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Draft A

Sampling and Analysis Plan for the 100 Area Remaining Sites

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For External Review

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Sampling and Analysis Plan for the 100 Area Remaining Sites

September 1999

United States Department of Energy

P.O. Box 550, Richland, Washington 99352

For External Review

EXECUTIVE SUMMARY

This confirmatory sampling and analysis plan (SAP) presents the rationale and strategy for the sampling and analysis activities that support of interim closure of remaining source operable unit waste sites as they are described in the *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units* (Remaining Sites ROD) (EPA 1999). The purpose of the proposed sampling and analysis activities is the characterization of waste sites, which are candidates for interim closure without remedial action. The results of the sampling and analysis activities will also support future waste profiling and waste designation if the candidate sites are determined to be contaminated at levels that require remedial actions. This SAP is based on the *Data Quality Objectives Summary Report for the 100 Area Remaining Confirmatory Sampling Effort Sites* (BHI 1999).

The remaining sites within the scope of this SAP are generally considered low-priority sites of low human health and ecological risk, based on process knowledge, site history, or previous sampling. These sites have been identified in the "Administrative Record" document (*Remedy Selection Process for Remaining Source Operable Unit Waste Sites* [DOE-RL 1998c]). In addition, as new sites are discovered, an unknown number of other waste sites may also be considered potentially clean. The term "candidate site" has been used to distinguish these sites from other waste sites where contaminant levels are known to exceed the remedial action goals.

The significant aspects of the SAP include the following:

- The candidate sites have been grouped into eight conceptual site models based on site configuration and waste stream characteristics during the data quality objectives process. These conceptual site models are distinct waste site groups based on similar waste deposition characteristics or unique physical configurations that must employ specific sampling designs for interim closure. The conceptual site models are presented in Section 1.2. The sampling designs for each of the eight conceptual site models are presented in Appendices A through H.

- Each of the candidate sites will be characterized for interim closure. If contamination levels are found to exceed the action levels, the project may elect to transfer the site(s) to the 100 Area Remedial Action Projects for cleanup, or perform additional sampling and analysis, based on the results of cost-benefit determinations.

- The applicable or relevant and appropriate requirements are consistent with the Remaining Sites Record of Decision (EPA 1999) (15 mrem/yr above background and *Model Toxics Control Act* for residual contamination levels in structures and soils).

- Shallow and deep zone distinctions have been applied to both structures and soil for assignment of the appropriate cleanup levels.

PART I	Part I presents project background and rationale for sampling and analytical strategies to provide cost-effective and timely data to support interim site closure and/or disposal activities.
PART II	The quality assurance project plan presents the activities and guidelines to provide for data of known and appropriate quality.
PART III	The field sampling plan provides field procedures to ensure representative data of known quality.

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ACRONYMS

BHI	Bechtel Hanford, Inc.
COPC	contaminant of potential concern
CSM	conceptual site model
D&D	decontamination and decommissioning
DCGL	derived concentration guideline levels
DOE	U.S. Department of Energy
DQA	data quality assessment
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
ERC	Environmental Restoration Contractor
HEIS	Hanford Environmental Information System
HPGe	high-purity germanium
MARSSIM	*Multi-Agency Radiation Survey and Site Investigation Manual*
MDA	minimum detectable activity
MDL	method detection limit
MTCA	*Model Toxics Control Act*
NaI	sodium iodide
PCB	polychlorinated biphenyl
PQL	practical quantitation limit
QA/QC	quality assurance/quality control
QAPjP	quality assurance project plan
RAG	remedial action goal
RCF	Radiological Counting Facility
RCRA	*Resource Conservation and Recovery Act of 1976*
RESRAD	RESidual RADioactivity dose model
RL	U.S. Department of Energy, Richland Operations Office
ROD	Record of Decision
RPD	relative percent difference
RSD	relative standard deviation
SAP	sampling and analysis plan
SD	standard deviation
SDMP	sample and data management process
SFL	standard fixed laboratory
SOP	standard operating procedure
SRM	standard reference material
TBD	to be determined
UCL	upper confidence limit
WIDS	Waste Information Data System

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METRIC CONVERSION CHART

The following conversion chart is provided to aid the reader in conversion.

Into Metric Units			Out of Metric Units		
If You Know	*Multiply By*	*To Get*	*If You Know*	*Multiply By*	*To Get*
Length			**Length**		
inches	25.4	millimeters	millimeters	0.039	inches
inches	2.54	centimeters	centimeters	0.394	inches
feet	0.305	meters	meters	3.281	feet
yards	0.914	meters	meters	1.094	yards
miles	1.609	kilometers	kilometers	0.621	miles
Area			**Area**		
sq. inches	6.452	sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.093	sq. meters	sq. meters	10.76	sq. feet
sq. yards	.0836	sq. meters	sq. meters	1.196	sq. yards
sq. miles	2.6	sq. kilometers	sq. kilometers	0.4	sq. miles
acres	0.405	hectares	hectares	2.47	acres
Mass (weight)			**Mass (weight)**		
ounces	28.35	grams	grams	0.035	ounces
pounds	0.454	kilograms	kilograms	2.205	pounds
ton	0.907	metric ton	metric ton	1.102	ton
Volume			**Volume**		
teaspoons	5	milliliters	milliliters	0.033	fluid ounces
tablespoons	15	milliliters	liters	2.1	pints
fluid ounces	30	milliliters	liters	1.057	quarts
cups	0.24	liters	liters	0.264	gallons
pints	0.47	liters	cubic meters	35.315	cubic feet
quarts	0.95	liters	cubic meters	1.308	cubic yards
gallons	3.8	liters			
cubic feet	0.028	cubic meters			
cubic yards	0.765	cubic meters			
Temperature			**Temperature**		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius	Celsius	multiply by 9/5, then add 32	Fahrenheit
Radioactivity			**Radioactivity**		
picocuries	37	millibecquerel	millibecquerel	0.027	picocuries

PART I

PROJECT BACKGROUND AND RATIONALE FOR SAMPLING AND ANALYTICAL STRATEGIES

Part I presents project background and rationale for sampling and analytical strategies, to support interim closure of candidate sites.

1.0 INTRODUCTION

This confirmatory sampling and analysis plan (SAP) presents the rationale and strategy for the sampling and analysis activities that support interim closure of remaining source operable unit waste sites as they are described in the *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units* (Remaining Sites ROD) (EPA 1999). The purpose of the proposed sampling and analysis activities is the characterization of these waste sites, which are candidates for closure without remedial action. The results of the sampling and analysis activities will also support future waste profiling and waste designation if the candidate sites are determined to be contaminated at levels that require remedial actions. This SAP is based on the *Data Quality Objectives Summary Report for the 100 Area Remaining Confirmatory Sampling Effort Sites* (BHI 1999).

This section provides background information about the project, as well as a discussion of the contaminants of potential concern (COPCs) and a summary of the data quality objectives (DQOs).

1.1 BACKGROUND

The Hanford Site became a Federal facility in 1943 when the U.S. Government took possession of the land to produce nuclear materials for defense purposes. The Hanford Site's production mission continued until the late 1980's, when the mission changed from producing nuclear materials to cleaning up the radioactive and hazardous wastes generated over the previous years.

The DQO Process Summary Report (BHI 1999) contains a compilation of site-specific information, such as facility descriptions, process history, study area, and spill/release history, and general housekeeping for the candidate sites. Generally, the candidate sites consist of past-practice waste disposal units that contain concrete, rubble, pipe, and soil. They were typically used for the disposal of potentially contaminated liquids or debris; however, process history indicates that these sites have the potential for interim closure without remedial action.

1.1.1 Process History Overview

Site-specific topics such as facility descriptions, process history, study areas, spill history, general housekeeping, etc., are provided in Appendix I of BHI (1999). Because of the large number of candidate sites, and their diverse configurations, it is not practical to provide a meaningful process history in this SAP.

1.1.2 Project Objectives

The objective of this project is to establish sampling and analysis strategies for clean site confirmation of candidate waste sites. The DQO process performed for the Remaining Sites identified the environmental measurement requirements for candidate site interim closeout. This SAP, generated as a result of the DQO process, provides eight sampling designs that will be

applied to the Remaining Sites, and may also be applied to future waste site groups within specific guidelines and requirements that constrain sample design applications.

1.2 CONCEPTUAL SITE MODEL

Eight conceptual site models (CSMs) were developed for the Remaining Sites. The CSMs are a categorization of waste sites that share physical or waste stream characteristics to enable the development of common interim closure sampling designs for the waste sites within each group. The eight CSMs are presented below.

1.2.1 Dispersing Liquid Discharge Sites

Dispersing liquid discharge sites are a common type of waste site in the 100 Areas. These typically include french drains, drywells, cribs, and trenches. The conceptual model for these sites is based on the deliberate use of the soil column to receive discharged aqueous liquids. The engineered structures for this CSM disperse the liquids underground, where they percolate into the soil column.

This CSM assumes that the constituent concentrations decrease with increasing distance from the point of discharge.

1.2.2 Nonradioactive Surface Spills

These surface spills include oil spills, acid surface spills, and unplanned releases. The soils are assumed to exhibit elevated waste constituent concentrations near the surface and the points of discharge. Concentrations are expected to decrease with increasing distance from the points of discharge.

1.2.3 Underground Confining Structures (Metal or Concrete) and Piping

These waste sites include tanks (not septic), concrete vaults/pits, as well as junction boxes (with internal contents), pipelines, and surrounding soils. The tank, piping components, and potential tank contents are the unique aspects of this category.

1.2.4 Construction Laydown Yards, Burn Pits, and Dumping Areas, Including Sandblast Areas

These sites contain coal plant ash, buried construction materials, buried silica gel, and sandblast media that may be surficial or buried under stabilizing fill. The soils underlying these sites may have been contaminated as a result of water migration through the wastes. The waste forms are expected to be heterogeneous.

1.2.5 Potentially Volumetric Contaminated Clear Wells and In Situ Decontamination and Decommissioning Sites

These sites include clearwells, the demolition rubble they contain, in situ decontamination and decommissioning (D&D) sites, and the potentially impacted surrounding soils. Clearwells were used to receive demolition rubble from the reactor and support facilities. In situ D&D sites are structures that have been demolished in-place. The demolition rubble is potentially noncontaminated. Release of this demolition waste was to U.S. Department of Energy (DOE) criteria at the time of site demolition and may or may not be acceptable under current cleanup criteria. Interim closure includes the concrete clearwells, in situ demolished structures, and the demolition rubble they contain.

1.2.6 Potentially Volumetrically Contaminated Intact Concrete Slabs

These waste sites include intact concrete slabs that remain after demolition of facility superstructures. These concrete slabs have potential for volumetric contamination. Release of these concrete slabs was to DOE criteria at the time of site demolition and may or may not be acceptable under current cleanup criteria. In addition, the surrounding/underlying soils will be evaluated for confirmation sampling requirements.

1.2.7 Septic Systems and Associated Piping

The Remaining Sites include septic tanks, associated piping, tile fields, and the surrounding soils. Septic systems may or may not be radiologically contaminated.

1.2.8 Reactor Stack Demolition Sites

Formerly used reactor stack structures were demolished by controlled detonation, causing the stacks to drop into prepared trenches. They were later buried in-place. The lower portions of the stacks are broken into large pieces of rubble. The upper portions of the stacks were pulverized due to the very high velocities attained prior to impacting the trench.

1.3 CONTAMINANTS OF POTENTIAL CONCERN

The Remaining Sites may have been contaminated with radiological and/or chemical constituents as a result of reactor or facility operations. The candidate sites have been sorted into 15 site profiles to form groupings with similar contaminants of potential concern (COPCs). The assignment of the site profile is based on site preliminary COPCs identified from historical process knowledge, sample data, analogous sites, and site construction information. The site profile groupings are independent of the CSMs discussed in Section 1.2. Each candidate site will be evaluated for the applicable site profile during confirmatory sampling. Additional site profiles may be identified in the future as other sites are evaluated and added to the list of candidate sites. A master list of site profiles is provided in Table 1-1, which identifies the site profiles and COPCs.

Table 1-1. List of COPCs (from Remaining Sites Site Profile List). (2 Pages)

Site Profile #	Site Profile	Waste	COPCs
1	119 Building sample station	Received sample waste, janitorial waste, and drainage from the evaporative cooler. Sample preparation solutions (fission products, including alpha emitters, sodium-dichromate-treated water, trace metals, and dioctyl phthalate).	^{14}C, ^{60}Co, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{155}Eu, ^{3}H, ^{90}Sr, ^{228}Th, ^{232}Th, ^{234}U, ^{235}U, ^{238}U, bis(2-ethylhexyl)phthalate, Cr^{+6}, Hg, Pb, SVOAs, VOAs
2	Condensate crib	Drainage from gas purification systems (fission products, including alpha emitters and sodium-dichromate-treated water).	^{14}C, ^{60}Co, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{155}Eu, ^{3}H, ^{226}Ra, ^{90}Sr, ^{228}Th, ^{232}Th, ^{234}U, ^{235}U, ^{238}U, bis(2-ethylhexyl)phthalate, Cr^{6+}, Hg, Pb, SVOAs, VOAs
3	Demolished building/ facility site (nonradioactive)	Site of a facility used for acids/caustics. Concrete base and piping remain in place. No known contaminant releases (metals).	Ag, As, Ba, Cd, Cr, Cr^{+6}, Hg, Pb, Se, sulfate
4	Demolished building/ facility site (radioactive)	Site of a potentially radionuclide contaminated building or facility (miscellaneous radionuclides, residual sodium dichromate).	^{60}Co, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{155}Eu, ^{238}Pu, $^{239/240}Pu$, ^{90}Sr, ^{234}U, ^{235}U, ^{238}U, As, Cr^{+6}, Pb, Zn
5	Dumping area/burn pit	Scrap metal, glass, nonfriable and friable asbestos; also office waste, laboratory waste, paint, and uncontaminated rubble and debris.	As, Hg, Pb, PCBs, TPH, pesticides, SVOAs, VOAs, asbestos
6	Hydrocarbon-contaminated soil	Site of fuel oil spillage or a steel underground storage tank (hydrocarbons).	Pb, SVOAs, TPH, VOAs, RCRA metals
7	Laboratory drainage pipe, sump, and/or french drain	No record of waste type or quantity (miscellaneous radionuclides and metals solutions).	^{60}Co, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{155}Eu, ^{131}I, ^{238}Pu, $^{239/240}Pu$, ^{90}Sr, ^{232}Th, ^{234}U, ^{235}U, ^{238}U, As, Cr^{+6}, Hg, Pb, benzo(a)antracene, benzo(a)pyrene, benzo(b)fluoranthrene, benzo(k)fluoranthrene, chlordane
8	Polychlorinated biphenyls (PCBs) in soil	PCBs	PCBs
9	Potentially contaminated sewer	Received sanitary sewage from facilities known to use/handle radioactive material.	^{241}Am, ^{60}Co, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{155}Eu, $^{239/240}Pu$, ^{90}Sr, As, Cd, Cr, Cr^{+6}, Hg, Pb, Zn, phthalates
10	Radiological soil contamination	Soil contaminated by radioactively contaminated liquid wastes.	^{14}C, ^{60}Co, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{3}H, ^{63}Ni, ^{238}Pu, $^{239/240}Pu$, ^{90}Sr, ^{234}U, ^{235}U, ^{238}U, Cr, Cr^{+6}, Hg

Table 1-1. List of COPCs (from Remaining Sites Site Profile List). (2 Pages)

Site Profile #	Site Profile	Waste	COPCs
11	Reactor french drain	Received effluent and decon solution. No record of dates of operation, waste type, or quantity.	^{60}Co, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{155}Eu, ^{238}Pu, $^{239/240}Pu$, ^{90}Sr, As, Ba, Cr^{+6}, Pb
12	Sanitary sewer	Received sanitary sewage from facilities known to not use/handle radioactive material.	Pb, pesticides, SVOCs
13	Shop drainage pipe, sump, and/or french drain	Used for disposal of low-level radioactive materials and shop waste.	^{60}Co, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{155}Eu, ^{90}Sr, Ag, As, Ba, Cd, Cr, Cr^{+6}, Hg, Pb, Se, SVOAs
14	Silica gel pit	Silica gel from dryers (fission products).	^{14}C, ^{60}Co, ^{137}Cs, ^{154}Eu, ^{3}H, ^{90}Sr
15	Spent acid/caustics pit/drain	Received sulfuric acid overflow or caustic solutions before disposal to the process sewer system.	Ag, As, Ba, Cd, Cr, Cr^{+6}, Hg, Pb, Se, sulfate

SVOA = semi-volatile organic analysis
VOA = volatile organic analysis

Table 1-2 lists the COPCs excluded from the investigation and the rationale for the exclusion.

Table 1-2. Rationale for COPC Exclusions.

Excluded COPCs	Rationale for Exclusion
^{131}I	Short half-life isotope (8 days).
^{226}Ra	Naturally occurring. Site processes did not contribute to accumulation of this isotope.
^{228}Th	A daughter product of, and in secular equilibrium with ^{232}Th.
^{232}Th	This is a naturally occurring isotope in the Hanford Site's 100 Areas.
Ba	Not found at levels that approach the RAGs in analogous sites.
Zn	Not found at levels that approach the RAGs in analogous sites.

Table 1-3 provides the final list of COPCs for each waste stream, with the rationale for inclusion.

Table 1-3. Final List of COPCs[a].

Site Profile#	Site Profile	COPCs
1	119 Building sample station	^{14}C, ^{60}Co, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{155}Eu, ^{3}H, ^{90}Sr, ^{234}U, ^{235}U, ^{238}U, bis(2-ethylhexyl) phthalate, Cr^{+6}, Hg, Pb, SVOAs, VOAs,
2	Condensate crib	^{14}C, ^{60}Co, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{155}Eu, ^{3}H, ^{90}Sr, ^{234}U, ^{235}U, ^{238}U, bis(2-ethylhexyl) phthalate, Cr^{+6}, Hg, Pb, SVOAs, VOAs
3	Demolished building/facility site (nonradioactive)	Ag, As, Cd, Cr, Cr^{+6}, Hg, Pb, Se, sulfate
4	Demolished building/facility site (radioactive)	^{60}Co, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{155}Eu, ^{238}Pu, $^{239/240}Pu$, ^{90}Sr, ^{238}U, As, Cr^{+6}, Pb
5	Dumping area/burn pit	As, Hg, Pb, PCBs, pesticides, SVOAs, TPH, VOAs, asbestos
6	Hydrocarbon contaminated soil	Pb, SVOAs, TPH, VOAs, RCRA metals
7	Laboratory drainage pipe, sump, and/or french drain	^{60}Co, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{155}Eu, ^{238}Pu, $^{239/240}Pu$, ^{90}Sr, ^{234}U, ^{235}U, ^{238}U, As, Cr^{+6}, Hg, Pb, benzo(a)antracene, benzo(a)pyrene, benzo(b)fluoranthrene, benzo(k)fluoranthrene, chlordane
8	PCBs in soil	PCBs
9	Potentially contaminated sewer	^{241}Am, ^{60}Co, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{155}Eu, $^{239/240}Pu$, ^{90}Sr, As, Cd, Cr(III), Cr^{+6}, Hg, Pb, phthalates
10	Radiological soil contamination	^{14}C, ^{60}Co, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{3}H, ^{63}Ni, ^{238}Pu, $^{239/240}Pu$, ^{90}Sr, ^{234}U, ^{235}U, ^{238}U, Cr, Cr^{+6}, Hg
11	Reactor french drain	^{60}Co, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{155}Eu, ^{238}Pu, $^{239/240}Pu$, ^{90}Sr, As, Cr^{6+}, Pb
12	Sanitary sewer	Pb, pesticides, SVOAs
13	Shop drainage pipe, sump, and/or french drain	^{60}Co, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{155}Eu, ^{90}Sr, Ag, As, Cd, Cr, Cr^{+6}, Hg, Pb, Se, SVOAs
14	Silica gel pit	^{14}C, ^{60}Co, ^{137}Cs, ^{154}Eu, ^{3}H, ^{90}Sr
15	Spent acid/caustics pit/drain	Ag, As, Cd, Cr, Cr^{+6}, Hg, Pb, Se, sulfate

[a] Determination of specific SVOAs and VOAs will be made on a site-by-site basis.

All waste sites and waste site groups (100 Area Remaining Sites and other sites that apply this SAP) must be evaluated for agreement with the Remaining Site profiles and CSMs to enable the use of the sampling designs presented in Section III. If new waste sites or waste site groups do not align with the site profiles or CSMs within this SAP, new profiles and/or CSMs will need to be developed. If new CSMs are required, new sampling designs will be required as well. The field engineer is responsible to perform and document these waste site evaluations.

1.4 DATA QUALITY OBJECTIVES

The U.S. Environmental Protection Agency's (EPA's) DQO (EPA 1994) process was used to support the development of this SAP. The DQO process is a strategic planning approach that provides a systematic method of defining the criteria that a data collection design should satisfy. Using the DQO process ensures that the type, quantity, and quality of environmental data used in decision making will be appropriate for the intended application.

This DQO summary contains only essential information that supports the sampling plan. Project-specific DQO information is provided in the *Data Quality Objectives Summary Report for the 100 Area Remaining Confirmatory Sampling Effort Sites* (BHI 1999), which is the complete record of project DQO considerations and decisions.

1.4.1 Statement of the Problem

Given the goal of determining if the Remaining Sites must be remediated or if they satisfy interim closure requirements without remedial action, the problem is to develop a series of sampling strategies for each conceptual waste site model that accounts for their unique physical and waste stream characteristics.

1.4.2 Decision Rules

This section captures the outputs of DQO Steps 2, 3, and 4 for each decision rule (e.g., statistical or nonstatistical parameter of interest, action level, scale of decision, and alternative actions). The decision rules are summarized in Table 1-4.

Table 1-4. Decision Rules. (3 Pages)

DR #	Decision Rule
Field Screening	
1	Radiological shallow zone[a]: If the maximum confirmed detected survey results in small sites, or the 95% UCL for the mean confirmed detected survey results in large sites[b] in soils, rubble and/or engineered structures within the candidate site(s) are less than the shallow zone threshold values in footnote c, then the site field screening results will be evaluated in accordance with DRs #2, 3 (if there are nonradiological COPCs), and 4. If the maximum confirmed detected survey results in small sites, or the 95% UCL for the mean confirmed detected survey results in large sites[b] in soils, rubble, and/or engineered structures within the candidate sites exceed the shallow zone threshold values in footnote c, then the site is radiologically contaminated and will be assigned to the 100 Areas remedial action projects team for remedial action. For sites that have chemical COPCs, the chemical field screening will be performed in accordance with DRs #2 and 3 for additional field information.

Table 1-4. Decision Rules. (3 Pages)

DR #	Decision Rule
2	Chemical shallow zone: If the maximum detected field screening results in small sites, or the 95% UCL for the mean detected field screening results for large sites[b] in soils, rubble, and/or engineered structures within the candidate site is less than the shallow zone threshold values in Table 2-1, then the site field screening results will be evaluated in accordance with DR#3. If the maximum detected field screening results in small sites, or the 95% UCL for the mean detected field screening results for large sites[b] in soils, rubble, and/or engineered structures within the candidate site(s) exceed the shallow zone threshold values in Table 2-1, then the site is chemically contaminated and will be assigned to the 100 Areas remedial action project team for remedial action.
3	Chemical deep zone: If the maximum detected field screening results in small sites, or the 95% UCL for the mean detected field screening results for large sites[b] in soils, rubble, and/or engineered structures within the candidate site is less than the deep zone threshold values in Table 2-1, then the site qualifies for confirmation sampling and analysis in accordance with DRs #4, 5, 6, and 7. If the maximum detected field screening results in small sites, or the 95% UCL for the mean detected field screening results for large sites[b] in soils and/or engineered structures within the candidate site exceeds the deep zone threshold values in Table 2-1, then the site is chemically contaminated and will be assigned to the 100 Areas remedial action project team for remedial action.
Standard Fixed Laboratory Analyses	
4	Radiological shallow zone: If RESRAD analysis of the 95% UCL for the mean sample results (pCi/g) for soils and/or engineered structures within the candidate site(s) indicates that the annual worst-case residential exposure is less than 15 mrem/yr, and the groundwater exposure is less than 4 mrem/yr[d], then the site meets the shallow zone radiological cleanup levels and will be evaluated for closure in accordance with DRs #5 and 7 (if there are nonradiological COPCs) and DR #6. If RESRAD analysis of the 95% UCL for the mean sample results (pCi/g) for soils and/or engineered structures within the candidate site indicates that either the annual worst-case residential exposure exceeds 15 mrem/yr or the groundwater exposure exceeds 4 mrem/yr[d], then the site is radiologically contaminated and will be assigned to the 100 Areas remedial action project team for remedial action.

Table 1-4. Decision Rules. (3 Pages)

DR #	Decision Rule
5	Chemical shallow zone If the analytical results of soil and/or engineered structures samples within the candidate sites satisfy the MTCA three-part statistical test (95% UCL for the mean concentration < cleanup level; the maximum detected value <2 times the cleanup level; and no more than 10% of the data exceeding the cleanup levels) in accordance with the shallow zone cleanup levels in Table 2-1, then the site(s) will be evaluated for deep zone constituents in accordance with DRs #6 and 7. If the analytical results of soil and/or engineered structures samples within the candidate sites do not satisfy the MTCA three-part statistical test (95% UCL for the mean concentration < cleanup level; the maximum detected value <2 times the cleanup level; and no more than 10% of the data exceeding the cleanup levels) in accordance with the shallow zone cleanup levels in Table 2-1, then the site(s) will be assigned to the 100 Areas remedial action project team for remedial action.
6	Radiological deep zone[e] If RESRAD analysis of the 95% UCL for the mean sample results (pCi/g) for soils and/or engineered structures within the candidate site indicates that the annual groundwater exposure is less than 4 mrem/yr[d], then the site meets the deep zone cleanup levels and will be evaluated for closure in accordance with DR #7. If RESRAD analysis of the 95% UCL for the mean sample results (pCi/g) for soils and/or engineered structures within the candidate site indicates that the annual groundwater exposure exceeds 4 mrem/yr[d], then the site is radiologically contaminated and will be assigned to the 100 Areas remedial action project team for evaluation of balancing factors or remedial action.
7	Chemical deep zone[e] If the 95% UCL for the mean derived from the analytical results of soil and/or engineered structures samples within the candidate sites satisfy the maximum contaminant levels (MCLs) or nonzero maximum concentration guideline levels (MCGLs), then the site meets the 100 Areas deep zone chemical cleanup levels and may be interim closed without remedial action. If the analytical results of soil and/or engineered structures samples within the candidate sites do not satisfy the MCLs or nonzero MCGLs, then the site is chemically contaminated and will be assigned to the 100 Areas remedial action project team for evaluation of balancing factors or remedial action.

[a] Because RESRAD is used to estimate groundwater RAGs for site-specific conditions and COPCs, field screening for radiological contaminants in the deep zone is for health and safety protection only, and does not address decision rules.

[b] Large sites include burn pits, construction laydown yards, dumping areas, clearwells, and in situ D&D sites. The field engineer may perform a cost/benefit evaluation that balances field screening and remediation costs on a site-by-site basis to determine whether a site should be considered small or large, and the extent of field screening required.

[c] Field screening criteria will be designed with the characterization of the contamination and the site conditions, such that field screening criteria perform similarly to SFL data, and conservatively when possible.

[d] The 4 mrem/yr dose is based on target organ protection from the consumption of groundwater as calculated by the NBS Handbook 69 methodology (NBS 1969).

[e] Deep zone sampling/analysis will only be performed for sites that are expected to contain COPCs at depths greater than 4.6 m (15 ft) below grade.

1.4.3 Decision Error Consequences

The decision error consequences portion (Step 6) of the Remaining Sites DQO is significant in scope because eight CSMs were evaluated. The summary of the decision error consequences provided in this SAP is therefore generic. Detailed information on the decision errors for the eight CSMs are provided in Appendices A through H in BHI (1999).

The results of Steps 2 and 4 in the DQO Summary Report (BHI 1999) indicated that a statistically based sampling design is required for the Remaining Sites. This section summarizes the selection of the decision error tolerances needed to support the statistical designs and the data assessment performed after the SAP has been implemented.

Several inputs for determining the acceptable rates of decision error are required, which include defining the types of decision errors and the statement of a null hypothesis for each decision, specifying the acceptable rates of decision error, and determining the upper and lower bounds of the gray region. Summaries of these inputs are presented below.

Two types of error are associated with each decision. In general, these errors can be stated as (1) mistakenly concluding that the action limit has been met, and (2) mistakenly concluding that the action limit has not been met. An evaluation of the consequences of these decision errors led to the designation of the null hypotheses shown in Table 1-5.

Table 1-5. Statement of the Null Hypothesis.

The site is assumed to be contaminated.

The 95% upper confidence limit (UCL) specified in Table 1-4 corresponds to a 5% tolerable error rate for mistakenly concluding that the action level is not exceeded. This error tolerance is applied to decision rules 4 through 7, which form the basis for the interim closure decisions. The tolerable error rate for mistakenly concluding that the action level is exceeded was set at 20%. Tolerable decision error rates are summarized in Table 1-6.

Table 1-6. Tolerable Decision Errors.

DS #	Media	COPCs	Parameter of Interest	Statistic of Interest	Tolerable Decision Error	
					False-Positives (%)	False-Negatives (%)
1	TBD	Radionuclides	Population mean concentration	Single-tailed 95% UCL of sample results	5%	20%
2	TBD	Nonradionuclides	Population mean concentration	Single-tailed 95% UCL of sample results	5%	20%
			Population maximum concentration	Maximum of sample results	N/A	N/A
			Proportion of elevated concentrations	Proportion of sample results greater than RAGs	N/A	N/A
3	TBD	Radionuclides	Population mean concentration	Single-tailed 95% UCL of sample results	5%	20%
4	TBD	Nonradionuclides	Population mean concentration	Single-tailed 95% UCL of sample results	5%	20%

N/A = not applicable (see text for discussion)
TBD = to be determined (on a site-specific basis)

Table 1-7 shows the boundaries of the gray region when the population mean is the parameter of interest. As stated above, the upper bound of the gray region is the action level; the lower bound will be determined based on the accuracy requirements from Table 2-2. The relative percent difference (RPD) is provided by analytical method in Table 2-2 as 30% for all methods. This RPD is converted to a relative standard deviation (RSD) of 21.2%. An additional 10% has been added to the RPD to account for some amount of population variability, which was chosen based on judgment. The LBGR is then determined as:

$$LBGR = RAG(1-RSD_a)$$

where:

LBGR = lower bound of the gray region
RAG = remedial action goal from Table 2-1
RSD_a = relative standard deviation of the analytical method plus 10%.

Hence, the LBGR for this project is always 68.8% of the action level. If the accuracy requirements of the analytical methods change, the LBGR will be adjusted accordingly.

Table 1-7. Boundaries of the Gray Region. (2 Pages)

Media	COPCs	Gray Region	
		Upper Bound (= RAG[a])	Lower Bound (= 68.8% of RAG[a])
		mg/kg	mg/kg
All components within Remaining Sites CSMs	***Shallow Zone Radionuclides***	pCi/g	pCi/g
	Am-241	31.1	21.39
	C-14	5.16	3.552
	Co-60	1.4	0.96
	Cs-137	6.2	4.3
	Eu-152	3.3	2.3
	Eu-154	3	2.1
	Eu-155	125	86
	H-3	510	351
	Ni-63	4,026	2,770
	Pu-238	37.4	25.7
	Pu-239/240	33.9	23.3
	Sr-90	4.5	3.1
	U-233/234	1.1	0.76
	U-235	1.0	0.69
	U-238	1.1	0.76
	Shallow Zone Chemical Constituents	mg/kg	mg/kg
	Ag	400	275
	As	6.5	4.5
	Cd	80	55
	Cr (III)	80,000	55,000
	Cr+6	2.2	1.5
	Hg	24	16.5
	Pb	353	243
	Se	400	275
	Benzo(a) anthracene	0.33	0.227
	Benzo(a) pyrene	0.33	0.227
	Benzo(b) flouranthrene	0.33	0.227
	Benzo(k) flouranthrene	0.33	0.227
	Bis(2-ethylhexyl) phthalate	71.4	49.12
	Chlordane	0.33	0.227
	Pesticides	Compound-specific: 1.0[b]	Compound-specific: 0.69
	Phthalates	Compound-specific: 32-320	Compound-specific: 22-220
	Sulfate	25,000	17,200
	TPH	Compound-specific: 100-200	Compound-specific: 69-137.6
	SVOAs	Compound-specific: 0.5-1.0[b]	Compound-specific: 0.34-0.69
	VOAs	Compound-specific: 0.5-20[b]	Compound-specific: 0.34-13.7
	PCBs	0.5	0.344

Table 1-7. Boundaries of the Gray Region. (2 Pages)

Media	COPCs	Gray Region	
		Upper Bound (= RAG[a])	Lower Bound (= 68.8% of RAG[a])
	Deep Zone Chemical Constituents	**mg/kg**	**mg/kg**
	Ag	400	275
	As	6.5	4.5
	Cd	0.5	0.34
	Cr (III)	36	24.7
	Cr+6	2.2	1.5
	Hg	0.33	0.33[c]
	Pb	10.2	10.2[c]
	Se	400	275
	Benzo(a) anthracene	0.33	0.227
	Benzo(a) pyrene	0.33	0.227
	Benzo(b) flouranthrene	0.33	0.227
	Benzo(k) flouranthrene	0.33	0.227
	Bis(2-ethylhexyl) phthalate	32	22
	Chlordane	0.33	0.227
	Pesticides	Compound-specific: 0.02	Compound-specific: 0.02[d]
	Phthalates	Compound-specific: 2-160	Compound-specific: 1.37-110
	Sulfate	25,000	17,200
	TPH	Compound-specific: 100[b]	Compound-specific: 69
	SVOAs	Compound-specific: 0.5[b]	Compound-specific: 0.34
	VOAs	Compound-specific: 0.05-0.1[b]	Compound-specific: 0.34-0.69
	PCBs	0.5	0.344

[a] RAGs developed from RDR/RAWP (DOE-RL 1998b) methodology or directly from RDR/RAWP Table 2-7, unless otherwise specified. RAGs for radionuclides are based on dose; therefore, deep and shallow zone classifications do not apply.

[b] No RAGs are specified for the general group of contaminants. The basis for RAGs of specified compounds may be determined using MTCA Method B (WAC 173-340), or as published in CLARC II update (EPA 1996).

[c] The calculated value is below background. The value presented is background.

[d] The calculated value is below the practical quantitation limit (PQL). The value presented is the PQL.

N/A = not applicable
TBD = to be determined
TPH = total petroleum hydrocarbons

1.5 SAMPLE DESIGN SUMMARY

This summary provides the sample design bases and a summary of the sample designs developed in DQO Step 7. The specific sampling guidance for each of the CSMs is provided in Appendices A through H.

The approach used for the characterization surveys/sampling design for the Group 5/Remaining Sites is based on a composite of the *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) (NRC 1997) approach using several techniques. The primary basis for the radiological surveys is the Class 3 MARSSIM scenario that assumes that the sites are not contaminated above releasable levels. The sampling design uses a Bayesian/Statistical approach that estimates the probability of contamination in certain areas of the sites, which may be further modified by the physical characteristics of the individual sites. In all cases, the surveys meet the intent of the MARSSIM document guidelines for area covered and data quality.

The sampling design for the Remaining Sites is based on a two-step approach that uses a combination of statistical and judgmental sampling. The Step I sampling design establishes the number of lateral sampling locations in the X-Y plane at each CSM waste site. Each site may consist of one or more components, each component having unique contaminant dispersion characteristics and physical construction. Figure 1-1 shows a three-dimensional perspective of a hypothetical waste site. As shown in Figure 1-1, the Step I sample design determines the number of sampling locations on the top planar surface of a waste site (X-Y dimensions). The Part I sample design is statistically derived using the error tolerances developed in DQO Step 6 and Appendices A through H of BHI (1999).

The Step II sampling design establishes the number of samples required at depth (Z dimension) within each depth interval. Several physical strata (components) are contained within the hypothetical site that must be sampled. The Step II sample design is developed judgmentally, taking into account the type, number, and thickness of the underlying components that exist within the site.

