commensurate with the hazards associated with the process for which the computer system controls. Systems controlling critical H&S processes will be verified and validated as prescribed in either the HASP or the RSPs, and must simulate working conditions prior to usage in real settings. Such systems will also be tested periodically to ensure functionality as defined in the RFETS *Radiation Control Manual* or the HASP.

Computerized systems used for data reduction and analysis will be controlled to:

- Ensure traceability of changes made to original data; and
- Allow independent peer reviewers to relate inputs to outputs.

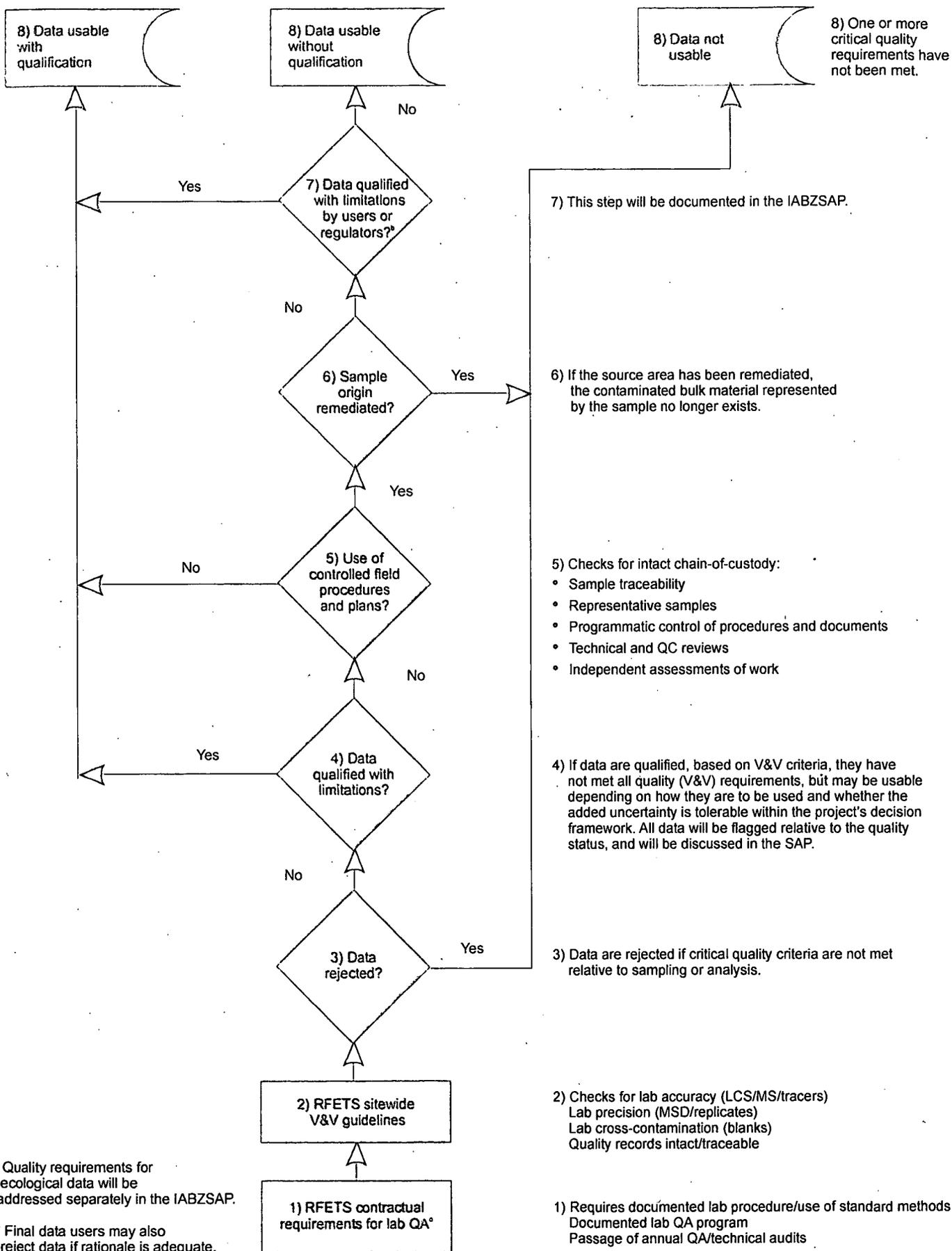
Computerized systems used for measurements will be calibrated via “system calibrations” (i.e., while integrated with all relevant software/hardware configurations, as they are to be operated during routine use). Management of digital data through computerized systems is described in the IABZSAP, Section 6.0.

Figures G1 through G5 illustrate the minimum quality criteria required of the data prior to its use in the IA and BZ Projects. Tables G3 through G7 provide further database filter criteria, illustrated on the flowcharts, relative to qualification of data required for characterization and/or risk assessment. Duplicate records from legacy data (i.e., historical analytical data digitally archived within the RFETS SWD) were removed from the IA data set to improve efficiency and integrity. Criteria for defining duplicate records were as follows:

- Location code;
- Sample collection date;
- Test method;
- Laboratory analysis date;
- Chemical Abstract Service (CAS) number;
- Result type code;
- Result; and
- Dilution factor.

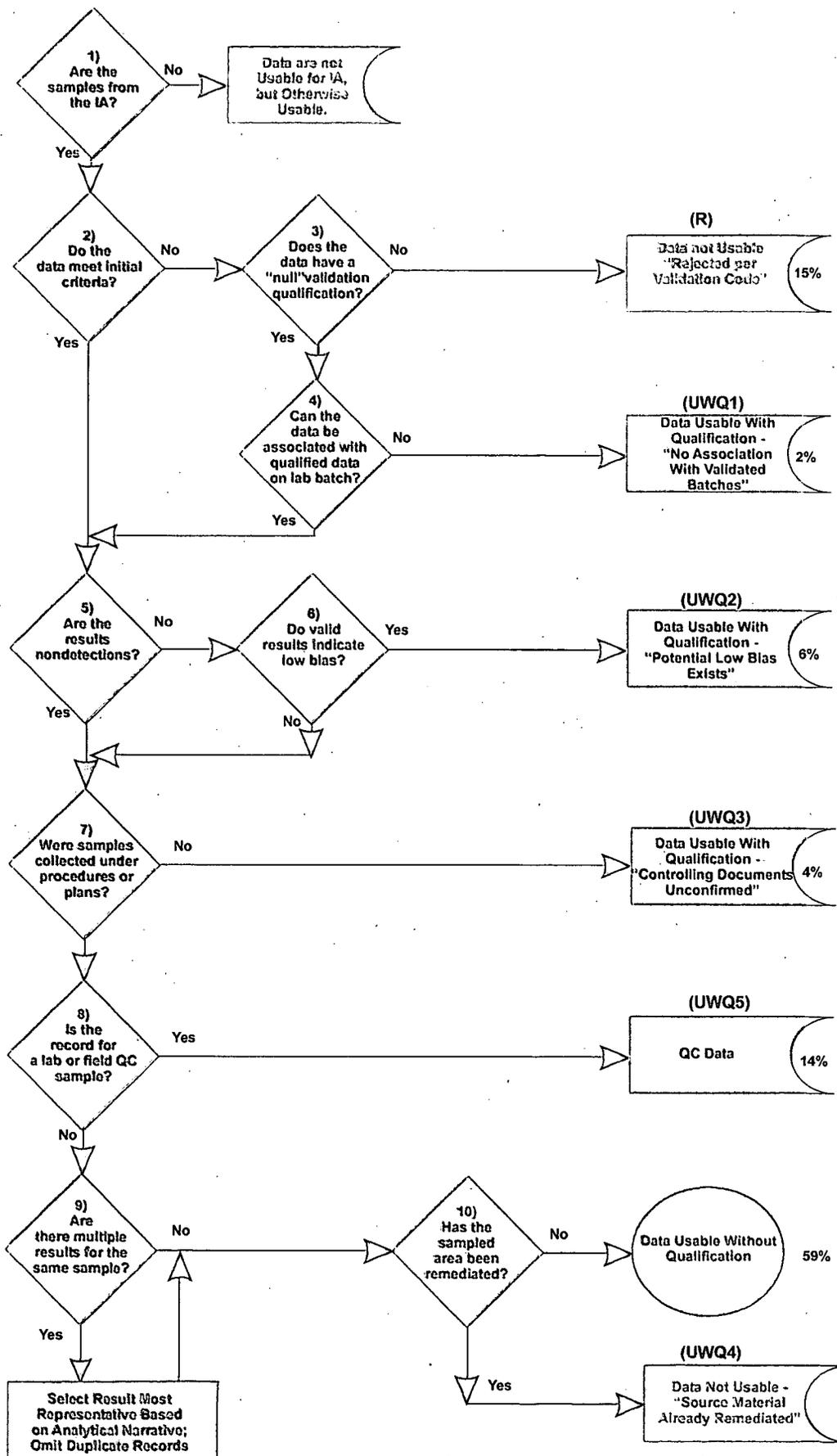
The ER Decision Management Plan (DMP) documents specifications, maintenance, and quality requirements for data produced, archived, and reported for the project. These data will be produced from various activities under control of the project, including characterization, remediation, and risk assessment.