An example of a hypothetical waste site is provided in Table 1-8, showing the probabilities that will be used to determine the number of sampling locations for nonradionuclide COPCs when historical data are not available. Table 1-8 also shows the additional inputs, namely the error tolerance rates, required in Step I to determine the number of samples required to support a decision based on the estimated population mean (e.g., 95% UCL).

Because there are different strata (components) underlying the surface of a waste site, the sampling at depth (Step II sample design) must be evaluated on a case-by-basis. The generic sampling frequencies and sampling requirements are provided in Table 1-9.

Figure 1-1. Simplified Illustration of Step I Lateral Sample Locations.

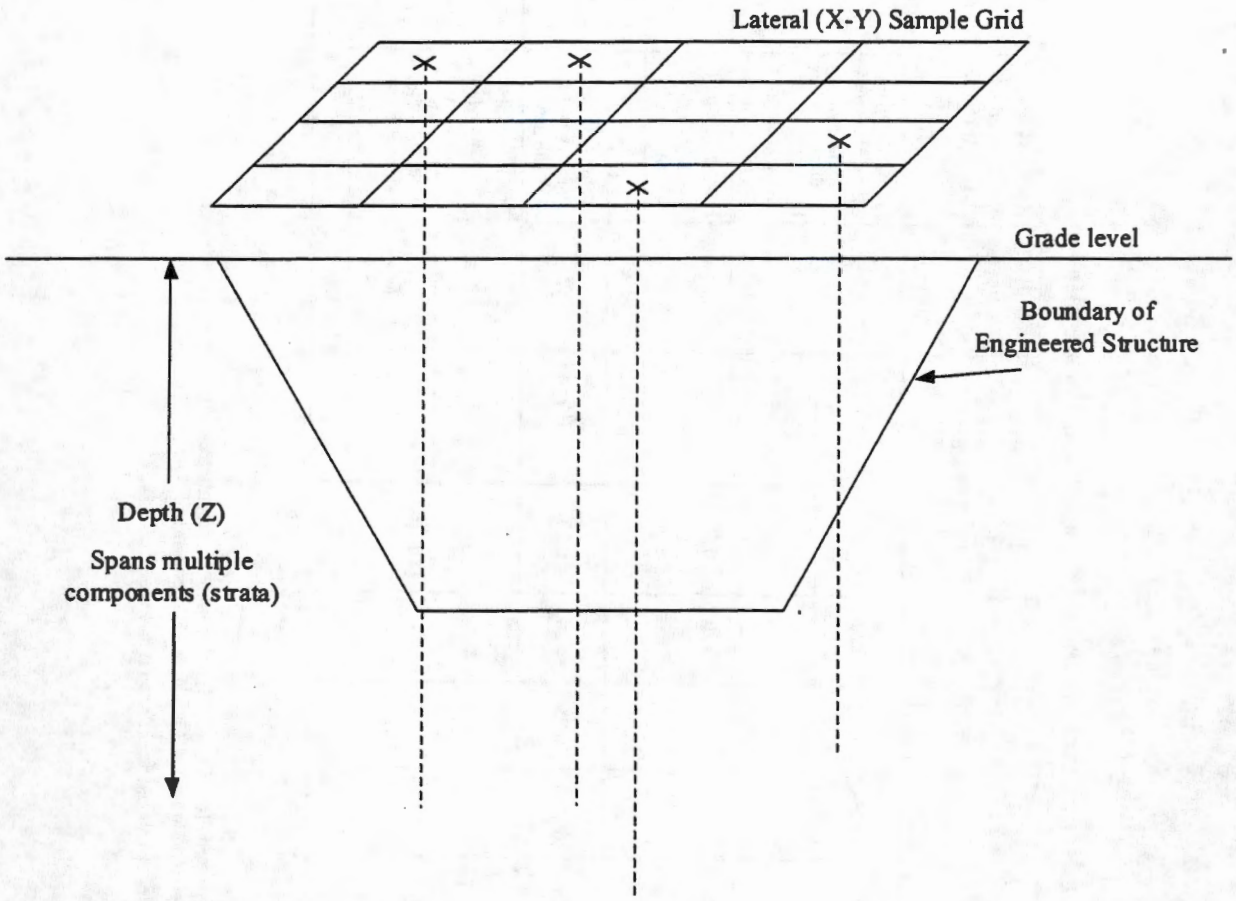


Table 1-8. Example Sampling Requirements for a Hypothetical Waste Site.

Site Component	COPCs[a]	Parameter of Interest	Statistic of Interest	RSD_{site}[b]	RPD_{lab}[b]	LBGR[b] (% of RAG)	Alpha	Beta	Pr (contam-inated)	Relative Error Consequence Ratio	Default # of Samples per Component per Depth Interval	# of Samples per Component per Depth Interval Based on Analogous Site	Calculated # of Samples per Component per Depth Interval
Native soil interface under aggregate	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	0.40	N/A	64	From computation using analogous site data	Site-specific computation
	Non-radionuclides	Maximum	Maximum concentration	1.00	0.30	68.8%	0.05	0.20	0.40	2	3[c]	From computation using analogous site data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	From computation using analogous site data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A
Native soil 2 ft below aggregate/ soil interface	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	0.20	N/A	64	From computation using analogous site data	Site-specific computation
	Non-radionuclides	Maximum	Maximum concentration	1.00	0.30	68.8%	0.05	0.20	0.20	2	3[c]	From computation using analogous site data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	From computation using analogous site data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A

[a] For deep zone nonradionuclides, the 95% UCL for the mean is the only statistic of interest.

[b] Default value:
In lieu of having a RSD_{site} at the time of sample planning, a value of 100% is assumed.
In lieu of having a RPD_{lab} at the time of sample planning, a value of 30% is assumed. If RPD_{lab} >30%, a determination regarding data suitability must be made.
In lieu of analytical data or field screening results, the LBGR may be taken at 68.8% of the RAG based on RPDs established above.

[c] Per the lookup table, n=3; however, 4 samples is the minimum number of samples that should be collected if n<4.

N/A = not applicable

Table 1-9. Part II Sampling Frequency and Requirements.

Sampling Media, or Component	Sampling Frequency and Requirements
Media or component with a probability of contamination; Pr (contaminated) that ranges from 5% to 10%.	Administrative agreement that areas with these low probabilities will not be sampled.
Underlying media/component of a waste site and interface with native soils	From the interface with native soils to 1 ft below the interface.
Underlying media/component within the shallow zone of a waste site.	From every 3-ft thickness of sampling media, collect at least one sample. Collect a representative sample from a 1-ft-thick increment, randomly selected from the 3-ft depth interval. If sampling media is less than 3-ft thick, collect at least one representative sample.
Underlying media or component within a waste site that extends to within 2 ft of the deep zone soils.	Collect at least one representative sample from a randomly located 1-ft-thick increment from the top 3-ft interval of the deep zone.
Underlying media or component within a waste site that extends into the deep zone soils.	From every 3-ft thickness of sampling media, collect at least one sample. Collect a representative sample from a 1-ft-thick increment, randomly selected from the 3-ft depth interval. If sampling media is less than 3 ft thick, collect a minimum of one representative sample.

1.5.1 Sampling Contingencies

The sampling requirements determined by the statistical equations in the Step I sampling design are directly related to the variability provided by existing analytical data for the sites in question. When there is no historical or analogous site data, the equations default to a minimum sampling requirement of 64 samples per sampling depth. Because little or no historical sampling data exist for the 100 Area Remaining Sites, the default number of samples is generally applied to these sites.

For this reason, this SAP relies heavily on the use of field screening techniques to quickly and cost-effectively obtain meaningful sampling data that can be used as input to the statistical equations, reducing the Step I sampling requirements. However, given the size and configuration of the Remaining Sites, the number of samples calculated in Step I may still exceed practical limits. Several sampling contingencies have therefore been developed to provide reasonable alternatives for the 100 Area Remaining Sites field engineer(s). Section 2.2.4.3 discusses the sampling contingencies and their applications.

If historical data are not available for any components, the probabilities will be assigned as outlined in the design group-specific subsections in the appendices of this SAP. The minimum probability of contamination for any component is 0.05. However, components with probability

values of less than 0.10 will not be sampled, as the likelihood of encountering contamination is too low. Project decision makers have determined that components or sampling media with contamination probabilities less than 10% will not be sampled, based on cost effectiveness and the assumption that if there is contamination, it will be detected on one of the more likely contaminated components. Furthermore, this risk management decision is based on the policy that even if only one component is contaminated, the site as a whole must be deferred to Remedial Action Projects. Remedial Action Projects will target all site components for cleanup as required.

PART II

QUALITY ASSURANCE PROJECT PLAN

The quality assurance project plan presents the activities and guidelines to provide for data of known and appropriate quality.

2.0 QUALITY ASSURANCE PROJECT PLAN

This quality assurance project plan (QAPjP) presents the objectives, functional activities, methods, and quality assurance (QA)/quality control (QC) procedures associated with the field screening and collection and analyses of concrete and soil samples for interim closure of the 100 Area Remaining Candidate Sites. Where appropriate, existing QA/QC guidelines, policies, and programs will be incorporated by reference. This QAPjP follows EPA guidelines contained in the *EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations* (EPA 1994a).

2.1 PROJECT MANAGEMENT/DATA QUALITY OBJECTIVES

2.1.1 Project/Task Organization

Project/task organization will be similar to the 100-BC-1 Area Remedial Action Project identified in Section 3.2, "Project Team," of the *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (RDR/RAWP) (DOE-RL 1998b).

Because of the complexity of implementing this sampling design, technically competent personnel will be required to be in the field full time and will have some very extensive responsibilities. The technical lead will be responsible for ensuring that the site fits the assumed CSM and all supporting statistical assumptions are verified to the degree possible. The observational approach will be used to identify and verify spatial boundaries and site components. Field data shall be used to assess contaminants and determine if there are factors that might validate or invalidate assumptions concerning contaminant distribution. The technical lead and project engineer are responsible for knowing and implementing the statistically based sample design properly such that the field crew can maintain the flexibility required to compensate for logistical constraints without compromising the defensibility of the sample design or invalidating the DQOs.

2.1.2 Problem Definition/Background

Problem definition/background has been presented in Part I of this document and detailed in the *Data Quality Objectives Summary Report for the 100 Area Remaining Confirmatory Sampling Effort Sites* (BHI 1999). The problem definition and background information are summarized in Section 2.1.4, "Quality Objectives and Criteria for Measurement Data."

2.1.3 Project/Task Description

The project/task description, including the schedule, is provided in the RDR/RAWP (DOE-RL 1998b).

2.1.4 Quality Objectives and Criteria for Measurement Data

A formal DQO process was conducted for the Remaining Sites in accordance with *Guidance for Data Quality Objective Process* (EPA 1994b). Input to the DQO process was provided by the 100 Area remediation project team and management. A summary of analytical parameters, data uses, and applicable detection levels for the Remaining Sites is presented in Table 2-1.

Table 2-1. Data Uses and Remedial Action Goals/Lookup Values.[a] (5 Pages)

Analytical Parameter	Data Use	Remedial Action Goals/ Lookup Values[b]
^{241}Am	Overburden/layback	31.1
	Site confirmation	
	- Shallow zone	31.1
	- Deep zone	1.57E6
^{14}C	Overburden/layback	5.16
	Site confirmation	
	- Shallow zone	5.16
	- Deep zone	2.0[c]
^{60}Co	Excavation guidance	1.4
	Overburden/layback	1.4
	Site confirmation	
	- Shallow zone	1.4
	- Deep zone	N/A[d]
^{137}Cs	Excavation guidance	6.2
	Overburden/layback	6.2
	Site confirmation	
	- Shallow zone	6.2
	- Deep zone	N/A[d]
^{152}Eu	Excavation guidance	3.3
	Overburden/layback	3.3
	Site confirmation	
	- Shallow zone	3.3
	- Deep zone	N/A[d]
^{154}Eu	Overburden/layback	3.0
	Site confirmation	
	- Shallow zone	3.0
	- Deep zone	N/A[d]
^{155}Eu	Overburden/layback	125
	Site confirmation	
	- Shallow zone	125
	- Deep zone	N/A[d]
^{3}H	Overburden/layback	35.5
	Site confirmation	
	- Shallow zone	35.5
	- Deep zone	35.5

Table 2-1. Data Uses and Remedial Action Goals/Lookup Values.[a] (5 Pages)

Analytical Parameter	Data Use	Remedial Action Goals/ Lookup Values[b]
^{63}Ni	Overburden/layback	4,026
	Site confirmation	
	- Shallow zone	4,026
	- Deep zone	N/A[d]
^{238}Pu	Overburden/layback	37.4
	Site confirmation	
	- Shallow zone	37.4
	- Deep zone	1,123
$^{239/240}Pu$	Overburden/layback	33.9
	Site confirmation	
	- Shallow zone	33.9
	- Deep zone	718,600
^{90}Sr	Overburden/layback	4.5
	Site confirmation	
	- Shallow zone	4.5
	- Deep zone	N/A[d]
^{234}U	Overburden/layback	1.1
	Site confirmation	
	- Shallow zone	1.1
	- Deep zone	1.1
^{235}U	Overburden/layback	1.1
	Site confirmation	
	- Shallow zone	1.1
	- Deep zone	1.1
^{238}U	Overburden/layback	1.1
	Site confirmation	
	- Shallow zone	1.1
	- Deep zone	1.1
Ag	Overburden/layback	400
	Site confirmation	
	- Shallow zone	400
	- Deep zone	400
	LDR Determination	5.0 (mg/L)/100 (mg/kg)[e]
As	Overburden/layback	6.5
	Site confirmation	
	- Shallow zone	6.5
	- Deep zone	6.5
	LDR Determination	5.0 (mg/L)/100 (mg/kg)[e]
Ba	LDR Determination	100 (mg/L)/2000 (mg/kg)[e]
Cd	Overburden/layback	80
	Site confirmation	
	- Shallow zone	80
	- Deep zone	0.5[c]
	LDR Determination	1.0 (mg/L)/20 (mg/kg)[e]

Table 2-1. Data Uses and Remedial Action Goals/Lookup Values.[a] (5 Pages)

Analytical Parameter	Data Use	Remedial Action Goals/ Lookup Values[b]
Cr (III)	Overburden/layback	80,000
	Site confirmation	
	- Shallow zone	80,000
	- Deep zone	36
	LDR Determination	5.0 (mg/L)/100 (mg/kg)[e]
Cr^{+6}	Overburden/layback	2.2
	Site confirmation	
	- Shallow zone	2.2
	- Deep zone	2.2
	LDR Determination	5.0 (mg/L)/100 (mg/kg)[e]
Hg	Overburden/layback	24
	Site confirmation	
	- Shallow zone	24
	- Deep zone	0.33[f]
	LDR Determination	0.2 (mg/L)/4 (mg/kg)[e]
Pb	Overburden/layback	353[g]
	Site confirmation	
	- Shallow zone	353[g]
	- Deep zone	10.2[f]
	LDR Determination	5.0 (mg/L)/100 (mg/kg)[e]
Se	Overburden/layback	400
	Site confirmation	
	- Shallow zone	400
	- Deep zone	400
	LDR Determination	1.0 (mg/L)/20 (mg/kg)[e]
Benzo(a) anthracene[h]	Overburden/layback	0.33[h]
	Site confirmation	
	- Shallow zone	0.33[h]
	- Deep zone	0.33[h]
Benzo(a) pyrene[h]	Overburden/layback	0.33[h]
	Site confirmation	
	- Shallow zone	0.33[h]
	- Deep zone	0.33[h]
Benzo(b) flouranthrene[h]	Overburden/layback	0.33[h]
	Site confirmation	
	- Shallow zone	0.33[h]
	- Deep zone	0.33[h]
Benzo(k) flouranthrene[h]	Overburden/layback	0.33[h]
	Site confirmation	
	- Shallow zone	0.33[h]
	- Deep zone	0.33[h]

Table 2-1. Data Uses and Remedial Action Goals/Lookup Values.[a] (5 Pages)

Analytical Parameter	Data Use	Remedial Action Goals/ Lookup Values[b]
Bis(2-ethylhexyl) phthalate	Overburden/layback	71.4
	Site confirmation	
	- Shallow zone	71.4
	- Deep zone	32
Chlordane	Overburden/layback	0.33
	Site confirmation	
	- Shallow zone	0.33
	- Deep zone	0.33
	LDR Determination	0.03 (mg/L)[e]
Pesticides[i]	Overburden/layback	Compound-specific: 1.0
	Site confirmation	
	- Shallow zone	Compound-specific: 1.0
	- Deep zone	0.02[c]
Phthalates[i]	Overburden/layback	Compound-specific: 32-320
	Site confirmation	
	- Shallow zone	Compound-specific: 32-320
	- Deep zone	Compound-specific: 2-160
Sulfate	Overburden/layback	2.5E4
	Site confirmation	
	- Shallow zone	2.5E4
	- Deep zone	2.5E4
TPH	Overburden/layback	Compound-specific: 100-200
	Site confirmation	
	- Shallow zone	Compound-specific: 100-200
	- Deep zone	Compound-specific: 100
SVOAs[i]	Overburden/layback	Compound-specific: 0.5-1.0
	Site confirmation	
	- Shallow zone	Compound-specific: 0.5-1.0
	- Deep zone	0.5[c]
VOAs[i]	Overburden/layback	MTCA Method B
	Site confirmation	
	- Shallow zone	Compound-specific: 0.5-20
	- Deep zone	Compound-specific: 0.05-0.1
PCBs	Overburden/layback	0.5
	Site confirmation	
	- Shallow zone	0.5
	- Deep zone	0.5

Table 2-1. Data Uses and Remedial Action Goals/Lookup Values.[a] (5 Pages)

Analytical Parameter	Data Use	Remedial Action Goals/ Lookup Values[b]

[a] This table is based on the DQO processes for the 100 Area waste sites to be remediated. The radionuclide overburden/layback and site confirmation limits are lookup values. Chemical cleanup levels are noted to indicate the source documents.

[b] Units in pCi/g for radionuclides, mg/kg for other constituents (unless otherwise indicated).

[c] The RAG is below the practical quantitation limit (PQL). The value presented is the PQL.

[d] The RESRAD model predicts that this contaminant will not break through to groundwater within a 1,000-year time frame.

[e] Limits shown determine whether land disposal restrictions (LDRs) apply. If the LDR limits are exceeded, Phase IV *Resource Conservation and Recovery Act* (RCRA) regulations are also imposed, requiring analysis of treated wastes for underlying hazardous constituents that can reasonably be expected to be present at the point of generation in accordance with 40 CFR 268.48.

[f] The RAG is below background. The value presented is background.

[g] This value is based on EPA's *Integrated Exposure Uptake Biokinetic Model for Lead in Children* (EPA 1994).

[h] MTCA requires the sum of the polycyclic aromatic hydrocarbons when evaluating for interim closure.

[i] No preliminary action level specified for the general group of contaminants. The basis for preliminary action level of specific compounds may be determined using MTCA Method B methodology (WAC 173-340), or as published in CLARC II update (EPA 1996).

N/A = not applicable
MTCA = *Model Toxics Control Act*
PCBs = polychlorinated biphenyls
SVOAs = semi-volatile organic analysis
TPH = total petroleum hydrocarbons
VOAs = volatile organic analysis

Site cleanup levels used for interim closure of the Remaining Sites were developed during the 100 Area Remaining Confirmatory Sampling Effort Sites DQO process (BHI 1999). They are consistent with the shallow and deep zone RAGs (and RAG development methods) shown in the RDR/RAWP (DOE-RL 1998b). Radionuclide cleanup levels are the 100 Area lookup values based on the RESidual RADioactivity (RESRAD) analytical dose model (ANL 1993). Chemical COPC cleanup levels are generally based on the *Model Toxics Control Act* (MTCA) B shallow zone cleanup criteria. Exceptions are noted in Table 2-1. Soils are subject to both deep zone and shallow zone cleanup levels, depending on elevation.

The QA objective of this plan is to develop implementation guidance that will provide data of known and appropriate quality. Data quality is assessed by precision, accuracy, representativeness, comparability, and completeness (PARCC parameters). Definitions of these parameters, applicable guidelines, and level of effort are described below. The applicable QC guidelines, quantitative target limits, and levels of effort for assessing data quality are dictated by the intended use of the data and the nature of the analytical methods. The quantitative DQOs, presented in Table 2-2, verify that the analytical methodology identified for this project have nominal practical quantitation limits (PQLs) below the action levels shown in Table 2-1. Analytical methodology and specific QC procedures are discussed in Section 2.2.6 and Part III.

Table 2-2. Analytical Performance Requirements. (2 Pages)

Data Type	Analyte	Analytical Method	Preliminary Action Level[a]	Detection Limit Requirements		Accuracy Req't (% Recovery)[b]	Precision Req't (%RSD or RSD)
				MDL[a]	PQL[a]		
Performance Requirements for Laboratory Radionuclide Measurements							
Rad	Am-241	AmAEA	31.1	0.1	1	70-130	±30
Rad	C-14	Chem sep/liq scintillation	5.16	2	2[c]/50	70-130	±30
Rad	Co-60	HPGe	1.4	0.05	0.1	80-120	±30
Rad	Ce-137	HPGe	6.2	0.05	0.1	80-120	±30
Rad	Eu-152	HPGe	3.3	0.1	0.2	80-120	±30
Rad	Eu-154	HPGe	3.0	0.1	0.2	80-120	±30
Rad	Eu-155	HPGe	125	0.1	0.2	80-120	±30
Rad	H-3	Distillation liq separation	35.5	5	400	70-130	±30
Rad	Ni-63	Chem sep/liq scintillation	4,026	5	30	70-130	±30
Rad	Pu-238	PuAEA	37.4	0.1	1	70-130	±30
Rad	Pu-239/240	PuAEA	33.9	0.1	1	70-130	±30
Rad	Sr-90	Rad-Sr	4.5	0.2	1	70-130	±30
Rad	U-233/234	UAEA	1.1	0.1	1	70-130	±30
Rad	U-235	UAEA	1.1	0.1	1	70-130	±30
Rad	U-238	UAEA	1.1	0.1	1	70-130	±30
Performance Requirements for Laboratory Nonradionuclide Measurements							
Chem	Ag	EPA 1311/6010	5.0 mg/L	0.01	0.05	70-130	±30
		EPA 6010	400	0.7	2	70-130	±30
Chem	As	EPA 1311/6010	5.0 mg/L	0.01	0.05	70-130	±30
		EPA 6010	6.5	2.5/0.2[d]	10/1[d]	70-130	±30
Chem	Ba	EPA 1311/6010	100 mg/L	0.01	0.05	70-130	±30
Chem	Cd	EPA 1311/6010		0.005	0.025	70-130	±30
		EPA 6010	0.5	0.3	0.5	70-130	±30
Chem	Cr(III)	EPA 1311/6010	5.0 mg/L	0.003	0.015	70-130	±30
		EPA 6010	36	0.4	1	70-130	±30
Chem	Cr6+	EPA 1311/6010	5.0 mg/L	0.003	0.015	70-130	±30
		EPA 7196	2.2	0.03	0.5	70-130	±30
Chem	Hg	EPA 1311/7471	0.2 mg/L	0.0001	0.005	70-130	±30
		EPA 7471	0.33	0.02	0.10	70-130	±30

Table 2-2. Analytical Performance Requirements. (2 Pages)

Data Type	Analyte	Analytical Method	Preliminary Action Level[a]	Detection Limit Requirements		Accuracy Req't (% Recovery)[b]	Precision Req't (%RSD or RSD)
				MDL[a]	PQL[a]		
Chem	Pb	EPA 1311/6010	5.0 mg/L	0.25	1.25	70-130	±30
		EPA 6010	10.2	5 (0.1)	20 (0.5)	70-130	±30
Chem	Se	EPA 1311/6010	1.0 mg/L	0.1	0.5	70-130	±30
		EPA 6010	400	5	20	70-130	±30
Chem	Benzo(a) anthracene	EPA 8270	0.33	0.1	0.3	e	e
Chem	Benzo(a)pyrene	EPA 8270 EPA 8310	0.33	0.1 0.002	0.3 0.010	e	e
Chem	Benzo(b) flouranthrene	EPA 8270 EPA 8310	0.33	0.1 0.002	0.3 0.010	e	e
Chem	Benzo(k) flouranthrene	EPA 8270 EPA 8310	0.33	0.1 0.002	0.3 0.010	e	e
Chem	Bis(2-ethylhexyl) phthalate	EPA 8270 EPA 8310	32	0.1 0.002	0.3 0.010	e	e
Chem	Chlordane	EPA 8080/8081	0.03 mg/L	0.005	0.02	e	e
		EPA 8080/8081	0.33	.005	0.02	e	e
Chem	Pesticides	EPA 8080/8081	Compound-specific: 0.02-1.0	0.005[f]	0.02[f]	e	e
Chem	Phthalates	EPA 8270	Compound-specific: 2-320	0.1[f]	0.3[f]	e	e
Chem	Sulfate	EPA 300.0	2.5E4	2	10	e	e
Chem	TPH	EPA 8015/418.1	Compound-specific: 100	2	5	e	e
Chem	PCBs	EPA 8080/8082	0.5	0.03	0.1	e	e
Chem	SVOA	EPA 8270	Compound-specific: 0.5-1.0[g]	0.1[f]	0.3[f]	e	e
Chem	VOA	EPA 8260	Compound-specific: 0.05-20[g]	0.001[f]	0.005[f]	e	e

[a] Units are in pCi/g or mg/kg unless otherwise specified.
[b] Accuracy for radionuclides are evaluated via associated batch laboratory control sample percent recoveries. The "AEA" and radioactive strontium measurements also require tracer/carrier recoveries to be 20% to 105%.
[c] The low PQL value requires negotiation with the laboratory prior to sampling.
[d] First value shown is routine ICP; the second value via "trace" ICP or graphite furnace atomic absorption.
[e] Accuracy and precision values are as identified and defined in the referenced EPA procedures.
[f] Pesticides, phthalates, SVOA, and VOA detection limits and precision/accuracy are for "typical" analytes. Some analytes will have significantly different detection limits and precision/accuracy limits.
[g] Multiple components have different requirements.

MDL = minimum detection limit
NaI = sodium iodide
PQL = practical quantitation limit
RSD = relative standard deviation
TBD = to be determined

The following is a description of the data quality parameters:

- Precision is a measure of the data spread when more than one measurement has been taken on the same sample. Precision can be expressed as the RPD for duplicate measurements. A quantitative definition of the RPD is given in Section 2.4.3. The level of effort for precision measurements will be a minimum of 1 in 20 samples.

- Accuracy is an assessment of the closeness of the measured value to the true value. Accuracy of chemical test results is assessed by spiking samples with known standards and establishing the average recovery. For a matrix spike, known amounts of a standard compound identical to the compounds being measured are added to the sample. For radionuclide measurements that require chemical separations, this method is also used. For radionuclides that are analyzed by gamma spectroscopy, the laboratories typically compare the results of known standards to establish accuracy. Validity of calibrations are evaluated by comparing results from measurement of the standard to known values and/or by generation of in-house statistical limits based on three standard deviations (SDs) (±3s).

  A quantitative definition of average recovery (accuracy) is given in Section 2.4.3. Accuracy measurement will be carried out with a minimum frequency of 1 in 20 samples analyzed. Target quantitative accuracy objectives are listed, as applicable, in Table 2-2. Specific requirements are found in the applicable laboratory statement of work, which will supercede Table 2-2 if there are considerable inconsistencies.

- Representativeness is a measure of how closely the results reflect the actual concentration or distribution of the chemical and radiological constituents in the matrix sampled. Sampling plan design, sampling techniques, and sample handling protocols (e.g., storage, preservation, and transportation) have been developed and are discussed in subsequent sections of this document. The proposed documentation will establish that protocols have been followed and sample identification and integrity ensured. Equipment blanks and field duplicates, collected at a minimum frequency of 1 per 20, will be used to assess field and transport contamination and method variation. To assess laboratory contamination, laboratory method blanks will be run at a minimum frequency of 5% of the samples.

- Comparability expresses the confidence with which one data set can be compared to another. Data comparability will be maintained using standard procedures when available and consistent methods and units. Table 2-2 lists specific parameters and applicable methods for analytes and target detection limits. Actual detection limits will depend on the sample matrix and will be reported as defined for the specific samples.

- Completeness is a measure of the amount of valid data obtained from the analytical measurement system and the complete implementation of defined field procedures. The quantitative definition of completeness is given in Section 2.4.3. The target completeness objective for this project is 90% for all confirmatory sample data.

2.1.5 Project Narrative

The following is a list of objectives and the associated methods (incorporated by reference) to achieve that objective:

- Determining survey and sampling design requirements and description (Section 2.2)
- Determining sample type and sampling location requirements (Sections 2.2.2 – 2.2.4)
- Determining sampling methods (Section 3.3)
- Determining sample handling and custody requirements (Section 3.6)
- Selecting analytical methods (Section 2.2.5)
- Determine quality control requirements (Section 2.2.6)
- Determining sampling or analytical instrumentation requirements (Section 2.2.5)
- Maintaining ongoing assessments during actual operation (oversight) (Section 2.3)
- Data validation will be determined by methods defined (Section 2.4)
- Data quality assessment of the sampling design, sampling procedures and analytical measurement system will be determined (Section 2.5).

2.1.6 Special Training Requirements/Certification

Training or certification requirements needed by personnel are described in BHI-HR-02, *ERC Training Procedures*. Field personnel shall have completed the following mandatory training, as described in BHI-HR-02, before starting work:

- Occupational Safety and Health Administration 40-Hour Hazardous Waste Worker Training
- Radiation Worker II Training
- Hanford General Employee Training.

Personnel conducting radiological surveys and sample collection shall meet additional training and certification requirements as specified in BHI-QA-03, *ERC Quality Assurance Program Plans*, which include the following:

- Section 5.1, "Field Sampling Quality Assurance Program Plan," for sampling personnel
- Section 5.2, "Onsite Measurement Quality Assurance Program Plan," for chemical field screening measurements

- Section 5.3, "Radiological Measurements and Environmental Support Quality Assurance Program Plan," for personnel conducting radiological survey measurements.

2.2 MEASUREMENT/DATA ACQUISITION

2.2.1 Nonintrusive Investigation Techniques

A variety of nonintrusive investigation techniques are available to aid in confirming applicability of the site conceptual models. These techniques are generally used to confirm site location and/or the presence of anomalous conditions (e.g., subsurface debris, geologic features, or elevated radioactivity). Table 2-3 lists nonintrusive investigation technologies that may be applied prior to intrusive characterization of the Remaining Sites.

Table 2-3. Potential Nonintrusive Field Investigation Techniques.

Variable	Potentially Appropriate Measurement Method[a]	Applications/Potential Limitations
Subsurface Anomalies	Ground Penetrating Radar (GPR)	Reflection technique. Detects contrasts in dielectric constants. Nearby buildings and utilities can cause interference. Heavy fly ash can act as a reflector.
	Electromagnetic Imaging (EMI)	Conductivity measuring technique. Detects contrasts in conductivity (changes in electrical fields). Nearby buildings and utilities can cause interference.
	Magnetics	Magnetic field measuring technique. Detects ferrous materials (iron containing materials). Nearby buildings and utilities can cause interference.
	Metal Detector	Similar to magnetics, only at a smaller scale. Limited in depth and sensitivity.
Elevated Radioactivity	MDRS Survey	Radiation survey technique using a variety of detectors, with background compensation, and positioning using the GPS system. Man-carried for portability
	RAD-Tractor Survey	Survey using arrays of sodium iodide detectors to cover large areas of clear space. Uses GPS for location. Tractor-attached and limited to open areas.

[a] Other methods may be identified and implemented in conjunction with technology development.

2.2.2 Radiological Survey Design

Radiological constituents will generally be the focus of the field screening efforts at sites that contain radionuclide as COPCs. Eight site conceptual models have been developed to aid in the segregation and interim closure of the areas. In general, instruments will be calibrated for the most likely contaminant of concern, and the response of the instrument to the derived concentration guideline level (DCGL) (above background) will be determined. Sites with detected contamination greater than the DCGL-based release criteria are declared to be contaminated and will be deferred to Remedial Action Projects, while sites with radiation levels that are less than the DCGL-based release criteria are considered candidates for interim closure. Following this determination, and sampling to determine the contamination level, the site will be modeled using the RESRAD SOIL dose model. Noncontaminated sites will be interim closed, and sites with contamination levels above the release levels will be transferred to the 100 Area Remediation Project for remedial action at a later time.

Candidate sites have been identified as unlikely to be contaminated or, if contaminated are unlikely to exceed the DCGLs, and are classified as MARSSIM (NRC 1997) class 3 areas to ensure that sufficient caution has been exercised for interim closure.

Contamination will be determined primarily with sodium iodide (NaI) detectors. Alpha and beta contamination monitors will be used only as indicators. In all cases where contamination levels are detected above background, sampling is required to quantify the concentrations.

All radiological surveys will be performed using a shielded NaI detector in conjunction with surface contamination monitors. The collected data will be used to provide an estimate of the spatial variability of the contamination so that sampling parameters for the confirmation sampling discussed in Section 2.2.4 can be established.

Because of unique size and contamination distributions, each site requires a slightly different design, but as a minimum, 10% areal coverage will be provided for elevated measurement detection, and each sampling location will be measured for contamination. Surveys will be performed based on the size of the area, ranging from a single count per strata for small sites to gridded surveys designed specifically for large sites. Surveys will be a combination of static counting, sequential static counting, and scanning counts, depending on the identity and level of contamination to be detected. Additional information and calculation of survey scan rates and associated minimum detectable activities (MDAs) are addressed in Appendix I.

2.2.2.1 Determination of Site-Specific Background and DCGLs. The background used to determine the contamination level in each area will be determined on a site-by-site basis and will be based on the guidance provided by the MARSSIM, until the Environmental Restoration Contractor (ERC)-specific procedures (e.g., BHI-EE-02, Procedure 1.19 "Determining Background Radiation Levels for Environmental Radiological Measurements," currently in draft) are approved. The MARSSIM document provides methodologies for both gross measurement and isotope-specific techniques. The DCGLs for each site will be determined on a site-by-site basis, based on the COPC list for that site, if the site is determined to be potentially contaminated (above DCGL-based release criteria). In most cases, the 100 Area cesium-137 limit can be used as the limiting DCGL.

Concrete and soil surfaces will be surveyed principally for cesium-137 using the NaI detector. Alpha- and beta-emitting isotopes will be screened by the use of scintillation detectors. In both cases, the laboratory data of concentration will be scaled to the field results to determine radioisotope spatial distribution and concentration.

Whenever possible, the response of the instrument should be calibrated to respond to the specific radionuclides of the COPCs that would be present after decay and long-term environmental exposure.

2.2.2.2 Determination of Minimum Detectable Activity and Survey Parameters. The determination of MDA and survey parameters such as static count time and estimated area of survey are discussed in Appendix I.

The MDA calculation requires the following specifications:

1. The desired tolerances of false-positive and false-negative errors
2. The target cleanup levels
3. The estimated variability of the sample measurement.

The MDA calculations used the method of Currie (1968) and relied on data provided in *Instrumental Basis Utilizing Sodium Iodide Detector for Radioactive Soil Evaluations for Site Remediation* (BHI 1996), as well as data from a similar surveys at the 105-C Reactor.

Definitions and specifications are listed below and are consistent with Currie (1968). The null hypothesis in the MDA derivation is that the measured sample contains no radioactivity greater than the background. This null hypothesis is the opposite of what is commonly used in making site cleanup decisions, where the null hypothesis is that the site (or sample) contains radioactivity at a level that is greater than background or the cleanup level. This MDA derivation uses the hypothesis that the sample contains no radioactivity greater than the background. Definitions and specifications are as follows:

1. False-positive (Type I) error rate: The false-positive error is defined as the probability of concluding that an uncontaminated sample (survey location) is contaminated. A 5% false-positive rate is consistent with most detection limit derivations and was selected for the calculations.

2. False-negative (Type II) error rate: The false-negative error is defined as the probability of concluding that a contaminated survey location is not contaminated. A 20% false-negative rate is consistent with most detection limit derivations and was selected for the calculations.

3. The target radionuclide survey levels are the residual levels of radionuclides that would not result in a dose to a credible receptor under a credible scenario that exceeds the cleanup standard. The DCGL is calculated by application of the residential exposure scenario and the estimated distribution of radionuclides to the RESRAD dose assessment model.

2.2.3 Chemical Field Screening Design

Field screening methods (e.g., x-ray fluorescence and soil gas analyzer) are generally capable of providing data with very short turnaround times and at low cost. However, the detection limits rarely meet the values required to meet the RAGs. In addition, some analyses are qualitative and not true real-time methods. Table 2-4 lists the field screening technologies that may be applied during initial characterization of the Remaining Sites.

Field screening techniques may be employed where feasible and appropriate to determine possible anomalous conditions, assess site contaminant variability, and confirm necessity for remediation. Assessment of site variability (e.g., standard deviation of contaminant concentration) can be used to refine the number of Standard Fixed Laboratory (SFL) samples required for a given site component. Field screening techniques may provide useful data at reasonable cost (cost evaluation must also include potential expense for disposal of hazardous wastes from the analysis and any site-specific modifications to the analysis procedures). The field engineer must evaluate the COPCs and RAGs in each site against potential screening technologies to determine if field screening offers an advantage. Censored data (nondetect results) are not likely usable when the PQL of the field screening method is equal to, or above, the RAG. For such field screening methods, the data are only usable for establishing the need for remedial action at a site (i.e., material detected). Potential logistical constraints may also result in unusable field data (e.g., high detection limit, matrix interference, or questionable sample representativeness).

Sites will be field screened using the most practical field screening methods available. Target constituents will be identified for field screening techniques that may be implemented under the expected logistic constraints. COPC fate and transport, constituent colocation, and environmental impacts (such as degradation) must be considered in determining the target compound for field screening. For example, Cr^{+6} may be considered a target constituent at sites that potentially received discharges of sodium dichromate. Mercury or total petroleum hydrocarbons may be identified as target compounds at the appropriate sites because of the detection limits offered by immunoassay techniques. Volatile organic compounds may not be appropriate target compounds due to the length of exposure to the environment and strong possibility of degradation.

If the field screening measurements indicate that the concentrations of target constituents at the site are sufficiently below the RAG, there may be sufficient evidence to suggest that the COPC being measured is not a valid COPC. In such cases, the analyte may be dropped from the list of COPCs for laboratory analysis with decision-maker concurrence. However, field screening efforts should be continued throughout the sampling effort to allow testing of the CSM to determine if target COPCs are reasonable.

Table 2-4. Potential Field Screening Methods. (3 Pages)

COPC	Waste Site COPC Profiles	Potential Field Screening Method[a]	Applications/Potential Limitations	Detection Limit/RAG (mg/kg)[b]
Radiological Field Screening				
Gross Cs-137 counts	Potentially all sites. All sites with radiological contamination.	Portable NaI detector	Field surveys, health and safety uses/very sensitive gamma detector .	3.1/6.2 pCi/g
Gross alpha		Portable contamination detector	Health and safety uses/limited detection capability, alpha particles are readily shielded; contamination may be missed during surveys.	100 dpm/ 100 cm^2/ indication only
Gross beta/ gamma		Portable contamination detector	Health and safety uses/limited detection capability, beta particles may be shielded by soil /concrete; contamination may be missed during surveys.	5000 dpm/ 100 cm^2/ indication only
Chemical Field Screening				
As	Demolished building/facility site (nonradioactive) Demolished building/facility site (radioactive) Dumping area/burn pit Laboratory drainage pipe, sump, and/or french drain Potentially contaminated sewer Reactor french drain Shop drainage pipe, sump, and/or french drain Spent acid/caustics pit/drain	XRF[c]	Detected concentrations indicate contaminated site, non-detects are inconclusive due to high instrument detection limit relative to RAG.	75/6.5
Cd	Demolished building/facility site (nonradioactive) Potentially contaminated sewer Shop drainage pipe, sump, and/or french drain	XRF[c]	Uncertainty as detection limit is within 7% of the RAG. May provide field indication that SFL analysis is required.	75/80
Cr (III)	Demolished building/facility site (nonradioactive) Potentially contaminated sewer Radiological soil contamination Shop drainage pipe, sump, and/or french drain Spent acid/caustics pit/drain	XRF[c]	Hanford soils typically only contain 10-27 mg/kg total chromium, far below detection limits. Can support field decisions at sites where chromium (III) concentration is above the DL.	400/80,000
Cr (VI)	119 Building sample station Condensate crib Demolished building/facility site (nonradioactive) Demolished building/facility site (radioactive) Laboratory drainage pipe, sump, and/or french drain Potentially contaminated sewer Radiological soil contamination Reactor french drain Shop drainage pipe, sump, and/or french drain Spent acid/caustics pit/drain	Water extraction and colorimetric analysis	Interferences (iron) and soil alkalinity. Detection limit is sufficiently close to RAG to render this field screening technique inconclusive for closing sites, but could indicate the need for additional SFL analysis.	2-5/2.2

Table 2-4. Potential Field Screening Methods. (3 Pages)

COPC	Waste Site COPC Profiles	Potential Field Screening Method[a]	Applications/Potential Limitations	Detection Limit/RAG (mg/kg)[b]
Pb	119 Building sample station Condensate crib Demolished building/facility site (nonradioactive) Demolished building/facility site (radioactive) Dumping area/burn pit Hydrocarbon contaminated soil Laboratory drainage pipe, sump, and/or french drain Potentially contaminated sewer Reactor french drain Sanitary sewer Shop drainage pipe, sump, and/or french drain Spent acid/caustics pit/drain	XRF[c]	Hanford soils typically only contain 5-15 mg/kg lead, far below detection limits. Can support field decisions at sites where lead concentrations exceed the DL.	100/353
Hg	119 Building sample station Condensate crib Demolished building/facility site (nonradioactive) Dumping area/burn pit Laboratory drainage pipe, sump, and/or french drain Potentially contaminated sewer Radiological soil contamination Reactor french drain Shop drainage pipe, sump, and/or french drain Spent acid/caustics pit/drain	Mercury vapor monitor	DL in soil concentrations well above the RAG (24 mg/kg).	DL in soil concentrations well above the RAG (24 mg/kg)
		Immunoassay	Results reported within a pre-specified range. Analysis takes 15 to 30 minutes.	0.5/24
		XRF[c]	Detected concentrations indicate contaminated site, non-detects are inconclusive due to high instrument detection limit.	100/24
Se	Demolished building/facility site (nonradioactive) Shop drainage pipe, sump, and/or french drain Spent acid/caustics pit/drain	XRF[c]	Hanford soils typically only contain 5-6 mg/kg selenium, far below detection limits. Potentially supports field decisions at site where selenium concentration is above the DL.	200/400
Ag	Demolished building/facility site (non-radioactive) Shop drainage pipe, sump, and/or french drain Spent acid/caustics pit/drain	XRF[c]	Hanford soils typically only contain 0.05-3.2 mg/kg silver, far below detection limits. Potentially supports field decisions at sites where silver concentration is above the DL.	100/400
Sulfate	Demolished building/facility site (non-radioactive) Spent acid/caustics pit/drain	XRF[c]	Calibration and correlation to elemental sulfur required	TBD/25,000
PAHs	Dumping area/burn pit	Immunoassay	Results reported within a pre-specified range. Analysis takes 15 to 30 minutes.	1-5/0.33
PCBs	Dumping area/burn pit PCBs in soil	Immunoassay	Results reported within a pre-specified range. Analysis takes 15 to 30 minutes.	0.1-0.3
Pesti-cides	Dumping area/burn pit Sanitary sewer	Immunoassay	Results reported within a pre-specified range. Analysis takes 15 to 30 minutes.	DL approximately 10 mg/kg. Compound-specific
TPH	Dumping area/burn pit Hydrocarbon-contaminated soil	Immunoassay	Results reported within a pre-specified range. Need to know if gasoline or diesel products. Analysis takes 15 to 30 minutes.	5-10

Table 2-4. Potential Field Screening Methods. (3 Pages)

COPC	Waste Site COPC Profiles	Potential Field Screening Method[a]	Applications/Potential Limitations	Detection Limit/RAG (mg/kg)[b]
VOCs	119 Building sample station Condensate crib Dumping area/burn pit Hydrocarbon-contaminated soil Sanitary sewer	Colorimetric tube	Tube capability must be compared to the site-specific need to determine if field detection limits will be sufficient for the VOC of interest. Need to know specific VOCs of interest.	
		Flame ionization detector (e.g., Foxboro OVA 128)	Instrument capability must be compared to the site-specific need to determine if field detection limits will be sufficient for the VOC of interest. Need to know specific VOCs of interest. Limited to hydrogen containing compounds.	1-5 (methane-equivalent)
		Photoacoustic infrared analyzer (e.g., B&K 1302)	Instrument capability must be compared to the site-specific need to determine if field detection limits will be sufficient for the VOC of interest. Need to know specific VOCs of interest.	
		Photo-ionization detector (e.g., thermo analytical OVM)	Instrument capability must be compared to the site-specific need to determine if field detection limits will be sufficient for the VOC of interest. Need to know specific VOCs of interest. Limited to photo-ionizing compounds at 10.6 eV.	1-5 (isobutylene-equivalent)
VOCs (cont.)	119 Building sample station Condensate crib Dumping area/burn pit Hydrocarbon-contaminated soil Sanitary sewer	Portable gas chromatograph with photo-ionization detector (e.g. Photovac 10S Plus)	Instrument capability must be compared to the site-specific need to determine if field detection limits will be sufficient for the VOC of interest. Need to know specific VOCs of interest. Limited to photo-ionizing compounds at 11.7 eV .	DL (sub-mL/m^3 levels depending on VOC of interest)
		Transportable mass spectrometer	Instrument use requires extensive training. Capital cost and setup is high, operational cost is moderate.	DL (sub-mL/m^3 levels depending on VOC of interest)

[a] Other methods may be identified and implemented in conjunction with technology development.
[b] Units in mg/kg for chemical methods, unless otherwise specified.
[c] Metals by XRF requires calibration to site-specific soils. Detection of chromium, aluminum, and sulfur could be greatly enhanced (50 to 100 mg/kg) with purchase of SiLi detector with Fe-55 source at cost of about $20,000. Requires management of radioactive source (i.e., Am-241, Cm-244, or Fe-55).
AEA = atomic energy analysis
GeLi = germanium-lithium
HPGe = high-purity germanium
NaI = sodium iodide
VOC = volatile organic compound
XRF = x-ray fluorescence

If field screening clearly indicates that a portion of the site is contaminated above cleanup levels, the site, or that portion (for large sites), should be deferred to Remedial Action Projects. In such cases, a bounding case (highest detected contamination) sample should be collected for waste profile development.

2.2.4 Confirmation Sampling Design

The sampling design for the 100 Area Remaining Confirmatory Sites is based on the results of the DQO process requirements (BHI 1999). As discussed in Section 1.2, eight CSMs were developed to group sites with similar confirmation sampling designs. Because the COPCs and CSMs for each site may vary, the field engineer must determine the sampling design on an individual site basis. Radiological surveys and field screening will be implemented on both a statistical and judgmental basis, as will the confirmation sampling for fixed laboratory analyses. Field screening and sampling will employ a statistically based sample design in order to allow decisions to be made regarding the contaminant population of the site. Furthermore, anomalous conditions will be investigated using the judgmental approach to ensure that materials potentially containing contaminant levels above the RAGs are quantified.

This section presents an overview discussion of the sample design. Detailed, CSM-specific requirements are presented in the appendices to this document. Although it is believed that many of the candidate sites are not contaminated above the cleanup levels, it was assumed that they are contaminated (null hypothesis) for the purpose of the statistical sampling design development. Designs are based on the physical components and sampling media associated with a structure or type of site. Environmental measurements will be obtained from the components or sampling media of a site to support or refute this hypothesis. Site components likely to be contaminated relative to the rest of the site will be preferentially sampled. Historical data, professional judgment, and/or field screening data will be used to identify and rank likely contaminated areas or components within a site. For the purposes of discussion, sites or components of sites will be considered "contaminated" if they exceed cleanup levels.

The sampling design for the candidate sites is based on a two-step design approach that uses a combination of statistical and judgmental sampling. The Step I sampling design establishes the number of lateral sampling locations in the X-Y plane for each CSM waste site. Location of these samples is then randomly assigned with a lateral sample grid (X and Y dimensions). The Step I sample design is statistically derived using the error tolerances developed in the DQO process (BHI 1999).

The Step II sampling design establishes the pertinent depth intervals for each component to be sampled (Z dimension). Several physical strata (components) are contained within the hypothetical site that must be sampled for each of the X-Y locations determined in Step 1. The Step II sample design is developed judgmentally, taking into account the type, number, and thickness of the underlying components that exist within the site. A significant core assumption supporting proper application of Step II is that, for a given component, contaminant concentration varies with depth. Stratification of component samples over a depth interval ensures adequate samples are taken to support or refute that assumption during later data quality assessment.

2.2.4.1 Step I Sample Design: Determination of Number of Lateral Sample Locations in the X-Y Plane. The Step I sampling design is used to determine how many sampling locations will be required on the top planar surface of the site (in the X-Y plane) as illustrated in Figure 1-1. The number of lateral sampling locations is statistically derived as described in the following text that follows. The Step I planar sampling design is applied at each of the depth intervals established in the Step II sample design (Section 2.2.4.2).

The number of lateral sample locations in the X-Y plane for each CSM is determined by the type of COPCs that are expected and the anticipated distribution of those COPCs throughout the site. The sample 95% UCL for the mean alone supports the decision for radionuclides; the sample maximum, proportion of elevated results, and the sample 95% UCL for the mean support the decision for nonradionuclide COPCs. The minimal detectable difference approach (EPA 1989) is used to determine the number of samples required to support decisions concerning the population mean. A Bayesian statistical approach is used to determine the required number of samples for estimating the population maximum. When both radionuclide and nonradionuclide COPCs are of interest, the number of samples is determined both ways (minimal detectable difference approach and Bayesian statistical approach), and the most conservative (largest) number is chosen.

Sampling of radiological contaminants is performed to estimate mean activity for each radiological COPC so the sample mean can be compared with the RAG. The number of sampling locations is determined based on the minimal detectable activity (MDA) approach (EPA 1987). For effective implementation of the minimal detectable difference approach, the site variability must be established. The variability, in the form of the relative standard deviation (RSD) or standard deviation (s), and average ($\bar{x}$), for each COPC must be known or approximated for each component of the site. This is because, unless evidence indicates otherwise, contaminant dispersion within components is likely to vary. These component and COPC-specific quantities (RSD or s, $\bar{x}$) must be calculated from historical data, approximated from analogous site data, or determined by assumption. The default assumption of a 100% variability relative (RSD=1) leads to the requirement for 64 samples per component per depth interval. Analogous site data are likely to yield a more definitive RSD. Field measurements, which are better yet, are likely to yield a truer approximation of site variance that can be used to determine a more realistic number of samples for the component of interest at a given site. Because the population mean is pertinent to decisions regarding both radionuclide and nonradionuclide COPCs, equation J-1 of Appendix J must be applied for all COPCs of interest.

If historical data are available and usable from QA, risk, and statistical perspectives, the RSD calculated from this data set is the best estimate of variability for a particular COPC. If historical data are not available, either field screening data or analogous site data may be used to estimate the RSD. As with any historical laboratory data, field screening data must be assessed for usability. That is, they must meet a minimum level of QA and must be assessed for anomalous values, distributional assumptions, etc. Field screening methods should be used in such a way that the detection limit does not hinder an estimate of the RSD.

If neither historical analytical data nor field screening data are available, the RSD can be estimated from analogous site data. The analogous site must have the same conceptual site model, the same COPCs, and occur under similar environmental conditions as the site in

question. If the CSM, COPCs, and environmental conditions differ significantly between the two sites, the site being referenced is not really analogous.

Sampling of the nonradiological contaminants is performed to collect data sufficient to satisfy the three-part MTCA evaluation criteria regarding the sample maximum, the proportion of sample results exceeding the RAG, and the sample mean. These criteria will be evaluated in sequence, and a site will be turned over to Remedial Action Projects if any one of the criteria is exceeded. Because the criteria are evaluated in sequence, the number of sampling locations will be based on collecting sufficient data to assess whether the site maximum exceeds twice the RAG. The number of sampling locations needed to assess the sample maximum is based on the probability of contamination, as required for the Bayesian statistical approach presented in the document.

Implementation of the Bayesian statistical approach is based on the likelihood of contamination for a given site component and the relative ratio of the error consequences. For remaining sites, the relative ratio of the error consequences has been set to two (i.e., mistakenly concluding a site is not contaminated [the moderately severe error] is twice as detrimental as mistakenly concluding a site is contaminated [the lowly severe error]). The probability of contamination (Pr(contamination)) is a site component-specific qualitative determination that may range between 5% and 20%. Once these two parameters have been established, a lookup table is then used to determine the corresponding number of samples per component per depth interval. Because the population maximum is pertinent to decisions regarding nonradionuclide COPCs, Table J-1 of Appendix J must be applied for all nonradionuclide COPCs of interest.

If historical data are not available for any components, the contamination probabilities will be assigned as outlined in the design group-specific subsections in the appendices of this SAP. Although the minimum probability of contamination for any component is 0.05, components with probability values of less than 0.10 will not be sampled, as the likelihood of encountering contamination is too low. Project decision makers have determined that components or sampling media with contamination probabilities less than 10% will not be sampled, based on cost effectiveness and the assumption that if there is contamination, it will be detected in one of the more likely contaminated components. Furthermore, this risk management decision is based on the policy that even if only one component is contaminated, the site as a whole must be deferred to Remedial Action Projects. Remedial Action Projects will target all site components for cleanup as required.

The resulting computations and supporting assumptions yield the required number of samples for the following:

- Number of radionuclide samples required for decisions concerning population mean
- Number of nonradionuclide samples required for decisions concerning population mean
- Number of nonradionuclide samples required for decisions concerning population maximum.

The largest of the three computed values is then considered the appropriate number of samples for the site component of interest for each applicable depth interval. For sites with either radionuclide or nonradionuclide COPCs, but not both, only the applicable computation need be performed.

Location of these samples is then randomly assigned with a lateral sample grid (X and Y dimensions). The minimal grid size (number of grid nodes) should be based on the volume and/or area of soil (or other material) that a single sample will represent. The physical dimensions of the grid should be laterally bound by the component of interest, for the depth interval of interest. Logistical constraints may make the establishment of such a grid unpractical. In these situations, good engineering judgment and common sense should be applied to determine the appropriate grid size. Most importantly, randomness of sample location must be preserved so that the sample data will accurately model the variability of the site. Refer to Table 1-8 for an example of the number of samples determination for a hypothetical site.

2.2.4.2 Step II Sample Design: Stratification of the Required Samples Over the Proper Depth Intervals. As previously stated, the Step II sampling design establishes the pertinent depth intervals for each component to be sampled (Z dimension). The number of lateral sample locations in the X-Y plane (developed in Step I) will be assigned to each of the depth intervals within the waste site. In Step II, the site components (below-grade strata) are divided into 3-ft sections to test the CSM assumption of decreasing contamination with depth. Thus, each component that is thicker than 3 ft will have more than a single depth interval available for sample collection.

Sampling at depth is performed within each 3-ft section, with one sample being collected from that 3-ft section. A representative sample is collected from a 1-ft-thick depth increment that is randomly chosen from within the 3-ft section. Components that are less than 3 ft thick (e.g., underlying component/interface with native soils) may be sampled within the available thickness of that component in such a fashion that sample representativeness is maintained.

If it is determined that the concentration of COPCs is constant with depth, or judgmental sampling at a specific depth is acceptable, random vertical stratification of samples will not be required. Refer to Table 1-9 for an example of the required depth of samples for a hypothetical site.

2.2.4.3 Sampling Contingencies. The DQO effort was used to evaluate a variety of factors concerning the potential consequences associated with making wrong decisions for interim closeout of 100 Area Remaining Sites, ultimately concluding that statistically based sampling designs are required. The approach for nonradionuclide contamination incorporates Bayesian statistics to determine the required number of samples for estimating the population maximum. The approach for sites with radionuclide contamination relies on existing EPA and MTCA guidance (which use Classical statistical methods) to determine the required number of samples for estimating the population mean. The required number of samples, as determined from each of these approaches, supports decisions within the specified tolerances.

The Bayesian methods used to derive the required number of samples for estimation of the population maximum are based on the relative ratio of the error consequences and the probability

of contamination for any given site component or strata. The relative ratio of the error consequences is determined judgmentally by project decision makers. In the case of Remaining Sites, the severity of decision errors ranges from low (not severe) to moderate. This is due primarily to the fact that the Remaining Sites do not have a history of receiving large amounts of hazardous waste and, therefore, are perceived as posing minimal risk. As a result, the relative severity of the error consequences is taken as two (i.e., mistakenly concluding a site is not contaminated [the moderately severe error] is twice as detrimental as mistakenly concluding a site is contaminated [the not-severe error]). Furthermore, project decision makers also assume probabilities for contamination in any given sampling medium. With the Remaining Sites, given that very little is known about the actual contamination levels at the site, a maximum probability of 50% is chosen. This corresponds to a "non-informative" probability; there is a 50%-50% chance that a sampling medium is contaminated.

In the Classical statistical framework, the equation used to derive the required number of samples for use in estimating the population mean is based primarily on the variability of the contaminant concentration within the population of interest. A population with a relatively large variability (compared to a population with less variability) requires more samples to assess contaminant distribution and meet error tolerances. To define the site variability, some degree of site characterization is required to estimate the standard deviation for the site. Furthermore, to ensure representativeness, the samples must be statistically (randomly) located so that potential bias is eliminated. In lieu of data for estimated site variance, a default relative standard deviation of 100% has been used, resulting in a default sampling requirement of 64 samples.

Neither of the statistically based sampling approaches used take into account site size or logistical restrictions. Furthermore, the Classical statistically based sample design for the population mean can result in a cost-prohibitive number of sample analyses for characterization of a relatively innocuous site. In this situation, reliable and cost-effective field screening techniques should be used to assess site variability. Establishing a site variability of less than 100% can significantly reduce the sampling requirements relative to the default values. However, available field screening techniques may be ineffective due to a limited amount of physical material for field screening, high detection levels, or background and matrix interference. With radiological field screening, there are logistical problems associated with sample representativeness and the ability to effectively limit the detector reading to the zone of interest. Physical isolation of the sampling media from neighboring media and background radiation may not always be possible.

Several options exist to overcome the limitations of the statistically based sampling designs used in this DQO. The initial number of samples required may be limited to a more realistic number. However, it is very important for the project decision makers to understand the fundamental assumptions within the statistically derived sample approach and how modifications can nullify assumptions, possibly leading to decision errors. Project decision makers must be cognizant of these risks when considering the contingencies discussed in the following text. Fortunately, the costs of confirmation sampling can be weighed against the cost of remedial action to determine the appropriate actions.

The contingency approaches are available to project decision makers if the default sampling design requires a cost-prohibitive or logistically unreasonable number of samples. Post-sampling assessment will be required using a power analysis if contaminant levels approach the RAGs.

1. **Analogous Site Approach:** For many Remaining Sites, analogous site data have been used to determine the COPCs. This logic may be further extended to assess the contaminant variability of the analogous site and apply it to the site of interest. Project decision makers should verify that the analogous site shares the same process history, contaminant releases, and similar media as the site of interest. The standard deviation of the analogous site may then be utilized in equation J.1 of Appendix J to calculate the required number of samples.

2. **Phased Sampling Approach:** As previously discussed, the number of samples determination (equation J.1 of Appendix J) for the population mean is highly dependent on the contaminant variability. Contaminant variability may be determined based on default assumptions, analogous site data, or determined with field measurements. For the latter, potential logistical constraints exist that may result in unusable field data (e.g., greater than 50% nondetect values, matrix interference, sample representativeness is questionable).

   However, defaulting to 64 samples may not be reasonable, particularly for small sites. In such cases, four samples may be taken for immediate analysis (Phase I), with some judgmentally determined additional number of samples archived for later (Phase II) analysis. If the field screening measurements indicate unequivocally that the contamination constituents are below action levels, the sampling may be reduced to one "worst-case" sample from each sampling medium. This reduction in sampling requirements is equivalent to the MARSSIM process of downgrading an area from Class 3 (slightly impacted) to Unimpacted status. Note that a 95% UCL cannot be calculated from a single sample and that if the sample exceeds the action limits, the maximum and 10% rule will be violated with a single sample. Additionally, analysis of error tolerance is not feasible; thus, site interim closure based on a single sample will not be possible. With decision-maker approval, field measurements may be used to support site verification decisions, provided data quality is sufficient.

   Evaluation of the Phase I sample results via the equation J.1 in Appendix J leads to one of several determinations:

   - The site is contaminated and a statistical power analysis indicates that the proper number of samples were collected and analyzed. Therefore, the site will be transferred to Remedial Action Projects.

   - The site is contaminated and a statistical power analysis indicates that additional samples are required. The archived samples may then be submitted for Phase II analysis.

- The sample results indicate that all decision criteria have been met and that the site is not contaminated. Therefore, no additional analyses are required and interim closure will proceed.

To properly support implementation of the phased approach, the depth, location, and sampling media for all of the samples must be adequately recorded so that the appropriate archived samples may be submitted if required. In addition, all sample locations should be randomly located to get a representative standard deviation for each component or sampling media of interest. Post-analytical evaluation is required for all COPCs (except those eliminated with decision-maker concurrence), not just target compounds identified for field measurements.

Refer to Section 3.2.2.1 for implementation guidance for the phase sampling approach.

3. **Combining Like Site Components:** If contaminant distribution, mean, and variability are determined to be consistent from one site component to another (e.g., aggregate fines and underlying soils), field measurements may combined to estimate the variability for those site components as if they were one component.

Where possible, statistical evaluation of field screening or sample results should be performed to determine if the site components are statistically similar. If such an evaluation demonstrates that this is the case, the variance for the like components may be estimated and a corresponding required number of confirmation samples may be calculated. The number of samples for combined components will likely result in a lower sampling frequency than for the components individually.

If field measurements cannot be used to distinguish site components (e.g., detector readings cannot be limited to the zone of interest due to logistics), then a judgmental determination of the number of site components may be performed, and like components combined. Archiving of individual site component samples is strongly recommended in case the data are not sufficient for evaluation of the null hypothesis. A minimum of four samples is recommended for each component identified. Post-sampling statistical evaluation of the sample data can be performed at a later time to determine if the number of samples taken are sufficient and if the error tolerances have been met.

2.2.5 Analytical Method Requirements

Analytical parameters and methods are listed in Table 2-2. Laboratory-specific standard operating procedures (SOPs) for analytical methods are in place. Field measurement SOPs are in place or are being prepared. Additional field methods will be referenced in the instruction guide. Changes or additional methods identified during future engineering or planning will be presented in the instruction guides, as appropriate.

2.2.5.1 Field Radionuclide Survey Measurements. Field measurements for radionuclides will be performed with NaI detectors and surface contamination monitors to generate radiological measurements in near real time. The NaI detector will monitor in the cesium-137 energy region of interest, or in another isotope spectra if cesium-137 is not a COPC. Detailed use of the survey

for soils excavation is presented in the Section II.3.4.1 of the 100 Area Remedial Action SAP (DOE-RL 1998a). The following discussion pertains to the use of survey measurements to evaluate concrete surfaces.

Sodium iodide detectors with the ability to discriminate the specific energy of cesium-137DA will be used to provide isotope-specific count rate information that will be used to support decisions relating to interim closure. The data will also provide estimates of spatial variability for the isotopic concentrations in the target area. The detected values and variability data will be used to refine the statistically based confirmation sampling requirements. Calculation of radiological survey detection limits is further discussed in Appendix I.

2.2.5.2 Field Screening Measurements. Field screening will be used as applicable. As described in Table 2-4, specific limitations on field screening methods result in the need to evaluate the applicability of the method for each site. In situations where the field screening method PQL is greater than the RAG, field screening can only be used to identify sites where remedial action is warranted.

Where field screening results can be used to determine a range of contaminant concentrations (e.g., immunoassay), a lower- and upper-bounded contamination range can be derived. EPA's *Methods for Evaluating the Attainment of Cleanup Standards* (EPA 1987) states that a standard deviation may be estimated by taking the range and simply dividing by six (box 6.2 of EPA 1987). The user is cautioned that this method of approximating the standard deviation should be used only if no other method is available. Application of this approximation method assumes that the frequency distribution of measurements is approximately bell shaped and that over 99% of the measurements lie within 3 standard deviations of the mean (e.g., contaminant distribution in normal). EPA also recommends 20 measurements when applying such an approximation. In situations where 20 field measurements are not practical, project decision makers may elect to collect a limited number (judgmentally determined) of field measurements. In doing so, project decision makers are accepting certain risks with the understanding that data needs may not be met by the limited amount of data derived from the field screening results.

Finally, where field screening can be used to detect and quantify contaminant concentrations at the site, an RSD or (s) and ($\bar{x}$), can be computed for application of equation J.1 in Appendix J. Nondetect results should be taken at half the detection limit for such computations (Ecology 1992). If more than 50% of the results are nondetectable, then the field measurements are not suitable for computing an RSD or (s) and ($\bar{x}$), and an alternate approach to applying equation J.1 in Appendix J should be used, or phased sampling (Section 2.2.4.3) should be implemented.

2.2.5.3 Standard Fixed Laboratory Measurements. Confirmation sampling will use SFL analyses for all COPCs. The SFL analyses will be accompanied by higher level documentation and a higher frequency of QC verification. The SFL SOPs will also be available prior to analysis.

2.2.6 Quality Control Requirements

Several QC samples are introduced into the collection system to monitor the adequacy of the sampling system and the integrity of samples during their transfer from the field collection point through the laboratory analysis. The QC requirements for the field sample collection process and the laboratory analysis are defined below.

2.2.6.1 Field Screening Quality Control Requirements. Field screening measurements will be performed in accordance with the QA/QC requirements provided in BHI-QA-03, Plan 5.2, "Onsite Measurements Quality Assurance Program Plan." The quality level QC-1 requirements specified in Section 10.0 will be applied to the Remaining Sites field screening activities.

2.2.6.2 Quality Control Requirements for Radiological Surveys. Alpha and beta/gamma surveys will be performed in accordance with QA/QC requirements provided in BHI-QA-03, Plan 5.3, "Radiological Measurements and Environmental Support Quality Assurance Plan." Instruments will be calibrated against known standards.

Radiological surveys will be reported as required by procedures found in the following BHI manuals:

- BHI-EE-05, *Field Screening Procedures*
- BHI-SH-04, *Radiological Control Work Instructions.*

2.2.6.3 Field Collected Quality Control Requirements. The QC requirements for the SFL sampling process are as follows.

- Equipment blanks will be collected to assess the cleanliness of the sampling equipment, the effectiveness of the sample equipment decontamination process, and the potential sampling environment contaminant contribution. Equipment blanks will be collected in the field using clean silica sand passed through decontaminated sampling equipment prior to use of the equipment. The blank will be analyzed for the same radionuclide and chemical analytes as actual samples collected during use of the equipment. Equipment blanks will be collected at a minimum frequency of one per waste site. All sample results should be evaluated to determine the possible effects of any contamination that may be detected in the equipment blank. Trace metals and background radioactivity are likely to be present in the clean silica sand and should not be considered to represent a QA deficiency. Volatile organic analysis trip blanks will be sent with volatile organic analysis samples to assess potential volatile organic contaminant contamination during sample shipment.

- Field duplicate samples will be collected during sampling at a minimum frequency of 1 per 20 samples of the same matrix in each waste site. Field duplicates are two samples produced from the same material and collected in the same location. Field duplicates are analyzed independently and provide information concerning the homogeneity of the matrix, as well as an evaluation of the precision of the sampling and analysis process.

2.2.6.4 Laboratory Quality Control Requirements. The QC requirements for the analytical laboratory are as follows:

- One laboratory method blank for every 20 samples (5% of all samples), analytical batch, or sample delivery group (whichever is most frequent) will be carried through the complete sample preparation and analytical procedure. The method blank will be used to document contamination resulting from the analytical process.

- One laboratory control sample or blank spike will be performed for every batch of samples for each analytical method criteria to monitor the effectiveness of the sample preparation process. The results from the analysis are used to assess laboratory performance.

- A matrix spike sample will be prepared and analyzed for every 20 samples (as applicable to method) of the same matrix or sample preparation batch, whichever is most frequent. The matrix spike results are used to document the bias of an analytical process in a given matrix.

- Laboratory duplicates or matrix spike duplicates will be used to assess precision and will be analyzed at the same frequency as the matrix spikes.

2.2.7 Instrument/Equipment Testing, Inspection, and Maintenance Requirements

Measurement and testing equipment used in the field and in the laboratory that directly affects the quality of the analytical data will be subject to preventive maintenance measures that ensure minimization of measurement system downtime. Laboratories and onsite measurement organizations must maintain their equipment. Maintenance requirements, such as parts lists and instructions, will be included in the individual laboratory and onsite measurements organization QA plan or operating procedures.

2.2.8 Instrument Calibration and Frequency

Instrument calibration will be according to the referenced standard methods and SOPs.

2.2.9 Inspection/Acceptance Requirements for Supplies and Consumables

Procurement activities will be limited to providing Bechtel Hanford, Inc. (BHI) Procurement with procurement requisitions. All subject activities will meet the requirements of BHI Procurement procedures.

The project will review received items and reagents for conformation to specifications set in the requisition. If the item or reagent does not meet specifications, the item or reagent will be dispositioned through the nonconformance system.

New standards acceptability will be determined by comparing the new standard with previous acceptable standards. Reagent acceptability will be determined by running blanks on the new

reagents. New reagents and standards will be separated from other standards and reagents until they have been checked and accepted.

2.2.10 Data Management

The sample and data management process (SDMP) (see BHI-EE-01, *Environmental Investigations Procedures*) shall be used to manage environmental radiological measurements and to collect samples, as shown in Figure 2-1. The environmental data and information will be used to develop tables and maps to guide the disposition of the Remaining Sites. The locations of the onsite measurements and sample collections are based on sample grid coordinates that are in turn tied to a landmark located in the Washington Plane Coordinate System and shall be recorded in a field logbook.

The SDMP will be used to obtain and communicate data results to support closeout decisions. Closeout data shall be stored in the Hanford Environmental Information System (HEIS) database. The site status will be updated in the Waste Information Data System (WIDS) database upon completion of the cleanup project. Data and information in these Tri-Party Agreement systems are managed under data configuration control procedures.

2.3 ASSESSMENT/OVERSIGHT

2.3.1 Assessments and Response Actions

The BHI QA staff will conduct random surveillance and audits to verify compliance with the requirements outlined in this QAPjP, the project work packages, the BHI Quality Management Plan, and BHI procedures and regulatory requirements. Collectively, data collection, processing, validation, management, self-assessment, and QA programs will address quality-affecting activities, which include, but are not limited to, measurement system accuracies.

Random surveillance and audits will be structured to meet the following system and performance audit classification. System audits consist of the evaluation of the components of the measurement systems to determine their proper selection and use. Performance audits ensure the accuracy of the total system and its individual parts.

2.3.2 Reports to Management

Corrective action required as a result of surveillance reports, nonconformance reports, or audit activities will be documented and dispositioned, as required by BHI-MA-02, *ERC Project Procedures*, Section 2.1, "Corrective Action Request." Other measurement systems, procedures, or plan corrections that may be required, as a result of routine review processes, will be resolved as required by governing procedures or will be referred to the technical lead for resolution. Project activities will be regularly assessed by random audits, surveillance, and assessments. All findings from audits, surveillance, and assessments will be transmitted to the project manager and the BHI QA Department for program-related tracking and trending. Otherwise, the routine evaluation of data quality described throughout this QAPjP will be documented and filed along with the data in the project file.