**Figure G1
Data Quality Filter for the Industrial Area and Buffer Zone Sampling
and Analysis Plan**

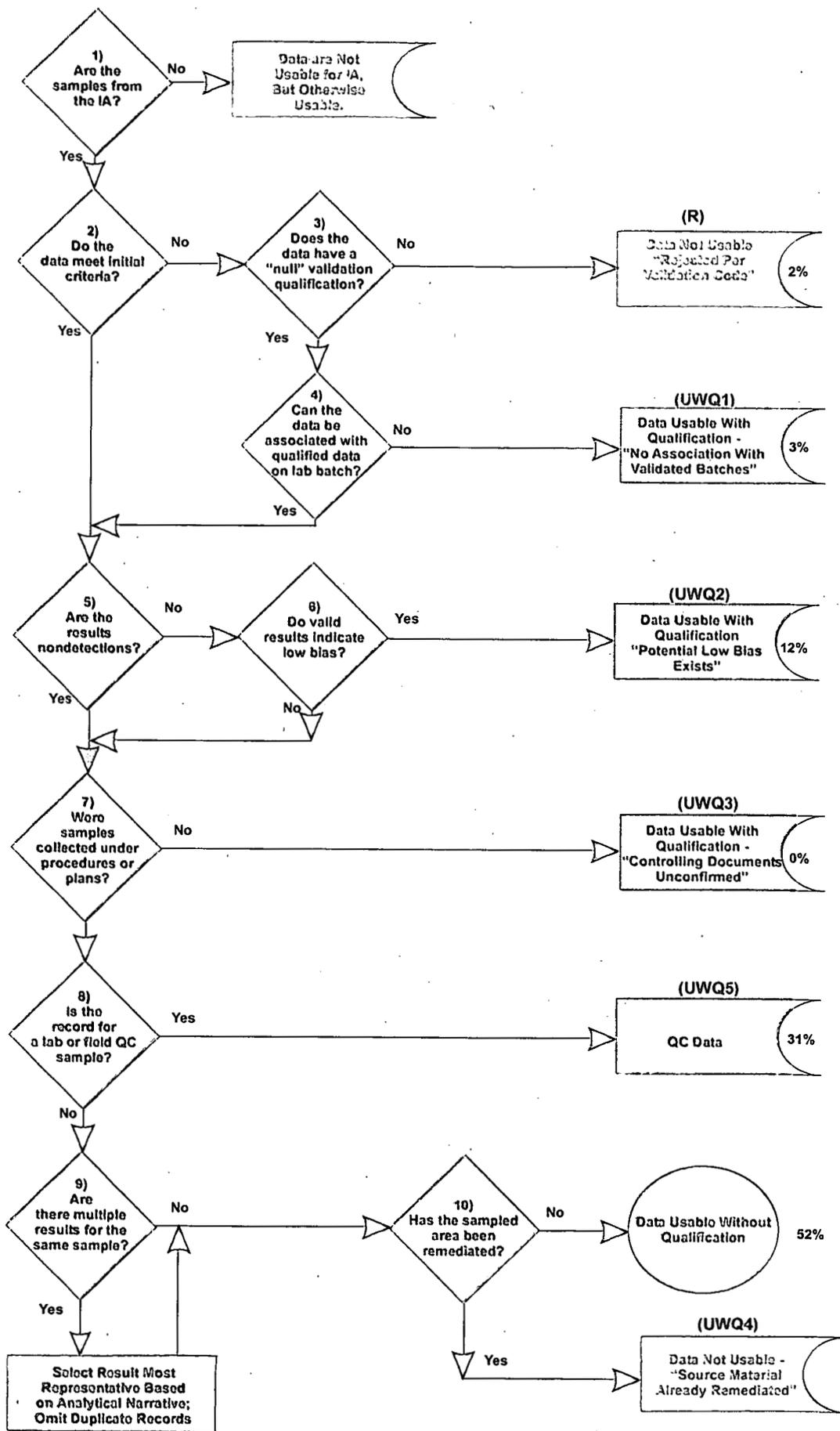


413

**Figure G2
Industrial Area Data Quality Filter - Subsurface Soil**

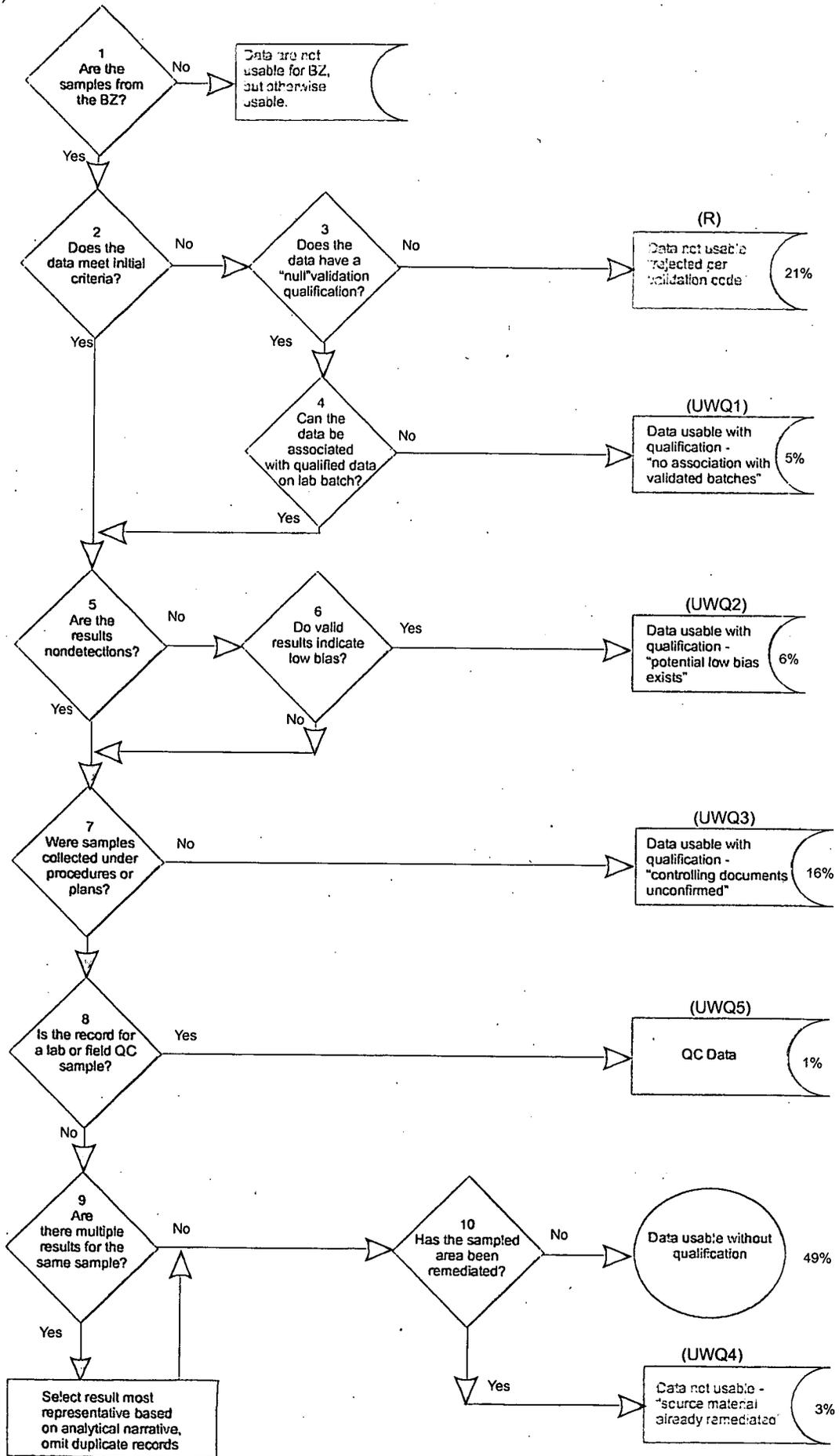


**Figure G3
Industrial Area Data Quality Filter - Surface Soil**



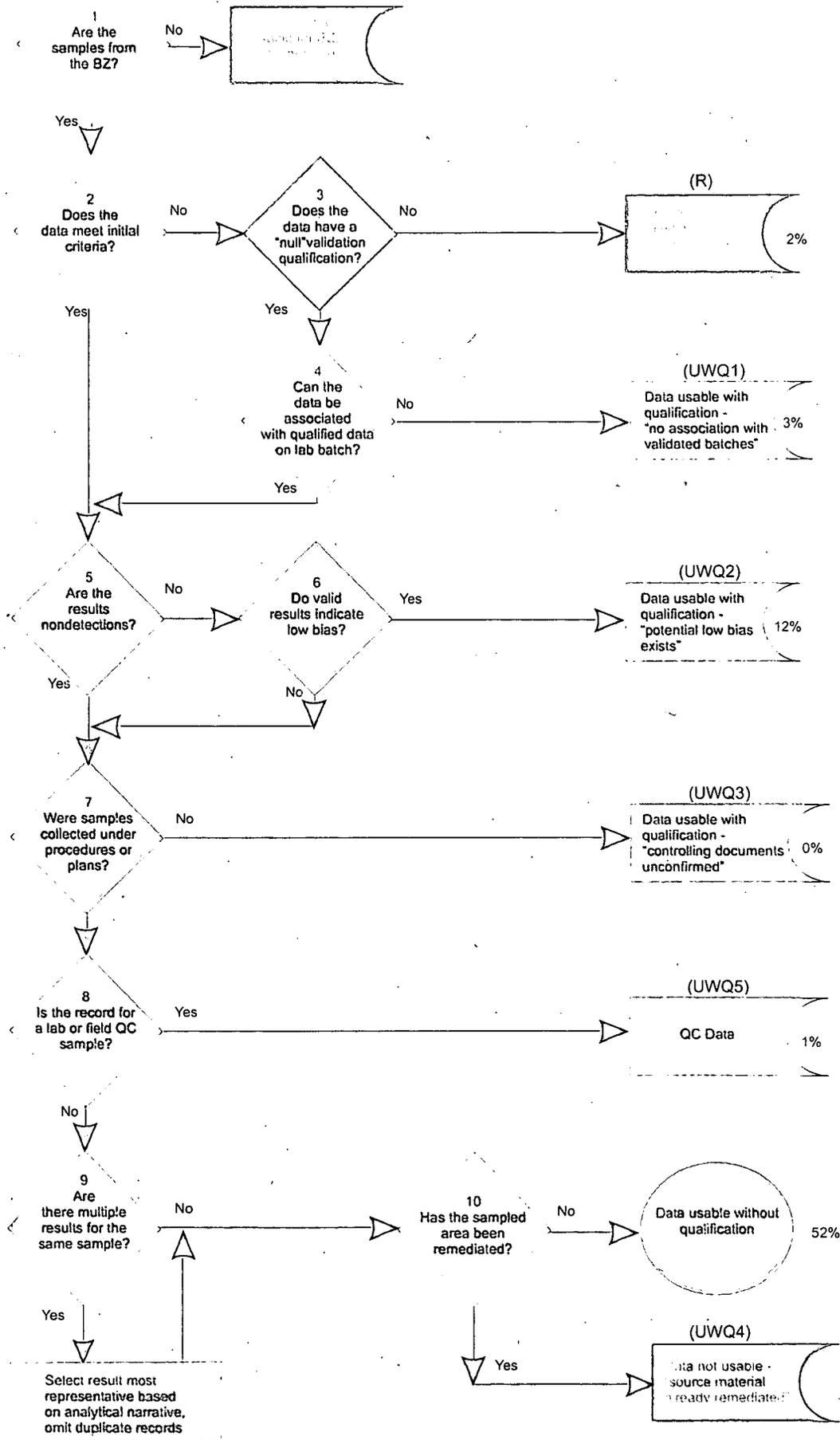
415

**Figure G4
Buffer Zone Data Quality Filter - Subsurface Soil**



416

**Figure G5
Buffer Zone Data Quality Filter - Surface Soil**



417

**Table G3
Validation Qualifier Codes**

Validation Qualifier Code	SWD Definition (sic)	How the Code Was Used in the Filter	Rationale for Inclusion in the Data Quality Filter
1	QC DATA; PACKAGE VERIFICATION (PARTIAL OR COMPLETE)	NA	NA
A	DATA ARE ACCEPTABLE, WITH QUALIFICATIONS	NA	NA
A1	DATA ARE ACCEPTED W/ QUALIF. BY ONSITE VALIDATORS	NA	NA
B	INDICATES COMPOUND WAS FOUND IN BLK AND SAMPLE	NA	NA
C	CALIBRATION	NA	NA
E	ASSOC VAL EXCEEDS CALIB RANGE DILUTE AND REANALYZE	NA	NA
J	Estimated quantity - Validation	NA	NA
J1	Estimated quantity - Verification	NA	NA
J2	Estimated quantity - Examination	NA	NA
N	HISTORICAL - VALIDATORS ASKED NOT TO VALIDATE THIS	NA	NA
P	SYSTEMATIC ERROR	NA	NA
R	Data are unusable - Validation	NA	NA
R1	Data are unusable - Verification	Fig 1, Diamond 3, Figs 2 & 3, Diamonds 2 & 3, R (rejected)	QC deficiency results in unquantifiable uncertainty of contaminant concentration
R2	Data are unusable - Examination	Fig 1, Diamond 3, Figs 2 & 3, Diamonds 2 & 3, R (rejected)	QC deficiency results in unquantifiable uncertainty of contaminant concentration
S	MATRIX SPIKE	NA	NA
U	ANALYZED, NOT DETECT AT/ABOVE METHOD DETECT LIMIT (MDL)	NA	NA
U1	ANALYZED, NOT DETECT AT/ABOVE MDL, VERIFICATION	NA	NA
V	No problems with the data - Validation	NA	NA
V1	No problems with the data - Verification	NA	NA
V2	No problems with the data - Examination	NA	NA
Y	ANALYTICAL RESULTS IN VALIDATION PROCESS	NA	NA
Z	VALIDATION WAS NOT REQUESTED OR PERFORMED	NA	NA
JA	Estimated, acceptable	NA	NA
JB	ORGANIC METHOD BLANK CONTAMINATION - VALIDATION	NA	NA
JB1	ORGANIC METHOD BLANK CONTAMINATION - VERIFICATION	NA	NA
JB2	ORGANIC METHOD BLANK CONTAMINATION - EXAMINATION	NA	NA
NJ	Associated value is presumptively estimated	NA	NA
NJ1	Value presumptively estimated - Verification	NA	NA
NJ2	Value presumptively estimated - Examination	NA	NA
R1	DATA ARE UNUSABLE - VERIFICATION	NA	NA
UJ	Associated value is considered estimated at an elevated detection	NA	NA
UJ1	Estimated at elevated level - Verification	NA	NA
UJ2	Estimated at elevated level - Examination	NA	NA
VA	Data are valid, acceptable with qualifications	NA	NA

NA This validation qualifier code was not used in the data quality filter.

417
6

Table G4
Data Quality Filter Validation Reason Codes

Validation Reason Code	Definition	How the Code Was Used In the Filter	Rationale for Inclusion in the Data Quality Filter
***	Unknown code from RFEDS	NA	NA
1	Holding times were exceeded	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
10	Laboratory Control Spike (LCS) recovery criteria were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
101	Holding times were exceeded (attributed to laboratory problem)	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
102	Holding times were grossly exceeded (attributed to laboratory problem)	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
103	Calibration correlation coefficient does not meet requirement	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
104	Calibration verification recovery criteria were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
105	Low-level check sample recovery criteria were not met	NA	NA
106	Calibration did not contain minimum number of STDS	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
107	Analyte detected but < RDL in calibration blank verification	NA	NA
109	Interference indicated in the ICS	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
11	Duplicate sample precision criteria were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
110	LCS recovery criteria were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
111	Laboratory duplicate sample precision criteria were not met	NA	NA
112	Predigestion matrix spike (MS) criteria were not met (+/- 25%)	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
113	Predigestion MS recovery is <30%	NA	NA
114	Postdigestion MS criteria were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
117	Serial dilution percent criteria not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
12	Predigestion MS criteria were not met (+/- 25%)	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
128	Improper aliquot size	NA	NA
129	Verification criteria for frequency or sequence were not met	NA	NA

Validation Reason Code	Definition	How the Code Was Used in the Filter	Rationale for Inclusion in the Data Quality Filter
13	Predigestion MS criteria were not met (<30%)	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
136	Minimum detectable activity (MDA) exceeded the RDL		
139	Tune criteria were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
14	Postdigestion MS recovery criteria were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
140	Requirements for independent calibration verification were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
141	Continuing calibration verification criteria were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
142	Surrogates were outside criteria	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
143	Internal standards were outside criteria	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
145	Results were not confirmed	NA	NA
147	Percent breakdown exceeded 20 percent	NA	NA
148	Linear range of measurement system was exceeded	NA	NA
149	Method, preparation, or reagent blank contamination > RDL	NA	NA
15	MS/matrix spike duplicate (MSD) was required but not performed	NA	NA
152	Reported data do not agree with raw data	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
153	Calculation error	NA	NA
155	Original result exceeded range of calibration, result report	NA	NA
159	Magnitude of calibration verification blank result exceeded	NA	NA
16	MS/MSD calibration correlation coefficient <0.995	NA	NA
168	QC sample frequency does not meet requirements	NA	NA
17	Serial dilution criteria were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
175	Blank data not submitted	NA	NA
18	Documentation was not provided	NA	NA
19	Calibration verification criteria not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
199	See hardcopy for further explanation	NA	NA
2	Holding times were grossly exceeded	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration

121
Industrial Area and Buffer Zone Sampling and Analysis Plan Modification 1 – Appendix G

Validation Reason Code	Definition	How the Code Was Used in the Filter	Rationale for Inclusion in the Data Quality Filter
20	AA duplicate injection precision criteria were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
201	Preservation requirements were not met by the laboratory	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
205	Unobtainable omissions or errors on SDP deliverables (requirement)	NA	NA
206	Analyses were not requested according to SOW.	NA	NA
207	Sample pretreatment or sample preparation method is incorrect	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
21	Reagent blanks exceeded MDA	NA	NA
213	Instrument detection limit is (IDL) greater than the associated rd	NA	NA
214	IDL is older than 3 months from date of analysis	NA	NA
216	Post digestion spike recoveries were outside of 85 -115% criteria	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
219	Standards have expired or are not valid	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
22	Tracer contamination	NA	NA
229	Element not analyzed in inductively coupled plasma (ICP) interference check sample	NA	NA
23	Improper aliquot size	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
230	QC sample/analyte (e.g. spike, duplicate, LCS) was not analyzed	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
231	MS/MSD criteria were not met.	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
232	Control limits were not assigned correctly.	NA	NA
234	QC sample does not meet method requirement	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
235	Duplicate sample control limits do no pass	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
236	LCS control limits do not pass	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
237	Prep blank control limits do not pass	NA	NA
238	Blank correction was not performed	NA	NA
24	Sample aliquot not taken quantitatively	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
242	Tracer requirements were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
243	Standard deviation (Std) values were not calculated correctly	NA	NA

424

Industrial Area and Buffer Zone Sampling and Analysis Plan Modification 1 - Appendix G

Validation Reason Code	Definition	How the Code Was Used in the Filter	Rationale for Inclusion in the Data Quality Filter
	(LCS, tracer, standards)		
246	Background calibration criteria were not met	NA	NA
249	Result qualified due to blank contamination	NA	NA
25	Primary standard had exceeded expiration date	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
250	Incorrect analysis sequence	NA	NA
251	Mis-identified target compounds	NA	NA
26	No raw data submitted by the Laboratory	NA	NA
27	Recovery criteria were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
28	Duplicate analysis was not performed	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
29	Verification criteria were not met	NA	NA
3	Initial calibration correlation coefficient <0.995	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
30	Replicate precision criteria were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
31	Replicate analysis was not performed	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
32	LCSs >+/- 3 sigma	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
33	LCSs >+/- 2 sigma and <+/- 3 sigma	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
36	MDA exceeded the RDL	NA	NA
37	Sample exceeded efficiency curve weight limit	NA	NA
38	Excessive solids on planchet	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
39	Tune criteria were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
4	Calibration verification criteria were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
40	Organics initial calibration criteria were not met	NA	NA
41	Organics cont. Calibration criteria were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
42	Surrogates were outside criteria	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
43	Internal standards were outside criteria	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration

123

Industrial Area and Buffer Zone Sampling and Analysis Plan Modification 1 – Appendix G

Validation Reason Code	Definition	How the Code Was Used in the Filter	Rationale for Inclusion in the Data Quality Filter
44	No mass spectra were provided	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
45	Results were not confirmed	NA	NA
47	Percent breakdown exceeded 20 percent	NA	NA
48	Linear range of instrument was exceeded	NA	NA
49	Method blank contamination	NA	NA
5	CRDL check sample recovery criteria were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
51	Nonverifiable Laboratory results and/or unsubmitted data	NA	NA
52	Transcription error	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
53	Calculation error	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
54	Incorrect reported activity or MDA	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
55	Result exceeds linear range, serial dilution validation reported	NA	NA
56	IDL changed due to significant figure discrepancy	NA	NA
57	Percent solids < 30 percent	NA	NA
58	Percent solids < 10 percent	NA	NA
59	Blank activity exceeded RDL	NA	NA
6	Incorrect calibration of instrument	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
60	Blank recovery criteria were not met	NA	NA
61	Replicate recovery criteria were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
62	LCS relative percent error criteria were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
63	LCS expected value was not submitted/verifiable	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
64	Nontraceable/noncertified standard was used	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
67	Sample results were not submitted/verifiable	NA	NA
68	Frequency of quality control samples was not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
69	Samples were not distilled	NA	NA
7	Analyte values > IDL were found in the blanks	NA	NA
70	Resolution criteria were not met	NA	NA

p27

Industrial Area and Buffer Zone Sampling and Analysis Plan Modification 1 - Appendix G

Validation Reason Code	Definition	How the Code Was Used in the Filter	Rationale for Inclusion in the Data Quality Filter
701	Holding times were exceeded (not attributed to Laboratory)	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
702	Holding times were grossly exceeded (not attributed to Laboratory)	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
703	Samples were not preserved properly in the field (not attrib)	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
71	Unit conversion of results	NA	NA
72	Calibration counting statistics were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
74	LCS data were not submitted	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
75	Blank data was not submitted	NA	NA
76	Instrument gain and/or efficiency not submitted	NA	NA
77	Detector efficiency criteria were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
78	MDAs were calculated by reviewer	NA	NA
79	Result obtained through dilution	NA	NA
8	Negative bias was indicated in the blanks	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
80	Spurious counts of unknown origin	NA	NA
801	Missing deliverables (required for data assessment)	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
802	Missing deliverables (not required for data assessment)	NA	NA
803	Omissions or errors on SDP deliverables (required for data A	NA	NA
804	Omissions or errors on SDP deliverables (not required for da	NA	NA
805	Information missing from narrative	NA	NA
806	Site samples were not used for sample matrix QC	NA	NA
807	Original documentation was not provided	NA	NA
808	Incorrect or incomplete Data Review Checklist (DRC)	NA	NA
81	Repeat count outside of 3 sigma counting error	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
810	EDD does not match hardcopy; may be resubmitted	NA	NA
82	Sample results were not corrected for decay	NA	NA
83	Sample results were not included on data sum. Table	NA	NA
84	Key fields wrong	NA	NA
85	Record added by validation	NA	NA

425

Industrial Area and Buffer Zone Sampling and Analysis Plan Modification 1 – Appendix G

Validation Reason Code	Definition	How the Code Was Used in the Filter	Rationale for Inclusion in the Data Quality Filter
86	Results considered. Qualitative not quantitative	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
87	Laboratory did not perform analysis for this record	NA	NA
88	Blank corrected results	NA	NA
89	Sample analysis was not requested	NA	NA
9	Interference indicated in the ICP interference check sample	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration.
90	Sample result was not validated due to reanalysis	NA	NA
91	Unit conversion, QC sample activity/uncertainty/MDA	NA	NA
99	See hardcopy for further explanation	NA	NA

NA This validation reason code was not used in the data quality filter.