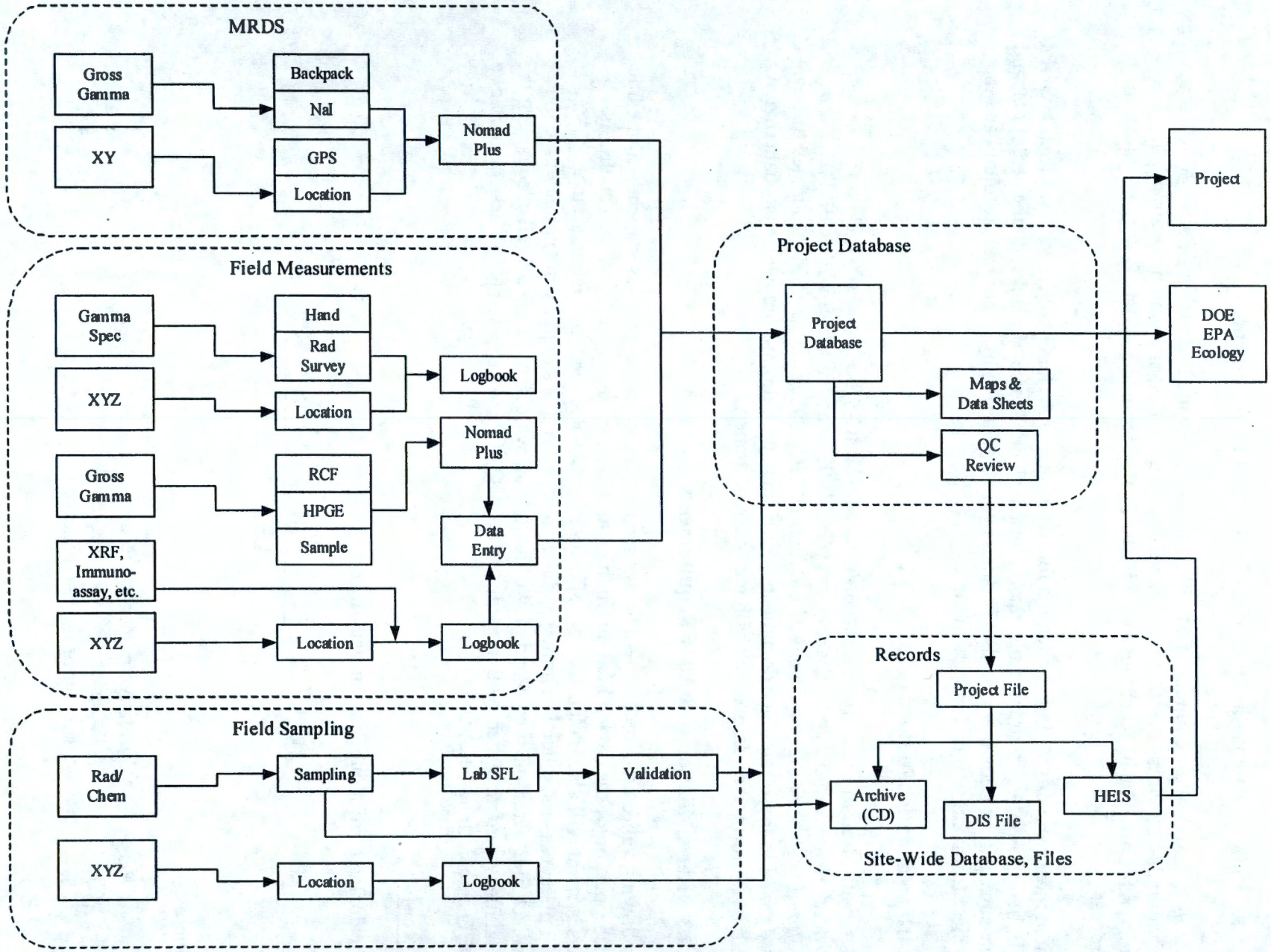


Figure 2-1. Sample and Data Management Process Flow.

2.4 DATA VALIDATION AND USABILITY

2.4.1 Data Review, Validation, and Verification Requirements

For SFL analyses, a minimum of 5% of all data will be validated per waste site. All coordination of validation services, execution of data validation activities, and handling/storage of deliverables will be in accordance with BHI-EE-01, Section 2.5, "Data Package Validation Process."

Field measurements will not undergo a formal validation. The QA/QC processes used in SOPs will be followed to ensure useable data. These include the use of blanks, duplicates, splits, and measurement of known standards. The data will be reviewed by analytical personnel and the project team and will be reported in the project file.

2.4.2 Validation Methods

Data validation of SFL will be in accordance with WHC-SD-EN-SPP-001, *Data Validation Procedure for Radiochemistry Analyses* (WHC 1993b), and WHC-SD-EN-SPP-002, *Data Validation Procedures for Chemical Analyses* (WHC 1993a). Data will be validated to Level C, as defined in these reference documents. Field and quick-turnaround laboratory data reviews will be performed in accordance with method requirements.

2.4.3 Reconciliation with User Requirements

Following validation, the data will be assessed by the project team. Assessment will include incorporation of the data validation findings into the database by entry of data qualifiers. Assessment will also include review of quantitative DQOs (e.g., precision, accuracy, completeness, and detection limits) and the preparation of a summary memorandum to the project file. The final memorandum will include an evaluation of the overall adequacy of the total measurement system with regards to the DQO of the data generated. These quantitative DQOs are defined below.

Precision

If calculated from duplicate measurements:

$$RPD = \frac{(C_1 - C_2) \times 100 \quad \%}{\frac{(C_1 - C_2)}{2}} \qquad (1)$$

where:

RPD	=	relative percent difference
C_1	=	larger of the two observed values
C_2	=	smaller of the two observed values.

If calculated from three or more replicates, use RSD rather than RPD:

$$RSD = (s/\bar{x}) \times 100\% \tag{2}$$

where:

RSD	=	relative standard deviation
s	=	standard deviation
$\bar{x}$	=	mean of replicate analyses.

Standard deviation, s, is defined as follows:

$$s = \sqrt{\sum_{i=1}^{n} \frac{(x_i - \bar{x})^2}{n-1}} \tag{3}$$

where:

s	=	standard deviation
x_i	=	measured value of the ith replicate
$\bar{x}$	=	mean of replicate measurements
n	=	number of replicates.

Accuracy

For measurements where matrix spikes are used:

$$\%R = 100 \times \left[\frac{S-U}{C_{sa}} \right] \tag{4}$$

where:

$\%R$	=	percent recovery
S	=	measured concentration in spiked aliquot
U	=	measured concentration in unspiked aliquot
C_{sa}	=	actual concentration of spike added.

For situations where a standard reference material (SRM) is used instead of or in addition to matrix spikes:

$$\%R = 100 \times \left[\frac{C_m}{C_{srm}} \right] \tag{5}$$

where:

$\%R$	=	percent recovery
C_m	=	measured concentration of SRM
C_{srm}	=	actual concentration of SRM.

Completeness

Defined as follows for all measurements:

$$\%C = 100 \times \left[\frac{V}{T} \right] \tag{6}$$

where:

$\%C$	=	percent completeness
V	=	number of measurements judged valid
T	=	total number of measurements.

Detection Limit

Defined as follows for metals measurements:

$$MDL = t_{(n-1,1-\alpha=0.99)} \times s \tag{7}$$

where:

MDL	=	method detection limit
s	=	standard deviation of the replicate analyses
$t_{(n-1,\ 1-\alpha=0.99)}$	=	students' t-value appropriate to a 99% confidence level and a standard deviation estimate with n-1 degree of freedom.

For radionuclides, the method detection limit is discussed in Appendix I per the methods referenced in Currie (1968).

2.5 DATA QUALITY ASSESSMENT

The data quality assessment (DQA) process is the scientific and statistical evaluation of data to determine whether the data are of the right type, quality, and quantity to support their intended use (EPA 1996). A DQA of the confirmation sampling results will be performed in accordance with BHI-EE-01, Procedure 1.22 "Data Quality Assessment."

Data quality analysis will not typically be performed on field screening data at this time because field screening data are not used in decisions regarding the rejection of null hypothesis. Given this, field decisions will be made based on the field screening data with the understanding that the decision to remediate a site shown to be contaminated based on field readings may not be within error tolerances. This is a risk management decision, and is deemed an acceptable risk by project decision makers.

PART III

FIELD SAMPLING PLAN

The field sampling plan provides field procedures to ensure representative data of known quality.

3.0 FIELD SAMPLING PLAN

3.1 SAMPLING OBJECTIVES

The objectives of each sampling event are described below. Specific sampling guidance will be provided in the instruction guide(s).

Radiological survey, field screening, and confirmation sampling data will be collected to meet the following objectives:

- Obtain mean and variance estimates of contaminants for use in calculating number of samples for confirmation
- Verify that the residual contamination levels in the Remaining Site soils and structures comply with the radiological and chemical cleanup levels in accordance with the appropriate statistical tests and the RESRAD dose assessment model
- Support remedial action decisions (interim closure or transfer to the 100 Area Remediation Projects for cleanup) and development of waste profiles.

3.2 APPLICATION OF THE 100 AREA REMAINING SITES SAMPLING DESIGN

3.2.1 Conformance with Site Profiles and CSMs

The field engineer is responsible for determining the COPCs for each site and the agreement between the site conditions and the CSMs. These inputs will be used to determine the number of samples, the depth of sampling, the types of samples, and their locations. Immobile COPCs and underlying strata can work to limit depth of sampling requirements, while highly mobile contaminants and certain soil matrices may indicate the need for sampling at greater depths. The field engineer must document the basis for the depth of sampling requirements for later use in the MP-14 form supporting documentation.

During field activities, the judgmental approach should be used with field screening to investigate anomalies discovered in the field. This not only ensures that potentially contaminated material is investigated, but is also needed to verify CSM assumptions. Anomalies, strata heterogeneity, and "spotty" contamination, if found unexpectantly, could indicate erroneous application of the CSM and thus invalidate the sample design. At a minimum, all decisions and deviations from the sample design shall be documented and clearly justified in the field logbook for reference by data users.

3.2.2 Application of the Sampling Design

The confirmation sampling design presented in Section 2.2.5 is a two-step process. The statistical sampling guidance for the eight CSMs is provided in Appendices A through H. To guide the field engineer in the proper application of this sampling design, a decision-making process is provided in this section, with an accompanying logic flow diagram in Figure 3-1.

Step I in the 100 Area Remaining Sites sampling design results in the determination of the number of lateral samples to be collected in the X-Y plane. Step II evaluates the sampling requirements at depth and applies the Step I sampling requirements for each component (media to be sampled at depth).

The two-step sampling design results in a calculated number of confirmation samples for 100 Area Remaining Sites that have historical or analogous data. However, because most of the 100 Area Remaining Sites have no historical or analogous data to draw upon for sampling design input, the default value of 64 samples will be required for each component in the waste site.

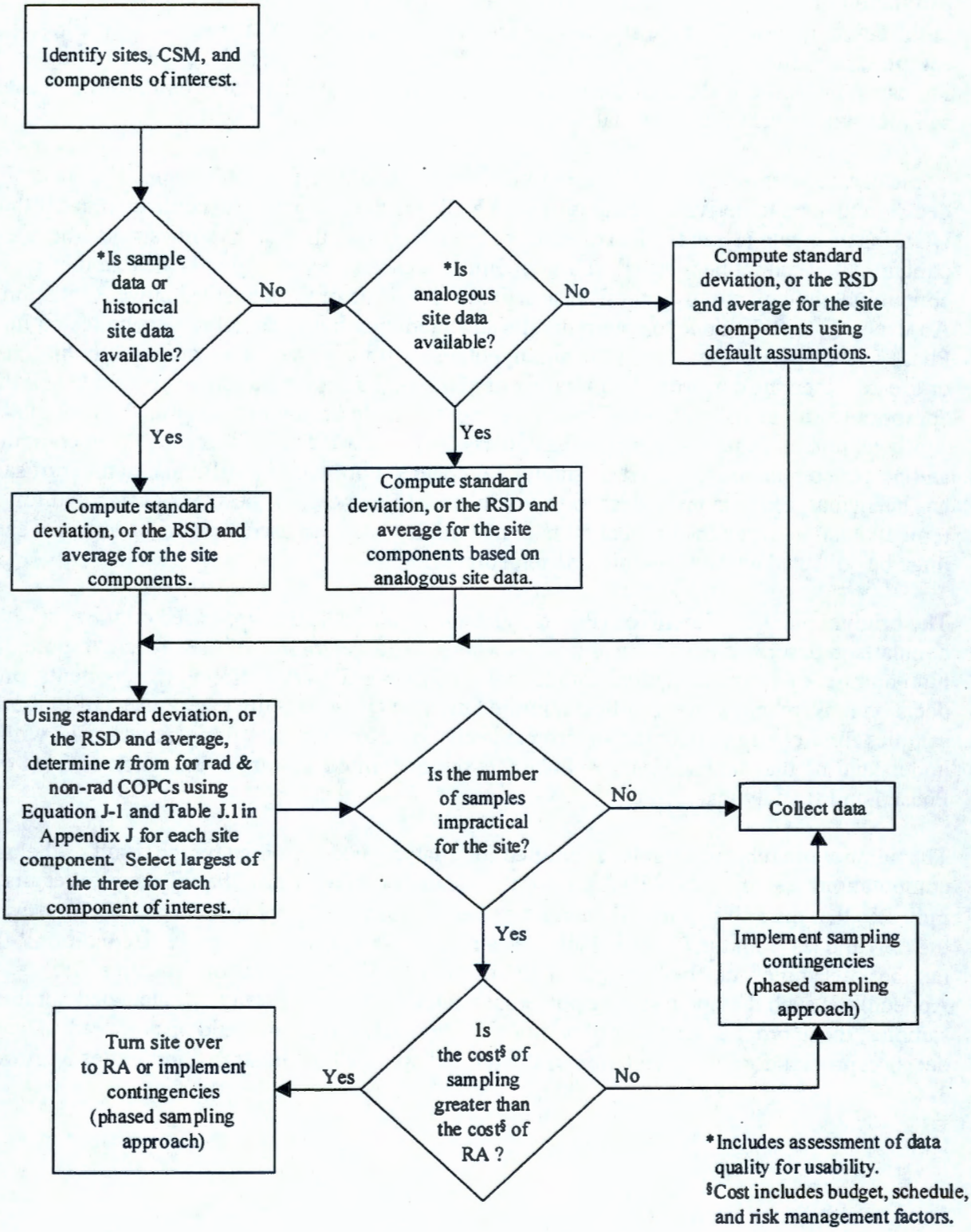
The default sampling requirement of 64 samples per site component will not be acceptable for confirmatory sampling in most cases, because it would be far more expensive to collect this number of samples than to perform site remediation for all but the largest sites. Therefore, the field engineer will need to consider possible sources of low-cost analytical data that may be used as input to the Step I sampling design, because such data may reduce the confirmatory sampling requirements. The possible alternatives include historical, or analogous site data, as well as field screening (Section 2.2.4).

If the confirmatory sampling requirements are still unacceptably high after consideration of historical, analogous and field screening data, the field engineer must evaluate the sample design contingencies identified in Section 2.2.5.3.

3.2.2.1 Phased Approach Sampling Contingency. The phased sampling contingency is expected to be applied on a regular basis for confirmatory sampling with the 100 Area Remaining Sites. Therefore, more specific application guidance is provided for the field engineer in this section.

Implementation of the phased approach requires the field engineer to evaluate sites in accordance with the Step I and Step II sample designs. Where a site variance cannot be determined for use in equation J.1 of Appendix J, the number of samples (for Phase I and Phase II analysis) should be determined according to an analysis of the cost of sampling versus the cost of remedial action. For small sites, it is likely that remedial action costs could be less than confirmation sampling costs given the potentially high number of samples required as a result of applying equation J.1 of Appendix J. For large sites, it is likely that confirmation sampling costs could be less than remedial action costs given the potentially high volume of material that would require remediation. These cost analyses must be performed on a site-by-site basis. If the results of these analyses indicate that the default or calculated number of confirmatory samples is not reasonable or cost-effective for interim closure of the waste site, the Phased Approach Sampling Contingency may be applied.

Figure 3-1. Decision Diagram for Sample Planning.



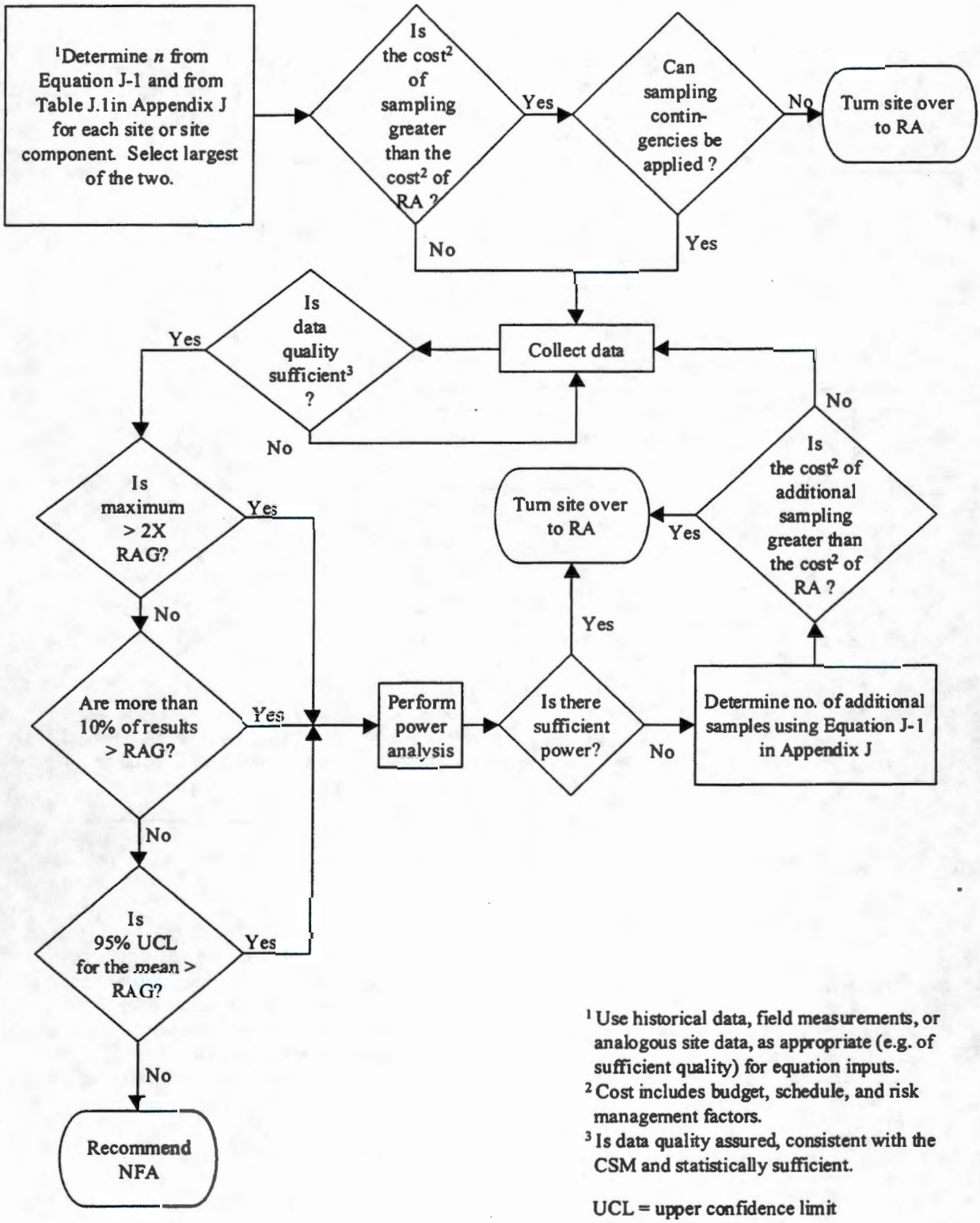
As discussed in Section 2.2.4.3, the phased approach involves collection of a pre-determined number of confirmation samples that are divided into Phase I and Phase II batches. The Phase I batch is promptly submitted to the SFL for analysis. The Phase II batch is archived pending evaluation of the Phase I results (as long as analytical hold times are not violated for the COPCs at the site in question). If the site may be interim closed based on the results of the Phase I samples, no further analyses will be required. If, however, analysis of the Phase I samples indicates that additional sample results are needed to close the site, some or all of the Phase II samples will be submitted for analysis.

Typically, the minimum number of Phase I samples should be four per component. This allows decision makers to derive a meaningful 95% UCL for the mean for site confirmation. If the 95% UCL for the mean is greater than or equal to the RAG, then the null hypothesis that the site is contaminated cannot be rejected. This condition does not necessarily indicate that the site is contaminated (e.g., null hypothesis is accepted). Analysis of the statistical power (equation J.8, Appendix J) must be done to determine if a sufficient number of samples were collected in Phase I to support acceptance of the null hypothesis. If the power is not sufficiently high (0.80 or greater) then the corresponding number of additional samples should be computed and the appropriate number of archived (Phase II) samples should be submitted for analysis. Finally, subsequent to analysis of the Phase II samples, the process (95% UCL for the mean computation and power computation, if needed) should be repeated until either a sufficient number of samples has been analyzed to support decisions within error tolerances, or the site is designated for remedial action. If an insufficient number of samples has been archived, then additional samples must be collected or the site should be remediated.

The original number of archived (Phase II) samples should be derived based on the cost comparison described above. In situations where the large volume of the site and/or potentially high number of samples required could result in cost-prohibitive sampling requirements, project decision makers may elect to collect a limited number (judgmentally determined) of Phase II samples for archiving. In doing so, project decision makers are accepting certain risks with the understanding that data needs may not be met by the limited amount of data derived from the Phase I and II analytical results.

The number of archived samples submitted for analysis is determined by the result of the power computation, assuming the 95% UCL for the mean as derived from Phase I samples results indicates that the null hypothesis cannot be rejected (95% UCL for the mean ≥ RAG). Assuming the ($\bar{x}$) and (s) from the Phase I results are a reasonable approximation of site conditions, the number of samples may be back calculated from the power computation (equation J.8, Appendix J) such that the resulting power is greater than 80%. From this calculated number of samples, the appropriate number of additional (Phase II) samples should be analyzed. The decision process for implementation of the phased approach is illustrated in Figures 3-2 through 3-4.

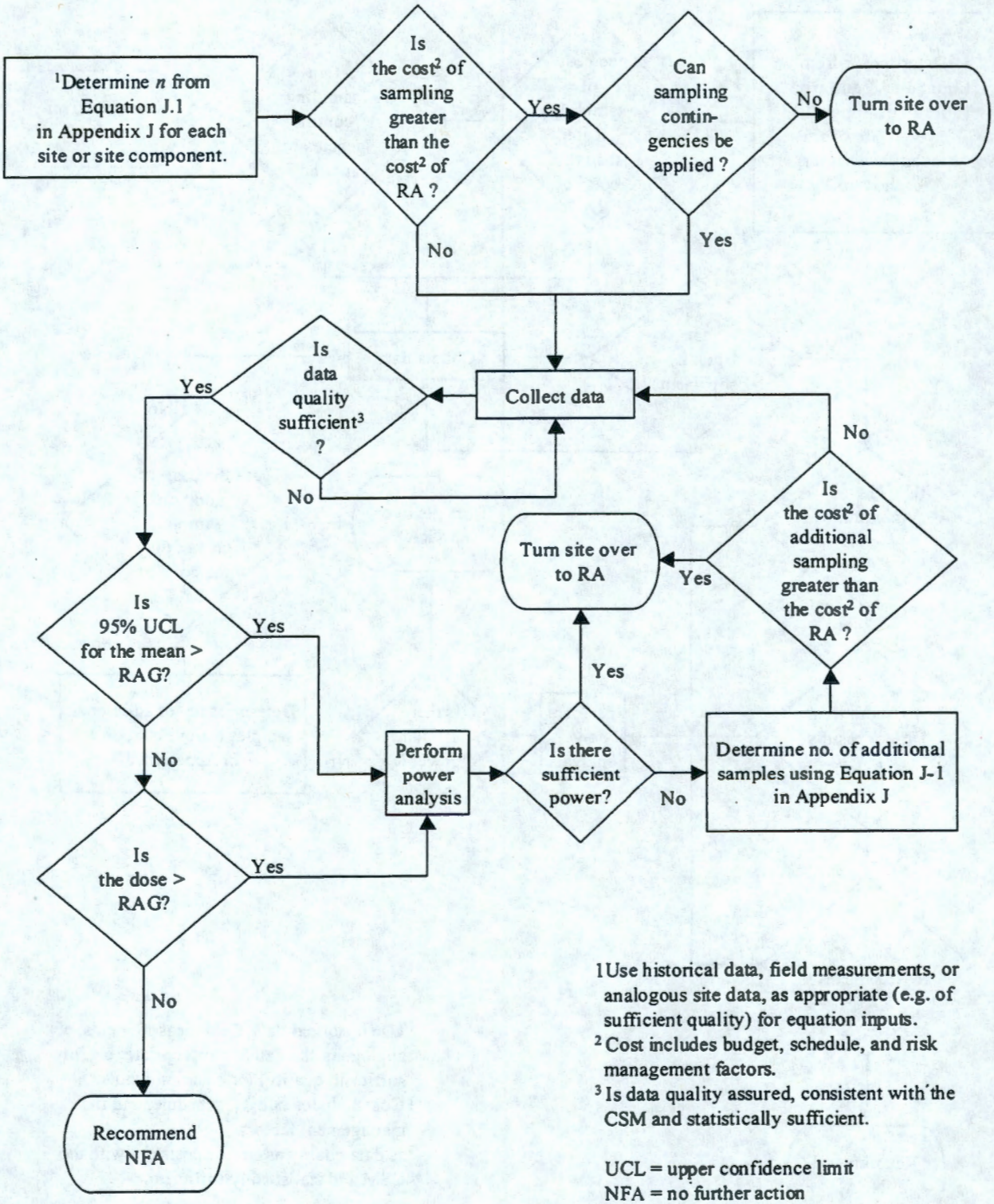
Figure 3-2. Flow Diagram for Sites with Nonradiological COPCs Only.



[1] Use historical data, field measurements, or analogous site data, as appropriate (e.g. of sufficient quality) for equation inputs.
[2] Cost includes budget, schedule, and risk management factors.
[3] Is data quality assured, consistent with the CSM and statistically sufficient.

UCL = upper confidence limit
NFA = no further action
RA = Remedial Action
RAG = Remedial Action Goal

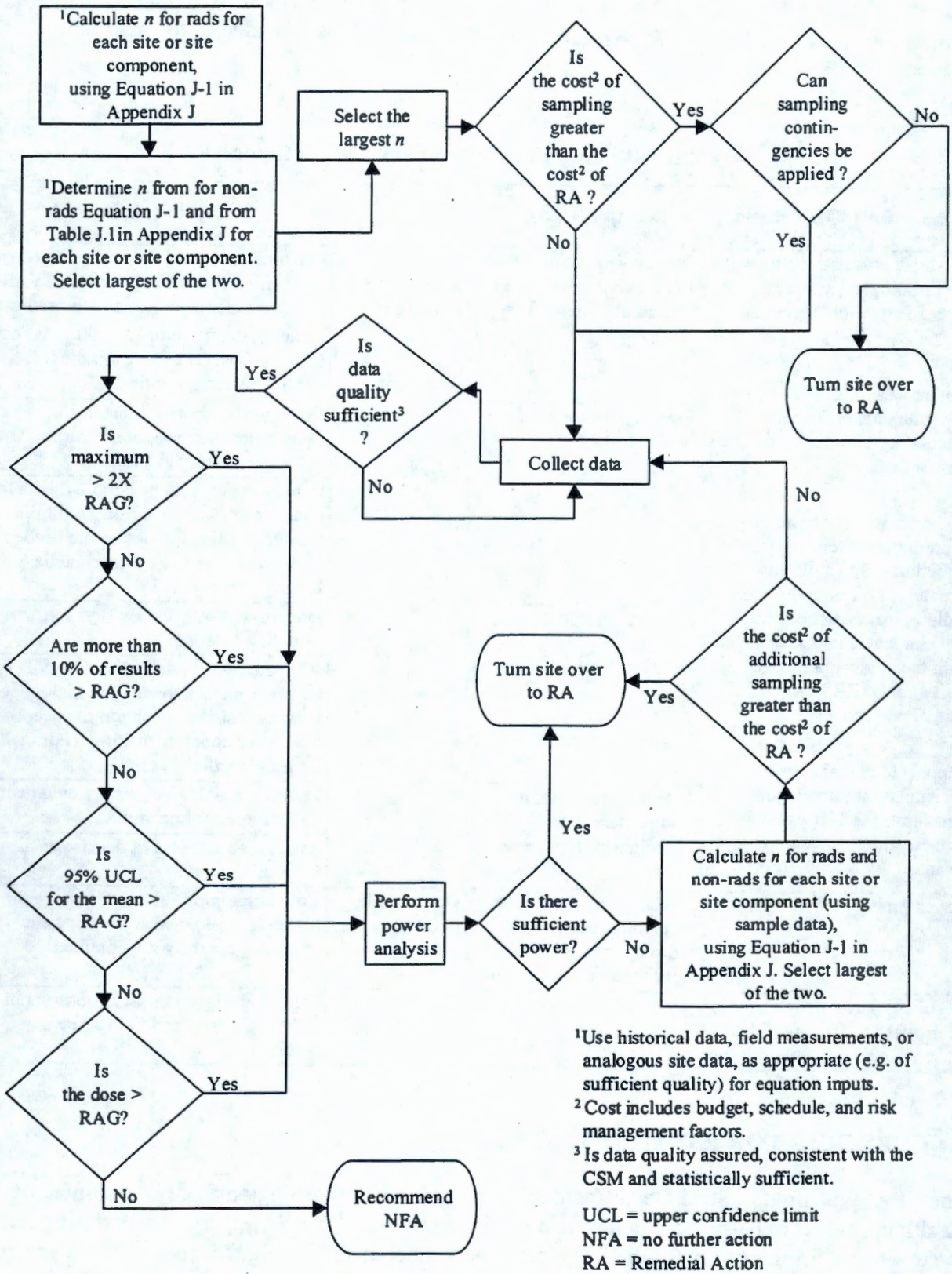
Figure 3-3. Flow Diagram for Sites with Radiological COPCs Only.



1 Use historical data, field measurements, or analogous site data, as appropriate (e.g. of sufficient quality) for equation inputs.
2 Cost includes budget, schedule, and risk management factors.
3 Is data quality assured, consistent with the CSM and statistically sufficient.

UCL = upper confidence limit
NFA = no further action
RA = Remedial Action
RAG = Remedial Action Goal

Figure 3-4. Flow Diagram for Sites with Both Radiological and Nonradiological COPCs.



[1]Use historical data, field measurements, or analogous site data, as appropriate (e.g. of sufficient quality) for equation inputs.
[2] Cost includes budget, schedule, and risk management factors.
[3] Is data quality assured, consistent with the CSM and statistically sufficient.

UCL = upper confidence limit
NFA = no further action
RA = Remedial Action
RAG = Remedial Action Goal

3.3 SAMPLING APPROACH

The sampling approaches are shown in Table 3-1. Sampling will follow SOPs per BHI-EE-01, *Environmental Investigations Procedures.* Further detail will be provided in the instruction guide.

Table 3-1. Sampling Objectives and Methods.

Sampling Objectives	Sampling Area	Number of Samples	Sampling Approach
Establish correlations between the radiological survey instruments, field screening, and SFL analyses Obtain variance of contaminants for use in calculating number of samples for confirmation To verify that the residual contamination levels in the Remaining Site soils and structures comply with the radiological and chemical cleanup levels in accordance with the appropriate statistical tests and the RESRAD dose assessment model Support remedial action decisions (interim closure or transfer to the 100 Area Remediation Projects for cleanup)	Potentially contaminated soil in, around, or under Remaining Sites	Refer to Appendices A through H	Perform direct radiological surveys over soil grids and sampling locations with NaI and other detectors as required. Collect discrete samples after radiological surveys from random or biased locations per the instruction guide.
	Exposed concrete slab surfaces		Grid the slab surface, perform radiological surveys, being particular to include sampling locations.
			After surveys, collect sample media from concrete surface by drilling multiple co-located positions to obtain the needed volume of concrete drilling media. Drilling depth is ¼ in.
	Concrete rubble surfaces		Perform radiological surveys over the sampling locations.
			After surveys, collect sample media from concrete surface by drilling multiple co-located positions to obtain the needed volume of concrete drilling media. Drilling depth is ¼ in.
	Potentially contaminated sludge, debris, and miscellaneous wastes		Perform radiological survey over debris, including sampling area.
			Select grab samples of debris per the instruction guide.
Development of waste profiles	Media determined to be contaminated by radiological surveys or field screening techniques	One sample per site	Collect sample from media where the highest radiological survey or field screening results were obtained.
Regulator participation in confirmatory site sampling and analysis	All	TBD	Sampling based on visual observation of field conditions and field screening results.

3.4 REGULATOR PARTICIPATION

The EPA, Washington State Department of Ecology, and/or Washington State Department of Health may elect to participate in the field implementation of this SAP, particularly during initial waste site confirmatory sampling. Regulatory personnel or their designees may also collect split samples for separate analysis, at no cost to the project.

Agreements reached with regulators on field decisions will be documented in the field logbook by signature of the ERC field engineer and regulatory field representative(s). If agreements are made by telecon, concurrence will be documented by confirming e-mail notes as a minimum. Typical field decisions that would require concurrence include elimination of COPCs, changes to the CSMs, and/or anomalous conditions that lead to changes in the sample design.

3.5 FIELD AND LABORATORY QUALITY CONTROL

Field QC sampling requirements are summarized in Table 3-2 for concrete survey and confirmation sampling. Field QC requirements for soil sites are summarized in Table 3-3. Details of the field QC samples and requirements are found in Section 3 of the 100 Area Remedial Action SAP (DOE-RL 1998a). Table 3-4 lists the field and analytical QC sampling requirements summary for concrete. The definitions of the field and laboratory QC samples are found in Section 2.2.6.1.

Table 3-2. QC Samples/Frequencies and Analytical Methods for Radiological Survey, Concrete Verification.

Field Activity	Analytical Parameters	Duplicates	Equipment Blanks	Analysis Method
Radiological survey	Cs-137	N/A	N/A	Field instrument (NaI)
Concrete confirmation sampling	COPCs Table 2-1	Minimum of 1 per 20 samples per waste site	Minimum of one per waste site	SFL/Table 2-2

Table 3-3. Sampling Frequencies and Analytical Methods for Soil Site Confirmation.

Field Activity	Analytical Parameters	Routine Sample Frequency	Duplicates/ Splits	Laboratory/ Method
Site Confirmation (Verification[a]) 0 to 4.5 m (0 to 15 ft) -- Shallow Zone				
Confirmation sampling	See 100 Area Remedial Action SAP (DOE-RL 1998a)			
Site Confirmation (Verification[a]) >4.5 m (15 ft) -- Deep Zone				
Confirmation sampling	See 100 Area Remedial Action SAP (DOE-RL 1998a)			

[a] The term "verification" is used in the 100 Area Remedial Action SAP.

Table 3-4. Field and Analytical Quality Control Sampling Requirements Summary.[a]

QC Sample Type	Purpose	Frequency Reference
Equipment blanks	Assess equipment cleaning and potential cross contamination	Minimum of one per area
Field duplicates	Assess homogeneity of concrete	Minimum of one per 20 samples in each waste site
Laboratory method blank	Assess laboratory contamination	1/20 samples of same matrix prepared in one batch
Laboratory control sample	Assess accuracy	1/20 samples of same matrix prepared and analyzed in a batch
Matrix spike	Assess accuracy	1/20 samples of same matrix per prepared in one batch
Laboratory duplicate or matrix spike duplicate	Assess precision	1/20 samples of same matrix prepared in one batch

3.6 SAMPLE MANAGEMENT

3.6.1 Sample Custody

3.6.1.1 Field Custody. All samples obtained during the course of this project will be controlled from the point of origin to the analytical laboratory, as required by BHI-EE-01, Procedure 3.0, "Chain of Custody."

3.6.1.2 Laboratory Custody Procedures. Sample custody during laboratory analysis will be addressed in the applicable laboratory SOPs. Laboratory custody procedures will ensure the maintenance of sample integrity and identification throughout the analytical process.

3.6.1.3 Sample Preservation, Containers, and Holding Times. Sample preservation and container details will be addressed on the sample authorization form in accordance with BHI-EE-01, Procedure 2.0, "Sample Event Coordination." Allowable holding times are 28 days for mercury samples and 6 months for radiological constituents and other metals, except for hexavalent chromium. There are two holding times that apply for hexavalent chromium; concrete samples are limited to 24 hours, but the holding time in moist soils is 30 days. The holding time limit for polychlorinated biphenyls (PCBs) is as follows: PCBs must be extracted from soils within 14 days of collection, followed by analysis within 40 days.

Volatile organics have a hold time limit of 14 days. For semi-volatiles, liquids extraction must be completed within 7 days, solids extraction must be performed within 14 days, and analysis for both liquids and solids must be completed within 40 days.

Final holding times will be specified on the sample authorization form and will supercede this document.

3.6.1.4 Sample Shipping. Sample packaging and shipping will be performed in accordance with BHI-EE-01, Procedure 3.1, "Sample Packaging and Shipping." Samples submitted for standard fixed laboratory analysis will be screened for radioactivity at the 100-N RCF prior to shipment offsite.

3.6.1.5 Field Documentation. Field documentation shall be kept in accordance with BHI-EE-01, including the following procedures:

- Procedure 1.5, "Field Logbooks"
- Procedure 1.13, "Environmental Site Identification and Information Reporting"
- Procedure 3.0, "Chain of Custody."

3.7 MANAGEMENT OF WASTES

All waste generated during field sampling will be managed in accordance with BHI-EE-10, *Waste Management Plan*. Efforts will be made to minimize not only the volume of waste generated from sampling and sampling equipment decontamination procedures, but the volume of personal protective equipment waste as well. Field screening and waste management procedures will be used to assist in segregating radiological waste from clean waste. Sampling equipment that cannot be successfully decontaminated and cannot be further used will be managed as waste.

Used samples will be disposed of by the analytical laboratory in accordance with laboratory-specific disposal requirements. Unused sample material that is no longer needed for archival (as directed by ERC Sample and Data Management and the project manager) will be disposed of by the laboratory or returned to the project for disposition in accordance with ERC waste management requirements. Any samples returned to the ERC for disposal must be unused and not altered from the original chemical, radiological, and physical form.

3.8 HEALTH AND SAFETY

All field operations will be performed in accordance with BHI health and safety requirements outlined in BHI-SH-01, *Hanford ERC Environmental, Safety, and Health Program*; the requirements of the *Hanford Site Radiological Control Manual* (HSRCM) (DOE-RL 1996b); and BHI-SH-04, *Radiological Control Work Instructions*, Instruction Number 3.1, "Conduct of Radiological Surveys." In addition, a work control package will be prepared in accordance with BHI-MA-02, *ERC Project Procedures*, which will further control site operations. This package will include an activity hazard analysis, site-specific health and safety plan, and applicable radiological work permits.

The sampling procedures and associated activities will take into consideration exposure reduction and contamination control techniques that will minimize the radiation exposure to the sampling team as required by BHI-QA-01, *ERC Quality Program*, and BHI-SH-01, *Hanford ERC Environmental, Safety, and Health Program*.

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APPENDIX A

SAMPLING DESIGN FOR THE DISPERSING LIQUID DISCHARGE SITES (FRENCH DRAINS, DRYWELLS, CRIBS, AND TRENCHES) CONCEPTUAL SITE MODEL

A1.0 SAMPLING DESIGN FOR THE DISPERSING LIQUID DISCHARGE SITES (FRENCH DRAINS, DRYWELLS, CRIBS, AND TRENCHES)

Dispersing liquid discharge sites (i.e., french drains and drywells) are waste sites where liquid discharges were deliberately released into the soil column, dispersing through the vadose zone. Section A2.0 provides details of the conceptual site model (CSM) for french drains and drywells. Cribs and trenches are addressed in Section A3.0, while Section A4.0 discusses decision error tolerances for all of the dispersing liquid discharge sites. The sampling design is developed in Section A5.0.

For the purposes of this sampling and analysis plan (SAP), french drains and drywells are considered equivalent, and cribs and trenches are considered equivalent. Hereafter, the term "french drain" will be used to refer to both french drains and drywells, and the term "crib" will be used for both cribs and trenches.

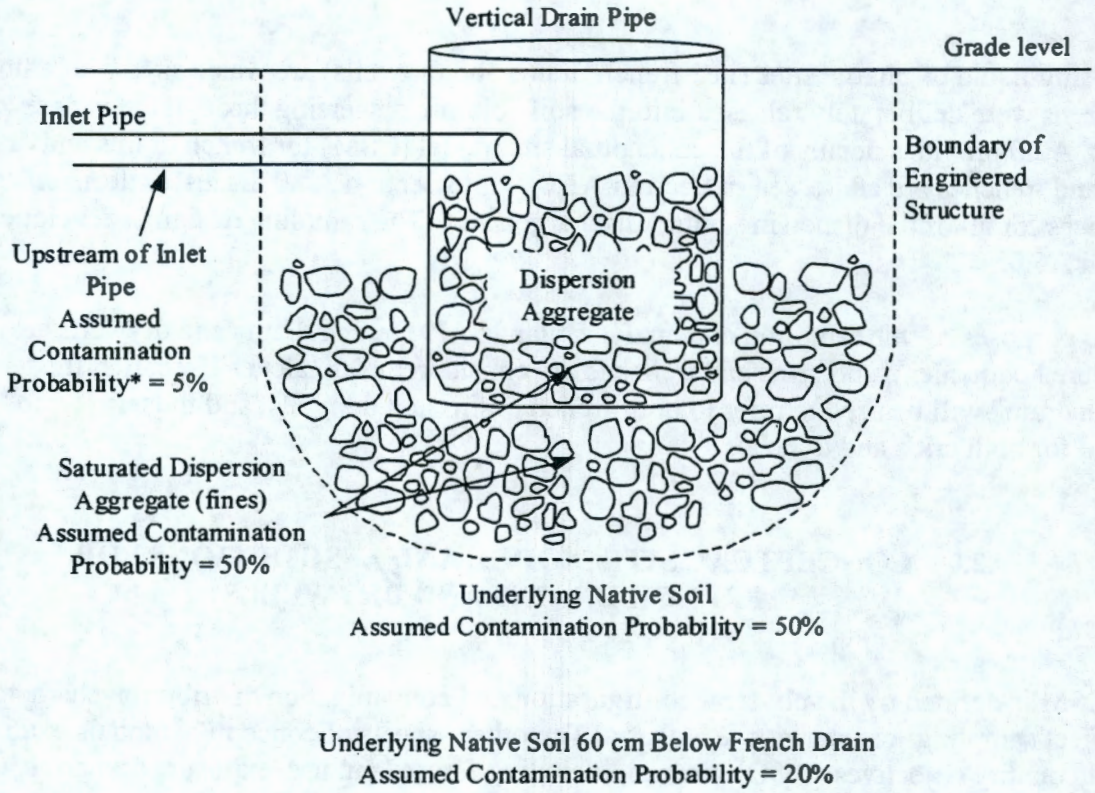
A2.0 CONCEPTUAL SITE MODEL AND ASSUMPTIONS FOR FRENCH DRAINS AND DRYWELLS

This CSM is defined by the physical configuration and contamination distribution characteristics that affect sampling for interim site closure. The other aspects of conceptual models examined in the data quality objectives (DQO) process, including future land use, exposure scenarios, and identification of contaminants of potential concern (COPCs), are found in Sections 1.0 through 5.0 of the DQO summary report (BHI 1999).

Figure A-1 shows a schematic of the assumed general layout of a french drain. If a french drain being investigated does not contain these general components, the sampling design will be updated as necessary.

The drain pipe is vertically oriented and generally has an open bottom to allow dispersal of liquid waste. Drain pipes are sometimes filled with aggregate. The aggregate in and around the drain pipe, as well as the soil under this aggregate, is assumed to be the component with the highest likelihood of exposure to contamination. The dispersion aggregate size may range from sand to 2.5- to 7.6-cm- (1- to 3-in.) diameter gravel and is assumed to be roughly the same size throughout the structure. The size of the dispersion aggregate affects the probability of finding measurable contamination concentrations. Typically, the aggregate is only surficially contaminated. Laboratory methods only digest or extract surface contaminants, but the entire sample weight is factored into the concentration values reported. Consequently, the reported concentrations for larger diameter aggregates are expected to be very low. Therefore, despite the potential for exposure to contaminated liquids, the aggregate is not considered a useful sampling media. It should be noted, however, that residual contamination on aggregate from radiologically contaminated liquids may be detectable by radiological field instruments.

Figure A-1. Schematic of a Typical French Drain.



* Pipes are covered under a separate CSM sample design. The probability of contamination near the pipe terminus at the site is assumed low because the open-ended pipe is unlikely to have caused sufficient back pressure to cause leakage into the pipe cradle right next to the site.

Fines within the aggregate and the fine-grained/native soil interface beneath the drain system are the most likely media to be contaminated. This is because the fines within the aggregate (if present) readily adsorb contaminants from the liquids being discharged. The fine-grained and native soils under the aggregate also adsorb contaminants from the liquids channeled through the dispersion aggregate. Soil contamination is assumed to decrease with depth and horizontal distance from the structure (i.e., the soils immediately beneath and adjacent to the structure are more likely contaminated than soils located farther away from the structure).

The inlet pipe is assumed to be situated below grade and may be located on aggregate. The interior of the inlet pipe will not be sampled as part of this effort because its contents are quite small compared with other structure components and it is likely difficult to locate. If the inlet pipe did leak, the most likely areas for leakage are at joints or elbows. The soil and pipe bedding beneath the inlet pipe and upstream of the discharge point will not be sampled because these areas are the least likely to be contaminated. Also, due to its unique nature, piping, per se, is covered by a sample design that is specific to piping systems.

The following media are identified as being the most likely to contain detectable COPC concentrations:

- Fines in the aggregate immediately under the inlet pipe discharge
- Large-diameter aggregate (+0.64-cm [+0.25-in.] diameter) generally measured by radiological field instruments only
- Native soil interface immediately beneath the drainage system
- Native soils at a depth of 0.6 m (2 ft) below the interface with the aggregate.

The sampling media associated with these components include fines within the inlet and drain pipes, the aggregate material itself, fines within the aggregate, and the surrounding soils.

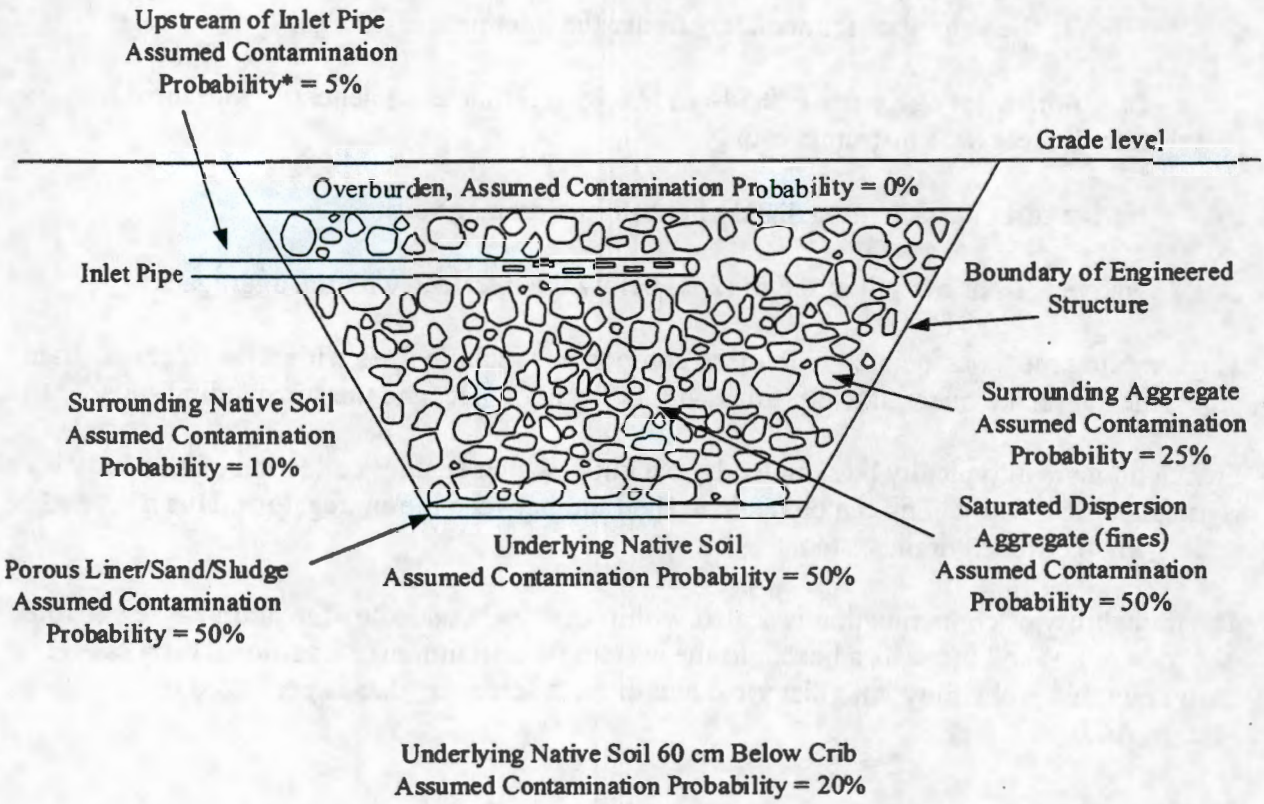
French drains will typically be sampled by backhoe, which enables collection of all soil types. It is assumed that distinctions can be made in the field between the aggregate and the native soils underlying the french drain system.

The probability of contamination is scaled within a range bounded by the drain aggregate fines (the maximum) and the soils adjacent to the system (the minimum). Additional discussion for estimating this probability with historical and/or field screening data is presented in Section A4.0.

A3.0 CONCEPTUAL SITE MODEL AND ASSUMPTIONS FOR CRIBS AND TRENCHES

As with the french drain CSM, this CSM is defined by the physical configuration and contamination distribution characteristics that affect sampling for interim site closure. The DQO summary report (BHI 1999) contains information on other aspects of the CSM. Figure A-2 shows a schematic of the conceptual crib layout.

Figure A-2. Schematic of Typical Crib or Trench.



* Pipes are covered under a separate CSM sample design. The probability of contamination near the pipe terminus at the site is assumed low because the open-ended pipe is unlikely to have caused sufficient back pressure to cause leakage into the pipe cradle right next to the site.

The contents of the inlet pipe will not be sampled as part of this CSM per se (refer to pipeline-specific sample planning). In addition, the overburden is assumed uncontaminated and will not be sampled. If a crib being investigated does not contain these general components, the sampling design will be revised accordingly.

The inlet pipe extends into the crib and discharges over a portion of the dispersion aggregate. The dispersion aggregate around the pipe discharge area is assumed to have the highest likelihood of contact with contaminated liquids. Dispersion aggregate, if contaminated, is assumed to be surface-contaminated only and will be characterized with available field screening methods. Fines, if present, contained within the aggregate may be collected for laboratory analysis.

A porous liner may or may not be present. Occasionally, cribs were constructed with a gravel or sand bedding under the layer of dispersion aggregate. If present, the liner is assumed to be gravel (6 to 12 mm diameter) or sand. If the crib is lined, it is assumed that native soils are located directly beneath the liner. If the crib is not lined, it is assumed that effluent dispersed directly into native soils.

The underlying and surrounding soils may be contaminated because this type of waste disposal site was designed to disperse liquids vertically and, possibly laterally, beyond the crib boundaries. Contamination is expected to decrease with depth/distance from the crib boundaries. It is assumed that the crib did not overflow during operation.

Because most sites received relatively small discharge volumes, sludge is not expected to be present at the bottom of the crib. If present, sludge would be the most likely media to be contaminated.

The following areas are the most likely candidates for detectable COPC concentrations:

- Fines (if present) in the dispersion aggregate under the inlet pipe discharge
- The dispersion aggregate under the inlet pipe discharge (radiological field instruments only)
- The porous bottom liner
- The native soil interface beneath the crib.

It is assumed that the location of the inlet pipe is known and that the aggregate and soils beneath and adjacent to the inlet pipe are accessible for field screening surveys. Finally, depth sampling of the surrounding and underlying soils is assumed possible.

If historical data are not available for any of the sampling media, field screening should provide information on the contamination status of the sampling media; otherwise, assume the probability that the fines within the aggregate (if present) are contaminated is 0.50. Assume the probability that the soil surrounding the system aggregate is contaminated is 0.10, and scale the other sampling media probabilities to values within the range defined by these maximum and minimum values. Additional discussion for estimating this probability with historical and/or field screening data is presented in Section A4.0.

A4.0 DECISION ERROR TOLERANCES FOR FRENCH DRAINS AND CRIBS

This section discusses the development of the error tolerances for the french drain and crib sample designs. This SAP makes frequent reference to the generic tables and discussions in Parts I through III of this SAP from which the sampling design was developed.

As shown in Table 1-4, the french drain waste streams are assumed to include reactor condensate, silica gel, laboratory effluent, decontamination fluid, and spent acid/caustics. For the cribs, the waste streams include animal waste, reactor effluent and condensate, decontamination fluid, laboratory effluent, sewage, and spent acid/caustics. The COPCs associated with these waste streams include radionuclides, metals, and a subset of organic constituents. Because there are no historical data associated with these sites, the concentration

ranges of the COPCs are unknown at this time; thus, upper and lower range limits associated with the Remaining Sites' french drains and cribs have not been established.

Refer to generic Table 2-1 for the action levels for the COPCs associated with the Remaining Sites' french drains and cribs. Action levels are provided for each parameter that will be used to support a decision. The derived concentration guideline levels (DCGLs) for radionuclide COPCs will be determined after the isotopic distributions have been estimated.

Generic Table 1-7 shows the tolerable decision errors for evaluation of the mean concentration (note: these errors apply to all media identified for the CSM and thus do not require specific identification for use of the table). The false-positive rate (5%) is based on the confidence limit for the mean specified in the *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (DOE-RL 1998b) and the *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units* (Remaining Sites ROD) (EPA 1999). The false-negative error rate (20% for the mean) follows from the 100 Areas remedial action SAP (DOE-RL 1998a).

Table A-1 specifies the input required to determine the number of samples for nonradionuclide COPCs. The probabilities are specified by the qualitative ranking of components identified in the CSM. These probability assumptions are used to determine the number of samples with the equations presented in Appendix J. Table A-1 summarizes the likely site components and their assumed probability of contamination in lieu of adequate analytical data.

The bounds of the gray region are presented in a generic format for evaluating the mean concentrations in all of the Remaining Sites in generic Table 1-8 and the associated text.

The bounds of the gray region are based on a DQO established for the analytical laboratory precision (BHI 1999). The laboratory relative percent difference (RPD_{lab}) is required to be equal to or less than 30% to satisfy the established analytical precision DQO. An additional 10% is added to the RPD_{lab} to account for some amount of population variability; the 10% is based solely on judgment. This assumption results in a LBGR default value that is approximately 68.8% of the applicable remedial action goal (RAG) (where the LBGR is 1-RSD, and RSD is derived from equation J-2 of Appendix J). The LBGR is always 68.8% of the RAG based on the DQO for laboratory precision unless the DQO changes. If the RPD from the laboratory is >30% (the DQO), then a decision has to be made about data usability.

Since there are no historical data associated with most of these sites, the "sampling variability" or the relative standard deviation for the site (RSD_{site}) is determined by equation J-2 in Appendix J. The sampling variability is a combination of all sources of variability: laboratory, site, sample collection, environmental conditions, time of day, etc. In lieu of having sampling variability information at the time of sample planning, a value of 100% is assumed. If the sampling variability (RSD_{site}) is greater than 100%, the original or default number of samples calculated for the site will not be sufficient to meet error tolerances. If the sampling variability (RSD_{site}) is less than 100%, the number of samples should be adequate. The details of proper application of the equations and the assumptions built into the computation of the default number of samples are presented in Appendix J.

Table A-1. Inputs for the Number of Samples Calculation When the Sample Maximum Will Be Compared to a Threshold.

DS #	Media	COPCs	Parameter of Interest	Range	Pr(contaminated)
			French Drains and Drywells		
2	Dispersion aggregate - Under drain (fines)	As, Ba, Cd, Cr, Pb, Hg, Se, Ag, sulfate, SVOCs, and VOCs	Population maximum concentration	TBD	0.50
	Native soil - Interface under aggregate - Soil 0.6 m below the aggregate/soil interface - Surrounding french drain (lateral, to the sides)				0.50 0.20 0.05
4	Dispersion aggregate - Under drain (fines)	As, Ba, Cd, Cr, Pb, Hg, Se, Ag, sulfate, SVOCs, and VOCs	Population maximum concentration	TBD	0.50
	Native soil - Interface under aggregate/soil interface - Soil 0.6 m below the aggregate - Surrounding french drain (lateral, to the sides)				0.50 0.20 0.05
			Cribs and Trenches		
2	Dispersion aggregate - Fines in aggregate under the inlet pipe - Fines in aggregate outside direct influence of inlet pipe discharge (to the sides)	As, Ba, Cd, Cr, Cr^{+6}, Pb, Hg, Se, Ag, Sulfate, Pesticides, SVOCs, PCBs, VOCs	Population maximum concentration	TBD	0.50 0.25
	Porous or sand liner				0.50
	Native soil interface - Under crib - Surrounding crib (lateral, to the sides)				0.50 0.10
4	Dispersion aggregate - Fines in aggregate under the inlet pipe - Fines in aggregate outside direct influence of inlet pipe discharge (to the sides)	As, Ba, Cd, Cr, Cr^{+6}, Pb, Hg, Se, Ag, Sulfate, Pesticides, SVOCs, PCBs, VOCs	Population maximum concentration	TBD	0.50 0.25
	Porous or sand liner				0.50
	Native soil interface - Under crib - Surrounding crib (lateral, to the sides)				0.50 0.10

TBD = to be determined

A5.0 SAMPLING DESIGN FOR FRENCH DRAIN, DRYWELL, CRIB, AND TRENCH SITES

This section provides the guidance for determining the sampling requirements for french drain, drywell, crib, and trench sites.

A5.1 STEP I SAMPLE DESIGN

Backhoe excavation is the preferred sample collection method for french drains and cribs. The Step I sample design establishes the number of lateral sampling locations in the X-Y plane (equal to the number of backhoe test pit sampling locations).

Sampling of radiological contaminants is performed to estimate mean activity for each radiological COPC so that the sample mean can be compared with the RAG. Sampling of the nonradiological contaminants is performed to collect data sufficient to satisfy the three-part *Model Toxics Control* Act (MTCA) evaluation criteria regarding the sample maximum, the proportion of sample results exceeding the RAG, and the single-tailed 95% upper confidence limit of the sample data (95% UCL).

The required number of samples is calculated for each COPC. The most conservative number (the largest) is chosen. If french drains or cribs have both types of COPCs, the number of sampling locations will be the maximum number calculated for either the radiological or nonradiological COPCs.

Table A-2 summarizes the Step I sampling requirements for french drain sites. This table shows the components and assumed RSD_{site}, RPD_{lab} (which is used to calculate the RSD_{lab}), LBGR, alpha, beta, Pr(contaminated), and default number of lateral sampling locations in the X-Y plane for each component. Components with an expected probability of contamination that is equal to or less than 0.10 are not shown in this table and will not be sampled. The number of samples may be approximated using the analogous site approach (e.g., using analogous site data in equation J.1 of Appendix J). This must be done of a case-by-case basis to ensure applicability of the analogous site to the CSM of the site to be sampled. The site-specific calculated number of samples in Table A-2 will be completed after field screening results have been obtained and used to support variability analyses per Appendix J. Table A-3 summarizes the Step I sampling requirements for the crib sites.

Table A-2. Step I Sampling Requirements for French Drain Sites.

Site Component	COPCs[a]	Parameter of Interest	Statistic of Interest	RSD_{site}[b]	RPD_{lab}[b]	LBGR[b] (% of RAG)	Alpha	Beta	Pr (contam-inated)	Relative Error Consequence Ratio	Default # of Lateral Sampling Locations in (X-Y) Plane	Number of Lateral Sampling Locations in (X-Y) Plane Based on Analogous Site Data	Calculated # of Lateral Sampling Locations in (X-Y) Plane
Dispersion aggregate fines under drain	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	0.50	N/A	64	Computed from analogous data	Site-specific computation
	Non-radionuclides	Maximum	Maximum Concentration	1.00	0.30	68.8%	0.05	0.20	0.50	2	3[c]	Computed from analogous data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	Computed from analogous data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A
Native soil interface under aggregate	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	0.50	N/A	64	Computed from analogous data	Site-specific computation
	Non-radionuclides	Maximum	Maximum Concentration	1.00	0.30	68.8%	0.05	0.20	0.50	2	3[c]	Computed from analogous data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	Computed from analogous data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A
Native soil 0.6 m below aggregate/ soil interface	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	0.20	N/A	64	Computed from analogous data	Site-specific computation
	Non-radionuclides	Maximum	Maximum Concentration	1.00	0.30	68.8%	0.05	0.20	0.20	2	3[c]	Computed from analogous data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	Computed from analogous data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A

[a] For deep zone nonradionuclides, the 95% UCL for the mean is the only statistic of interest.

[b] Default value:

In lieu of having a RSD_{site} at the time of sample planning, a value of 100% is assumed.

In lieu of having a RPD_{lab} at the time of sample planning, a value of 30% is assumed.

In lieu of analytical data or field screening results, the LBGR may be taken at 68.8% of the RAG based on RPDs established above.

[c] Per the lookup table, n=3; however, 4 samples is the minimum number of samples that should be collected if n<4.

N/A = not applicable

Table A-3. Step I Sampling Requirements for Crib Sites.

Site Component	COPCs[a]	Parameter of Interest	Statistic of Interest	RSD_{site}[b]	RPD_{lab}[b]	LBGR[b] (% of RAG)	Alpha	Beta	Pr (contam-inated)	Relative Error Consequence Ratio	Default # of Lateral Sampling Locations in (X-Y) Plane	Number of Lateral Sampling Locations in (X-Y) Plane Based on Analogous Site Data	Calculated # of Lateral Sampling Locations in (X-Y) Plane
Dispersion aggregate fines below inlet pipe discharge	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	0.50	N/A	64	Computed from analogous data	Site-specific computation
	Non-radionuclides	Maximum	Maximum Concentration	1.00	0.30	68.8%	0.05	0.20	0.50	2	3[c]	Computed from analogous data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	Computed from analogous data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A
Dispersion aggregate fines outside direct influence of inlet pipe discharge	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	0.20	N/A	64	Computed from analogous data	Site-specific computation
	Non-radionuclides	Maximum	Maximum Concentration	1.00	0.30	68.8%	0.05	0.20	0.20	2	3[c]	Computed from analogous data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	Computed from analogous data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A
Porous or sand liner under dispersion aggregate	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	0.40	N/A	64	Computed from analogous data	Site-specific computation
	Non-radionuclides	Maximum	Maximum Concentration	1.00	0.30	68.8%	0.05	0.20	0.40	2	3[c]	Computed from analogous data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	Computed from analogous data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A
Native soil interface under porous/sand liner or aggregate	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	0.40	N/A	64	Computed from analogous data	Site-specific computation
	Non-radionuclides	Maximum	Maximum Concentration	1.00	0.30	68.8%	0.05	0.20	0.40	2	3[c]	Computed from analogous data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	Computed from analogous data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A

[a] For deep zone nonradionuclide, the 95% UCL of mean is the only statistic of interest.

[b] Default value:

In lieu of having a RSD_{site} at the time of sample planning, a value of 100% is assumed.

In lieu of having a RPD_{lab} at the time of sample planning, a value of 30% is assumed.

In lieu of analytical data or field screening results, the LBGR may be taken at 68.8% of the RAG based on RPDs established above.

[c] Per the lookup table, n=3; however, 4 samples is the minimum number of samples that should be collected if n<4.

N/A = not applicable

A5.2 STEP II SAMPLE DESIGN

The Step II sampling design determines the sampling requirements at each depth interval below the grade elevation.

A5.2.1 French Drain Sites

The minimum sample grid will be based on the volume and/or area of soil (or other material) that a single sample will represent (e.g., width of a backhoe bucket [or drain pipe plus 15 cm for auger sampling]) and will follow either a line perpendicular to the inlet pipe, if present, or a line dictated by site limitations on access. Because the french drain sites are generally very small-diameter sites, it is anticipated that each pass with the bucket will remove material that will provide samples for a given depth interval. Excavation will be performed so that intermixing of site components is kept to minimum and sample representativeness is maintained. Aggregate sampling will be limited to the fines (if present) from the area below the drain.

The components within the french drain and crib waste sites have been evaluated to determine their specific sampling frequencies; depths are based on professional judgment of the general construction of the site. If a specific site does not meet the general construction assumptions, the sampling frequency and/or locations will be modified to allow for sample coverage of the lateral and vertical dimensions of each sampling media present at the site. The french drain sampling frequency is shown in Table A-4. Field screening requirements are also included.

Table A-4. Step II Sampling Frequency and Requirements for French Drain Sites. (2 Pages)

Component	Sampling Frequency/Requirements per Backhoe Pit
Dispersion aggregate fines (if present) under the drain	Radiological field screening of french drain aggregate immediately within and under the drain during excavation.
	Radiological field screen each bucket (or auger sample) used for sample collection with sodium iodide detector.
	From every 0.9-m thickness of component, collect a minimum of one sample. Collect a representative sample from a 0.3-m-thick increment, randomly selected from the 0.9-m-depth interval. If sampling media is less than 0.9 m thick, collect at least one 0.3-m-thick increment.
Native soil interface under aggregate	Radiological field screen each bucket (or auger sample) used for sample collection with sodium iodide detector.
	Native soil interface is considered to be 0.3 m thick. Collect a minimum of two samples from this stratum. One sample to be taken from central area under the drain, and one sample from an adjacent location at the same depth.
Contingency sample from native soil interface under aggregate (if no fines were present in the aggregate)	If no fines were present in the dispersion aggregate, collect at least one representative 0.3-m-thick sample from native soils, at the aggregate/native soil interface.

Table A-4. Step II Sampling Frequency and Requirements for French Drain Sites. (2 Pages)

Component	Sampling Frequency/Requirements per Backhoe Pit
Native soil 0.6 m below the aggregate/soil interface	Radiological field screen each bucket (or auger sample) used for sample collection with sodium iodide detector.
	From the interval that begins 0.6 m below the onset of native soils below the aggregate, collect at least one randomly selected sample from the next 0.9-m depth interval. Sample is collected from a 0.3-m-thick increment, from under the drain.
Contingency sample from native soil interface within 0.6 m of deep zone soils	If native soil interface is within 0.6 m of the deep zone, collect at least one randomly located sample from the top 0.9-m interval if the deep zone. Sample is collected from a 0.3-m-thick increment, from under the drain.

A5.2.2 Crib Sites

The minimum grid will be based on the volume and/or area of soil (or other material) that a single sample will represent (e.g., width of a backhoe bucket) and will follow either a line perpendicular to the inlet pipe, if present, or a line based on site limitations on backhoe access.

Samples will be randomly selected from a bucket, except as noted in Table A-5, which summarizes the sampling requirements for the crib sites. Field screening requirements are also included in Table A-5.

Table A-5. Step II Sampling Frequency and Requirements for Crib Sites. (2 Pages)

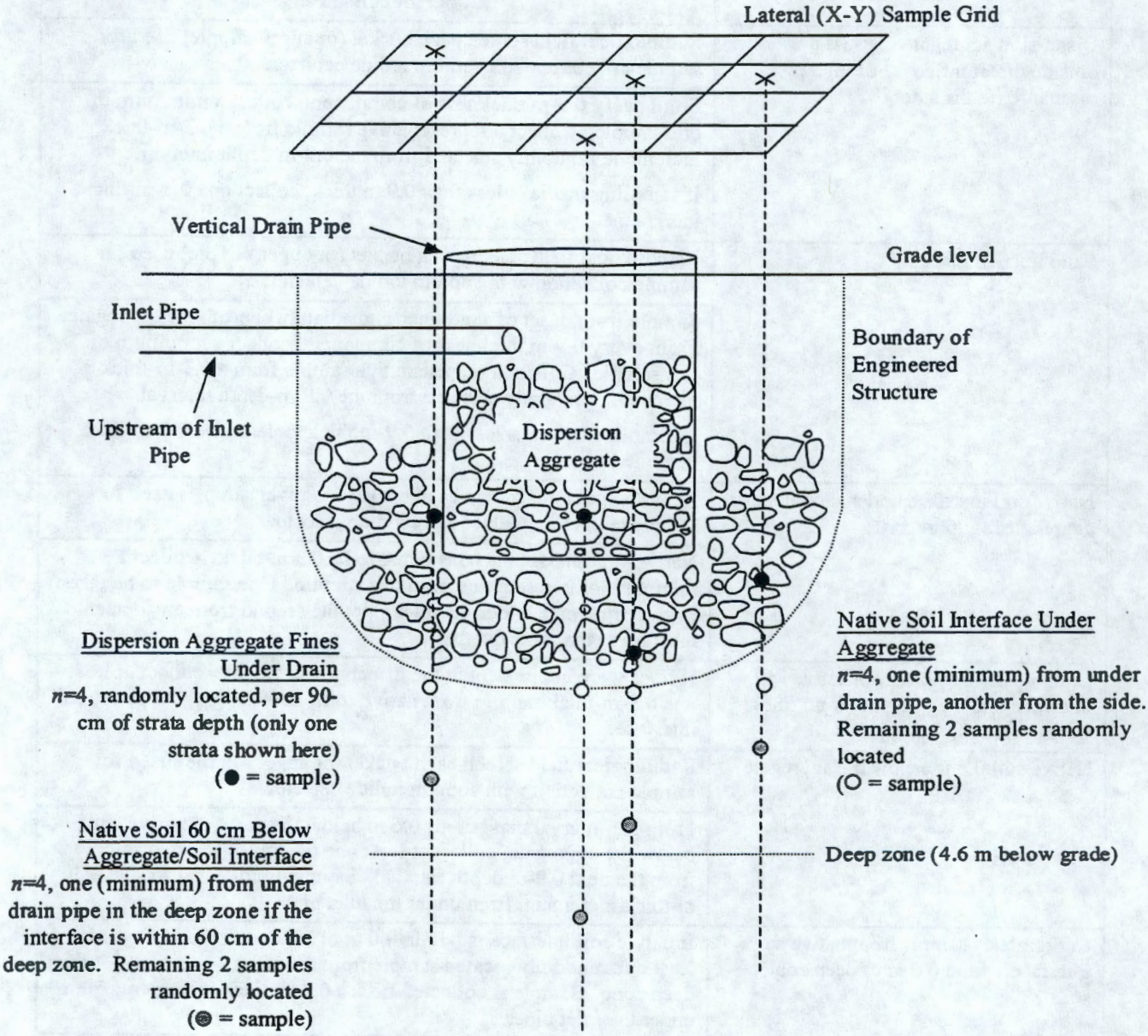
Component	Sampling Frequency/Requirements per Backhoe Pit
Dispersion aggregate fines (if present) under the inlet pipe	Radiological field screening of crib aggregate immediately within and under the inlet pipe during excavation.
	Radiological field screen each bucket (or auger sample) used for sample collection with sodium iodide detector.
	From every 0.9-m thickness of component, collect a minimum of one sample. Collect a representative sample from a 0.3-m-thick increment, randomly selected from the 0.9-m-depth interval. If sampling media is less than 0.9 m thick, collect at least one 0.3-m-thick increment.