**Table G5
Result Type Codes**

Result Type Code	Definition	How the Code Was Used in the Filter	Rationale for Inclusion in the Data Quality Filter
BL1	Reagent blank - 1st try (rads only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
BL2	Reagent blank - 2nd try (rads only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
BL3	Reagent blank - 3rd try (rads only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
BL4	Reagent blank - 4th try (rads only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
BLK	Blank	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
BS	Blank spike	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
BS1	Blank spike – 1st try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
BS2	Blank spike – 2nd try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
BS3	Blank spike – 3rd try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
BS4	Blank spike – 4th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
BSD	Blank spike duplicate	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
D	Laboratory duplicates	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
DIL	3rd analysis run dilution	NA	NA
DL	Normal 1st run dilution	NA	NA
DL1	Dilution	NA	NA
DL2	2nd analysis run dilution	NA	NA
DL3	Dilution	NA	NA
DL4	4th analysis run dilution	NA	NA
DL5	5th analysis run dilution	NA	NA
DL6	6th analysis run dilution	NA	NA
DL7	7th analysis run dilution	NA	NA
DL8	8th analysis run dilution	NA	NA
DL9	9th analysis run dilution	NA	NA
DP1	Laboratory duplicate – 1st try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
DP2	Laboratory duplicate – 2nd try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
DP3	Laboratory duplicate – 3rd try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
DUP	Laboratory duplicate	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
FIX	Laboratory incorrectly used tic or	NA	NA

427

Industrial Area and Buffer Zone Sampling and Analysis Plan Modification 1 - Appendix G

Result Type Code	Definition	How the Code Was Used in the Filter	Rationale for Inclusion in the Data Quality Filter
	surrogate, Quantalex will fix		
LC1	Laboratory control sample - 1st try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
LC10	Laboratory control sample - 10th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
LC11	Laboratory control sample - 11th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
LC12	Laboratory control sample - 12th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
LC1B	Laboratory control blank - 1st try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
LC2	Laboratory control sample - 2nd try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
LC3	Laboratory control sample - 3rd try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
LC4	Laboratory control sample - 4th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
LC5	Laboratory control sample - 5th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
LC6	Laboratory control sample - 6th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
LC7	Laboratory control sample - 7th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
LC8	Laboratory control sample - 8th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
LC9	Laboratory control sample - 9th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
LCS	Laboratory control sample	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
LD	Laboratory duplicate	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
LD1	1st Laboratory duplicate	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
LD1B	Laboratory control duplicate blank	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
LD2	2nd Laboratory duplicate	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
LD3	3rd Laboratory duplicate	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
LD4	4th Laboratory duplicate	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
LD5	5th Laboratory duplicate	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
LD6	6th Laboratory duplicate	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
LD7	7th Laboratory duplicate	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
LD8	8th Laboratory duplicate	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are

427

Industrial Area and Buffer Zone Sampling and Analysis Plan Modification 1 – Appendix G

Result Type Code	Definition	How the Code Was Used in the Filter	Rationale for Inclusion in the Data Quality Filter
			aggregated for characterization, risk assessment, or statistics.
LD9	9th Laboratory duplicate	Figures 2 & 3, Diamond 10, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
LFB	Laboratory field blank	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
MB	Method blank	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
MB1	Method blank - 1st try (non-rad only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
MB2	Method blank - 2nd try (non-rad only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
MB3	Method blank - 3rd try (non-rad only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
MB4	Method blank - 4th try (non-rad only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
MB5	Method blank - 5th try (non-rad only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
MB6	Method blank - 6th try (non-rad only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
MB7	Method blank - 7th try (non-rad only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
MB8	Method blank - 8th try (non-rad only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
MB9	Method blank - 9th try (non-rad only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
MD1	Matrix spike duplicate - 1st try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
MD2	Matrix spike duplicate - 2nd try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
MD3	Matrix spike duplicate - 3rd try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
MD4	Matrix spike duplicate - 4th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
MD5	Matrix spike duplicate - 5th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
MD6	Matrix spike duplicate - 6th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
MD7	Matrix spike duplicate - 7th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
MD8	Matrix spike duplicate - 8th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
MD9	Matrix spike duplicate - 9th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
MS	Matrix blank	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
MS1	Matrix spike - 1st try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
MS2	Matrix spike - 2nd try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are

429

Industrial Area and Buffer Zone Sampling and Analysis Plan Modification I - Appendix G

Result Type Code	Definition	How the Code Was Used in the Filter	Rationale for Inclusion in the Data Quality Filter
			aggregated for characterization, risk assessment, or statistics.
MS3	Matrix spike - 3rd try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
MS4	Matrix spike - 4th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
MS5	Matrix spike - 5th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
MS6	Matrix spike - 6th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
MS7	Matrix spike - 7th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
MS8	Matrix spike - 8th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
MS9	Matrix spike - 9th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
MSD	Matrix blank duplicate	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
PB	Prep blank	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
PB1	Preparation blank - 1st try (tritium only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
PB2	Preparation blank - 2nd try (tritium only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
PB3	Preparation blank - 3rd try (tritium only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
PB4	Preparation blank - 4th try (tritium only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
R	Reanalysis	NA	NA
RA1	Reanalysis 1st try	NA	NA
RA2	Reanalysis 2nd try	NA	NA
RA3	Reanalysis 3rd try	NA	NA
RB	Reagent blank	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
RB1	Reagent blank - 1st analysis	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
RB2	Reagent blank - 2nd analysis	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
RE	Re-extraction	NA	NA
REA	Reanalysis	NA	NA
REP	Replicate	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
REX	Re-extraction	NA	NA
RP1	Replicate - 1st try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
RP2	Replicate - 2nd try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
RP3	Replicate - 3rd try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are

Result Type Code	Definition	How the Code Was Used in the Filter	Rationale for Inclusion in the Data Quality Filter
			aggregated for characterization, risk assessment, or statistics.
RP4	Replicate - 4th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
RS	Historical value - unknown meaning	NA	NA
RX1	Re-extraction 1st try	NA	NA
RX2	Re-extraction 2nd try	NA	NA
RX3	Re-extraction 3rd try	NA	NA
RX4	Re-extraction 4th try	NA	NA
RX5	Re-extraction 5th try	NA	NA
RX6	Re-extraction 6th try	NA	NA
RX7	Re-extraction 7th try	NA	NA
RX8	Re-extraction 8th try	NA	NA
RX9	Re-extraction 9th try	NA	NA
S	Spike	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
S1	Spike 1st try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
S2	Spike 2nd try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
S3	Spike 3rd try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
SD	Spike duplicate	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
SP	Spike 3rd try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
SPK	Spike	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
SUR	Surrogate	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
TB	Trip blank	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
TB1	Trip blank - 1st analysis	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
TB2	Trip blank - 2nd analysis	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data are aggregated for characterization, risk assessment, or statistics.
TIC	Tentatively identified compound	NA	NA
TR1	Target analysis 1st try	NA	NA
TR2	Target analysis 2nd try	NA	NA
TR3	Target analysis 3rd try	NA	NA
TR4	Target analysis 4th try	NA	NA
TR5	Target analysis 5th try	NA	NA
TR6	Target analysis 6th try	NA	NA
TR7	Target analysis 7th try	NA	NA
TR8	Target analysis 8th try	NA	NA
TR9	Target analysis 9th try	NA	NA
TRG	Target	NA	NA
UNK	Historical value - unknown meaning	NA	NA

431

Industrial Area and Buffer Zone Sampling and Analysis Plan Modification 1 - Appendix G

Result Type Code	Definition	How the Code Was Used in the Filter	Rationale for Inclusion in the Data Quality Filter
------------------	------------	-------------------------------------	--

NA This result type code was not used in the data quality filter.

**Table G6
Validation Reason Codes**

Reason Code	Reason Description
101	Holding times were exceeded (attributed to Laboratory problem)
102	Holding times were grossly exceeded (attributed to Laboratory problem)
103	Calibration correlation coefficient does not met requirements
104	Calibration verification recovery criteria were not met
105	Low-level check sample recovery criteria were not met
106	Calibration did not contain minimum number of Standards
107	Analyte detected but < RDL in calibration blank verification
109	Interference indicated in the ICP Interference Check Sample
110	LCS recovery criteria were not met
111	Laboratory duplicate sample precision criteria were not met
112	Predigestion MS criteria were not met (+/- 25%)
113	Predigestion MS recovery is <30%
114	Postdigestion MS criteria were not met
115	MS/MSD was required but not performed
116	MS/MSD calibration correlation coefficient <0.995
117	Serial dilution percent D criteria were not met
123	Improper aliquot size
128	Laboratory duplicate was not analyzed
129	Verification criteria for frequency or sequence were not met
130	Replicate precision criteria were not met
131	confirmation % difference criteria not met
132	Laboratory control samples >+/- 3 sigma
136	MDA exceeded the RDL
139	Tune criteria were not met
140	Requirements for independent calibration verification were not met
141	Continuing calibration verification criteria were not met
142	Surrogates were outside criteria
143	Internal standards were outside criteria
145	Results were not confirmed
147	Percent breakdown exceeded 20 percent
148	Linear range of measurement system was exceeded
149	Method, preparation, or reagent blank contamination > RDL
150	Unknown carrier volume
152	Reported data do not agree with raw data
153	Calculation error
155	Result exceeds linear range, serial dilution value reported
159	Magnitude of calibration verification blank result exceeded the RDL
164	Standard traceability or certification requirements not met
166	Carrier aliquot nonverifiable
168	QC sample frequency does not meet requirements
170	Resolution criteria were not met
172	Calibration counting statistics were not met
174	LCS data were not submitted
175	Blank data were not submitted

432

Industrial Area and Buffer Zone Sampling and Analysis Plan Modification 1 – Appendix G

Reason Code	Reason Description
177	Detector efficiency criteria were not met
188	Blank corrected results
199	See hardcopy for further explanation
201	Preservation requirements were not met by the Laboratory
205	Unobtainable omissions or errors on SDP deliverables (required for data assessment)
206	Analyses were not requested according to SOW
207	Sample pretreatment or sample preparation method is incorrect
211	Poor cleanup recovery
212	Instrument detection limit was not provided
213	Instrument detection limit is greater than the associated RDL
214	IDL is older than 3 months from date of analysis
215	Blank results were not reported to the IDL/MDL
216	Post digestion spike recoveries were outside of 85 –115% criteria
217	Post digestion spike recoveries were less than 10%
218	Sample COC was not verifiable (attributed to laboratory)
219	Standards have expired or are not valid
220	Toxicity Characteristic Leaching Procedure (TCLP) sample percent solids are less than 0.5%
222	TCLP particle size was not performed
224	Incomplete TCLP extraction data
225	Insufficient TCLP extraction time
226	Tentatively identified compound (TIC) misidentification
227	No documentation regarding deviations from methods or SOW
228	Calibration requirements affecting data quality have not been met
229	Element not analyzed in ICP Interference Check Sample
230	QC sample/analyte (e.g. Spike, Duplicate, LCS) not analyzed
231	MS/MSD criteria were not met
232	Control limits not assigned correctly
233	Sample matrix QC does not represent samples analyzed
234	QC sample does not meet method requirement
235	Duplicate sample control limits do not pass
236	LCS control limits do not pass
237	Prep blank control limits do not pass
238	Blank correction was not performed
239	Winsorized mean and std deviation of the same were not calculated or calculated incorrectly
240	Sample prep for soil, sludge, or sediments have not been homogenized or aliquotted properly
241	No micro ppt. or electroplating data available
242	Tracer requirements were not met
243	Standard values were not calculated correctly (LCS, tracer or standards)
244	Standard or tracer is not National Institute of Standards Technology (NIST) traceable
245	Energy calibration criteria was not met
246	Background calibration criteria was not met
247	Sample or control analytes not chemically separated from each other
248	Single combined TCLP result was not repeated for sample with both miscible and nonmiscible liquids
249	Result qualified due to blank contamination
250	Incorrect analysis sequence
251	Mis-identified target compounds
252	Result is suspect due to level of dilution

433

Reason Code	Reason Description
701	Holding times were exceeded (not attributed to laboratory)
702	Holding times were grossly exceeded (not attributed to laboratory)
703	Samples were not preserved properly in the field (not attributed to laboratory)
704	Sample chain-of-custody (COC) was not verifiable (not attributed to laboratory)
801	Missing deliverables (required for data assessment)
802	Missing deliverables (not required for data Assessment)
803	Omissions or errors on SDP deliverables (required for data assessment)
804	Omissions or errors on SDP deliverables (not required for data assessment)
805	Information missing from narrative
806	Site samples not used for sample matrix QC
807	Original documentation not provided
808	Incorrect or incomplete DRC
809	Non-Site samples reported with Site samples
COMMENTS	
131	Added 8/10/99 per TechLaw request
252	Added 11/3/00 per letter 01EAB003

**Table G7
Validation Qualifiers**

Qualifier	Description
V	No problems with the data were observed at the indicated review level.
J	The associated value is an estimated quantity.
JB	Result was qualified due to blank contamination for results below the RDL.
U	The associated value is considered undetected at an elevated level of detection.
NJ	The associated value is presumptively estimated.
UJ	The associated value is considered estimated at an elevated level of detection.
R	The data are unusable. (Note: Analyte may or may not be present.)

3.2.3 Data Quality Assessment

Data Quality Assessment (DQA) is the scientific and statistical evaluation of data to determine whether data are adequate to support project decisions and quantify uncertainties. DQA consists of two basic processes: verification and validation (V&V), with application of statistical tests as necessary. V&V ensure that data used to design and conclude the project are usable and defensible.

Verification and Validation

Data collected during ER characterization and remediation sampling will be verified and validated in accordance with QA requirements. Verification will consist of ensuring that data received from the vendor(s) are complete and correctly formatted. Validation will consist of a systematic comparison of QC requirements with QC results reported by the vendor (e.g., relative to LCS, MS, MSD, blanks). The V&V module (process) will establish ultimate usability of the data by determining, reporting, and archiving the following criteria relative to each measurement set or batch:

434

- Precision;
- Accuracy;
- Bias;
- Sensitivity; and,
- Completeness.

Representative portions of hardcopy data will be formally validated. Formal validation is currently performed on a Sitewide basis at approximately 25 percent frequency of all RFETS subcontracted laboratories managed by K-H ASD. Satisfactory validation at this frequency indicates that the subcontracted laboratories are operating competently on an industry-wide basis. More specifically, analytical procedures are implemented under adequate quality controls. Sitewide data validation coupled with annual laboratory audits also provides the inference that all analytical and radiochemical results that are not specifically validated are under adequate control as well.

PARCC Parameters

Data will be evaluated relative to the precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters as described in the following subsections. Data aggregation and statistical tests are described in the appropriate sections throughout the IABZSAP.

Precision

Precision is a measure of the reproducibility of results, and is measured through the following sample types:

- Laboratory replicates (radionuclides);
- MSD; and
- Field duplicates.

Through use of these samples, precision is evaluated from two perspectives:

1. Analytical standpoint (reproducibility within the laboratory that reflects analytical precision inherent to the method); and
2. Overall project standpoint, which combines both analytical precision and reproducibility of the field sampling method specific to the matrix type.

Precision may be expressed quantitatively by at least two functions. The most typical measure for nonradiological analyses is the relative percent difference (RPD) term, whereas, because of the stochastic nature of radioactivity, a statistical measure is better suited for evaluating radiological reproducibility - the duplicate error ratio (DER).

Chemical

$$RPD = \frac{C_1 - C_2}{(C_1 + C_2)/2} * 100$$

Where:

- C₁ = first sample
- C₂ = duplicate sample

The RPD targets are 35 percent for solids and 20 percent for liquids. If QC results exceed these tolerances, the data must be qualified and/or additional samples may be required.

Radiological

$$DER = \frac{C_1 - C_2}{\sqrt{(TPU^2 + TPU^2)}}$$

Where:

TPU = total propagated uncertainty

(Note: The counting error, also known as the 2-sigma error, may be used in lieu of the TPU as a conservative measure. If precision exceeds the critical value of 1.96, TPU should be used in the equation prior to qualifying precision of the measurements in question.)

The DER must be less than 1.96 as defined in Evaluation of Radiochemical Data Usability (Lockheed Martin 1997). If DER values exceed the test statistic, associated data must be qualified and additional samples may be necessary. Alternatively, an RPD may also be evaluated to put the statistical exceedance in perspective (i.e., the RPD value may be used as a benchmark value). Commentary will be provided as to how qualifications in precision affect overall uncertainty in the sample results.

Ongoing precision of the radiological survey instrumentation will be evaluated based on logging periodic (daily) source check measurements. Any measurement that exceeds defined tolerance limits (+20 percent) will result in corrective action (e.g., instrument repair or replacement) before measurement of real samples. Further tolerance specifications may be found in the applicable RSPs.

Accuracy

Accuracy is a measure of how closely a measurement corresponds to a standard reference (or the "true") value.

Accuracy will be based on the following criteria:

- Calibrations, with reference standards, periodic full-range and 1-point "performance checks" (all equipment);
- LCS/spikes;

- Laboratory MS;
- Relative standard deviation (%RSD);
- Laboratory blanks (method and equipment);
- Chemical yield (radionuclides);
- Counting time (radionuclides; XRF); and
- Sensor efficiency (radionuclides).

In general, accuracy of instrumentation will be based on annual calibrations of instrumentation and daily source checks that perform within specified tolerances (e.g., ± 20 percent) as specified in the RSPs (radionuclides) or manufacturer's specifications (nonradiological field instrumentation). Novel or prototypical instrumentation also requires satisfactory passage of blind performance evaluation (PE) samples (within 20 percent of standard value), where existing validation and verification documentation does not cover the equipment (configuration), geometry, or matrix of interest.

Accuracy relative to a standard reference value is typically evaluated relative to percent recovery (%R) or, stated differently, a percent difference (%D), expressed as

$$\%D = \frac{X_1 - X_2}{X_1} * 100$$

Where:

- x = observation (concentration or activity)
- n = number of observations

Bias will also be considered as a component affecting accuracy, as it indicates the tendency of a measurement system to be consistently higher or lower than the true value. Bias will be discussed relative to its impact on final project decisions.

Representativeness

Representativeness will be achieved through use of the IABZSAP, together with the use of standard field sampling and analytical procedures. All work-controlling documents undergo required reviews and approvals to ensure representativeness of the sampling and analysis effort. Compliance with controlling documents coupled with implementation of other quality controls contributes to corroboration of representative sampling. If the representativeness of any sample set is ambiguous, the data will be qualified and/or additional samples may be required.

Completeness

Completeness is a quantitative measure of data quality expressed as the percentage of valid or acceptable data obtained from the project relative to each medium and analytical suite of interest. The completeness goal for each discrete IA and BZ sampling effort is 90 percent. If completeness of any sample set is not achieved, additional data will be required or the data set (and decisions) qualified.

Completeness will be established based on a comparison (ratio, expressed as a percentage) of actual sample results reported versus the number of samples planned.

The formula for calculating completeness is presented below:

$$\% \text{ completeness} = \frac{\text{number of valid results}}{\text{number of planned results}}$$

A summary table, such as the one outlined below, will be used to summarize the data subsets; specific analytes will be broken-out as necessary.

Hazard Type	Planned Number of Samples	Actual Number of Samples	Completeness	Comments
Chemical				
Radiochemical				
Radiological Survey unit				
Other				

Comparability

All results will be comparable with characterization analyses (methods and media) on a national- and DOE Complex-wide basis. This comparability will be based on nationally recognized methods (especially EPA-approved methods), systematic quality controls, use of standardized units of measure, and thorough documentation of the planning, sampling, and analysis process.

Sample collection methods and analyses in accordance with the protocols specified in the IABZSAP provide comparability with other similar media types and contaminants of concern (COCs) across the DOE Complex and the commercial sector.

Sensitivity

All measurements must have adequate sensitivity, or resolution, to confidently compare results with action levels (ALs). For chemical constituents, MDLs will be provided based on formal MDL studies as stated in Appendix E. For radiochemical constituents, MDLs must also be less than half the associated action level. Derivations of radiological MDLs will be provided for all measurement equipment used, and will follow guidance provided in §6.7.1 of MARSSIM (EPA 1997b).

3.3 PROCUREMENT

Quality requirements will be specified in procurement and subcontract documents. All contracts (subcontracts) that have the potential to affect quality of IA Project services or deliverables will be reviewed for QA requirements to ensure that adequate quality controls are established and implemented. Quality control of procurements will be implemented as described in PRO-572-PQR-001, *Procurement Quality Assurance Requirements*.

438

3.4 INSPECTION AND ACCEPTANCE TESTING

Items or activities that require inspections and/or acceptance testing will be specified in work-controlling documentation (e.g., work plans, SOPs, and data management plans). Acceptance criteria and any hold points will be clearly defined, and will be based on manufacturer's specification unless otherwise stated. M&TE will be accepted or rejected based on calibration information and pre-established tolerances, including unique identification, traceability, accuracy, resolution, measurement ranges, and acceptance/rejection criteria. Materials and equipment that affect quality (of items or services) or H&S will be controlled (i.e., identified, maintained, and traceable) according to their intended purpose. Measurement, monitoring, and data collection equipment will be of the accuracy and resolution needed for their intended purposes based on calibrations. Calibrations will be traceable to nationally recognized or industry standards. Essential policies, plans, procedures, decisions, data, and transactions of the project will be documented to an appropriate level of detail.

4.0 ASSESSMENTS

4.1 MANAGEMENT ASSESSMENT

At least once during the fielding of the project, management will evaluate the organization to determine the effectiveness of the QAPjP and overall K-H organization performance. Management assessments will be documented in formal reports, and will be implemented in accordance 3-W24-MA-002, *K-H Management Assessment Program*.

4.2 INDEPENDENT ASSESSMENT

Independent assessments, in contrast to management assessments, will be performed by personnel who are not directly responsible for the work being performed. Independent assessments will be performed according to MAN-013-SIOM, *Site Integrated Oversight Manual*.

5.0 REFERENCES

10 CFR 830.120, Quality Assurance.

ANSI/ASQC 1994, *American National Standard Institute/American Society of Quality Control, Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs, E-4*.

DOE Order 5400.1, General Environmental Protection Program.

DOE, 1997, Rocky Flats Integrated Monitoring Plan, Rocky Flats Environmental Technology Site, Golden, Colorado, June.

DOE, 1999, DOE Order 414.1A, Quality Assurance.

DOE, EPA, and CDPHE, 2003, Rocky Flats Cleanup Agreement, Modification, June.

EPA, 1994a, Guidance for the Data Quality Objectives Process, EPA QA/G-4.

EPA, 1994b, USEPA Contract Laboratory Program National Function Guidelines for Inorganic Data Review.

EPA, 1995, Superfund Innovative Technology Evaluation Program, Final Demonstration Plan for the Evaluation of Field Portable X-Ray Fluorescence Technologies, EPA Contract No. 68-CO-0047.

EPA, 1997a, EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations, QA/R-5.

EPA, 1997b, 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, 1999, Guidance on Environmental Data Verification and Validation, QA/G-8.

Lockheed Martin, 1997, Evaluation of Radiochemical Data Usability, ES/ER/MS-5, Lockheed Martin Environmental Restoration Program, April.

Site Documents and Procedures

K-H, QAPD-001, Quality Assurance Program Description.

MAN-063-DC-06-01, Document Control Program Manual

MAN-001-SDRM, Site Document Requirements Manual

1-V41-RM-001, Records Management Guidance for Records Sources

K-H Module RC01, Isotopic Determinations by Alpha Spectrometry

K-H Module GR04, General Laboratory Requirements.

K-H Module SS05, Inorganic Metals

K-H Module RC11, Determination of Radionuclides by Gamma Spectrometry

K-H Module SS01, Volatile Organics

K-H Module SS02 Semivolatile Organics

K-H Module SS03, PCB/Pesticides

PRO-572-PQR-001, Procurement Quality Assurance Requirements

3-W24-MA-002, K-H Management Assessment Program

MAN-013-SIOM, Site Integrated Oversight Manual

1-PRO-072-001, Inspection and Acceptance Test Program

MAN-071-IWCP, Integrated Work Control Manual

RFETS Radiological Control Manual (Radcon Manual)

1-W56-COEM-AMN-101, Site Design Control Manual

MAN-066-COOP, Conduct of Operations Manual

K-H Team Quality Assurance Program

EPA Method 6200, Field Portable XRF Spectrometry

RFETS Radiation Control Manual

APPENDIX H

Elevated Measurement Comparison

LIST OF TABLES

Table H1	Hot Spot Equation Analysis Single Sample Exceedance of Action Level Pentachlorophenol Soil Data	2
Table H2	Hot Spot Equation Analysis Single Sample Exceedance of WRW Action Level HCB Soil Data	5

ACRONYM LIST

AF	area factor
AOC	area of concern
AL	Action Level
BZ	Buffer Zone
COC	contaminant of concern
EMC	Elevated Measurement Comparison
ft ²	square feet
hs	hot spot
HCB	hexachlorobenzene
IA	Industrial Area
IABZSAP	Industrial Area and Buffer Zone Sampling and Analysis Plan
IHSS	Individual Hazardous Substance Site
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
mg/kg	milligrams per kilogram
MYAPC	Maine Yankee Atomic Power Company
PAC	Potential Area of Concern
RESRAD	Residual Radioactivity Computer Code
RFCA	Rocky Flats Cleanup Agreement
RFETS	Rocky Flats Environmental Technology Site
SAP	Sampling and Analysis Plan
UBC	Under Building Contamination
UCL	upper confidence limit
WRW	Wildlife Refuge Worker

The Elevated Measurement Comparison (EMC) is discussed in Section 5.3 of the Industrial Area (IA) and Buffer Zone (BZ) Sampling and Analysis Plan (SAP) (IABZSAP). The EMC (MYAPC 1999) defines significantly high measurements relative to the size of a hot spot, magnitude of an action level (AL), and mean of the surrounding measurements. The comparison includes an equation that depends on several variables: AL, measured value, size of the hot spot, and size of the area of concern (AOC). The EMC is applicable to all sample results or hot spots that are above the Rocky Flats Cleanup Agreement (RFCA) WRW ALs. In AOCs where all sample results are less than ALs, the EMC is not required.

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 WRW AL, action is indicated. The EMC is calculated using Equation H1.

Equation H1

$$\text{If: } \sum_{i=1}^n \left[\frac{95\% \text{UCL}_{\text{AOC}}}{\text{AL}} \right]_i + \sum_{j=1}^n \left[\frac{(\text{SampleResult}_{\text{hs}} - 95\% \text{UCL}_{\text{AOC}})}{\left(\frac{\text{AL} * \text{Area}_{\text{AOC}}}{\text{Area}_{\text{hs}}} \right)} \right]_j \geq 1$$

Then: Action is Indicated

Where:

(95%UCL)_{AOC} = 95% UCL of the mean concentration in Individual Hazardous Substance Sites (IHSSs), Potential Areas of Concern (PACs), Under Building Contamination (UBC) Sites, or IHSS Groups

AL = WRW AL

(Sample Result)_{hs} = hot spot sample result

(Area)_{AOC} = IHSS Group

(Area)_{hs} = hot spot site (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 H1 will be applied to each contaminant of concern (COC) separately. The first term will be used for all observations less than WRW ALs within the AOC. As shown in Equation H1, the first term is defined as the ratio of the 95% upper confidence limit (UCL) of the mean to the RFCA WRW AL for the AOC. Observations greater than the ALs will be excluded from the 95% UCL calculations because this type of censorship will ensure that the data set will comply with normality assumptions required for calculating the 95% UCL.

The second term (j) of the equation will be applied to each sample result that exceeds the RFCA WRW 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 H1 is defined as the difference between the 95% UCL of the mean

concentration and the sample result divided by the RFCA WRW AL for the given COC. The AL is area-weighted, which is appropriate because the weighted exposure to contamination is random across an area.

For radionuclides, the equation is shown in Equation H2. An area factor (AF) consistent with Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (1997) guidance is applied to the AL as shown in Equation H2. Radionuclide-specific AFs are based on exposure pathway models, which can be estimated from Residual Radioactivity Computer Code (RESRAD) simulations.

Equation H2

$$\text{If: } \sum_{i=1}^n \left[\frac{95\%UCL_{AOC}}{AL} \right]_i + \sum_{j=1}^n \left[\frac{(\text{SampleResult}_{hs} - 95\%UCL_{AOC})}{(AL * AF)} \right]_j \geq 1$$

Then: Action is Indicated

Where:

(95%UCL)_{AOC} = 95% UCL of the mean concentration in IHSS, PAC, or UBC Site

AL = WRW 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

Examples 1, 2, and 3 use the data listed in Table H1 to illustrate how the equation works for different hot spot sizes and hot spot concentrations. These data were fabricated and are not representative of any area at the Rocky Flats Environmental Technology Site (RFETS).

Table H1
Hot Spot Equation Analysis
Single Sample Exceedance of Action Level Pentachlorophenol Soil Data

Sampling Location	Pentachlorophenol Soil Concentration at Sampling Location (mg/kg)	Pentachlorophenol Hot Spot Concentration in AOC (mg/kg)	Part 2 Hot Spot Equation Ratio *	Part 1 + Part 2 Hot Spot Equation Total Ratio **
1	50	5000	0.05	0.34
2	100	6000	0.06	0.35
3	150	7000	0.07	0.37
4	200	8000	0.09	0.38
5	250	9000	0.10	0.39
6	500	10000	0.11	0.40
7	600	20000	0.24	0.54
8	700	30000	0.37	0.67
9	600	40000	0.51	0.80
10	800	50000	0.64	0.93
11	1000	60000	0.77	1.06
12	1500	70000	0.90	1.19

Sampling Location	Pentachlorophenol Soil Concentration at Sampling Location (mg/kg)	Pentachlorophenol Hot Spot Concentration in AOC (mg/kg)	Part 2 Hot Spot Equation Ratio *	Part 1 + Part 2 Hot Spot Equation Total Ratio **
13	2000	80000	1.03	1.32
14	2500	90000	1.16	1.45
15	3000	100000	1.29	1.58
Number of Sample Results	15			
Mean Concentration	930.0			
Standard Deviation	916.7			
95% Confidence Interval	463.9			
95% UCL of Mean	1,393.9			
WRW AL	4,770.0			
WRW Ratio (Part I - Hot Spot Equation) $(\frac{95\%UCL}{AL})_{AOC/AL}$	0.2922			

* - $([Sample\ result]_{hs} - [95\%UCL]_{AOC}) / ([AL][Area]_{AOC} / [Area]_{hs})$

** - Assumes that only one hot spot is present.

Example 1:

Assume 1 hot spot, pentachlorophenol concentration equals 5,000 milligrams per kilogram (mg/kg), the area of the hot spot equals 1 square foot (ft²) and the area of concern equals 16 ft².

$$\sum_{i=1}^n \left[\frac{1393.9}{4770.0} \right]_i + \sum_{j=1}^n \left[\frac{(5000_{hs} - 1393.9_{AOC})}{\left(\frac{4770 * 16}{1} \right)} \right]_j = .34$$

This value is less than 1, therefore this hot spot does not need to be remediated. This value is low because of the following:

- 1) The concentration of the hot spot is close to the WRW AL.
- 2) The size of the hot spot is small.

Example 2:

If the size of the hot spot was larger, remediation might be necessary. For this example, remediation will occur when the hot spot size equals the AOC size. Remediation of a hot spot of the same size as in Example 1 would occur when the concentration of the hot spot is 4,781 mg/kg.

$$\sum_{i=1}^n \left[\frac{1393.9}{4770.0} \right]_i + \sum_{j=1}^n \left[\frac{(4,781_{hs} - 1393.9_{AOC})}{\left(\frac{4770 * 16}{16} \right)} \right]_j = 1$$

Example 3:

The EMC calculation indicates that action is not required for this hot spot, however, as stated in Section 5.3 that action will be taken at three times the AL. For example, action is warranted at this hot spot when the measurement is $\geq 14,310$ mg/kg (4770 mg/kg [AL] x 3).

$$\sum_{i=1}^n \left[\frac{1393.9}{4770.0} \right]_i + \sum_{j=1}^n \left[\frac{(15000_{hs} - 1393.9_{AOC})}{\left(\frac{4770 * 16}{36} \right)} \right]_j = .93$$

Example 4:

For an assumed 36- square feet (ft²) hot spot in an 6,000 ft² Individual Hazardous Substance Site (IHSS) with pentachlorophenol, and a hot spot concentration of 10,000 mg/kg:

$$\sum_{i=1}^n \left[\frac{1393.9}{4770.0} \right]_i + \sum_{j=1}^n \left[\frac{(10000_{hs} - 1393.9_{AOC})}{\left(\frac{4770 * 6000}{36} \right)} \right]_j = .303$$

Example 5:

Example 5 is being used because the AL is lower than the AL for pentachlorophenol. Example 5 is an assumed 36-ft² hot spot in a 6,000-ft² IHSS with hexachlorobenzene (HCB) as the COC using the data in Table H2. Table H2 is a hot spot analysis for HCB in soil assuming a hot spot concentration of 7.5 mg/kg. The data listed in Table H2 are not based on actual information or data from RFETS.

$$\sum_{i=1}^n \left[\frac{2.7}{2.8} \right]_i + \sum_{j=1}^n \left[\frac{(7.5_{hs} - 2.7_{AOC})}{\left(\frac{2.8 * 6000}{36} \right)} \right]_j = .98$$

**Table H2
Hot Spot Equation Analysis
Single Sample Exceedance of WRW Action Level
HCB Soil Data**

Sampling Location	HCB Soil Concentration at Sampling Location (mg/kg)	HCB Hot Spot Concentration in AOC (mg/kg)	Part 2 Hot Spot Equation Ratio *	Part 1 + Part 2 Hot Spot Equation Total Ratio *
1	0.1	3.9	0.00	0.97
2	0.5	5.0	0.00	0.98
3	0.9	6.3	0.01	0.98
4	1.2	7.5	0.01	0.98
5	1.4	9.8	0.02	0.99
6	1.7	10.5	0.02	0.99
7	2.0	12.0	0.02	0.99
8	2.2	15.0	0.03	1.00
9	2.5	16.0	0.03	1.00
10	2.8	21.0	0.04	1.01
11	3.0	25.0	0.05	1.02
12	3.6	88.0	0.18	1.15
13	3.5	104.0	0.22	1.19
14	3.7	200.0	0.42	1.39
15	3.0	251.0	0.53	1.50
Number of Sample Results	15			
Mean Concentration	2.1			
Standard Deviation	1.2			
95% Confidence Interval	0.6			
95% UCL of Mean	2.72			
WRW AL	2.80			
WRW Ratio (Part I - Hot Spot Equation - $([95\%UCL]_{AOC}/AL)$)	0.9715			

* - $([Sample\ result]_{hs} - [95\%UCL]_{AOC}) / ([AL][Area]_{AOC} / [Area]_{hs})$

** - Assumes that only one hot spot is present.

References

EPA, 1997, Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), NUREG-1575, EPA 402-R-97-016.

MYAPC, 1999, Maine Yankee License Termination Plan, November.