Table A-5. Step II Sampling Frequency and Requirements for Crib Sites. (2 Pages)

Component	Sampling Frequency/Requirements per Backhoe Pit
Dispersion aggregate fines (if present) outside direct influence of inlet pipe discharge (to the sides)	Radiological field screen each bucket (or auger sample) used for sample collection with sodium iodide detector.
	From every 0.9-m thickness of component, collect a minimum of one sample. Collect a representative sample from a 0.3-m-thick increment, randomly selected from the 0.9-m-depth interval. If sampling media is less than 0.9 m thick, collect one 0.3-m-thick increment.
Sand liner (if present)	Radiological field screen each bucket (or auger sample) used for sample collection with sodium iodide detector.
	Sample from onset of sand liner immediately beneath the aggregate. From every 0.9-m thickness of component, collect a minimum of one sample. Collect a representative sample from a 0.3-m-thick increment, randomly selected from the 0.9-m-depth interval. If sampling media is less than 0.9-m thick, collect one 0.3-m-thick increment.
Native soil interface under sand liner or aggregate, as appropriate	Radiological field screen each bucket (or auger sample) used for sample collection with sodium iodide detector.
	Native soil interface is considered to be 0.3 m thick. Collect a minimum of two samples from this stratum. One sample to be taken from central area under the inlet pipe; the second from an adjacent location at the same depth.
Contingency sample from native soil interface under aggregate (if no fines were present in the aggregate)	If fines were not present in the dispersion aggregate, collect at least one 0.3-m-thick sample from native soils, at the aggregate/native soil interface.
Native soil 0.6 m below the aggregate	Radiological field screen each bucket (or auger sample) used for sample collection with sodium iodide detector.
	From the interval that begins 0.6 m below the onset of native soils below the aggregate, collect at least one randomly selected sample from the next 0.9-m depth interval. Sample is collected from a 0.3-m-thick increment, from under the inlet pipe.
Contingency sample from native soil interface within 0.6 m of deep zone soils	If native soil interface is within 0.6 m of the deep zone, collect at least one randomly located sample from the top 0.9-m interval if the deep zone. Sample is collected from a 0.3-m-thick increment, from under the inlet pipe.

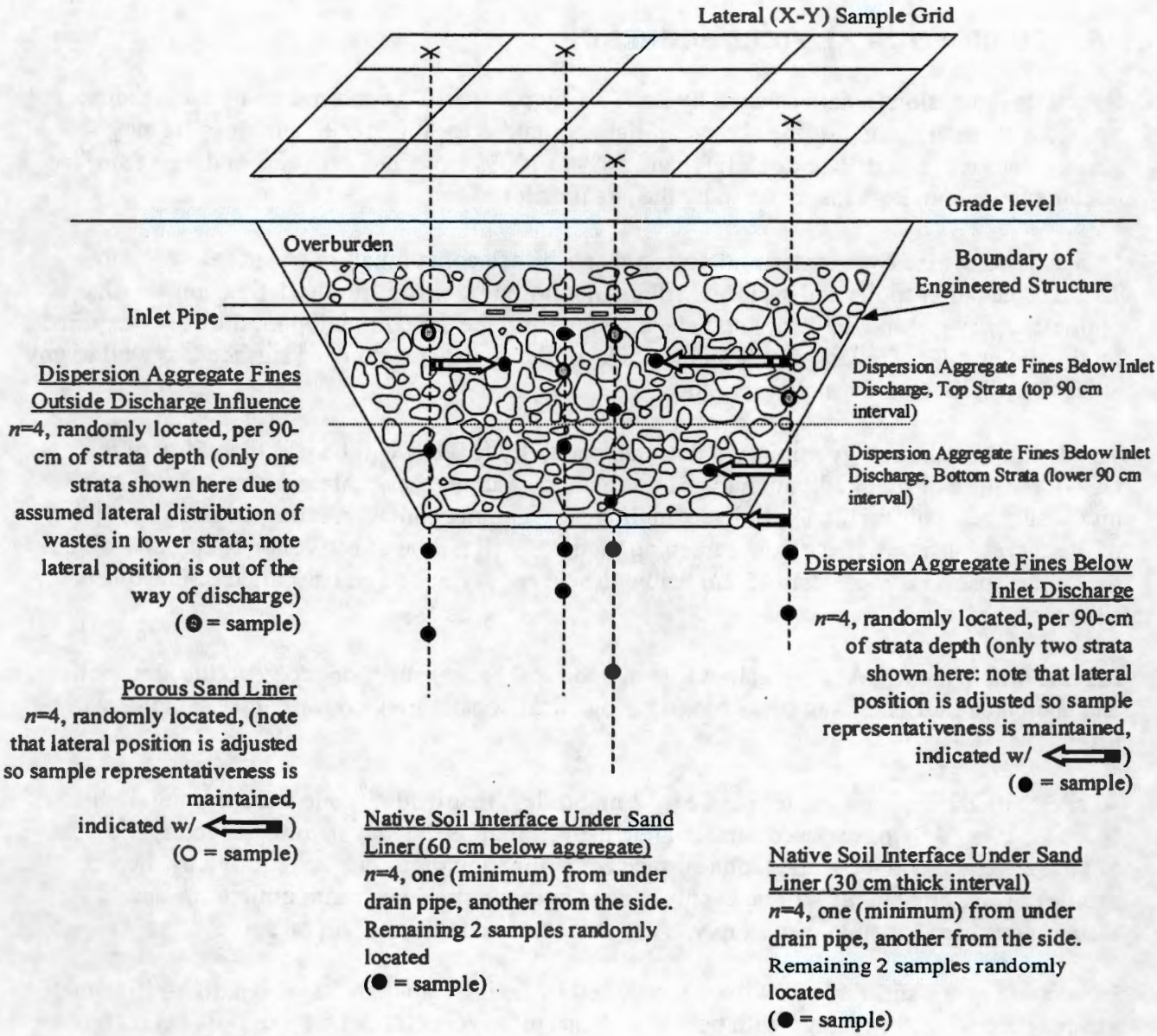
Figures A-3 and A-4 combine the assumptions for each of the CSM discussed above and illustrate the resulting plan for Step I and Step II sample planning.

Figure A-3. Sampling Schematic of a Typical French Drain.



Sampling Req'ts (for example):
The above illustrates how Steps I and II of the sample design are integrated. Assume that n=4 lateral sample locations are determined based on equations in Appendix J. Note that lateral (X-Y) locations are random with the exception of the "Native Soil Interface Under Aggregate" sample that is required to be under the drain pipe. In this example, no sludge deposits have been identified at the structure/soil interface and only 3 components have been identified (Dispersion Aggregate Fines Under Drain, Native Soil Interface Under Aggregate, and Native Soil 60 cm Below Aggregate/Soil Interface).

Figure A-4. Sampling Schematic of Typical Crib or Trench.



Sampling Req'ts (for example):

The above illustrates how Steps I and II of the sample design are integrated. Assume that n=4 lateral sample locations are determined based on equations in Appendix J. Note that lateral (X-Y) locations are random with the exception of the "Native Soil Interface Under Sand Liner" and the "Native Soil Interface Under Sand Liner (60 cm below aggregate)" sample that is required to be under the discharge pipe. These two components could be combined if it can be assumed that contaminant distribution will not vary w/ depth in the soil. Likewise, "Dispersion Aggregate Fines Below Inlet Discharge" can be combined into one strata if it can be assumed that contaminant distribution will not vary w/ depth of the fine material. This example assumes sample representativeness is maintained by relocating sample as needed (test pitting situation, indicated by arrows). If the site is to be sampled by boring/augering, the lateral grid for such sampling should be limited to the footprint of the site. In this example, 5 components have been identified (Dispersion Aggregate Fines Outside Discharge Influence, Dispersion Aggregate Fines Below Inlet Discharge, Porous Sand Liner Native Soil Interface Under Sand Liner (30 cm thick interval) and Native Soil Interface Under Sand Liner (60 cm below aggregate).

A6.0 MINIMUM FIELD SCREENING REQUIRMENTS

A6.1 RADIOLOGICAL FIELD SCREENING

Sites with dimensions smaller than 2 by 2 m (6.5 by 6.5 ft) will be monitored by taking single static counts in the center of the site or similar anomalous locations with a high-efficiency gamma detector (e.g., HPGe or NaI:Tl) and 50% to 100% coverage with beta and alpha surface contamination monitors (as required by the site profile).

In such cases where overburden and potential subsurface contamination exists below the top 15 cm, excavation spoils and surfaces will be monitored by taking single static counts with a high-efficiency gamma detector and beta and alpha surface contamination monitors (as required by the site profile). Coverage will include 50% of the spoils and exposed surfaces, as well as any anomalies discovered during excavation.

The detector/methodology minimum detectable activity (MDA) will be less than 50% of the DCGL for the expected radionuclides. This method assumes that contamination is most likely on the surface. This method will detect high-energy gamma contamination within 15 cm (6 in.) of the survey surface. These field screening methods will not be effective for conditions where the contamination is more than 15 cm below the survey surface (e.g., backfilled or unexposed site).

In cases where the MDA is not achievable due to local background, or access to the site spoils and anomalous surfaces is not feasible (e.g., logistical constraints), confirmatory samples will be taken.

At sites with dimensions greater than 2 by 2 m, but less than 100 m^2, one static count will be taken for every 4 m^2 of exposed surface area, using a high-efficiency gamma detector, and 25% to 50% coverage with beta and alpha surface contamination monitors (as required by the site profile). The static counts will be evenly spaced over the site. The same limitations and assumptions used for small sites apply. Any anomalous conditions will be surveyed as well.

Excavation spoils and surfaces will be monitored by taking static counts with a high-efficiency gamma detector and coverage with beta and alpha surface contamination monitors (as required by the site profile). Coverage will include 25% to 50% of the spoils and exposed surfaces, as well as anomalies discovered during excavation.

A6.2 NONRADIOLOGICAL FIELD SCREENING

Due to the limited applicability of nonradionuclide field screening methods, it is not practical to specify a percentage of coverage or when or at which sites nonradiological field screening is needed. At sites where nonradiological field screening is warranted, after selection of target field screening compounds (based on site COPCs), a minimum of four samples should be collected from each site component present. Where practical constraints do not limit the number of field screening samples collected, the minimum should be at least 10.

In addition, key to application of the field screening approach is the proper application of the observational approach. Anomalous conditions identified should be field screened for elevated COPC levels.

A7.0 REFERENCES

BHI, 1999, *Data Quality Objectives Summary Report for the 100 Area Remaining Confirmatory Sampling Effort Sites*, BHI 01249, Draft, Bechtel Hanford, Inc., Richland, Washington.

DOE-RL, 1998a, *100 Area Remedial Action Sampling and Analysis Plan*, DOE/RL-96-22, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1998b, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, DOE/RL-96-17, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

EPA, 1999, *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units*, U.S. Environmental Protection Agency, Region X, Richland, Washington.

APPENDIX B

SAMPLING DESIGN FOR THE SURFACE SPILLS CONCEPTUAL SITE MODEL

B1.0 SAMPLING DESIGN FOR SURFACE SPILLS

Surface spill sites are waste sites where potentially contaminated solid and liquid discharges were accidentally released onto surface soils. Section B2.0 provides details of the conceptual site model (CSM) for surface spills. A discussion of error tolerances for surface spills is presented in Section B3.0. The surface spill sampling design is presented in Section B4.0.

B2.0 CONCEPTUAL SITE MODEL AND ASSUMPTIONS FOR SURFACE SPILLS

This CSM is defined by the physical configuration and contamination distribution characteristics that affect sampling for interim site closure. The other aspects of conceptual models examined in the data quality objective (DQO) process, including future land use, exposure scenarios, and identification of contaminants of potential concern (COPCs), are found in Sections 1.0 through 5.0 of the DQO summary report (BHI 1999). Figure B-1 provides a schematic of a surface spill conceptual model.

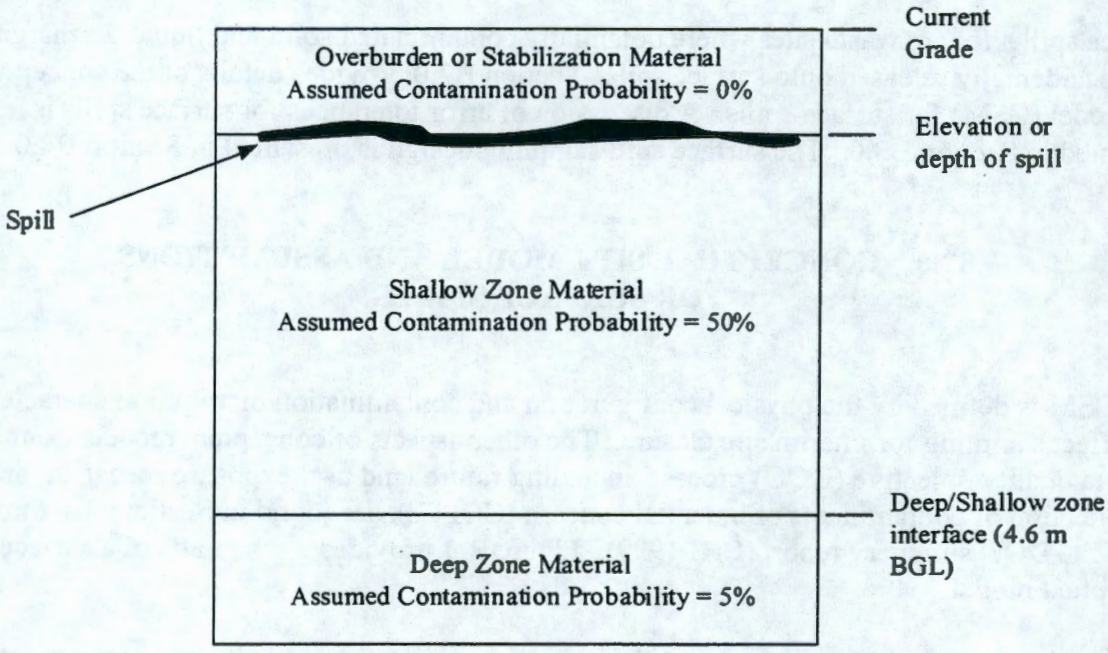
Because there are no structures associated with surface spills, the only physical component in the CSM is environmental media (e.g., gravel, sand, and soil). Spills that occurred on concrete, asphalt, or other man-made surfaces are not included. The spills may or may not be covered by clean soil or gravel, but it is assumed that the location and dimensions of the spill site are known. The physical components of the site include surface and subsurface soils and gravel within the known boundaries of the spill.

Unimpeded access is assumed for all spill sites and sampling media. Backhoe trenching is the assumed sample collection method. As stated above, the lateral dimensions of the spill are known and the edges of the spill define the lateral sampling boundaries. Regardless of the type of material (i.e., solid or liquid) spill media, the vertical boundaries are assumed to extend into the deep zone soils. Because these sites have been exposed to weather (precipitation) since their spill occurrences, some transport into the subsurface is likely to have occurred; therefore, to support interim evaluation, the deep zone is included within the boundaries of the sites.

The area within the spill is assumed to have relatively homogenous lateral contaminant distribution. Spurious, or "hot spot," contamination is not expected. Because some of these sites may have been covered with clean soil or gravel, it cannot be assumed that contamination decreases with depth from the surface. However, from the surface that received the spill, whether or not that is the current surface, contamination is expected to decrease with depth.

As stated earlier in this section, if the spill material is solid (i.e., sand), then this medium is the most likely contaminated, and the soil beneath it is considered as likely to be contaminated. If the spill medium was liquid, then the surface soil or gravel is likely contaminated. The soil between the surface and the deep zone (spill elevation and 4.6 m [15 ft] below grade) is given the same probability of being contaminated.

Figure B-1. Schematic of a Typical Surface Spill Site.



Below the shallow zone contaminated soils, it is assumed that contamination decreases with depth; therefore, the deep zone soils are assigned a lower probability of being contaminated.

The probability of contamination will be scaled within a range bounded by the solid spill material and the spill surface soils (the maximum) and the deep zone soils beneath the spill (the minimum).

B3.0 DECISION ERROR TOLERANCES FOR SURFACE SPILLS

This section discusses the development of the error tolerances for the surface spills sample designs. This SAP makes frequent reference to the generic tables and discussions in Parts I through III of this SAP from which the sampling design was developed.

Table 1-4 shows the surface spill waste streams to include animal waste, reactor effluent, garnet (minerals), hydrocarbons, and mercury. The COPCs associated with these waste streams include radionuclides, metals, and a subset of organic constituents. Because there are no historical data associated with these sites, the concentration ranges of the COPCs are unknown at this time; thus, upper and lower range limits associated with the Remaining Sites' surface spills have not been established.

Refer to generic Table 2-1 for the action levels for the COPCs associated with the Remaining Sites' surface spills. Action levels are provided for each parameter that will be used to support a

decision. The derived concentration guideline levels (DCGLs) for radionuclide COPCs will be determined after isotopic distributions have been estimated.

Generic Table 1-7 shows the tolerable decision errors for evaluation of the mean concentration (note: these errors apply to all media identified for the CSM and thus do not require specific identification for use of the table). The false-positive rate (5%) is based on the confidence limit for the mean specified in the remedial design report/remedial action work plan for the 100 Area (DOE-RL 1998b) and the *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units* (Remaining Sites ROD) (EPA 1999). The false-negative error rate (20% for the mean) follows from the 100 Area remedial action SAP (DOE-RL 1998a).

Table B-1 specifies the inputs required to determine the number of samples for nonradionuclide COPCs. Because there are no historical data associated with these sites, the probability that a site component is contaminated is specified as stated in Table B-1. The probabilities are specified by the qualitative ranking of components identified in the CSM. If contamination is found at the bottom of the shallow zone, the probability of contamination in the deep zone should be changed from 5% to 50%.

Table B-1. Inputs for the Number of Samples Calculation When the Sample Maximum Will Be Compared to a Threshold.

DS #	Media	COPCs	Parameter of Interest	Range	Pr(component is contaminated)
2	Spill material	As, Cr^{+6}, Hg, Pb, Sb, Se, pesticides, PCBs, SVOCs, TPH, VOCs	Population maximum concentration	TBD	0.50
	Surface soil				0.50
	Deep zone soil				0.05
4	Spill material	As, Cr^{+6}, Hg, Pb, Sb, Se, pesticides, PCBs, SVOCs, TPH, VOCs	Population maximum concentration	TBD	0.50
	Surface soil				0.50
	Deep zone soil				0.05

PCB = polychlorinated biphenyl
SVOC = semi-volatile organic compound
TPH = total petroleum hydrocarbons
TBD = to be determined
VOC = volatile organic compound

The bounds of the gray region are presented in a generic format for evaluating the mean concentrations in all of the Remaining Sites in generic Table 1-8 and related text.

The bounds of the gray region are based on a DQO established for the analytical laboratory precision (BHI 1999). The laboratory relative percent difference (RPD_{lab}) is required to be equal to or less than 30% to satisfy the established analytical precision DQO. An additional 10% is added to the RPD_{lab} to account for some amount of population variability; the 10% is based solely on judgment. This assumption results in a LBGR default value that is approximately 68.8% of the applicable remedial action goal (RAG) (where the LBGR is 1-RSD, and RSD is derived from equation J-2 of Appendix J). The LBGR is always 68.8% of the RAG based on the

DQO for laboratory precision unless the DQO changes. If the RPD from the laboratory is >30% (the DQO), then a decision has to be made about data usability.

Since there are no historical data associated with most of these sites, the "sampling variability" or the relative standard deviation for the site (RSD_{site}) is determined by equation J-2 in Appendix J. The sampling variability is a combination of all sources of variability: laboratory, site, sample collection, environmental conditions, time of day, etc. In lieu of having sampling variability information at the time of sample planning, a value of 100% is assumed. If the sampling variability (RSD_{site}) is greater than 100%, the original or default number of samples calculated for the site will not be sufficient to meet error tolerances. If the sampling variability (RSD_{site}) is less than 100%, the number of samples should be adequate. The details of proper application of the equations and the assumptions built into the computation of the default number of samples are presented in Appendix J.

B4.0 SAMPLING DESIGN FOR SPILL SITES

The following section presents sampling design guidance for surface spill sites. Information is provided on the approaches used to determine the number of sampling locations, the sampling frequencies, and contingencies based on accessibility constraints.

B4.1 STEP I SAMPLE DESIGN

Backhoe excavation is the preferred sample collection method for surface spill sites. The Step I sample design establishes the number of lateral sampling locations in the X-Y plane (equal to the number of backhoe test pit sampling locations).

Sampling of radiological contaminants is performed to estimate mean activity for each radiological COPC so the sample mean can be compared with the RAG. Sampling of the nonradiological contaminants is performed to collect data sufficient to satisfy the three-part *Model Toxics Control Act* (MTCA) evaluation criteria regarding the sample maximum, the proportion of sample results exceeding the RAG, and the single-tailed 95% upper confidence limit of the sample data (95% UCL).

The required number of samples is calculated for each COPC. The most conservative number (i.e., the largest) is chosen. If surface spill sites have both types of COPCs, the number of sampling locations will be the maximum number calculated for either the radiological or nonradiological COPCs.

Table B-2 summarizes the Step I sampling requirements for the surface spill sites. This table shows the components and assumed relative standard deviations (RSDs) (i.e., RSD_{site}, RPD_{lab} [which is used to calculate the RSD_{lab}]), LBGR, alpha, beta, Pr(contaminated), and default number of lateral sampling locations in the X-Y plane for each component. Components with an expected probability of contamination that is equal to or less than 0.10 are not shown in this table and will not be sampled. The number of samples may be approximated using the analogous site

Table B-2. Step I Sampling Requirements for Surface Spill Sites.

Site Component	COPCs [a]	Parameter of Interest	Statistic of Interest	RSD_{site} [b]	RPD_{lab} [b]	LBGR [b] (% of RAG)	Alpha	Beta	Pr (contam-inated)	Relative Error Consequence Ratio	Default # of Lateral Sampling Locations in (X-Y) Plane	Number of Lateral Sampling Locations in (X-Y) Plane Based on Analogous Site Data	Calculated # of Lateral Sampling Locations in (X-Y) Plane
Spill material, if present	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	0.50	N/A	64	Computed from analogous data	Site-specific computation
	Non-radionuclides	Maximum	Maximum Concentration	1.00	0.30	68.8%	0.05	0.20	0.50	2	3[c]	Computed from analogous data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	Computed from analogous data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A
Soil or gravel that received spill material	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	0.50	N/A	64	Computed from analogous data	Site-specific computation
	Non-radionuclides	Maximum	Maximum Concentration	1.00	0.30	68.8%	0.05	0.20	0.50	2	3[c]	Computed from analogous data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	Computed from analogous data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A

[a] For deep zone nonradionuclides, the 95% UCL for the mean is the only statistic of interest.

[b] Default value:

In lieu of having a RSD_{site} at the time of sample planning, a value of 100% is assumed.

In lieu of having a RPD_{lab} at the time of sample planning, a value of 30% is assumed.

In lieu of analytical data or field screening results, the LBGR may be taken at 68.8% of the RAG based on RPDs established above.

[c] Per the lookup table, n=3; however, 4 samples is the minimum number of samples that should be collected if n<4.

N/A = not applicable

approach (e.g., using analogous site data in equation J.1 of Appendix J). This must be done of a case-by-case basis to ensure applicability of the analogous site to the CSM of the site to be sampled. The site-specific calculated number of lateral sampling locations in the X-Y plane column will be completed after field screening results have been obtained and will be used to support variability analyses per Appendix J.

After the number of samples is determined, the sampling locations will be randomly selected from a grid that covers the surface area of the spill.

B4.2 STEP II SAMPLE DESIGN

The Step II sampling design determines the sampling requirements at each depth interval below the grade elevation. Excavation will be performed in a manner that minimizes intermixing of site components and maintains sample representativeness.

The components within the surface spill sites have been evaluated to determine sampling requirements at depth. The first sample will be collected from the spill media, if present. The first soil sample will be collected from the spill media interface with soil or the soil surface, to a depth of 0.3 m (1 ft), whether or not spill media is present. Soil samples taken at depth will be collected from 0.9-m- (3-ft) depth intervals beginning at a depth of 0.3 m (1 ft) below the spill surface. Samples will be a 0.3-m (1-ft)-thick increment of soil, randomly selected from the 0.9-m (3-ft)-depth intervals. If a specific site does not meet the general construction assumptions, the sampling frequency and/or locations will be modified to allow for sample coverage of the lateral and vertical dimensions of each sampling media present at the site. The sampling frequency for the surface spill sites is summarized in Table B-3. Field screening requirements are also included.

Table B-3. Step II Sampling Frequencies and Requirements for Surface Spill Sites.

Component	Sampling Frequency/Requirement per Backhoe Pit
Spill material (if present)	Radiological field screen with sodium iodide detector, and other techniques as determined by the field engineer.
	If spill media is less than 0.3 m thick, collect a minimum of one sample. If spill media is more than 0.3 m thick, collect one sample for each 0.3-m-depth increment.
Soil or gravel that received spill material	Radiological field screen with sodium iodide detector, and other techniques as determined by the field engineer.
	Collect a minimum of one sample from spill media or the soil surface to a depth of 30.5 cm (under the spill). Collect at least 1 random sample from each successive 0.9-m-depth interval to the deep zone under the spill. Each sample will be collected from a 0.3-m-thick soil increment.
Deep zone soils beneath the spill	Radiological field screen with sodium iodide detector, and other techniques as determined by the field engineer.
	Collect a minimum of one sample from the top 0.3 m of the deep zone soils under the spill.

Figure B-2 combines the assumptions for each of the CSM discussed above and illustrates the resulting plan for Step I and Step II sample planning.

B5.0 MINIMUM FIELD SCREENING REQUIREMENTS

B5.1 RADIOLOGICAL FIELD SCREENING

Sites with dimensions smaller than 2 by 2 m (6.5 by 6.5 ft) will be monitored by taking single static counts in the center of the site or similar anomalous locations with a high-efficiency gamma detector (e.g., HPGe or NaI:Tl) and 50% to 100% coverage with beta and alpha surface contamination monitors (as required by the site profile).

In such cases where overburden and potential subsurface contamination exists below the top 15 cm, excavation spoils and surfaces will be monitored by taking single static counts with a high-efficiency gamma detector and beta and alpha surface contamination monitors (as required by the site profile). Coverage will include 50% of the spoils and exposed surfaces, as well as any anomalies discovered during excavation.

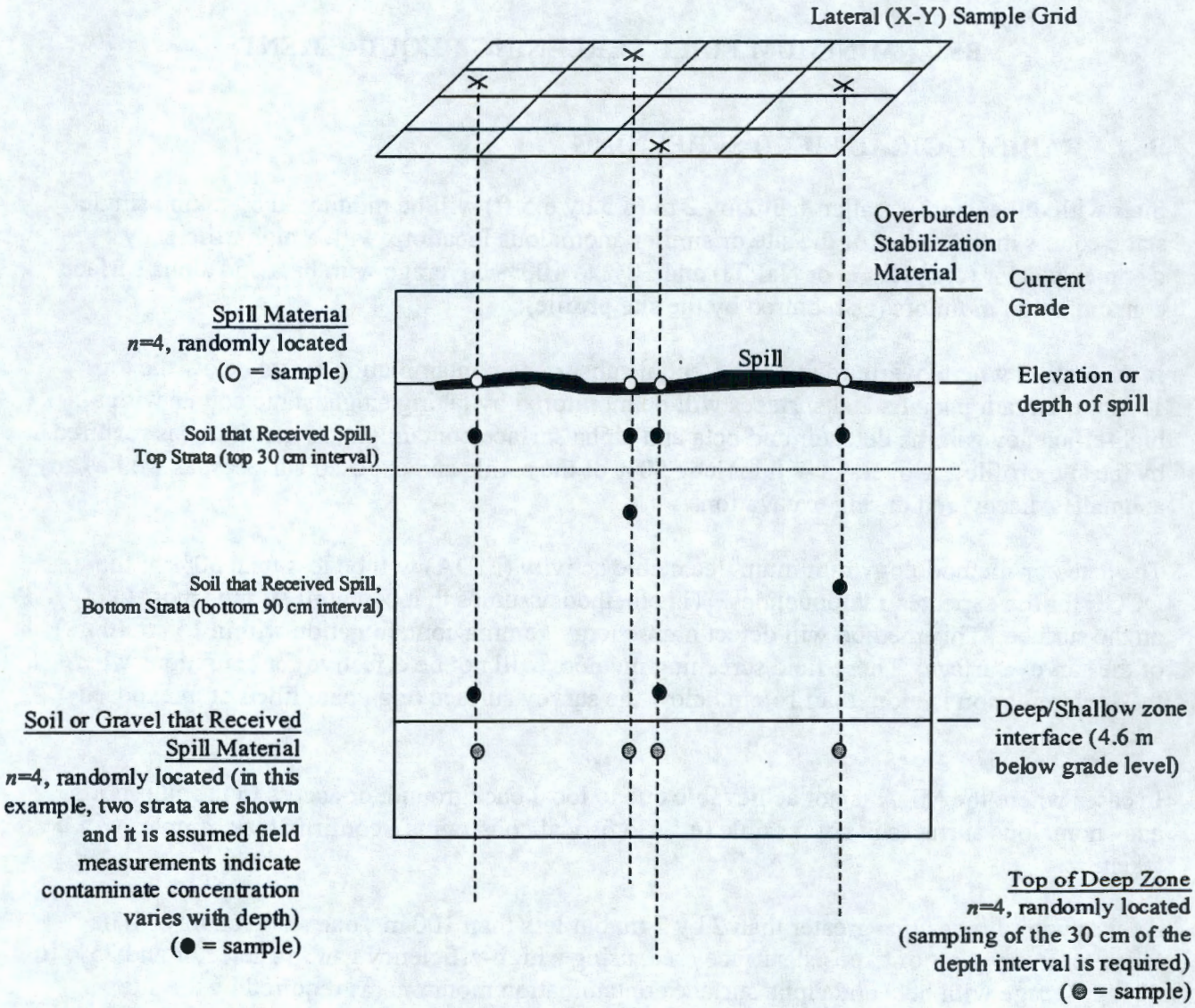
The detector/methodology minimum detectable activity (MDA) will be less than 50% of the DCGL for the expected radionuclides. This method assumes that contamination is most likely on the surface. This method will detect high-energy gamma contamination within 15 cm (6 in.) of the survey surface. These field screening methods will not be effective for conditions where the contamination is more than 15 cm below the survey surface (e.g., backfilled or unexposed site).

In cases where the MDA is not achievable due to local background, or access to the site spoils and anomalous surfaces is not feasible (e.g., logistical constraints), confirmatory samples will be taken.

At sites with dimensions greater than 2 by 2 m, but less than 100 m^2, one static count will be taken for every 4 m^2 of exposed surface area, using a high-efficiency gamma detector and 25% to 50% coverage with beta and alpha surface contamination monitors (as required by the site profile). The static counts will be evenly spaced over the site. The same limitations and assumptions used for small sites apply. Any anomalous conditions will be surveyed as well.

Excavation spoils and surfaces will be monitored by taking static counts with a high-efficiency gamma detector and coverage with beta and alpha surface contamination monitors (as required by the site profile). Coverage will include 25% to 50% of the spoils and exposed surfaces, as well as anomalies discovered during excavation.

Figure B-2. Sampling Schematic of a Typical Spill Site.



Sampling Req'ts (for example):
The above illustrates how Steps I and II of the sample design are integrated. Assume that n=4 lateral sample locations are determined based on equations in Appendix J. Note that lateral (X-Y) locations are random. In this example, two strata have been identified in the soil under the spill, with sampling of the top foot and subsequent 90-cm depth interval below. Sampling of the lower soil strata and deep zone can be eliminated based on the assumption that contaminant concentrations do not vary with depth. Only 3 components have been identified (Spill Material, Soil or Gravel that Received Spill Material, and Top of Deep Zone).

Sites with surface areas greater than 100 m^2 may employ one of three options.

1. The methodology for medium-sized (4 m^2 to 100 m^2) sites may be employed.

2. Mapping technologies that record radiation levels may be used (e.g., MRDS, Mobile Surface Contamination Monitoring tractor), with limited follow-up static counts. If advanced mapping technologies are used, only contaminants that are not monitored (e.g., alpha) require separate contamination surveys. In this case, 10% coverage surveys would suffice.

3. The third option is to use MARSSIM guidance to locate a statistically-generated number of static count locations based on observed sample variance, and scan survey 50-100% of the area to a higher MDA, the elevated measurement comparison (EMC). The EMC is a MARSSIM concept where the samples determine the average concentration and variance, and the EMC surveys are designed to demonstrate that no large areas of significantly elevated activity exist. This option is best utilized as verification that the site is clean following the discovery of anomalous conditions.

On sites with backfill material over the site, or sites where the areas of likely contamination cannot be reached, backfill removal and sampling are required to determine if the site is contaminated. In this case, contamination monitoring for interim closure is not possible and will not be considered as a potential interim closure mechanism. Direct measurements and confirmation samples will be taken for site categorization.

B5.2 NONRADIOLOGICAL FIELD SCREENING

Due to the limited applicability of nonradionuclide field screening methods, it is not practical to specify a percentage of coverage or when or at which sites nonradiological field screening is needed. At sites where nonradiological field screening is warranted, after selection of target field screening compounds (based on site COPCs), a minimum of four samples should be collected from each site component present. Where practical constraints do not limit the umber of field screening samples collected, the minimum should be at least 10.

B6.0 REFERENCES

BHI, 1999, *Data Quality Objectives Summary Report for the 100 Area Remaining Confirmatory Sampling Effort Sites*, BHI 01249, Draft, Bechtel Hanford, Inc., Richland, Washington.

DOE-RL, 1998a, *100 Area Remedial Action Sampling and Analysis Plan*, DOE/RL-96-22, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1998b, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, DOE/RL-96-17, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

EPA, 1999, *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units*, U.S. Environmental Protection Agency, Region X, Richland, Washington.

APPENDIX C

SAMPLING DESIGN FOR THE UNDERGROUND CONFINING STRUCTURES/PIPING CONCEPTUAL SITE MODEL

C1.0 SAMPLING DESIGN FOR UNDERGROUND CONFINING STRUCTURES/PIPING

Underground confining structures include underground storage tanks (USTs) that are not part of the Washington State Department of Ecology's (Ecology's) UST program. This conceptual site model (CSM) also applies to former UST sites where the USTs are no longer present, but a site assessment has not been properly performed due to a lack of regulation at the time of tank removal (e.g., prior to the UST program). Underground confining structures also include pipelines, vaults, and concrete pits that contain potentially contaminated liquids and sludges and may have leaked into the vadose zone. Section C2.0 provides details of the CSM for USTs that are specific to these types of potentially contaminated sites. Section C3.0 presents the same for underground vaults and pits. Section C4.0 addresses sites composed of underground pipes. Section C5.0 discusses decision error tolerances for these design groups. Section C6.0 presents the general sampling design.

Underground confining structures are unique in that they were designed to hold wastes as opposed to dispersal or release of the waste material. Confining structures are more likely to contain raw residual waste material (e.g., sludge and scale) than any other CSM presented in this document. Because of their nature, if the site contains sludge and/or scale, and that material is determined to be contaminated at some point during the field investigation or in evaluation of the analytical results, then the site should be deferred to remedial action. This gives the project flexibility in that prior to analysis of other site components, the sludge or scale may be analyzed first to determine if the site will even remain a candidate for interim closure. This strategy should be implemented whenever feasible in an effort to minimize analytical costs. Likewise, if it is determined that the structure cradle is not contaminated, then sampling of the underlying soil is not necessarily required.

C2.0 CONCEPTUAL SITE MODEL AND ASSUMPTIONS FOR UNDERGROUND STORAGE TANKS

This CSM is defined by the physical configuration and contamination distribution characteristics that affect sampling for interim site closure. The other aspects of conceptual models examined in the data quality objectives (DQO) process, including future land use, exposure scenarios, and identification of contaminants of potential concern (COPCs), are found in Sections 1.0 through 5.0 of the DQO summary report (BHI 1999).

Figure C-1 shows a schematic of the assumed general layout of a UST; Figure C-2 shows the assumed layout if a tank and associated piping have been removed. If the UST being investigated does not contain these general components and/or does not conform to the general layout, the sampling design will be updated to reflect the relevant components.

Figure C-1. Side View of a Typical UST Site.

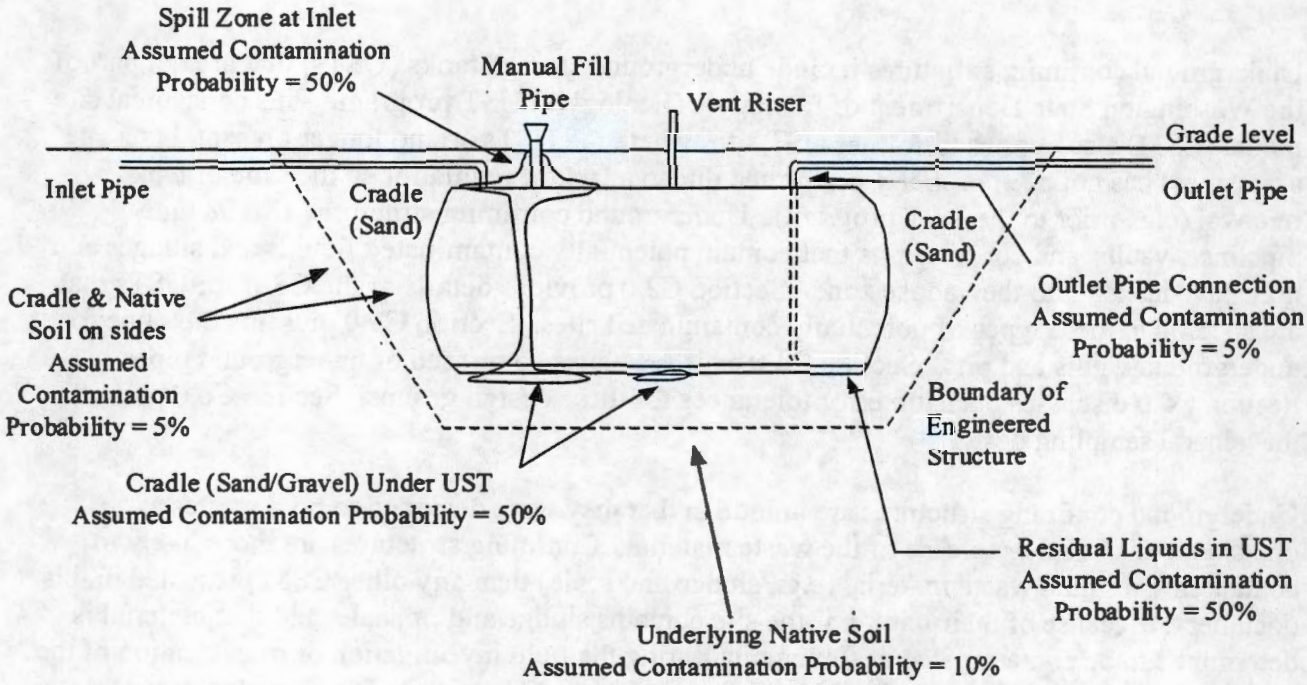
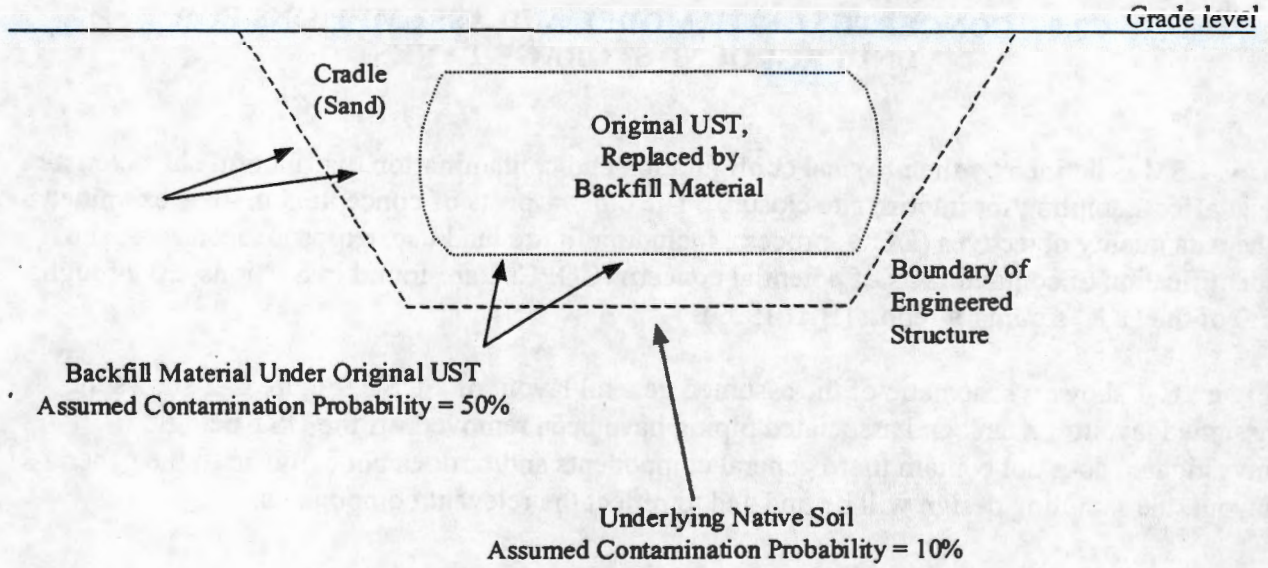


Figure C-2. Schematic of a Typical UST Site with the Tank and Piping Removed.



The following assumptions have been made about physical components and sampling media at the UST sites:

- Tanks contained petroleum products (e.g., fuel oil, diesel fuel, gasoline, or waste oil); thus, vertical and horizontal migration of tank leakage was minimal over time.
- Tanks and inlet and outlet pipes have a low probability of leaking, except at joints and interfaces between components.
- Construction and excavation backfill were clean when placed at the site.
- If the tank and/or piping were removed, the associated construction backfill was also removed and replaced by clean backfill.

The excavation backfill is assumed to be clean; thus, it will not be sampled, and the contents of the piping will not be sampled. The access to all sampling media at the site affects the ability to implement a sampling design. The following assumptions are being made regarding sampling access. The location of the tank, even if removed, will be known. The location of all associated piping, even if removed, will be known.

Sampling will be performed by backhoe for all areas around and under the UST. If the tank is not empty, then at least one access port is available to use for sampling the residual contents.

The relative scaling of probabilities, as well as estimates of the probabilities of contamination for one or more of the media, lead to the determination of the probability of contamination for all sampling media.

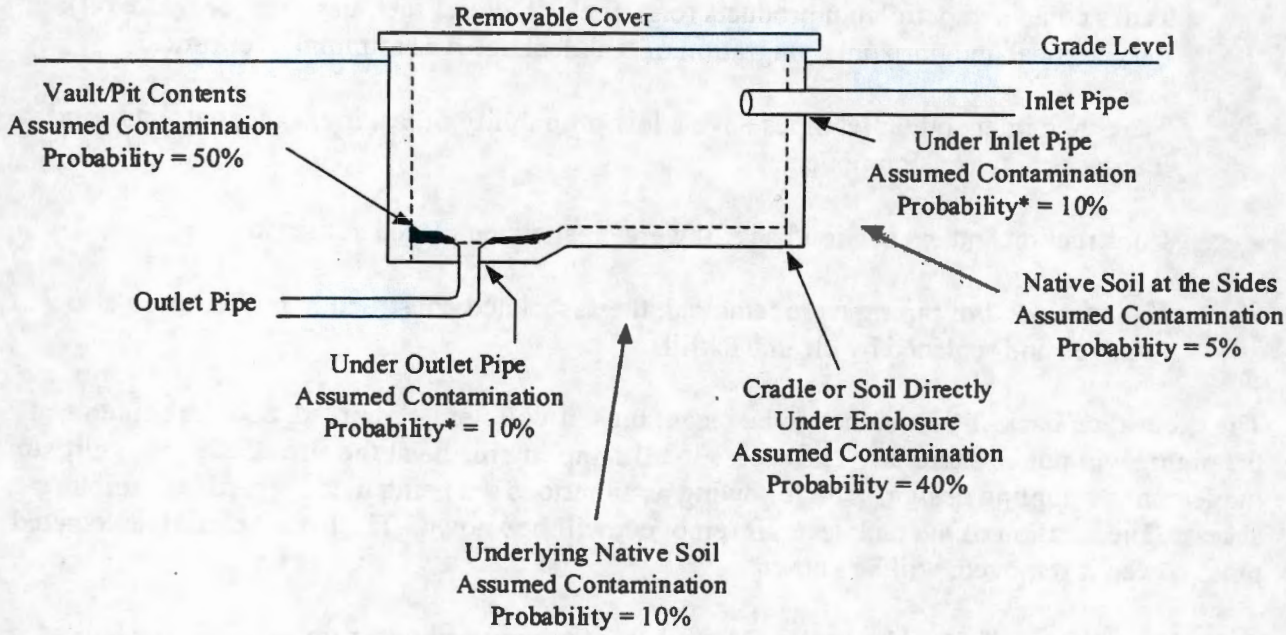
If historical data are not available for any of the sampling media, field screening may provide contamination status information. Otherwise, assume that the probability is 0.50 that the tank contents (if present) and soil around the fill inlet are contaminated. Assume that the probability is 0.05 that the cradle and soil at the sides of the tank is contaminated. Scale all other sampling media probabilities to values within the range defined by these maximum and minimum values.

C3.0 CONCEPTUAL SITE MODEL AND ASSUMPTIONS FOR VAULTS AND CONCRETE PITS

As with the underground storage tank CSM, this CSM is defined by the physical configuration and contamination distribution characteristics that affect sampling for interim site closure, and the DQO summary report (BHI 1999) contains information on other aspects of the CSM.

Figure C-3 shows a schematic of the conceptual vault/concrete pit layout. If the vault or pit being investigated does not contain these general components and/or does not conform to the general layout, the sampling design will be updated to reflect the relevant components.

Figure C-3. Schematic of Typical Vaults and Concrete Pits.



The following assumptions have been made about physical components and sampling media at vaults and pits:

- The vault/pit contained contaminated fluids and sludge temporarily and, thus, vertical and horizontal migration of leakage was minimal over time.
- The vault/pit and the inlet and outlet pipes have a low probability of leaking, except at joints and interfaces between components.
- Construction and excavation backfill were clean when placed at the site.

The contents of the inlet pipe will not be sampled as part of this CSM per se (refer to pipeline-specific sample planning). The access to all sampling media at the site affects the ability to implement a sampling design. The following assumptions are being made regarding sampling access. The location of the vault or pit will be known. The location of all associated piping, even if removed, will be known. Sampling will be performed by backhoe for all areas around and under the vault/pit. If the vault/pit is not empty, then at least one access port is available to use for sampling the residual contents.

The relative scaling of probabilities, as well as the estimates of the probabilities of contamination for one or more of the media, lead to the determination of the probability of contamination for all sampling media.

The probability of contamination will be scaled within a range bounded by the vault/pit contents (the maximum) and the cradle and soil at the sides of the vault/pit (the minimum). Scale all other sampling media probabilities to values within the range defined by these maximum and minimum values.

C4.0 CONCEPTUAL SITE MODEL AND ASSUMPTIONS FOR UNDERGROUND PIPELINES

As with the other CSMs, this CSM is defined by the physical configuration and contamination distribution characteristics that affect sampling for interim site closure. The DQO summary report (BHI 1999) contains information on other aspects of the CSM.

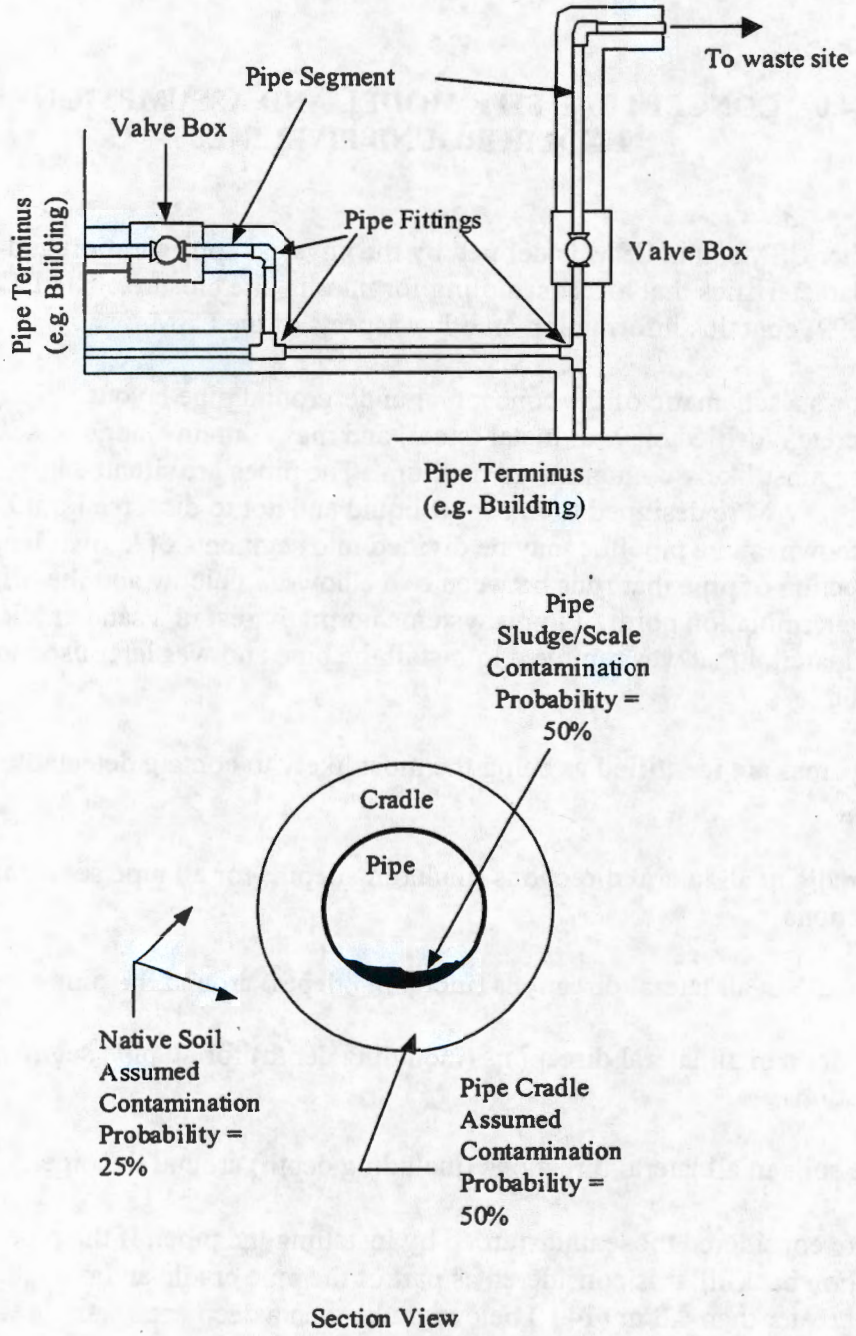
Figure C-4 shows a schematic of the conceptual underground pipe layout. Piping systems consist of concrete, vitrified clay, or metal (steel) and may contain sludge or scale. If sludge is present, it is the most likely contaminated medium. The pipes are situated horizontally and are not perforated; they were designed to transport liquid and not to disperse liquid. The locations of the pipes are known, and a pipeline may be divided into segments of known length. A pipe segment is a section of pipe that runs between two elbows, an elbow and the origination point, or an elbow and a termination point. Piping systems normally rest in a sand cradle. Construction backfill is the material that was removed to install the pipe and was later used to bury the pipe after installation.

The following areas are identified as being the most likely to contain detectable COPC concentrations:

- Pipe cradle in all lateral directions (including depth) for all pipe segments at elbows and connections
- Pipe cradle in all lateral directions (including depth) around the pipe
- Native soils in all lateral directions (including depth) for all pipe segments at elbows and connections
- Native soils in all lateral directions (including depth) around the pipe.

Native soils are considered those undisturbed by installing the pipe. If the pipe trench was filled with construction backfill, it is considered as part of the pipe cradle and not native soil. If the pipe invert is greater than 4.3 m (14 ft) below grade, then a deep zone sample will be collected. It is assumed that these pipes did not leak massively over the course of use, so the leakage is limited to the pipe cradle and native soils adjacent to the pipe trench. Therefore, unless the pipe sits in or within 0.3 m (1 ft) of the deep zone, the deep zone will not be sampled for pipeline sites.

Figure C-4. Schematic of a General Pipeline Site.



Sampling access assumptions include the following:

- The locations of all pipelines are known and accessible for sampling.
- Backhoe excavation (trenching) will be performed for all piping systems.
- The interior of the pipes is accessible at elbows, origin, and termination points.
- Field screening methods, such as vapor and radiological field detection, can be performed at these locations, and sludge and pipe samples can be collected at these locations.

The pipe scale/sludge is the most likely contaminated component, and elbows and valves are the most likely place for contaminated sludge, as the change in fluid momentum causes sludge deposits. Piping is the next most contaminated medium. The sand cradle is the third most likely contaminated media. The native soil is the least likely to be contaminated. The elbows, origin, and termination points are the most likely areas to leak, so the cradle and soils beneath these areas are the most likely surrounding media to be contaminated.

The probability of contamination will be scaled within a range bounded by the pipe contents (the maximum) and the native soil laterally adjacent to the pipes (the minimum). Additional discussion for estimating this probability with historical and/or field screening data is presented in Section C5.0.

C5.0 DECISION ERROR TOLERANCES FOR UNDERGROUND STORAGE TANKS, VAULTS/CONCRETE PITS, AND PIPING

This section shows the development of the error tolerances for the USTs, vaults/concrete pits, and pipeline sample designs. This SAP makes frequent reference to the generic tables and discussions in Parts I through III of this SAP from which the sampling design was developed.

The number of samples and the sample collection design will be statistically based wherever possible.

Specific waste streams are assumed to include reactor condensate, hydrocarbons, animal waste, reactor effluent and condensate, decontamination fluid, laboratory effluent, sewage, and spent acid/caustics. The COPCs associated with these waste streams include radionuclides, metals, and a subset of organic constituents (BHI 1999). Because there are no historical data associated with these sites, the concentration ranges of the COPCs are unknown at this time; thus, upper and lower range limits associated with the Remaining Sites' USTs, vaults/concrete pits, and pipelines have not been established.

Refer to generic Table 2-1 for the action levels for the COPCs associated with the Remaining Sites' french drains and cribs. Action levels are provided for each parameter that will be used to support a decision. The derived concentration guideline levels (DCGLs) for radionuclide COPCs will be determined after isotopic distributions have been estimated.

Generic Table 1-7 shows the tolerable decision errors for evaluation of the mean concentration (note: these errors apply to all media identified for the CSM and thus do not require specific identification for use of the table). The false-positive rate is based on the confidence limit for the mean specified in the remedial design report/remedial action work plan for the 100 Areas (DOE-RL 1998b) and the *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-R-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units* (Remaining Sites ROD) (EPA 1999). The false-negative error rate follows from the 100 Areas remedial action SAP (DOE-RL 1998a).

Table C-1 specifies the inputs required to determine the number of samples for nonradionuclide COPCs. Because there are no historical data associated with these sites, the probability that a site component is contaminated is specified as stated in Table C-1. The probabilities are specified by the qualitative ranking of components identified in the CSM.

The bounds of the gray region are presented in a generic format for evaluating the mean concentrations in all of the Remaining Sites in generic Table 1-8 and the associated text.

The bounds of the gray region are based on a DQO established for the analytical laboratory precision (BHI 1999). The laboratory relative percent difference (RPD_{lab}) is required to be equal to or less than 30% to satisfy the established analytical precision DQO. An additional 10% is added to the RPD_{lab} to account for some amount of population variability; the 10% is based solely on judgment. This assumption results in a LBGR default value that is approximately 68.8% of the applicable remedial action goal (RAG) (where the LBGR is 1-RSD, and RSD is derived from equation J-2 of Appendix J). The LBGR is always 68.8% of the RAG based on the DQO for laboratory precision unless the DQO changes. If the RPD from the laboratory is >30% (the DQO), then a decision has to be made about data usability.

Since there are no historical data associated with most of these sites, the "sampling variability" or the relative standard deviation for the site (RSD_{site}) is determined by equation J-2 in Appendix J. The sampling variability is a combination of all sources of variability: laboratory, site, sample collection, environmental conditions, time of day, etc. In lieu of having sampling variability information at the time of sample planning, a value of 100% is assumed. If the sampling variability (RSD_{site}) is greater than 100%, the original or default number of samples calculated for the site will not be sufficient to meet error tolerances. If the sampling variability (RSD_{site}) is less than 100%, the number of samples should be adequate. The details of proper application of the equations and the assumptions built into the computation of the default number of samples are presented in Appendix J.

Table C-1. Inputs for the Number of Samples Calculation When the Sample Maximum Will Be Compared to a Threshold.

DS#	Media	COPCs	Parameter of Interest	Range	Pr(component is contaminated)
	Underground Storage Tanks				
2	Tank contents	As, Ba, Cd, Cr, Cr^{+6}, Pb, Hg, Se, Ag, sulfate, TPH, SVOCs, VOCs	Population maximum concentration	TBD	0.50
	Spill zone above UST				0.50
	Tank cradle				
	- Under tank				0.40
	- Under outlet pipe				0.10
	- At sides of tank				0.05
	Native soils				
	- Under tank cradle				0.10
	- At sides of tank				0.05
4	Tank contents	As, Ba, Cd, Cr, Cr^{+6}, Pb, Hg, Se, Ag, sulfate, TPH, SVOCs, VOCs	Population maximum concentration	TBD	0.50
	Spill zone above UST				0.50
	Tank cradle				
	- Under tank				0.40
	- Under outlet pipe				0.10
	- At sides of tank				0.05
	Native soils				
	- Under tank cradle				0.10
	- At sides of tank				0.05
	Vaults and Concrete Pits				
2	Vault/pit contents	As, Ba, Cd, Cr, Cr^{+6}, Pb, Hg, Se, Ag, sulfate, TPH, SVOCs, VOCs	Population maximum concentration	TBD	0.50
	Cradle (at concrete seams)				
	- Under vault/pit				0.40
	- Under outlet or inlet pipe				0.10
	- At sides of vault/pit				0.05
	Native soils				
	- Under cradle				0.10
	- At sides of vault/pit				0.05
4	Vault/pit contents	As, Ba, Cd, Cr, Cr^{+6}, Pb, Hg, Se, Ag, sulfate, TPH, SVOCs, VOCs	Population maximum concentration	TBD	0.50
	Cradle (at concrete seams)				
	- Under vault/pit				0.40
	- Under outlet or inlet pipe				0.10
	- At sides of vault/pit				0.05
	Native soils				
	- Under cradle				0.10
	- At sides of vault/pit				0.05
	Buried Pipes				
2	Pipe contents (scale/sludge)	As, Cr^{+6}, Pb, Se, TPH, pesticides, SVOCs, VOCs	Population maximum concentration	TBD	0.50
	Concrete pipe				N/A
	Underlying cradle				0.50
	Adjacent native soil				0.25
4	Pipe contents (scale/sludge)	As, Cr^{+6}, Pb, Se, TPH, pesticides, SVOCs, VOCs	Population maximum concentration	TBD	0.50
	Concrete pipe				N/A
	Underlying cradle				0.50
	Adjacent native soil				0.25

N/A = not applicable
TPH = total petroleum hydrocarbons
TBD = to be determined

C6.0 SAMPLING DESIGN FOR UNDERGROUND STORAGE TANKS, CONCRETE VAULTS AND PITS, AND PIPELINES

This section presents guidance for determining the sampling requirements for underground confining structures, including USTs, underground concrete vaults and pits, and underground pipelines.

C6.1 STEP I SAMPLE DESIGN

Backhoe excavation is the preferred sample collection method for all of the underground confining structures. The Step I sample design establishes the number of lateral sampling locations in the X-Y plane (equal to the number of backhoe test pit sampling locations).

Sampling of radiological contaminants is performed to estimate mean activity for each radiological COPC so that the sample mean can be compared with the RAG. Sampling of the nonradiological contaminants is performed to collect data sufficient to satisfy the three-part *Model Toxics Control Act* (MTCA) evaluation criteria regarding the sample maximum, the proportion of sample results exceeding the RAG, and the single-tailed 95% upper confidence limit of the sample data (95% UCL).

The required number of samples calculated for each COPC. The most conservative number (the largest) is chosen. If both types of COPCs are present, the number of sampling locations will be the maximum number calculated for either the radiological or nonradiological COPCs.

Table C-2 summarizes the Step I sampling requirements for the USTs. This table shows the components and assumed relative standard deviations (RSDs) (i.e., RSD_{site}, RPD_{lab} [which is used to calculate the RSD_{lab}]), lower bound of the gray region (LBGR), alpha, beta, Pr(contaminated), and default number of lateral sampling locations in the X-Y plane for each component. Components with an expected probability of contamination that is equal to or less than 0.10 are not shown in this table, and will not be sampled. The number of samples may be approximated using the analogous site approach (e.g., using analogous site data in equation J.1 of Appendix J). This must be done of a case-by-case basis to ensure applicability of the analogous site to the CSM of the site to be sampled. The site specific calculated number of samples will be completed after field screening results have been obtained and used to support variability analyses per Appendix J. Tables C-3 and C-4 summarize the Step I sampling requirements for the underground concrete vaults/pits, and underground pipelines, respectively.

Table C-2. Step I Sampling Requirements for Underground Storage Tank Sites.

Site Component	COPCs [a]	Parameter of Interest	Statistic of Interest	RSD_{site} [b]	RPD_{lab} [b]	LBGR[b] (% of RAG)	Alpha	Beta	Pr (contaminated)	Relative Error Consequence Ratio	Default # of Lateral Sampling Locations in (X-Y) Plane	Number of Lateral Sampling Locations in (X-Y) Plane Based on Analogous Site Data	Calculated # of Lateral Sampling Locations in (X-Y) Plane
Tank contents	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	0.50	N/A	64	Computed from analogous data	Site-specific computation
	Non-radionuclides	Maximum	Maximum Concentration	1.00	0.30	68.8%	0.05	0.20	0.50	2	3[c]	Computed from analogous data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	Computed from analogous data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A
Spill Zone above UST	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	0.50	N/A	64	Computed from analogous data	Site-specific computation
	Non-radionuclides	Maximum	Maximum Concentration	1.00	0.30	68.8%	0.05	0.20	0.50	2	3[c]	Computed from analogous data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	Computed from analogous data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A
Tank cradle under tank	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	0.40	N/A	64	Computed from analogous data	Site-specific computation
	Non-radionuclides	Maximum	Maximum Concentration	1.00	0.30	68.8%	0.05	0.20	0.40	2	3[c]	Computed from analogous data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	Computed from analogous data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A

[a] For deep zone nonradionuclides, the 95% UCL for the mean is the only statistic of interest.
[b] Default value:
In lieu of having a RSD_{site} at the time of sample planning, a value of 100% is assumed.
In lieu of having a RPD_{lab} at the time of sample planning, a value of 30% is assumed.
In lieu of analytical data or field screening results, the LBGR may be taken at 68.8% of the RAG based on RPDs established above.
[c] Per the lookup table, n=3; however, 4 samples is the minimum number of samples that should be collected if n<4.
N/A = not applicable

Table C-3. Step I Sampling Requirements for Underground Concrete Vaults and Pits.

Site Component	COPCs [a]	Parameter of Interest	Statistic of Interest	RSD_{site} [b]	RPD_{lab} [b]	LBGR [b] (% of RAG)	Alpha	Beta	Pr (contaminated)	Relative Error Consequence Ratio	Default # of Lateral Sampling Locations in (X-Y) Plane	Number of Lateral Sampling Locations in (X-Y) Plane Based on Analogous Site Data	Calculated # of Lateral Sampling Locations in (X-Y) Plane
Vault/pit contents	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	0.50	N/A	64	Computed from analogous data	Site-specific computation
	Non-radionuclides	Maximum	Maximum Concentration	1.00	0.30	68.8%	0.05	0.20	0.50	2	3[c]	Computed from analogous data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	Computed from analogous data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A
Cradle (at concrete seams) under enclosure	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	0.40	N/A	64	Computed from analogous data	Site-specific computation
	Non-radionuclides	Maximum	Maximum Concentration	1.00	0.30	68.8%	0.05	0.20	0.40	2	3[c]	Computed from analogous data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	Computed from analogous data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A
Cradle (random locations in X-Y plane)	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	0.40	N/A	64	Computed from analogous data	Site-specific computation
	Non-radionuclides	Maximum	Maximum Concentration	1.00	0.30	68.8%	0.05	0.20	0.40	2	3[c]	Computed from analogous data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	Computed from analogous data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A

[a] For deep zone nonradionuclides, the 95% UCL for the mean is the only statistic of interest.

[b] Default value:

In lieu of having a RSD_{site} at the time of sample planning, a value of 100% is assumed.

In lieu of having a RPD_{lab} at the time of sample planning, a value of 30% is assumed.

In lieu of analytical data or field screening results, the LBGR may be taken at 68.8% of the RAG based on RPDs established above.

[c] Per the lookup table, n=3; however, 4 samples is the minimum number of samples that should be collected if n<4.

N/A = not applicable

Table C-4. Step I Sampling Requirements for Underground Pipelines.

Site Component	COPCs [a]	Parameter of Interest	Statistic of Interest	RSD_{site} [b]	RPD_{lab} [b]	LBGR [b] (% of RAG)	Alpha	Beta	Pr (contaminated)	Relative Error Consequence Ratio	Default # of Lateral Sampling Locations in (X-Y) Plane	Number of Lateral Sampling Locations in (X-Y) Plane Based on Analogous Site Data	Calculated # of Lateral Sampling Locations in (X-Y) Plane
Pipe contents (scale/silt sludge)	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	0.50	N/A	64	Computed from analogous data	Site-specific computation
	Non-radionuclides	Maximum	Maximum Concentration	1.00	0.30	68.8%	0.05	0.20	0.50	2	3[c]	Computed from analogous data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	Computed from analogous data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A
Underlying cradle soils	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	0.50	N/A	64	Computed from analogous data	Site-specific computation
	Non-radionuclides	Maximum	Maximum Concentration	1.00	0.30	68.8%	0.05	0.20	0.50	2	3[c]	Computed from analogous data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	Computed from analogous data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A
Adjacent native soils	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	0.25	N/A	64	Computed from analogous data	Site-specific computation
	Non-radionuclides	Maximum	Maximum Concentration	1.00	0.30	68.8%	0.05	0.20	0.25	2	3[c]	Computed from analogous data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	Computed from analogous data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A

[a] For deep zone nonradionuclides, the 95% UCL for the mean is the only statistic of interest.

[b] Default value:

In lieu of having a RSD_{site} at the time of sample planning, a value of 100% is assumed.

In lieu of having a RPD_{lab} at the time of sample planning, a value of 30% is assumed.

In lieu of analytical data or field screening results, the LBGR may be taken at 68.8% of the RAG based on RPDs established above.

[c] Per the lookup table, n=3; however, 4 samples is the minimum number of samples that should be collected if n<4.

N/A = not applicable

After the number of samples is determined, the locations of these samples will be randomly selected from a grid covering the surface area for the specific component. The minimum sample grid size will be based on the volume and/or area of soil (or other material) that a single sample will represent (e.g., the width of a backhoe bucket) and will follow a line determined by the field engineer, or follow a line based on backhoe access constraints. Certain biased locations will be sampled if they are not selected randomly, including the following:

- Locations above the junction of the tank and the inlet and outlet pipes
- Locations above joints in the tank, if present
- Location at the inlet pipe.

C6.2 STEP II SAMPLE DESIGN

The Step II sampling design determines the sampling requirements at each depth interval below the grade elevation.

C6.2.1 Underground Storage Tanks

The components within the USTs have been evaluated to determine their specific sampling frequencies. The UST sampling frequency is shown in Table C-5. Field screening requirements are included as well.

Table C-5. Step II Sampling Frequency and Requirements for Underground Storage Tanks.

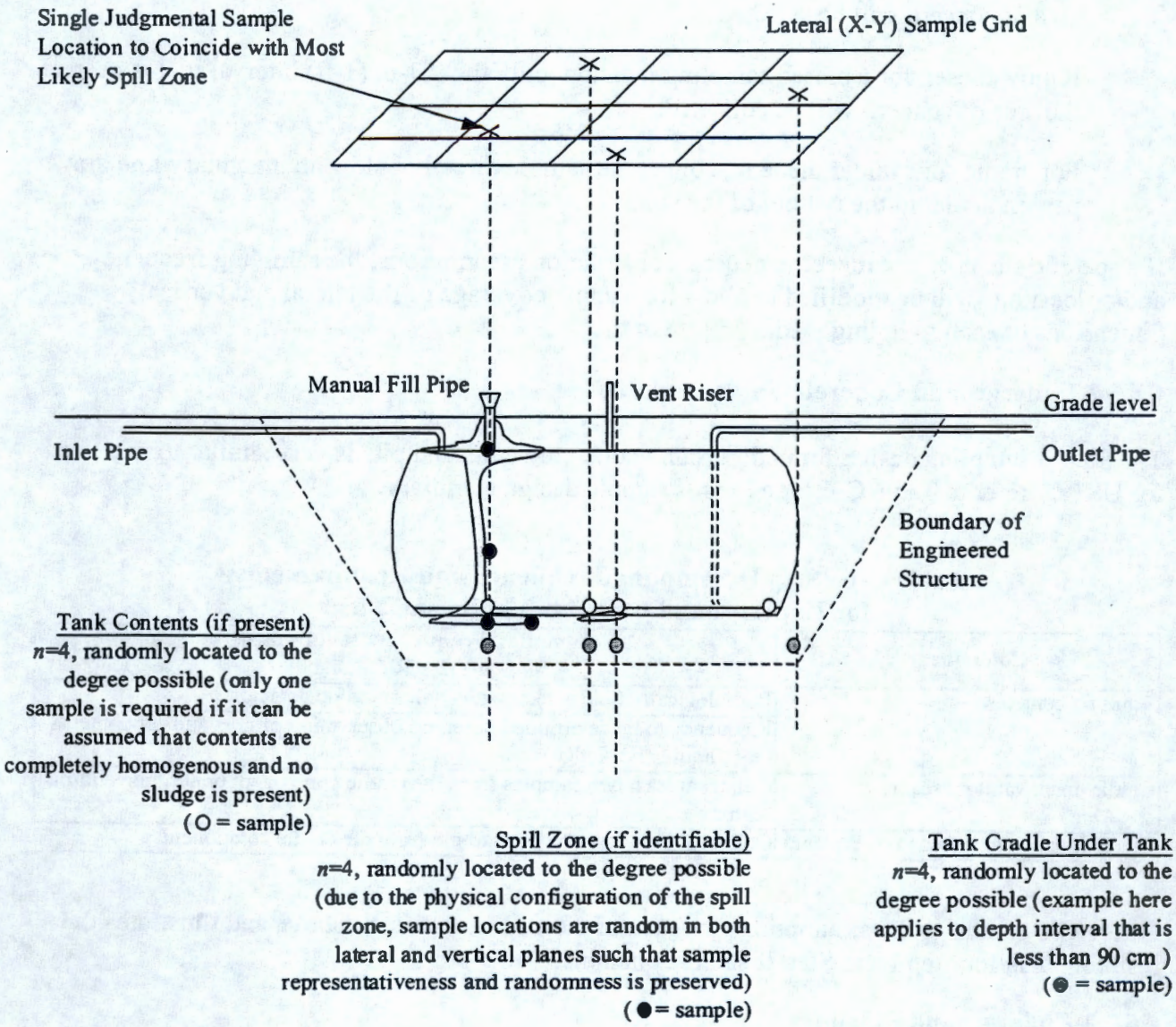
Component	Sampling Frequency/Requirements per Backhoe Pit
Tank contents	Radiologically field screen with sodium iodide detector.
	Frequency to be determined based on observation of the tank contents (e.g., liquid and sludge).
Spill zone above the UST	From every 0.9-m thickness of component, collect a minimum of one sample. Collect a representative sample from a 0.3-m-thick increment, randomly selected from the 0.9-m-depth interval. If sampling media is less than 0.9 m thick, collect at least one 0.3-m-thick increment.
Tank cradle under tank	Collect at least one sample from the cradle component under the UST.

Figure C-5 combines the assumptions for each of the CSMs discussed above and illustrates the resulting plan for Step I and Step II sample planning.

Generally, 0.3-m- (1-ft) thick soil increments will be randomly sampled from each 0.9-m (3-ft) thickness of component with the following exceptions:

- For construction backfill above the tank, the first 0.3-m (1-ft) depth from the surface under the inlet pipe will be collected, to ascertain the presence of surface spills at the inlet pipe.

Figure C-5. Sampling Schematic of a Typical Underground Storage Tank.