APPENDIX I

903 Pad Linear Regression Case Study

450

TABLE OF CONTENTS

1.0 LINEAR REGRESSION ANALYSES - CASE HISTORY 1
2.0 OVERVIEW OF THE 903 PAD CHARACTERIZATION FIELD HPGE SURVEY 1
 2.1 SURFACE SOIL INVESTIGATION 1
 2.1.1 In-Situ HPGe Methodology 1
 2.2 Verification Sampling Correlation Technique 4
 2.2.1 Alpha Spectroscopy: HPGe Pu-239/240 and Am-241 Correlations 6
 2.2.2 Alpha Spectroscopy: HPGe U-235 and U-236 Correlations 6
3.0 HPGE METHODS TO BE EMPLOYED DURING THE IA CHARACTERIZATION .. 9
 3.1 Linear Regression Models 9
 3.1.1 Verification of "Best Fit" Regression Model 9
 3.2 HPGe Survey Design 10
4.0 REFERENCES 11

LIST OF FIGURES

Figure I1 HPGe Measurement Location Map 3
Figure I2 HPGe 15-Point Surface Soil Sampling Pattern 5
Figure I3 Linear Regression Am-241 7
Figure I4 Linear Regression Pu-239/240 7
Figure I5 Minimum Detectable Activities U-235 8
Figure I6 Minimum Detectable Activities U-238 8

LIST OF TABLES

Table I1 Am-241 Activity Profile 2
Table I2 HPGe Gamma Spectroscopy Measurements – Precision Summary 4

ACRONYM LIST

AL	action level
Am	americium
ANOVA	Analysis of Variance
BZ	Buffer Zone
cm	centimeter
DOE	U.S. Department of Energy
ER	Environmental Restoration
FOV	field of view
HPGe	High Purity Germanium
IA	Industrial Area
IHSS	Individual Hazardous Substance Site
ISOCS	In Situ Object Counting System
m	meter
MeV	mega-electron volt
NBS	National Bureau of Standards
OU	Operable Unit
PAC	Potential Area of Concern
pCi/g	picocuries per gram
Pu	plutonium
R ²	correlation coefficient
RCRA	Resource Conservation and Recovery Act
RFCA	Rocky Flats Cleanup Agreement
RFETS	Rocky Flats Environmental Technology Site
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RPD	relative percent difference
SOP	Standard Operating Procedure
U	uranium
UBC	Under Building Contamination
UCL	upper confidence limit

1.0 LINEAR REGRESSION ANALYSES - CASE HISTORY

Radionuclide contamination in surface and subsurface soil will be characterized using gamma spectroscopy technology (i.e., High Purity Germanium [HPGe] detectors). The HPGe measurements may follow the same procedures and methodologies that were effectively used during previous Rocky Flats Environmental Technology Site (RFETS) Environmental Restoration (ER) projects, specifically the 903 Drum Storage Area, 903 Lip Area, and Americium Zone Characterization (903 Pad Characterization [Kaiser-Hill 2000]). The "best fit" regression modeling approach used to standardize the HPGe results to alpha spectroscopy results during the 903 Pad Characterization will be implemented for the Industrial Area (IA) and Buffer Zone (BZ) characterization. A similar regression modeling technique will be used for evaluating metals.

IA and BZ characterization is similar to the 903 Pad Characterization in that radionuclides in surface soil will be analyzed using an HPGe field method. An in-situ field analytical technique was successfully used to characterize the lateral extent of radiological contamination in the Americium Zone and a portion of the 903 Lip Area (Kaiser-Hill 2000). In addition, most IA and BZ characterization HPGe measurements of soil samples will be performed in a mobile laboratory. This appendix provides an overview of the HPGe methodologies used in the 903 Pad Characterization. Topics of discussion include (1) sample collection techniques for the alpha spectroscopy analyses, which were used to standardize the HPGe results; (2) the physics of the HPGe in-situ measurements; (3) the results of the "best fit" linear regression model used to standardize the HPGe results; and (4) the application of in-situ HPGe survey methods to IA and BZ characterization.

2.0 OVERVIEW OF THE 903 PAD CHARACTERIZATION FIELD HPGE SURVEY

2.1 SURFACE SOIL INVESTIGATION

Delineation of radiologically contaminated soil in the Americium Zone was performed in situ using gamma ray spectroscopy methods and an HPGe instrument. The HPGe instrument was used to obtain 1,110 contiguous gamma ray measurements with a circular field of view (FOV) of 10 meters (m) in diameter within the investigation area. The activities of Americium (Am)-241, Plutonium (Pu)-239, Uranium (U)-234, U-235, and U-238 in surface soil within the Americium Zone and a portion of the 903 Lip Area were measured or estimated in situ using an HPGe survey. The HPGe measurements were standardized by correlation with laboratory-derived alpha spectroscopy measurements.

2.1.1 In-Situ HPGe Methodology

The sensitivity of the HPGe instrument is capable of measuring in-situ activities of Am-241, U-235, and U-238. For the 903 Pad Characterization, the HPGe measurement had a FOV of 10 m in diameter with the detector placed 1 m over the ground surface. The Compendium of In Situ Radiological Methods and Applications at Rocky Flats Plant (EG&G 1993) provides a detailed discussion on the physics of in-situ measurement of radionuclides in the environment.

The HPGe survey was primarily performed in the Americium Zone (Figure I1) and includes all surface soil with elevated activities of Pu-239/240 and/or Am-241 identified during the Operable Unit (OU) 2 Resource Conservation and Recovery Act (RCRA) Facility Investigation/Remedial

Investigation (RFI/RI) including:

- The 35 HPGe measurements that exhibited elevated (above 10 picocuries per gram [pCi/g]) Am-241 activities;
- The area directly below the culvert that drains the 903 Pad and Lip Area where sediments are deposited during surface runoff events; and
- The five 2.5-acre plots where surface soil exceeds Rocky Flats Cleanup Agreement (RFCA) Tier I action levels (ALs).

The HPGe system used to perform in-situ measurements for the investigation employed the Canberra In Situ Object Counting System (ISOCS) software. To estimate counting efficiencies, this software requires the entry of various parameters that accurately represent the actual field conditions at the site. One important parameter is the vertical distribution of radionuclides. In the HPGe investigation area, contamination was deposited via airborne and/or surface water releases. This resulted in a distribution with high activities near the surface and decreasing activities with depth. Surface soil sampling was previously performed in the study area to determine the vertical distributions.

In general, the radionuclides are concentrated in the top 5 centimeters (cm). Based on available data, the ISOCS model assumes all contamination is contained in the top 5 cm, and is distributed with 66 percent in the top 3 cm and 33 percent in the next 2 cm. This distribution was used to be consistent with the surface soil sampling methodologies (RMRS 1998a), which specifies sampling surface soil to a depth of 2 inches (5 cm). In addition, the contribution from Am-241 below a depth of 5 cm in soil is quite small in undisturbed surface soil. It is possible that the actual distributions in the top 5 cm may be more concentrated near the surface or more uniformly distributed throughout the 5-cm layer.

A set of standards with different vertical distributions was prepared and the efficiency of acquisition was analyzed. As shown in Table II, the overall error of a likely range of possible distributions is approximately +1- 10 %.¹

**Table II
Am-241 Activity Profile**

Sample Layer	Am-241 pCi/g
Default 2 layers 0-3 cm 66%, 3-5 cm 33%	12.2
Single layer, 0-5 cm uniform	14.3
3 layers, 0-1.5 cm 50%, 1.5-3 cm 30%, 3-5 cm 20%	11.6
3 layers, default with 1-cm grass cover	13.2
2 layers with 0-3 cm 60%, 3-5 cm 40%	12.2

¹ These ISOCS modeling parameters used to define the vertical distribution of radionuclides will initially be used for in-situ screening during the IA characterization. However, these modeling parameters may be reevaluated as additional data are collected and adjusted accordingly to meet the site-specific conditions. For HPGe screening of subsurface samples, modeling parameters will be adjusted according to the specifications of the sample container.

454

Figure 11

HPGe Measurement Location Map

EXPLANATION

Investigation Area

FOV (Field of View) Stake Number

Standard Map Features

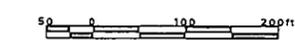
- Steep Topography
- Wetland Area
- Cement
- Buildings and other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Topographic Contour (20-Foot)
- Paved roads
- Dirt roads

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
 Topology (contours) were derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at - 10 meter resolution. DEM post-processing performed by MK, Winter 1997.

DISCLAIMER:
 Neither the United States nor the State of Nevada, nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.



Scale = 1 : 2370
 1 inch represents approximately 198 feet



State Plane Coordinate Projection
 Colorado Central Zone
 Datum: NAD27

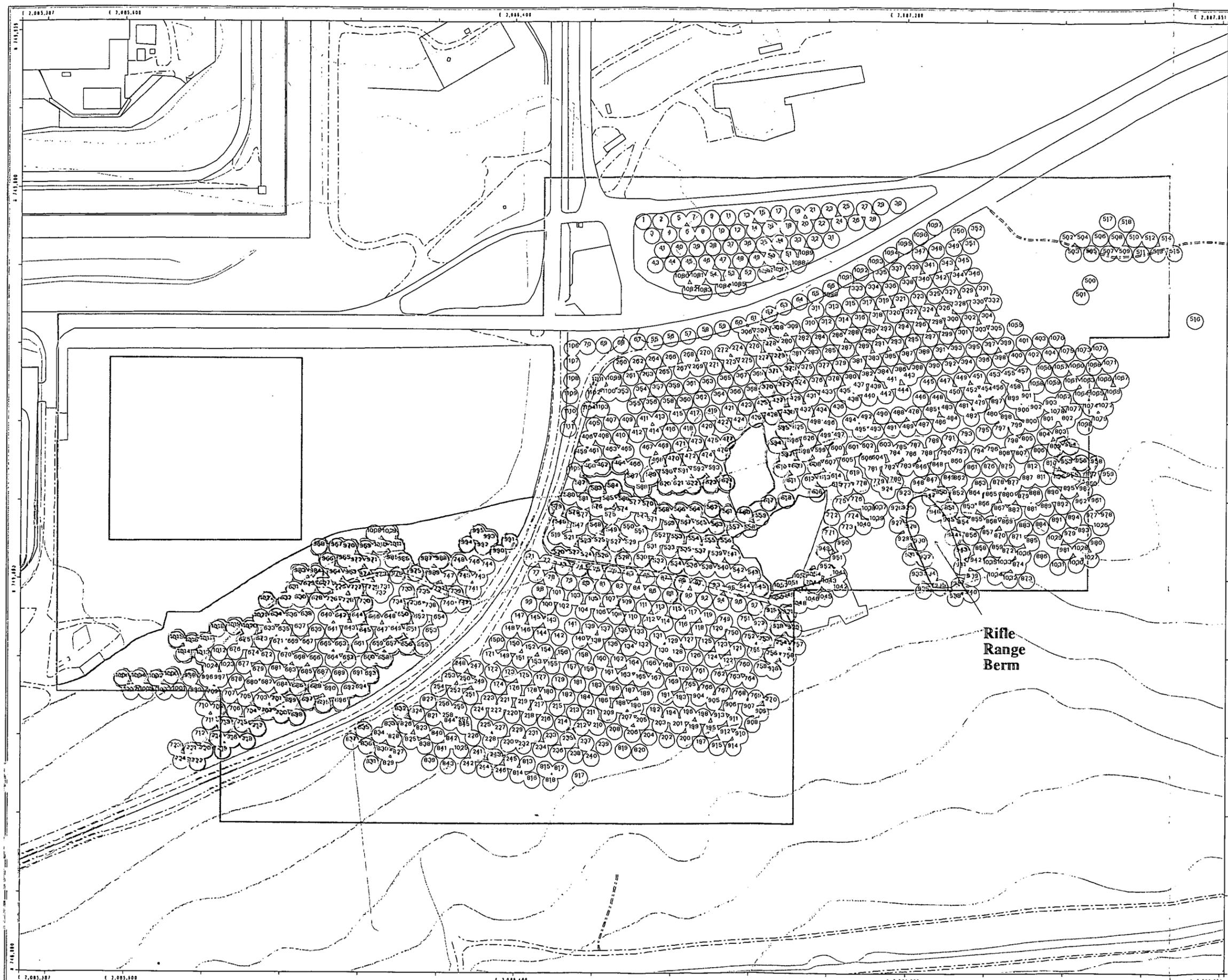
U.S. Department of Energy
 Rocky Flats Environmental Technology Site

Prepared by:
DynCorp
 THE ART OF TECHNOLOGY

Prepared for:

MAP ID: 99-0408

July 18, 2001



456

NT_Srv_w:\projects\fy99\99-0408\hpga_fov_b_fig-11.am

2.2 VERIFICATION SAMPLING CORRELATION TECHNIQUE

To “standardize” the in-situ method, a double sampling technique was employed whereby soil samples were collected from select HPGe measurement locations (RMRS 1998a). These samples were analyzed in the laboratory for Am-241, Pu-239/240, U-233/234, U-235, and U-238 using alpha spectroscopy, and gamma spectroscopy for Am-241 and U-235. The gamma spectroscopy data were collected by the laboratory to simply “validate” the alpha spectroscopy results, and the two sets of results show a high degree of correlation as indicated by their linear relationship (e.g., correlation coefficient $[R^2] > 0.90$).

In order to acquire a good duplicate sampling correlation over the anticipated range of Am-241 activities, eight HPGe measurement locations were selected that encompass five Am-241 activity intervals; 0-10 pCi/g (three measurements), 10-20 pCi/g, 20-50pCi/g (two measurements), 50-100pCi/g, and 100-200 pCi/g. These intervals were selected based on detection frequencies of Am-241 activities measured in surface soil samples collected in support of the OU2 Phase II RFI/RI (DOE 1995; RMRS 1998a) and to bound the high and low measurements collected in the field during the HPGe investigation.

Multiple HPGe measurements were taken at some of the double sampling locations for quality control. These results are provided in Table I2. In these cases, the measurements at each duplicate sampling location were averaged to create the HPGe data set used in the correlation. Table I2 also indicates the HPGe measurements at each duplicate sampling location are relatively uniform.

**Table I2
HPGe Gamma Spectroscopy Measurements – Precision Summary**

HPGe Measurement 30		HPGe Measurement 104		HPGe Measurement 265		HPGe Measurement 266		HPGe Measurement 305		HPGe Measurement 406		HPGe Measurement 460		HPGe Measurement 669	
Am-241 (pCi/g)	RPD %	Am-241 (pCi/g)	RPD %	Am-241 (pCi/g)	RPD %	Am-241 (pCi/g)	RPD %	Am-241 (pCi/g)	RPD %	Am-241 (pCi/g)	RPD %	Am-241 (pCi/g)	RPD %	Am-241 (pCi/g)	RPD %
1.1	NA	14.5	19.4	34.3	2.2	9.1	NA	7.0	21.3	70.2	8.2	106.3	7.0	32.2	8.3
		17.6	0.1	39.0	10.6			7.5	28.1	62.9	2.8	113.2	13.3	32.8	6.5
		20.6	15.6	39.1	10.9			4.7	18.4	61.7	4.7	80.2	21.1	39.5	12.1
		15.5	12.8	37.3	6.2			6.0	6.0	62.6	3.2	98.3	0.8	35.3	0.9
		22.6	24.8	31.7	10.1			4.9	14.2	65.9	1.9	115.7	15.5	35.2	0.6
		17.6	0.1	29.2	18.3			5.7	0.9			80.8	20.3		
		23	26.5	31.3	11.4			5.4	4.5						
		15.1	15.4	39.3	11.4			4.0	34.2						
		17.6	0.1	34.4	1.9										
		13	30.2												
		18.6	5.4												
		19.4	9.6												
		15.8	10.9												
		15.8	10.9												
1.1 ^a		17.6 ^a		35.1 ^a		9.1 ^a		5.7 ^a		64.7 ^a		99.1 ^a		35 ^a	

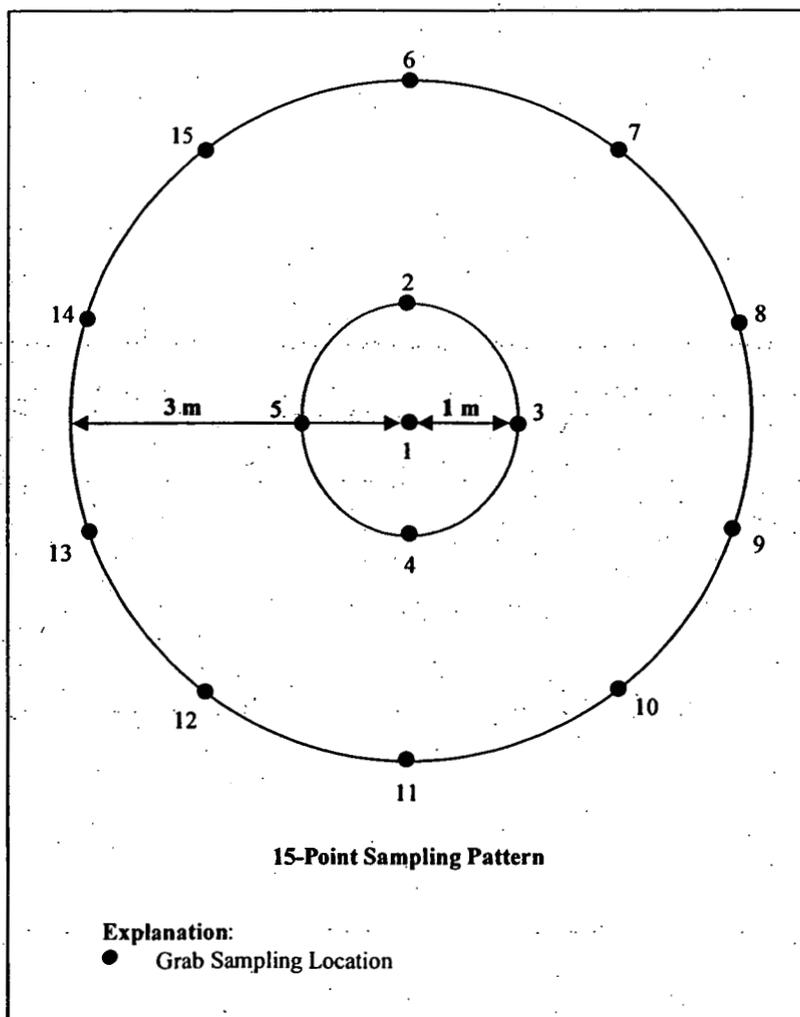
Relative percent difference (RPD) between individual measurements and group mean

^a group mean

457

Fifteen grab samples were then collected at each duplicate sampling location: 1 grab sample from the center, 4 grab samples collected at a 1-m radius, and 10 grab samples from a 3-m radius. Figure I2 provides this surface soil sampling geometry, which was developed by the U.S. Department of Energy (DOE) at the Fernald Environmental Management Project site in Ohio to correlate HPGe results to surface soil results (DOE 1997). The 1-m and 3-m radius grab samples were then composited into a 1-m and 3-m sample representative of each individual band. Therefore, three separate alpha (and gamma) spectroscopy analyses were performed at each duplicate sampling location. Samples were collected in this "bulls eye" pattern to mimic the averaging done by the field HPGe detector over the instrument's FOV. The HPGe detector receives gamma ray photons from every point within the circle; however, it receives more gamma rays from soil closer to the detector than from soil farther from the detector. If the circle is divided into concentric bands, the relative weighting factor for each band can be calculated based upon the percentage of influence of gamma photons at the detector which originates from a given band of soil, assuming a uniform source distribution with depth and a 1 value of energy (MeV) photon energy. The relative weighting factor is the relative importance of each band with respect to the probability of gamma rays emitted from within that band being detected by the HPGe.

Figure I2
HPGe 15-Point Surface Soil Sampling Pattern



458

The sample results were multiplied by the weighting factor per band, then the products were summed to determine the activity of the soil in the FOV area. It should be noted that these results were adjusted for moisture content in order to report results on a wet weight or "in situ moisture" basis. At every duplicate sampling location, the "real" and "duplicate" data were averaged (denoted as "combined"), and the "combined" data were used in the weighted averaging process to develop the data for the correlation.

2.2.1 Alpha Spectroscopy: HPGe Pu-239/240 and Am-241 Correlations

The linear regressions (using the method of least squares) between the alpha spectrometry data (Am-241 and Pu-239/240) and the HPGe data (Am-241) show very high degrees of correlation (Figures I3 and I4). The correlation coefficients (R^2) are greater than or equal to 0.97. The Am-241 (alpha spectrometry) to Am-241 (HPGe) correlation has a slope (1.25) near 1.0 and a small intercept (4.43 pCi/g) near 0 as would be expected when correlating the activities of the same radionuclide (Figure I3). The Pu-239/240 (alpha spectrometry) to Am-241 (HPGe) correlation has a slope of 8.08, which is within the expected range of Pu-239/240 to Am-241 activity ratios considering the in-growth of Am-241 in weapons-grade Pu over 30 to 40 years (elapsed time since the release). The intercept (3.24 pCi/g) is also small in magnitude (Figure I4). These results indicate the regression lines are appropriate models to correlate HPGe data to alpha spectroscopy data.

The Pu-239/240/Am241 ratio derived from the "best fit" line regression model compares favorably to those ratios derived from previous studies. The National Bureau of Standards (NBS) collected soil samples from RFETS for isotopic analyses, which were eventually used as a standard radioactive source reference (NBS 1980). The NBS sampling and analysis of RFETS soil indicated a Pu-239/240 to Am-241 ratio of 6.42. A second study performed by Ibrahim et al. (1996) included an isotopic inventory (using alpha spectroscopy) of RFETS soil to determine the activity ratio of Pu-239/240 to Am-241. The regression model between Am-241 and Pu-239/240 resulted in a strong correlation ($R=0.96$) between the two radionuclides, and a Pu-239/240 to Am-241 activity ratio of 5.29. Based on their findings, Ibrahim et al. (1996) concluded that Pu-239/240 values could be inferred from gamma spectroscopy results of Am-241. The Pu-239/240 to Am-241 ratio (8.08) derived here from the "best fit" line regression model compares favorably to the 6.42 and 5.29 ratios derived from the NBS (1980) and Ibrahim et al. (1996) studies, respectively. It is also conservatively high with respect to Pu-239/240/Am-241 ratios for estimating Pu-239/240 activities from Am-241 activities.

2.2.2 Alpha Spectroscopy: HPGe U-235 and U-238 Correlations

As shown in Figures I5 and I6, correlations for the alpha spectroscopy/HPGe data for U-235 and U-238 were not performed because in both cases the U isotopes were not detected by in-situ HPGe. The plots show minimum detectable activities when the isotopes were nondetect ions. Also, alpha spectroscopy did not measure detectable levels of U-235, and only in a few instances was U-238 detected at estimated activities. Therefore, U-235 and U-238 results derived from the HPGe survey were used directly as the surface soil radiological data for these isotopes (i.e., values were not standardized to laboratory alpha spectroscopy measurements). The lack of correlation for the U data does not impact the findings reported in the 903 Pad Characterization Report (Kaiser-Hill 2000), because the activities for U isotopes are well below the ALs throughout the investigation area.

Figure I3
Linear Regression Am-241

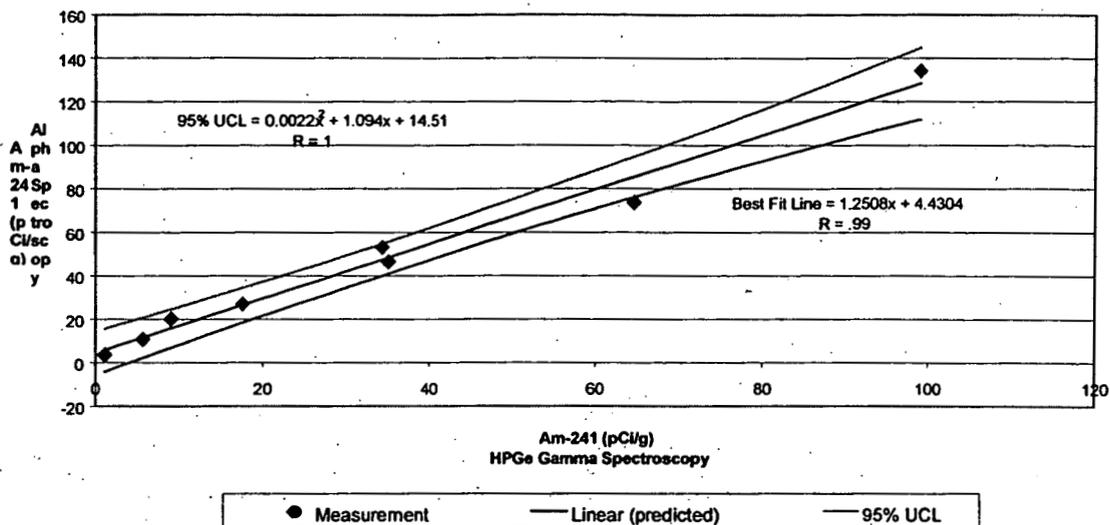


Figure I4
Linear Regression Pu-239/240

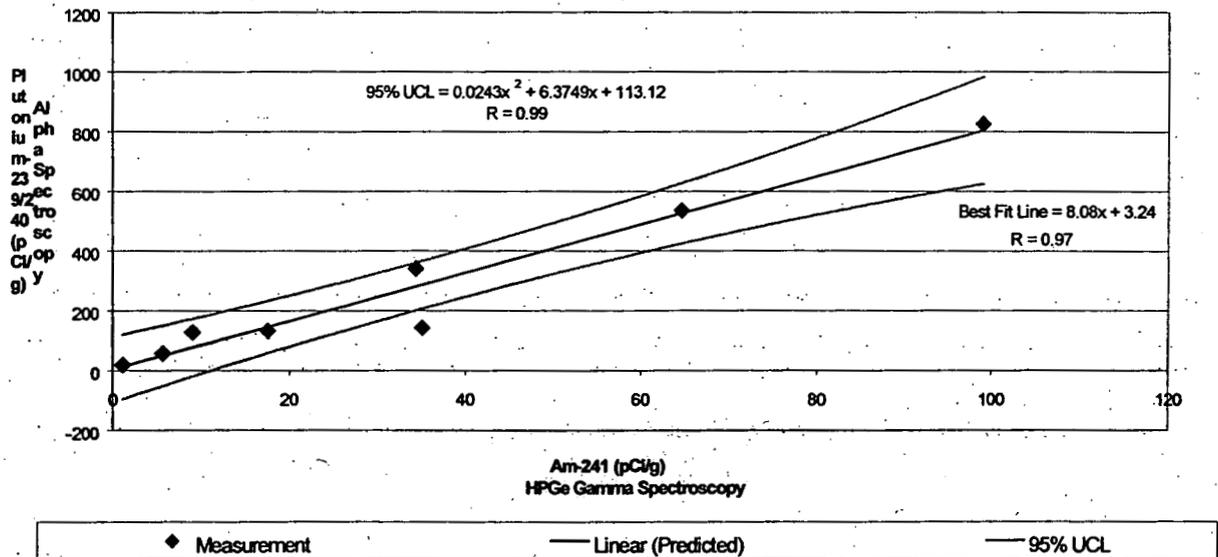


Figure I5
Minimum Detectable Activities U-235

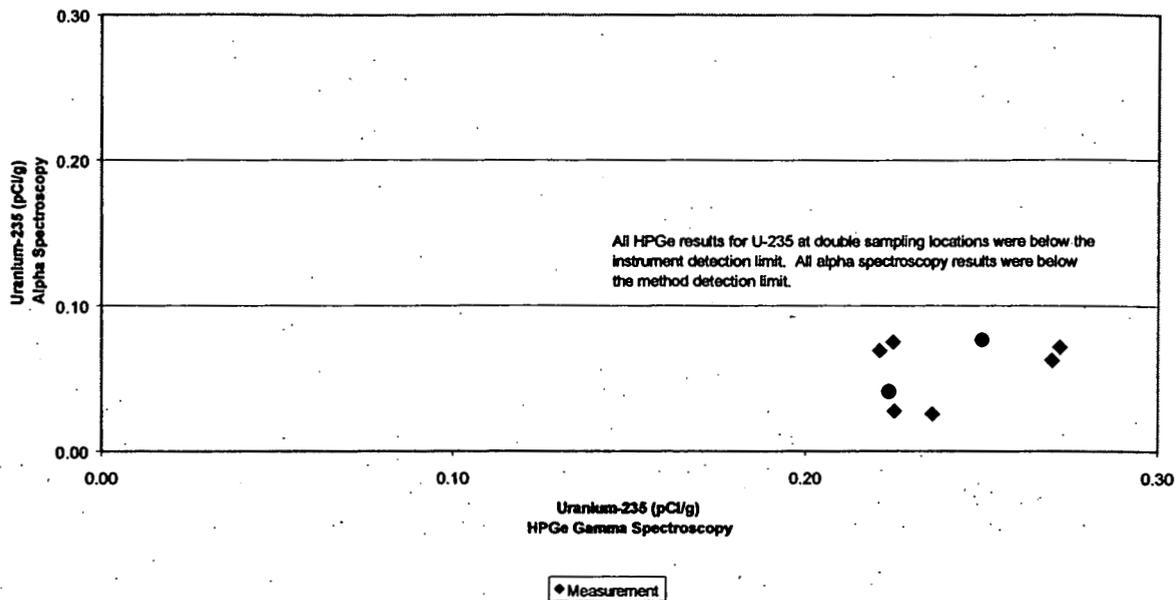
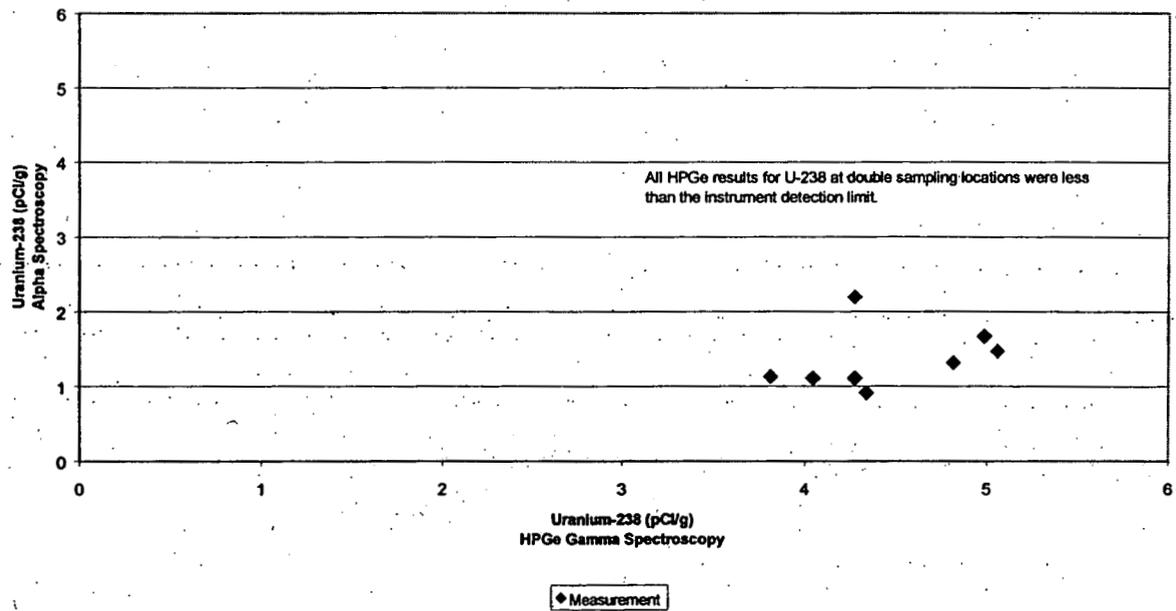


Figure I6
Minimum Detectable Activities U-238



The activity of U-233/234 was estimated based on the fact that under natural conditions, U-234 is in equilibrium with U-238 (the contribution of U-233 activity is insignificant). The equilibrium between the radioactive parent (U-238) and daughter (U-234) suggests the activity ratio between these two isotopes should be 1.0. Surface soil data collected in support of the OU 2 Phase II RFI/RI support this relationship with an average activity ratio of 0.97 between the two isotopes. Therefore, the activity of U-233/234 in surface soil was assigned the value measured by the HPGe survey for U-238.

461

3.0 HPGe METHODS TO BE EMPLOYED DURING CHARACTERIZATION

The fundamental approach of the HPGe methodology used during the 903 Pad Characterization may be incorporated into IA and BZ characterization. This will provide a basis for establishing the setup parameters for the HPGe detector and regression modeling for standardizing the HPGe measurements. However, variation in physical conditions and process knowledge (i.e., spills and releases of hazardous constituents) of specific Individual Hazardous Substance Sites (IHSSs), Potential Areas of Concern (PACs), and Under Building Contamination (UBC) Sites may warrant changes in the in situ HPGe methodology. Despite such changes, the physics and fundamental processes of the HPGe measurements will remain the same. The HPGe methodology discussed previously in Sections 2.1 and 2.2 will provide the outline for the in situ HPGe techniques to be employed during IA and BZ characterization.

3.1 LINEAR REGRESSION MODELS

The "best fit" regression modeling approach used to standardize the HPGe Am-241 and Pu-239/240 alpha spectroscopy measurements for the 903 Pad Characterization will also be used for in situ HPGe characterization. The following equations will initially be used to standardize the in situ HPGe measurements:

$$\text{Pu - 239/240}_{y_i} = 8.08 * x_i + 3.24 \quad (\text{Equation I1})$$

$$\text{Am - 241}_{y_i} = 1.25 * x_i + 4.43 \quad (\text{Equation I2})$$

Where:

x_i = Am-241 activity measured by the HPGe instrumentation

Equations I1 and I2 will provide the basis for standardizing the HPGe measurements however may be changed as additional data are obtained during characterization (see Section 3.1.1). As discussed in Section 2.2.1, the majority of the U-235 and U-238 measurements were nondetectable, which prevented a correlation between HPGe and laboratory alpha spectroscopy measurements. Therefore, for lower activities, U-235 and U-238 activities will be obtained by direct HPGe measurements. However, activity levels of U-235 and U-238 measured by HPGe near or above the ALs may warrant verification sampling (i.e., soil sampling) for analysis by laboratory alpha spectroscopy. If a linear relationship is observed between the HPGe and laboratory U-235 and U-238 activities, then the HPGe results will be standardized using the appropriate regression equation. Activities of U-233/234 will be based on the HPGe direct reading of U-238, given the equilibrium state between the two isotopes (i.e., 1:1 ratio).

3.1.1 Verification of "Best Fit" Regression Model

The "best fit" regression models (Equations I1 and I2) will be verified by routine duplicate

462

sampling events. As discussed in Section 5.1.1, Linear Regression Analysis, observations within the range of interest will be obtained to validate the acceptability of the regression model. Validity of the observations will be evaluated relative to the 95% upper confidence limit (UCL) of the "best fit" regression line (Figures I3 and I4). The 95% CL defines the range about the sample mean where the true population mean is expected to lie at a 95% level of probability. This type of evaluation not only provides quantified boundaries about the "best fit" regression line, but also provides a quick visual inspection of the data sets. Observations that fall outside the 95% CL indicate a higher degree of variability about the "best fit" regression line (or predicted values) and therefore, may warrant a reevaluation of the regression model. The acceptability criteria of the regression model(s) will be based on a high degree of correlation ($R^2 > 0.90$) and statistical comparison between the predicted values and independent variables using an Analysis of Variance (ANOVA) and corresponding F-Test.

Regression models will need to be developed for subsurface soil samples. Unlike the HPGe survey of surficial soil, these samples will be analyzed ex situ. The HPGe instrumentation will have to account for such variations as the FOV and physical and chemical properties of the sample container. In addition, some IHSS, UBC Sites and PACs may require a site-specific regression model that varies slightly from Equations I1 and I2. For example, the presence of enriched Am-241 in soil at OU 4 will likely result in a reduction in the Pu-239/240/Am-241 ratio of 8.08 (Equation I1). In general, the regression model should be appropriate for the given site conceptual model.

3.2 HPGE SURVEY DESIGN

In-situ HPGe surveys to be conducted during IA and BZ characterization will follow the methodology presented in Section 2.1.1. The instrumentation FOV (10 m in diameter), detector height above the soil (1m), and ISOCS modeling parameters will be consistent with those settings used during the 903 Pad Characterization. However, these settings/parameters may be altered to account for changes in site conditions and materials being measured (e.g., asphalt is denser than natural soil). Ex-situ measurements of subsurface soil samples will follow standard guidelines presented in Determination of Radionuclides by Gamma Spectroscopy, Module RC03-A.1 (RMRS 1998b).

Methods to be employed for the verification sampling and analysis (i.e., duplicate sampling) will follow the methods presented in Section 2.2. However, some deviations for ex-situ HPGe measurements of subsurface soil will be performed. For subsurface soil samples, core samples will be homogenized prior to being placed in containers. Final sample preparation will follow the guidelines presented in Standard Operating Procedure (SOP) GT.08. It should be noted that normal procedure requires that coarse-grained fragments be separated from the finer-grained fragments because Pu and Am have a tendency to absorb to the fine-grained fraction. However, sieving out the coarse-grained fragments may result in a high bias in the HPGe and alpha spectroscopy results. Therefore, deviations to the existing SOPs may be implemented to minimize the apparent sample bias.

4.0 REFERENCES

DOE, 1995, Final Phase II RFI/RI Report, 903 Pad, Mound, East Trenches Area, Operable Unit No. 2, RF/ER-95-0079.UN, U.S. Department of Energy, Rocky Flats Plant, Golden, Colorado.

DOE, 1997, Comparability of In-Situ Gamma Spectrometry and Laboratory Data 20701-RF-001, U.S. Department of Energy, Fernald Area Office, Fernald, Ohio.

EG&G, 1993, Compendium of In Situ Radiological Methods and Applications at Rocky Flats Plant, EG&G Rocky Flats Inc., Rocky Flats Plant, Golden, Colorado, December 1.

Ibrahim, S.A., M.J. Schierman, and F.W. Whicker, 1996, Comparative Distribution Of ²⁴¹Am and ^{239/240}Pu In Soils Around The Rocky Flats Environmental Technology Site, 1996 Health Physics Society, Volume 70, Number 4, pp 520-526.

Kaiser-Hill, 2000, Site Characterization Report for the 903 Drum Storage Area, 903 Lip Area, and Americium Zone, RF/RMRS-99-427.UN, June 26.

NBS, 1980, National Bureau of Standards Certificate, Standard Reference Material 4353, Environmental Radioactivity, December 1.

RMRS, 1998a, Sampling and Analysis Plan for the Site Characterization of the 903 Drum Storage Area, 903 Lip Area and Americium Zone, RF/RMRS-97-084, Rev. 1, Rocky Flats Environmental Technology Site, Golden, Colorado, August.

RMRS, 1998b, Determination of Radionuclides by Gamma Spectroscopy, Module RC03-A.1 Statement of Work Prepared by the Analytical Services Division, Rocky Flats Environmental Technology Site, March 24.

464

APPENDIX J

Example Data Aggregation Problem

LIST OF TABLES

Table J1 Hot Spot Methodology Sample Problem Data..... 2

LIST OF MAPS

Map 1 Existing Soil Data3
Map 2 Triangular Grid Superimposed Over IHSS Using a Random Start4
Map 3 Additional Soil Sampling Points Designated.....5
Map 4 Analytical Results6
Map 5 WRW AL Exceedances7
Map 6 HCB > WRW AL Remedial Area With Confirmation Samples8
Map 7 PU > WRW AL Remedial Area With Confirmation Samples9

ACRONYM LIST

AL	action level
AOC	Area of Concern
df	degrees of freedom
EMC	elevated measurement comparison
HCB	hexachlorobenzene
HS	hot spot
IHSS	Individual Hazardous Substance Site
mg/kg	milligrams per kilogram
PAC	Potential Area of Concern
pCi/g	picocuries per gram
Pu	plutonium
RFCA	Rocky Flats Cleanup Agreement
UBC	Under Building Contamination
UCL	upper confidence limit
WRW	Wildlife Refuge Worker

Example Problem

This appendix consists of an example problem that illustrates how the Industrial Area and Buffer Zone Sampling and Analysis Plan statistical methods will be implemented. The locations, buildings, and analytical results that appear in this appendix have been fabricated and do not provide data for any part of the Rocky Flats Environmental Technology Site. This appendix includes the following:

Map 1 – Existing sampling locations and analytical data for Individual Hazardous Substance Site (IHSS) 1.1. This map is used to determine whether additional data are needed to characterize the IHSS.

Map 2 – A triangular grid superimposed over IHSS 1.1 using a random start point. This map is used to illustrate the 36-foot triangular grid that has been proposed for IHSS, Potential Area of Concern (PAC), and Under Building Contamination (UBC) Site characterization.

Map 3 – Additional soil sampling points at the nodes of the grid system

Map 4 – Analytical results from new sampling points

Map 5 – Contoured Rocky Flats Cleanup Agreement (RFCA) Action Level exceedances

Map 6 – Remediation confirmation sampling locations for nonradionuclide analytes

Map 7 – Remediation confirmation sampling locations for radionuclide analytes

Table J1 Sum of Ratios and Elevated Measurement Comparison (EMC) for Hot Spots

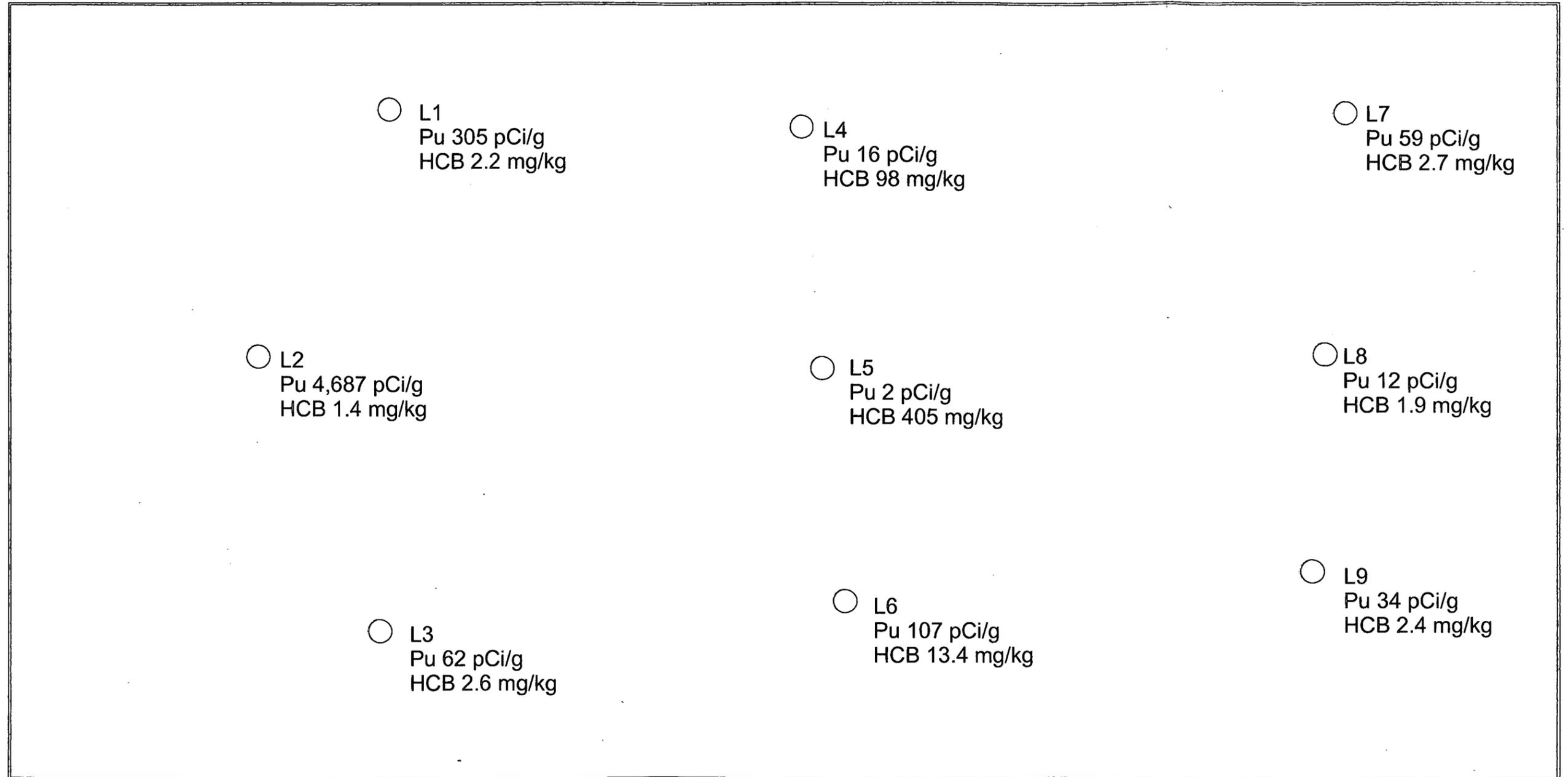
**Table J1
Hot Spot Methodology Sample Problem Data**

Sampling Location	Sample Results		AL Exceedance	2nd Term of EMC Sum > AL
	Pu (pCi/g)	HCB (mg/kg)		
S1	232	2	Pu	0.0047
S2	235	2.2	Pu	0.0049
S3	4	3.2		
S4	41	4.1		
S5	41	2.6		
S6	30	2.1		
S7	5521	1.8	Pu	0.3350
S8	4712	2.1	Pu	0.2845
S9	101	1.2	Pu	0
S10	8	320	HCB	0.0462
S11	11	9.6	HCB	
S12	12	2.1		
S13	968	1.6	Pu	0.0507
S14	301	2.6	Pu	0.0090
S15	129	3.9	Pu	0
S16	48	10.1		
S17	30	2.5		
S18	17	0.8		
S19	12	1.1		
S20	14	2.4		
S21	20	2.5		
S22	72	1.9	Pu	0
S23	32	2.8		
S24	12	0.9		
L1	305	2.2	Pu	0.0093
L2	4687	1.4	Pu	0.2830
L3	62	2.6	Pu	
L4	16	98		
L5	2	405	HCB	0.0590
L6	107	13.4	Pu	0
L7	59	2.7	Pu	0
L8	12	1.9		
L9	34	2.4		
No. of Sample Results	33	33		
Mean Concentration (excl. > AL)	98.9	7.6		
Standard Deviation (excl. > AL)	185.6	18.2		
t =	1.699	1.697		
n =	30	31		
df = (n-1) =	29	30		
Action Level	50	299		
Area AOC (sq feet)	20000	20000		
Area HS (sq feet)	1785	900		
95% UCL AOC	156.46	13.16		
95% UCL/AL	3.129	0.044		
EMC =	4.032	0.149		
Shaded cells indicate AL exceedance				

469

IHSS 1.1

BUILDING 172.66



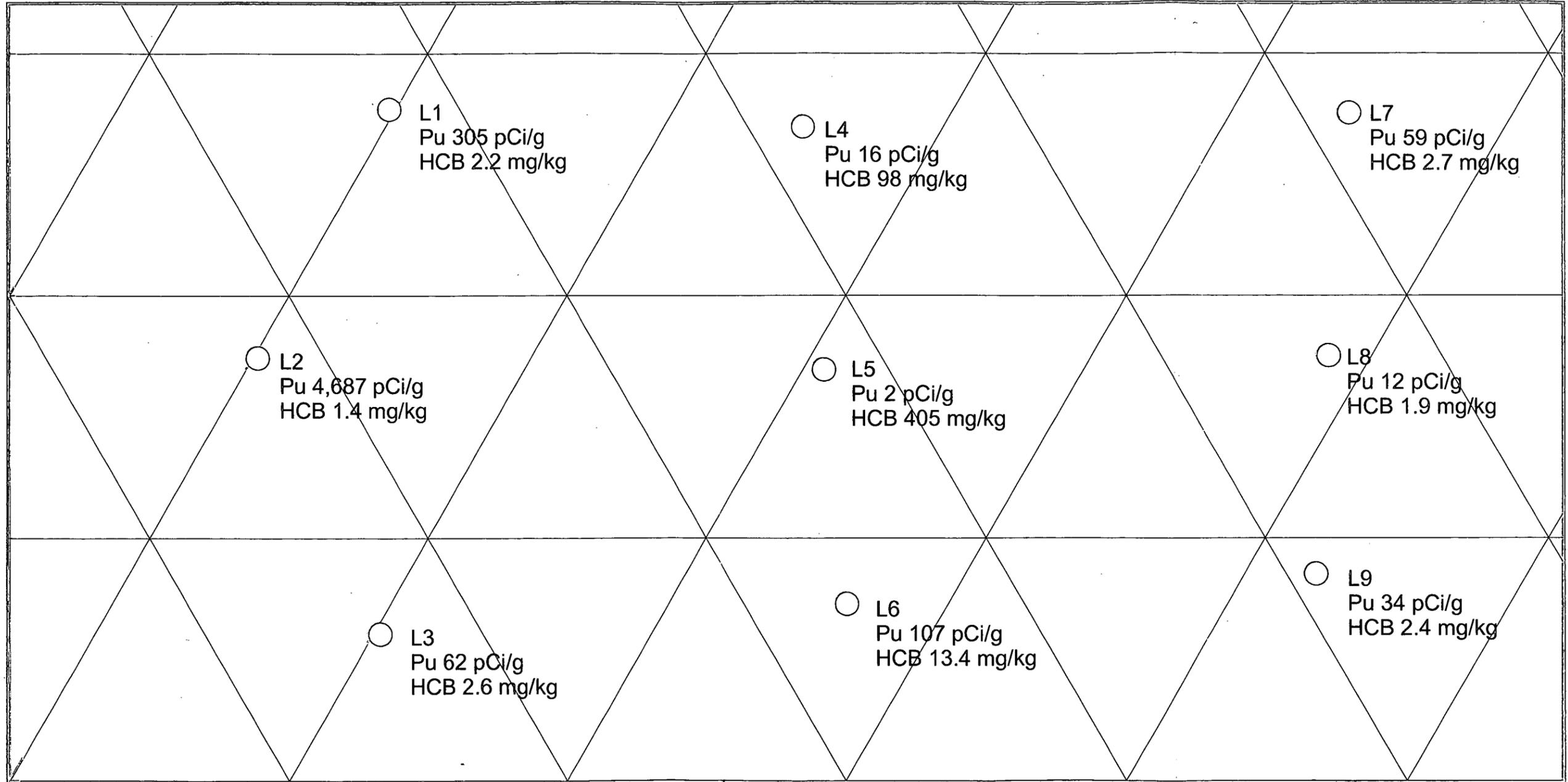
20,000 SQUARE FT

Map 1 Existing Soil Data

* This IHSS and building do not exist. Data have been fabricated to provide an example of how the IASAP process will work.

IHSS 1.1

BUILDING 172.66



Grid Spacing = 36 Feet

20,000 SQUARE FT

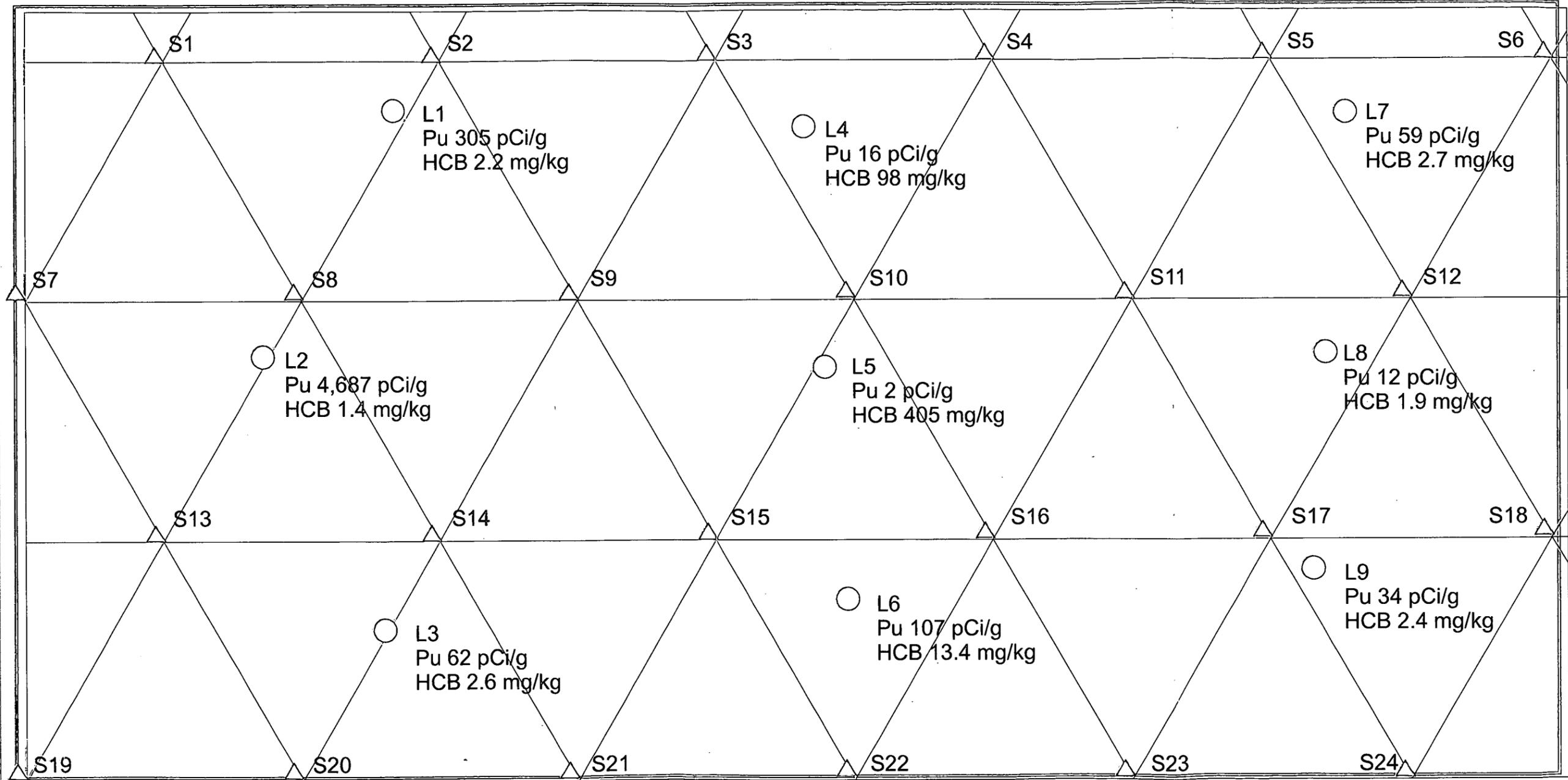
Map 2 Triangular Grid Superimposed Over IHSS Using a Random Start

Legend:
— = Triangular Grid
○ = Existing Sampling Points

* This IHSS and building do not exist. Data have been fabricated to provide an example of how the IASAP process will work.

IHSS 1.1

BUILDING 172.66



Grid Spacing = 36 Feet

20,000 SQUARE FT

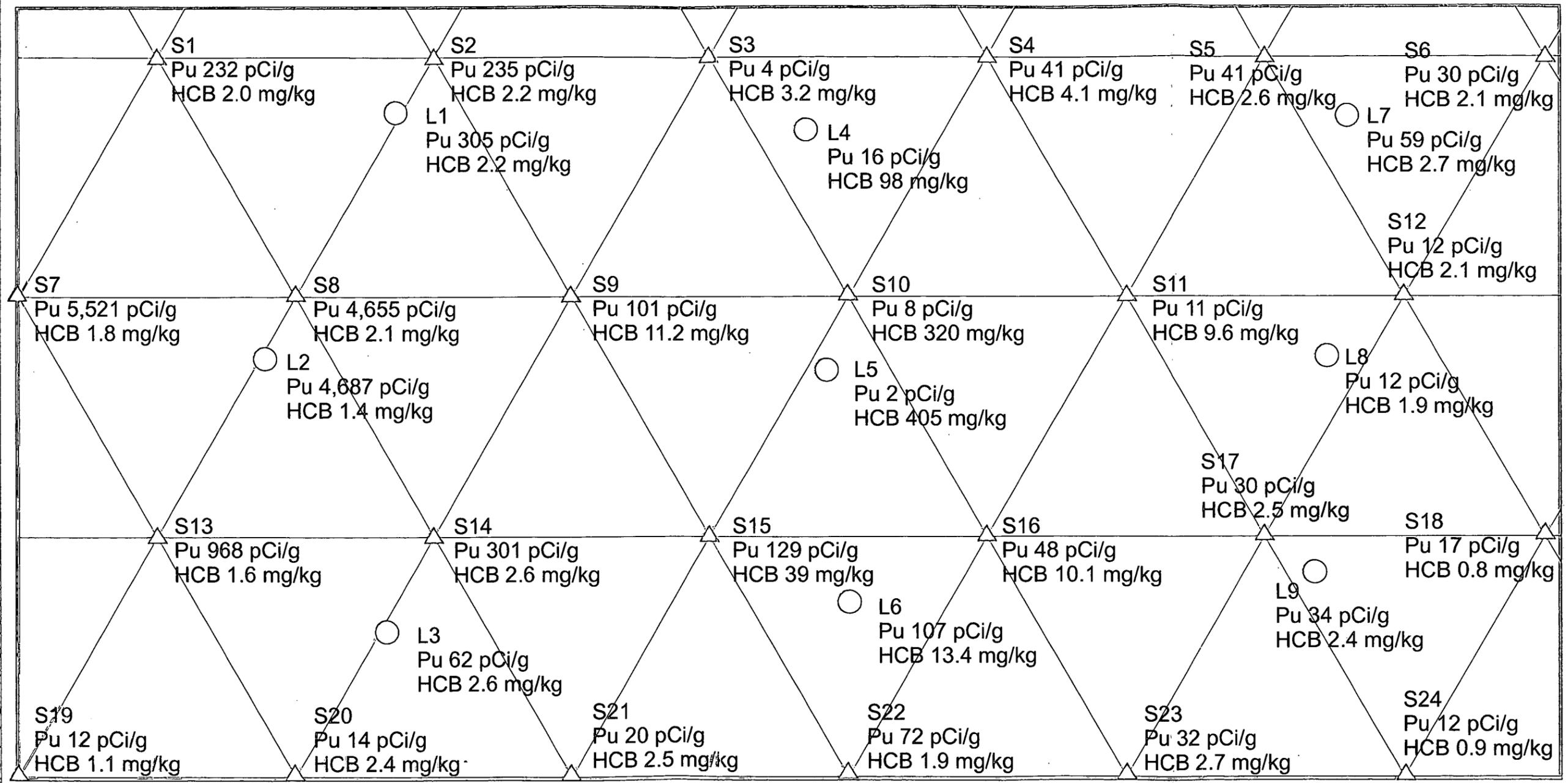
Map 3 Additional Soil Sampling Points Designated

Legend:
 — = Triangular Grid
 ○ = Existing Sampling Points
 △ = New Additional Sampling Points

* This IHSS and building do not exist. Data have been fabricated to provide an example of how the IASAP process will work.

BUILDING 172.66

IHSS 1.1



Grid Spacing = 36 Feet

20,000 SQUARE FT

Map 4 Analytical Results

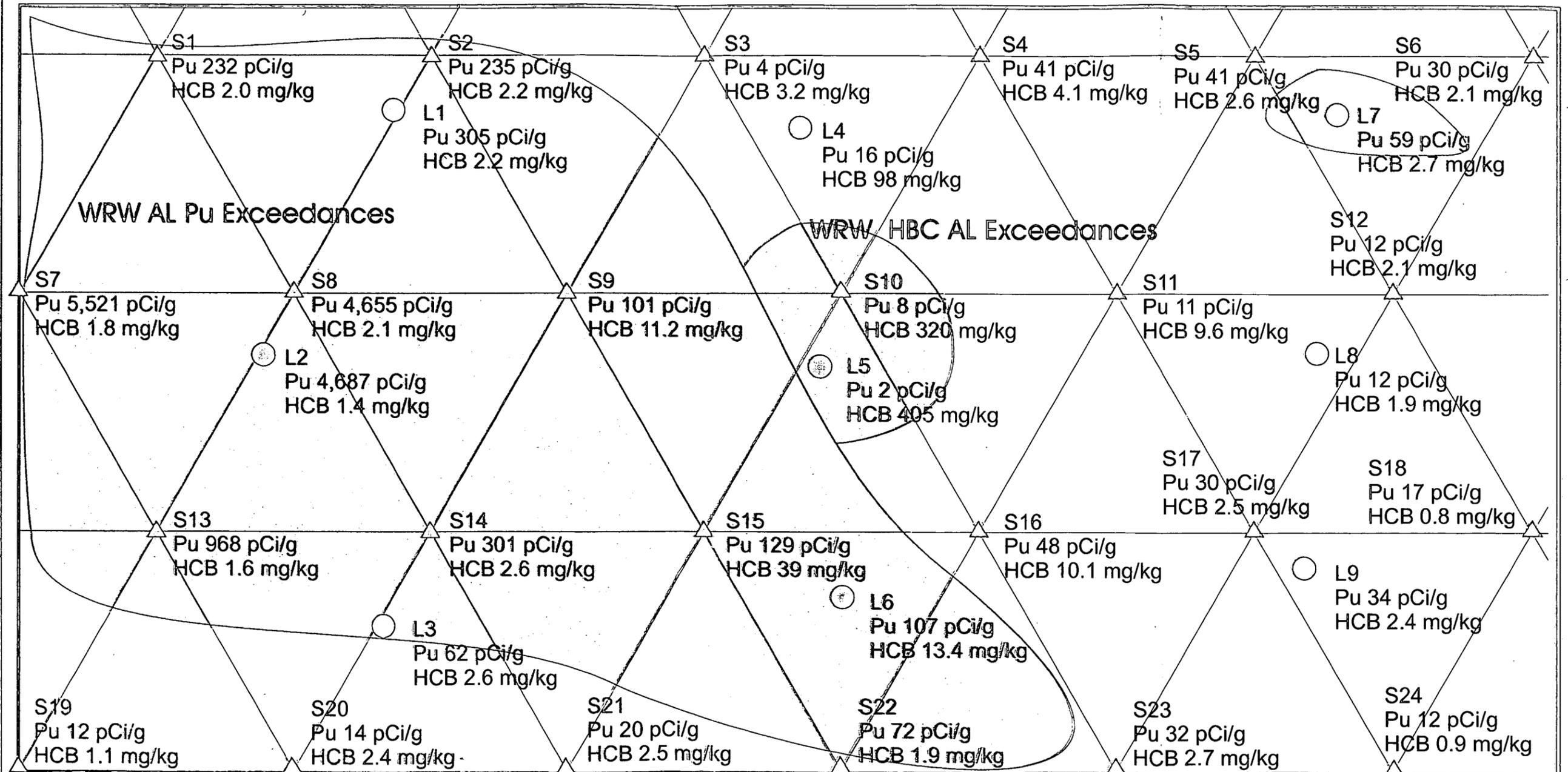
Legend:

- = Triangular Grid
- = Existing Sampling Points
- △ = New Additional Sampling Points

* This IHSS and building do not exist. Data have been fabricated to provide an example of how the IASAP process will work.

IHSS 1.1

BUILDING 172.66



Grid Spacing = 36 Feet

20,000 SQUARE FT

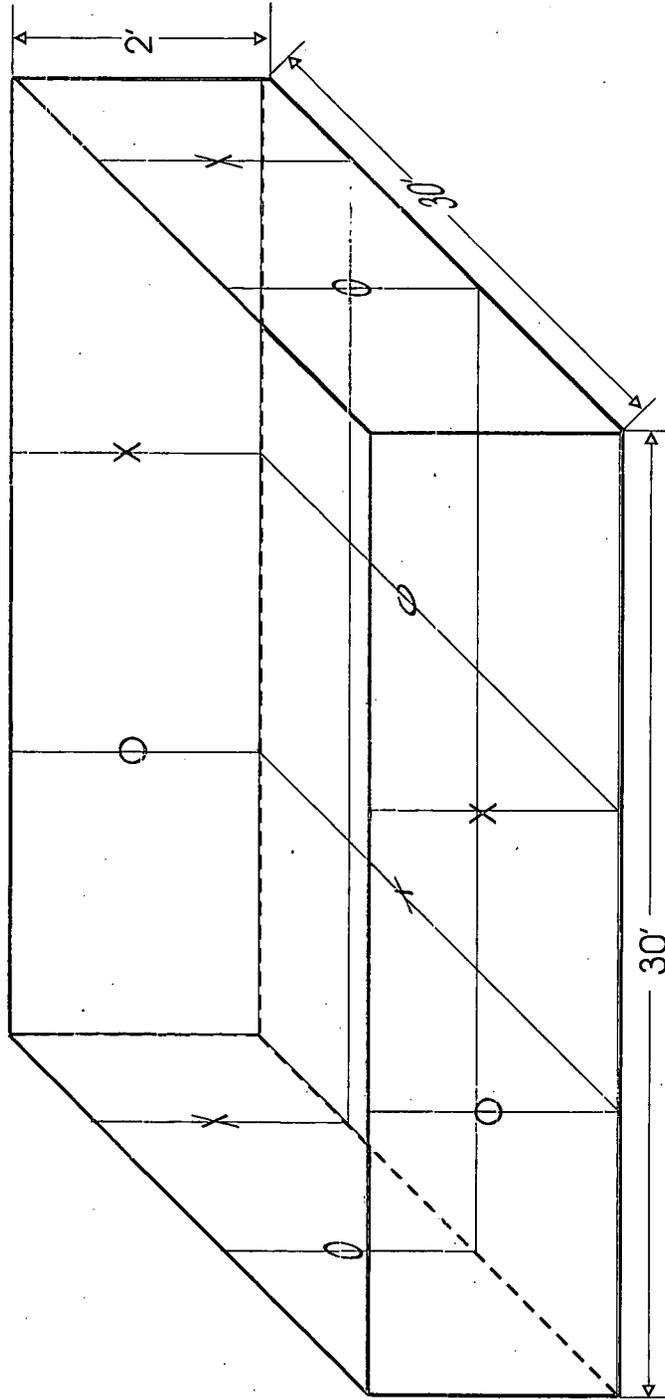
Map 5 WRW AL Excedences

Legend:	
—	= Triangular Grid
○	= Existing Sampling Points
△	= New Additional Sampling Points

* This IHSS and building do not exist. Data have been fabricated to provide an example of how the IASAP process will work.

474

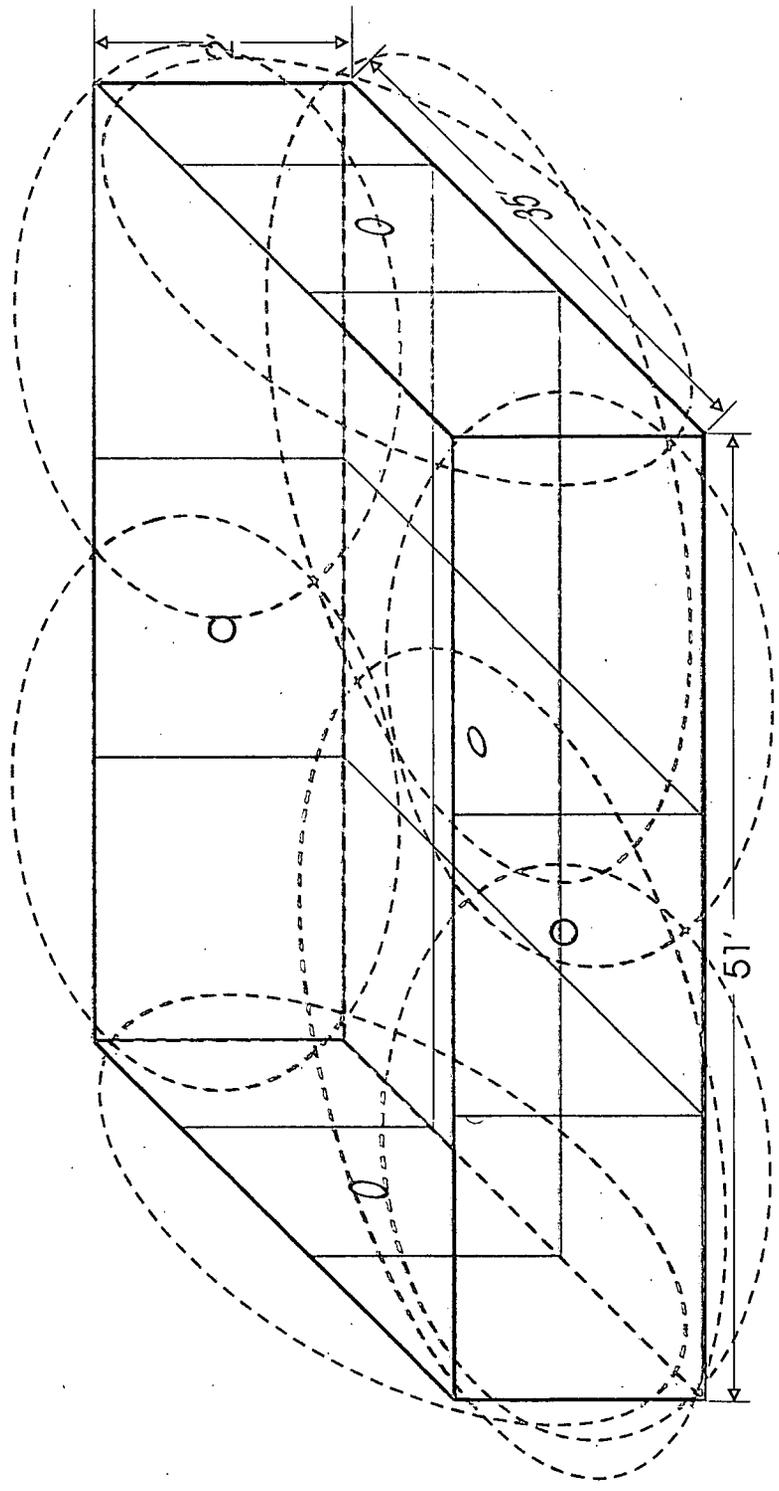
Map 6
HCB > WRW AL Remedial Area
With Confirmation Samples



X = Field Analytical Sample Collection Point
O = Analytical Sample Collection Point

900 Sq. Ft. Area
1,800 ft³ Soil Removal

Map 7
Pu > WRW AL Remedial Area
With Confirmation Samples



○ = HPGe Sample Location
○ = Analytical Sample Collection Point

1785 Sq. Ft. Area
3570 ft³ Soil Removal