Sampling Req'ts (for example):
The above illustrates how Steps I and II of the sample design are integrated. Assume that n=4 lateral sample locations are determined based on equations in Appendix J. Note that lateral (X-Y) locations are random with the exception of the single location that is to coincide with the likely spill zone of the tank. If it can be demonstrated that tank contents are homogenous, one sample may be used to characterize tank contents. If sludge or other heterogeneous conditions are present, multiple samples will be required. Because of the unique physical orientation of the spill zone, sample locations should be randomly determined within the spill zone, with adjustment as needed to preserve sample representativeness. If the cradle is greater than 90 cm in depth from the original tank bottom, samples locations should be randomly selected 30-cm increments from the 90-cm interval. Only 3 components have been identified (Tank Contents, Spill Zone, and Tank Cradle). Underlying soil is not sampled as the probability of contamination there is considered low due to the adsorptive effect of the cradle on leaked tank contents.

For the biased sample locations:

- If also chosen randomly, the 0.3-m (1-ft) interval in a 0.9-m (3-ft) core that is nearest the area of concern will be selected.
- if only chosen for a biased sampling location, only the 0.3-m (1-ft) interval that is nearest the area of concern will be collected.
- For cradle soils under the tank, collect the sample directly below an imaginary line drawn perpendicular to the bottom of the tank.

If a specific site does not meet the general construction assumptions, the sampling frequency and/or locations will be modified to allow for sample coverage of the lateral and vertical dimensions of each sampling media present at the site.

C6.2.2 Underground Concrete Vaults and Pits

The Step II sampling design for underground concrete vaults and pits is very similar to that used for USTs. Refer to Table C-6 for a Step II sample design summary.

Table C-6. Step II Sampling Frequency and Requirements for Underground Concrete Vaults and Pits.

Component	Sampling Frequency/Requirements per Backhoe Pit
Vault/pit contents	Radiologically field screen with sodium iodide detector.
	Frequency to be determined based on observation of the vault/pit contents (e.g., liquid and sludge).
Cradle under vault/pit seams	Collect at least two samples from the cradle component under the vault/pit seams.
Cradle (random locations in X-Y plane)	Collect at least one random sample from the cradle component.

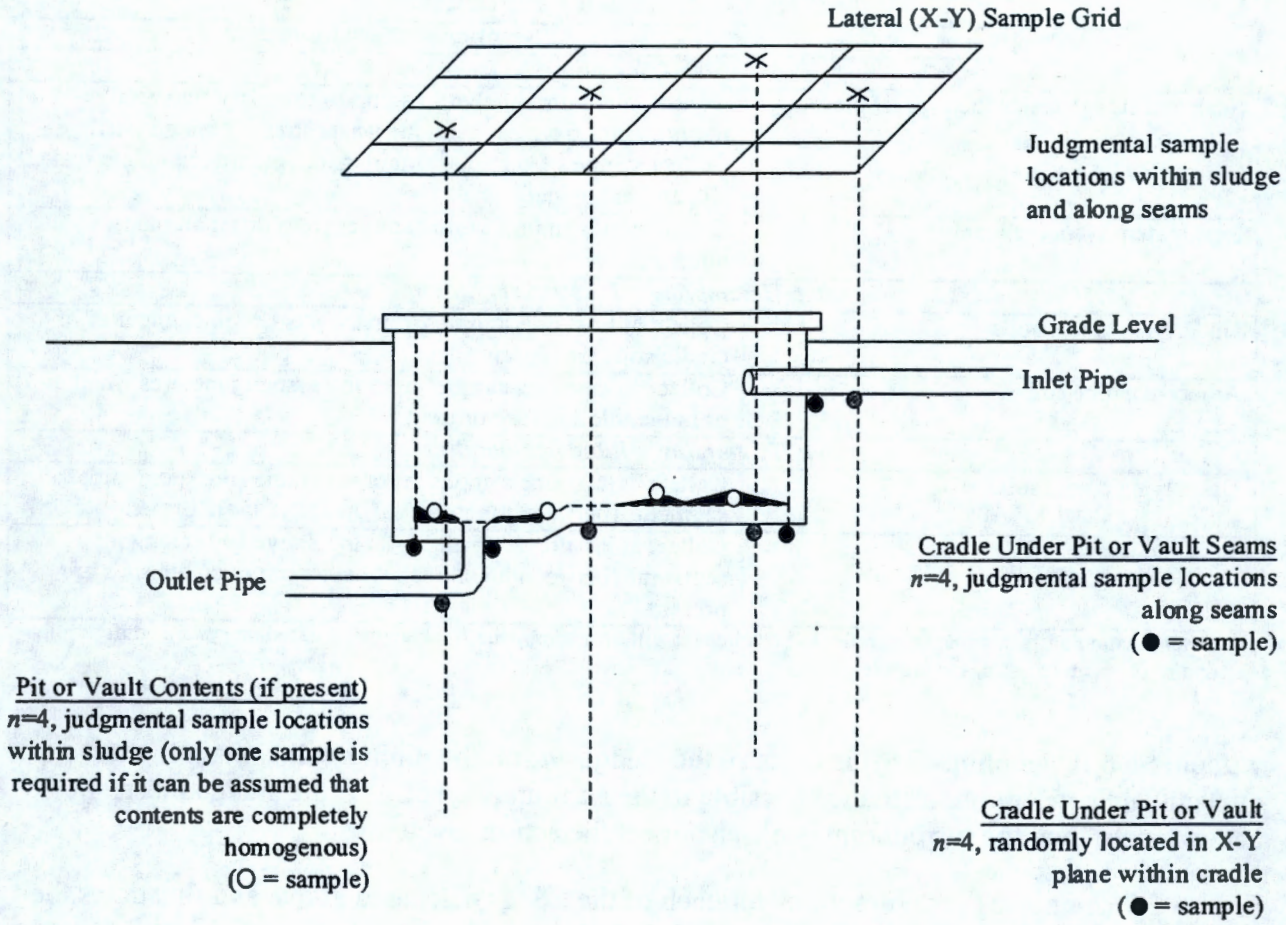
Figure C-6 combines the assumptions for each of the CSMs discussed above and illustrates the resulting plan for Step I and Step II sample planning.

C6.2.3 Underground Pipelines

The sampling design for pipelines will be performed in two stages to avoid unnecessary sampling and analytical costs. Stage 1 sampling will be performed in the piping internals to determine the contamination status. Stage 2 sampling is performed in the surrounding and underlying soils for interim closure. Table C-7 summarizes the sampling frequency and requirements for piping systems. The supporting decision logic for the Stage 1 and Stage 2 underground pipeline sampling is discussed below.

C6.2.3.1 Underground Pipeline Sampling Decision Logic. The underground piping will be sampled for scale, silt and/or sludge (hereafter referred to as sludge). If sludge is present in the piping and contains COPCs at concentrations above the action levels, the piping system will be transferred to the Remedial Action Project for removal/disposal. If the sludge does not contain COPCs above the action levels, the piping system and surrounding soils will be interim closed

Figure C-6. Sampling Schematic of a Typical Vault Pit.



Sampling Req'ts (for example):
The above illustrates how Steps I and II of the sample design are integrated. Assume that n=4 sample locations are determined based on equations in Appendix J. Note that lateral (X-Y) locations are not necessarily random. If it can be demonstrated that pit or vault contents are homogenous, one sample may be used to characterize pit or vault contents. If multi-colored, or course and fine sludge, or other heterogeneous conditions are present, multiple samples will be required. If the cradle is greater than 90-cm in depth from the original tank bottom, samples locations should be randomly selected 30-cm increments from the 90-cm interval. Only 3 components have been identified (Pit or Vault Contents, Cradle Under Pit or Vault Seams, and Cradle Under Pit or Vault). Underlying soil (away from pit or vault seams) is not sampled as the probability of contamination there is considered low.

Table C-7. Step II Summary of Sampling Frequency and Requirements for Pipelines.

Component	Number of Biased Locations
Step I Sampling	
Scale/silt/sludge inside the pipe, if present	Collect minimum number of samples to satisfy statistical requirements from each unique waste stream piping system. Collect samples from pipe appurtenances that accumulate scale, silt, and/or sludge.
Pipe material (concrete only)	Collect a maximum of four samples from different pipe junctures.
Step II Sampling – Biased Sampling	
Underlying cradle soils	Collect at least one sample[a] from the system pipe junctures, if cradle soils are present.
Adjacent native soil	Collect at least one sample[a] from the system junctures whether or not cradle soils are present.
Step II Sampling – Random Sampling	
Underlying cradle soils	Collect at least one sample[a] from the cradle soils along pipe segments (between junctures), if cradle soils are present.
Adjacent native soil	Collect at least one sample[a] from the native soils along pipe segments (between junctures), whether or not cradle soils are present.

[a] Determination of the number of samples to be collected will be made by the field engineer, based on system configuration and representativeness of the samples.

without Step II sampling. This is because the sludge within the piping will contain higher contaminant concentrations than is possible in the surrounding soils. If the sludge meets the action levels, then the surrounding soils also meet the action levels.

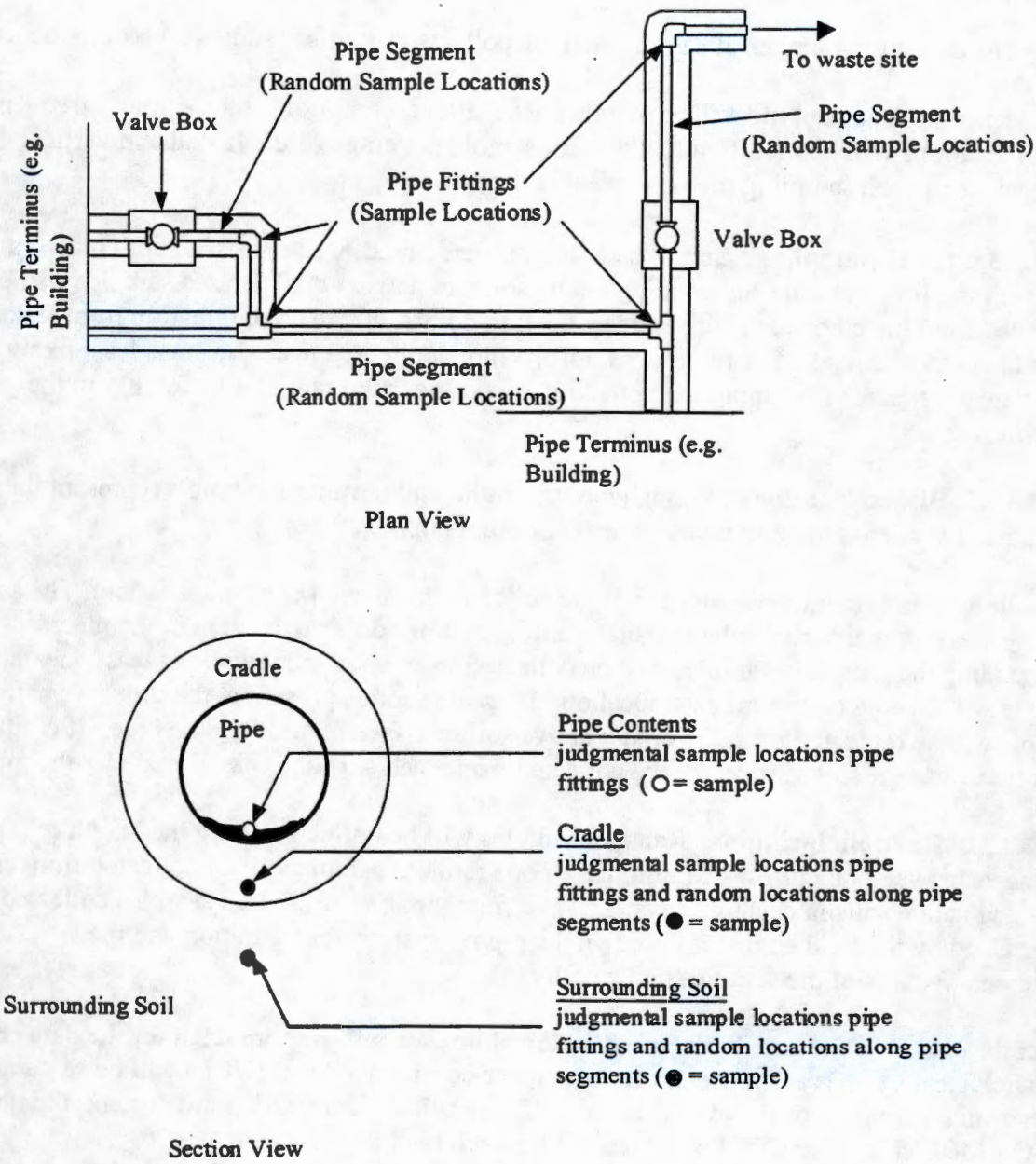
Figure C-7 combines the assumptions for each of the CSMs discussed above and illustrates the resulting plan for Step I and Step II sample planning.

If the internals of the piping do not contain scale, silt or sludge, the piping will undergo field screening. If the field screening results show detectable concentrations of COPCs, the piping system will be transferred to RA for removal/disposal. If the field screening results do not show detectable COPC concentrations, then Step II sampling will be performed in the surrounding soils for interim closure.

C6.2.3.2 Step I Sampling. Step I sampling will be biased to find sludge within the piping systems, as it will contain the highest COPC concentrations. The sampling locations that likely contain sludge include the following:

- Initial piping system connections
- Termination connections
- Connections to secondary waste streams

Figure C-7. Sampling Schematic of a Typical Pipe.



Sampling Req'ts (for example):
The above illustrates the unique approach taken for pipe sampling. The number of samples locations, *n*, is determined based on equations in Appendix J. Note that locations are a combination of judgmental (at pipe fittings) and random (along pipe segments). If it can be demonstrated that pipe are homogenous, one sample may be used to characterize pipe contents. If multi-colored, or course and fine sludge, or other heterogeneous conditions are present, multiple samples will be required. Concrete pipe may require up to 4 samples pure juncture due to its porous nature. Only 3 components have been identified (Pipe Contents, Cradle, and Surrounding Soil).

- Locations (piping appurtenances) where fluid momentum is diminished (e.g., junction boxes, reservoirs, and expansion joints).

The minimum number of samples will be collected to satisfy statistical requirements.

If a specific site does not meet the general construction assumptions, the sampling frequency and/or locations will be modified to allow for sample coverage of the lateral and vertical dimensions of each sampling media present at the site.

C6.2.3.3 Step II Sampling. Step II sampling, if performed, will consist of both biased and random sampling from the surrounding cradle soil and native soils. Biased samples will be collected from the elbows, origin, and termination points, where contamination from leakage is most likely to be found. The random samples will be collected from the areas least likely to experience leakage. This approach potentially maximizes the range of variability in the analytical results.

C6.2.3.3.1 Biased locations. Piping elbows, origin, and termination points represent the biased locations that are assumed to be likely leakage points in the system.

If cradle sand is present, one sample will be collected from each exposed location. The samples will be biased toward areas where visual staining and/or odors are present in the media surrounding the pipe. No samples will be collected from above the pipe. At least one native soil sample will be collected from each location. If cradle sand is present at the time, the native soil sample will be collected from the cradle/native soil interface underlying the pipe. If cradle sand is not present, one soil sample will be collected from each side and one from under the pipe.

C6.2.3.3.2 Random locations. Random samples will be collected along the length of piping segments between junctures. A minimum of one random sample will be collected from cradle soils and native soils in each pipe system. The final number of random samples collected will be determined by the field engineer based on the piping system configuration and the representativeness of the samples being collected.

After the data are collected, both biased and random data will be combined for the data analysis. If radiological COPCs are present, the 95% upper confidence level (UCL) will be calculated for each medium from all of the available data. If nonradiological COPCs are present, the three MTCA Method B criteria will be addressed for each media.

C7.0 MINIMUM FIELD SCREENING REQUIREMENTS

C7.1 RADIOLOGICAL FIELD SCREENING

Sites with dimensions smaller than 2 by 2 m (6.5 by 6.5 ft) will be monitored by taking single static counts in the center of the site or similar anomalous locations with a high-efficiency gamma detector (e.g., HPGe or NaI:Tl) and 50% to 100% coverage with beta and alpha surface contamination monitors (as required by the site profile).

In such cases where overburden and potential subsurface contamination exists below the top 15 cm, excavation spoils and surfaces will be monitored by taking single static counts with a high-efficiency gamma detector and beta and alpha surface contamination monitors (as required by the site profile). Coverage will include 50% of the spoils and exposed surfaces, as well as any anomalies discovered during excavation.

The detector/methodology minimum detectable activity (MDA) will be less than 50% of the DCGL for the expected radionuclides. This method assumes that contamination is most likely on the surface. This method will detect high-energy gamma contamination within 15 cm (6 in.) of the survey surface. These field screening methods will not be effective for conditions where the contamination is more than 15 cm below the survey surface (e.g., backfilled or unexposed site).

In cases where the MDA is not achievable due to local background, or access to the site spoils and anomalous surfaces is not feasible (e.g., logistical constraints), confirmatory samples will be taken.

At sites with dimensions greater than 2 by 2 m, but less than 100 m^2, one static count will be taken for every 4 m^2 of exposed surface area, using a high-efficiency gamma detector and 25% to 50% coverage with beta and alpha surface contamination monitors (as required by the site profile). The static counts will be evenly spaced over the site. The same limitations and assumptions used for small sites apply. Any anomalous conditions will be surveyed as well.

Excavation spoils and surfaces will be monitored by taking static counts with a high-efficiency gamma detector and coverage with beta and alpha surface contamination monitors (as required by the site profile). Coverage will include 25% to 50% of the spoils and exposed surfaces, as well as anomalies discovered during excavation.

Sites with surface areas greater than 100 m^2 may employ one of three options.

1. The methodology for medium-sized (4 m^2 to 100 m^2) sites may be employed.

2. Mapping technologies that record radiation levels may be used (e.g., MRDS, Mobile Surface Contamination Monitoring tractor), with limited follow-up static counts. If advanced mapping technologies are used, only contaminants that are not monitored (e.g., alpha) require separate contamination surveys. In this case, 10% coverage surveys would suffice.

3. The third option is to use MARSSIM guidance to locate a statistically generated number of static count locations based on observed sample variance, and scan survey 50% to 100% of the area to a higher MDA, the elevated measurement comparison (EMC). The EMC is a MARSSIM concept where the samples determine the average concentration and variance, and the EMC surveys are designed to demonstrate that no large areas of significantly elevated activity exist. This option is best utilized as verification that the site is clean following the discovery of anomalous conditions.

On sites with backfill material over the site, or sites where the areas of likely contamination cannot be reached, backfill removal and sampling are required to determine if the site is contaminated. In this case, contamination monitoring for interim closure is not possible and will not be considered as a potential release mechanism. Direct measurements and confirmation samples will be taken for site categorization.

C7.2 NONRADIOLOGICAL FIELD SCREENING

Due to the limited applicability of nonradionuclide field screening methods, it is not practical to specify a percentage of coverage or when or at which sites nonradiological field screening is needed. At sites where nonradiological field screening is warranted, after selection of target field screening compounds (based on site COPCs), a minimum of four samples should be collected from each site component present. Where practical constraints do not limit the umber of field screening samples collected, the minimum should be at least 10.

C8.0 REFERENCES

BHI, 1999, *Data Quality Objectives Summary Report for the 100 Area Remaining Confirmatory Sampling Effort Sites*, BHI 01249, Draft, Bechtel Hanford, Inc., Richland, Washington.

DOE-RL, 1998a, *100 Area Remedial Action Sampling and Analysis Plan*, DOE/RL-96-22, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1998b, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, DOE/RL-96-17, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

EPA, 1999, *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units*, U.S. Environmental Protection Agency, Region X, Richland, Washington.

APPENDIX D

SAMPLING DESIGN FOR THE SURFACE AND SUBSURFACE AREAS (BURN PITS, CONSTRUCTION LAYDOWN YARDS, AND DUMPING AREAS) CONCEPTUAL SITE MODEL

D1.0 SAMPLING DESIGN FOR SURFACE AND SUBSURFACE AREAS (BURN PITS, CONSTRUCTION LAYDOWN YARDS, AND DUMPING AREAS)

Surface and subsurface disposal areas include burn pits, construction laydown yards, and dumping areas where debris was deliberately disposed, and in some cases, burning of solid wastes occurred. The discussion on burn pit disposal areas in Section D2.0 should be consulted for sites where buried debris is present. For sites where construction materials and debris were deliberately disposed on the land surface, refer to the construction laydown yard and dumping area discussion in Section D3.0. The general strategy for investigation of these large area sites is (1) conduct some degree of investigation, (2) determine the anomalous conditions and assign the anomalies to their applicable conceptual site model (CSM) (use the corresponding sample design for the anomaly to support site decisions), and (3) confirm that the remaining real estate is acceptable for interim closure.

The *Model Toxics Control Act* (MTCA) presents an approach for systematic sample designs for large sites that is based on the sampling design presented by Gilbert's *Statistical Methods for Environmental Pollution Monitoring* (Gilbert 1987) as the "hot spot approach." This approach has been adopted for use for confirmatory sampling of the sites described by this CSM. These sites generally contain localized zones of potential contamination while the real estate located between these sites is generally undisturbed or otherwise innocuous. It is important to note that debris burning locations and/or solid debris (past or present) are considered localized pockets of contamination, termed "anomalies" for the CSM discussions that follow. The use of this nomenclature avoids the use of the term "hot spot," which carries other connotations. Gilbert presents a statistically based approach for establishing a grid for the systematic sampling of large areas. The following inputs are required to implement this approach:

- The acceptable probability of missing an anomaly that is present (error tolerance)
- The required grid pattern (triangular, square, rectangular)
- The two-dimensional size and shape of the anomaly
- The lateral dimensions of the site.

The error tolerance (5%) and the grid pattern (triangular) were established in the data quality objective (DQO) effort (BHI 1999); therefore, only the size and shape of the anomaly must be specified.

D2.0 BURN PITS

D2.1 CONCEPTUAL SITE MODEL AND ASSUMPTIONS FOR BURN PITS

This CSM discussion is defined by the physical configuration and contamination distribution characteristics that affect sampling for interim site closure. The other aspects of conceptual models examined in the DQO process, including future land use, exposure scenarios, and identification of contaminants of potential concern (COPCs), are found in Sections 1.0 through 5.0 of the DQO summary report (BHI 1999).

The physical components and sampling media of the site are the waste, backfill, underlying soils, and surrounding soils. For this project, burn pits are assumed to be surface pits or depressions that were used to dump miscellaneous small debris (e.g., paint cans, scrap metal, and glass) and to burn such items as office waste, solvents, and laboratory waste. The sites may have been backfilled and used for burning over time so that layers of waste and backfill have formed. It is assumed that the backfill was clean when used at the site (i.e., no additional contamination was introduced via the backfill material). It is possible that the backfill may have become contaminated by dumping and burning activities at the site subsequent to its introduction. Because the sites have been exposed to environmental conditions for several years, contaminant leaching is a possibility.

The spatial distribution of contamination is expected to be extremely heterogeneous. The model for a burn pit is a depression or large hole in which debris was disposed of and burned over time, potentially in different areas of the burn pit. Backfill was introduced at various times to cover the debris and ash to prevent resuspension. Debris was then disposed of or burned on top of this backfill, creating layers of contamination. Therefore, the vertical distribution of contamination is expected to vary, and not necessarily decrease with depth. Contamination is expected in the native soils from leaching under the lowest level burn pit and is assumed to decrease with depth. The lateral distribution of contamination is also expected to be heterogeneous because the entire pit was not used for burning at any particular time; disposal and burning likely took place in discrete locations within the burn pit.

Because the distribution of contamination is expected to be heterogeneous and some uncertainty exists about the types of waste that may be contained in the pits, sampling access to the pits may be limited. For safety reasons, sampling is expected to follow a phased approach. The first phase involves the use of applicable nonintrusive investigation techniques. The second phase will involve intrusive field investigation, which will include trenching to determine the types, depth, and amounts of waste that may be present and will involve collecting data to support the risk based decisions for the site (calculating 95% upper confidence limits [UCLs] for the mean concentrations of COPCs).

Project personnel will use the appropriate nonintrusive techniques (e.g., ground penetrating radar [GPR] and electromagnetic imaging [EMI], radiation surveys, and walkdowns) to identify zones where anomalies may exist. Phase II trenching will be performed across as many zones as possible to estimate the vertical and spatial distribution of media (e.g., waste, backfill, and depth of pits). The visual, qualitative, and quantitative data collected from trenching will be used to determine the accessibility and need for subsequent sampling.

The spatial boundaries of a burn pit site include lateral and vertical boundaries within which sampling will take place to support the decisions stated in DQO Step 5 (BHI 1999). It is assumed that the location and surface dimensions of all burn pits are known. Lateral sampling boundaries extend 0.3 m (1 ft) on all sides beyond the dimensions of a burn area. The vertical boundary will be extended to a depth of 0.6 m (2 ft) into undisturbed soils beneath the waste stream. Surface and subsurface waste will be sampled wherever possible. Surface backfill and undisturbed areas that have not been subjected to subsequent burning or dumping activities will also be sampled to rule out the potential for undiscovered or unknown anomalies. A sample grid

shall be superimposed over the area to be sampled in accordance with the "hot spot" approach described in EPA's *Methods for Evaluating the Attainment of Cleanup Standards, Volume 1: Soil and Solid Media* (EPA 1989). Soils underlying and adjacent to the burn pits may be sampled via trenching in Phase II.

D2.2 DECISION ERROR TOLERANCES FOR BURN PITS

Specific sampling media for burn pits are assumed to include debris, backfill, underlying soils, and surrounding soils. The COPCs associated with these waste streams include radionuclides, metals, and a subset of organic constituents (BHI 1999). Because there are no historical data associated with these sites, the concentration ranges of the COPCs are unknown at this time, thus, upper and lower range limits associated with the Remaining Sites' burn pits have not been established.

Refer to generic Table 2-1 for the action levels for the COPCs associated with the Remaining Sites' burn pits. Action levels are provided for each statistic that will be used to support a decision (the sample maximum, the sample mean). The derived concentration guideline levels (DCGLs) for radionuclide COPCs will be determined after isotopic distributions have been estimated.

Generic Table 1-7 shows the tolerable decision errors for evaluation of the mean concentration (note: these errors apply to all media identified for the CSM and thus do not require specific identification for use of the table). The false-positive rate is based on the confidence limit for the mean specified in the remedial design report/remedial action work plan for the 100 Areas (DOE-RL 1998b) and the *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units* (Remaining Sites ROD) (EPA 1999). The false-negative error rate follows from the 100 Area remedial action sampling and analysis plan (SAP) (DOE-RL 1998a).

The supplemental site specific sampling plan will be based on the systematic approach (Gilbert's "hot spot" approach). The spacing for the sampling grid is set either by the anticipated size of the smallest anomaly of interest (based on available data) or the overall number of samples required for the site as determined with equations in Appendix J. Table D-1 presents the parameters required to design such a plan, in addition to those shown in generic Table 1-7. For implementation of the systematic sampling approach, grid spacing shall be such that a 95% probability of sampling an anomaly is the norm. This is consistent with the 5% false-positive error rate established in the DQO effort (BHI 1999). For error tolerances for specific anomalous conditions that might be present, the appropriate CSM for the anomaly of interest should be consulted.

The bounds of the gray region are presented in a generic format for evaluating the mean concentrations in all of the Remaining Sites in generic Table 1-8 and the associated text.

Table D-1. Inputs to Calculate the Number of Sample Locations for Anomaly Approach.

Grid Geometry	Probability of Hitting an Anomaly $(1-\alpha)^a$	Anomaly Characteristics			Grid Spacing $= G^b$	Area of Site = A	Number of Sampling Locations
		L = Length Parameter	S = Width Parameter	ES = Shape Parameter			
Triangular	0.95	TBD	TBD	S/L	$\sqrt{\frac{A}{0.866n}}$	TBD	A/G

[a] α = probability of missing hot spot as big or bigger than the size specified and of the shape specified.
[b] The grid spacing (G) may be determined from the number of samples required when data is available for calculating *n* from equation J.1 of Appendix J.
L = one-half of the length of the long axis of the ellipse describing the expected size of the anomaly.
S = one-half of the length of the short axis of the ellipse describing the expected size of the anomaly
TBD = to be determined

D3.0 CONSTRUCTION LAYDOWN YARDS AND DUMPING AREAS

D3.1 CONCEPTUAL MODEL FOR CONSTRUCTION LAYDOWN YARDS AND DUMPING AREAS

This CSM is defined by the physical configuration and contamination distribution characteristics that affect sampling for interim site closure. The other aspects of conceptual models examined in the DQO process, including future land use, exposure scenarios, and identification of COPCs, are found in Sections 1.0 through 5.0 of the DQO summary report (BHI 1999).

Because construction laydown yards and dumping areas are not engineered disposal units, the only physical components included in the CSM are the surface debris present at the site and the soil immediately underlying the debris. The debris is assumed to be visible from the surface. The sampling media will include the surface debris, surface soils, and the underlying soils. The spatial boundaries are assumed to be clearly delineated in the sites' documentation. The subsurface boundary is 0.6 m (2 ft) below the waste stream into undisturbed soils. Within the delineated site boundaries, project personnel will use the appropriate nonintrusive techniques (e.g., GPR, EMI, radiation surveys, and walkdowns) to identify zones where anomalies may exist. If any subsurface anomalies are discovered, these will be considered separate sites and sampled as "subsurface pits."

Access to all sampling media is assumed to be unimpeded. As stated above, it is assumed that all debris disposed of at the site is visible and accessible for radiological surveys and physical sampling (for possible land disposal restriction [LDR] determinations). The intended purpose of the surveys and sampling is to verify that the debris and underlying soils are uncontaminated and that the sites may be closed without remedial actions. Debris/soil that exceed the action levels based on surveys and physical sampling will be transferred to the 100 Areas Remedial Action Project for subsequent cleanup. All debris and surface and subsurface soils are assumed to be suitable for sampling by trenching.

Laydown and surface disposal areas generally have histories that include a variety of disposals and removals of debris. These activities result in potentially extremely heterogeneous spatial distributions of contaminants; areas of contamination where debris was, or is currently stored, as well as areas where debris was never disposed. Thus, the current state of the site may not always identify areas of concern. The areas where debris was, or is present, are considered localized pockets of contamination, termed "anomalies." Sampling to locate the anomalies involves systematic sampling from a grid arranged in a particular geometric pattern. To implement a sampling plan designed to detect anomalies, the theoretical shape and size of the smallest anticipated anomaly must be specified or the required number of samples must be pre-determined. The DQO summary report (BHI 1999) assumes that anomalies are elliptical in shape, which is consistent with approaches outlined in Gilbert (1987) and EPA (1989). Anomaly size will be determined on a site-by-site basis; however, Gilbert (1987) recommends that the ellipse width be set at half the length for a conservative approach where other data are not available.

Sampling at surface disposal sites will follow a phased approach. The first step will be to characterize any potentially contaminated debris, as well as overburden (if present) and underlying soils. All debris and soil will be screened for radiological contamination. Debris/soils and liquid wastes with the potential for volumetric contamination will be sampled and analyzed for possible LDR constituents (it is important to note that waste designation is beyond the scope of this document and will be addressed in a separate effort). The results of these screening and laboratory analyses will determine the disposition of the debris and soils.

Other areas within a waste site between anomalies will also be sampled using the systematic approach (Gilbert's "hot spot approach" [Gilbert 1987]). A sampling grid will be applied to provide the needed assurance that the surface soils have been adequately characterized. Additional biased samples will be collected at suspect locations in and between the anomalies to account for soil stains or areas with liquid waste puddles.

The anomalies themselves will be identified and assigned to another CSM. This ensures that each anomalous conditions will be investigated to ensure that the presence of isolated instances of contamination above the remedial action goals (RAGs) have been addressed. Refer to Section D4.1.2 for additional details.

D3.2 DECISION ERROR TOLERANCES FOR CONSTRUCTION LAYDOWN YARDS AND DUMPING AREAS

This subsection discusses the development of the error tolerances for the construction laydown and dumping area sample designs. This SAP makes frequent reference to the generic tables and discussions in Parts I through III of this SAP from which the sampling design was developed.

Specific sampling media for construction laydown and dumping areas are assumed to include debris, surface soils, and subsurface soils. The COPCs associated with these media include radionuclides, metals, and a subset of organic constituents (BHI 1999). Because there are no historical data associated with these sites, the concentration ranges of the COPCs are unknown at

this time; thus, upper and lower range limits associated with the Remaining Sites' construction laydown and dumping areas have not yet been established.

Refer to generic Table 2-1 for action levels for the COPCs associated with the Remaining Sites' construction laydown and dumping areas. Action levels are provided for each statistic (sample maximum, sample mean) that will be used to support a decision. The DCGLs for radionuclide COPCs will be determined once isotopic distributions have been estimated.

Generic Table 1-7 shows the tolerable decision errors for evaluation of the mean concentration (note: these errors apply to all media identified for the CSM and thus do not require specific identification for use of the table). The false-positive rate is based on the confidence limit for the mean specified in the remedial design report/remedial action work plan for the 100 Areas (DOE RL 1998b) and the Remaining Sites ROD (EPA 1999). The false-negative error rate follows from the 100 Areas remedial action SAP (DOE-RL 1998a).

As stated in Section D3.1, the sampling plan will be based on a systematic approach, with applicable CSM specific sampling of the appropriate anomalous conditions. Table D-2 presents the parameters required to design such a plan, in addition to those shown in generic Table 1-7. For implementation of the systematic sampling approach, grid spacing shall be such that a 95% probability of sampling an anomaly is the norm. This is consistent with the 5% false-positive error rate established in the DQO effort (BHI 1999). For error tolerances for specific anomalous conditions that might be present, the appropriate CSM for the anomaly of interest should be consulted.

Table D-2. Inputs to Calculate the Number of Sample Locations for Anomaly Approach.

Grid Geometry	Probability of Hitting an Anomaly $(1-\alpha)^a$	Anomaly Characteristics			Grid Spacing = G^b	Area of Site = A	Number of Sampling Locations
		L = Length Parameter	S = Width Para-meter	ES = Shape Parameter			
Triangular	0.95	TBD	TBD	S/L	$\sqrt{\frac{A}{0.866n}}$	TBD	A/G

[a] α = probability of missing hot spot as big or bigger than the size specified and of the shape specified.
[b] The grid spacing (G) may be determined from the number of samples required when data is available for calculating *n* from equation J.1 of Appendix J.
L = one-half of the length of the long axis of the ellipse describing the expected size of the anomaly
S = one-half of the length of the short axis of the ellipse describing the expected size of the anomaly
TBD = to be determined

The bounds of the gray region are presented in a generic format for evaluating the mean concentrations in all of the Remaining Sites in generic Table 1-8 and the associated text.

D4.0 SAMPLING DESIGN

The preceding sections presented the error tolerances, and the following discussion presents the sampling guidance needed for burn pits, construction laydown yards, and dumping areas. Information is provided on the approaches used to determine the number of sampling locations and sampling frequencies. Burn pits, dumping areas, and construction laydown yards are described below.

Burn pits probably received a variety of combustible and noncombustible solid waste: vegetation, scrap metal, glass, office waste, laboratory waste, asbestos, paint waste, chemical solvents, hardware, machinery, miscellaneous equipment, asbestos, coal ash, and experimental animal farm carcasses. Backfilling may have occurred periodically to minimize ash resuspension. Due to the nature and pattern of disposals, burning, and backfilling, localized pockets of contamination can be expected.

The waste materials in burn pits were likely distributed heterogeneously. In addition, historical documentation is not sufficient to support interim closure decisions or sampling guidance. Consequently, additional information is required to support development of a statistical sampling plan for interim site closure.

Dumping areas received a variety of solid and liquid wastes very similar in nature to that disposed of at burn pits only combustion of the waste material was not used as a disposal method. Backfilling may have occurred periodically to minimize pest intrusion. Due to the nature and pattern of disposals, localized pockets of contamination can be expected.

Construction laydown areas were used for temporary storage of construction-related materials and equipment during reactor construction. These areas received a variety of solid and liquid wastes very similar to that of dumping areas; however, discharges were limited as the area was not designed for waste disposal.

D4.1 BURN PITS

D4.1.1 Preliminary Investigation

Due to the extensive size of many of these sites combined with the anticipated heterogeneity of the anticipated contamination, a preliminary site investigation (Phase I noninstrusive investigation) will be used to gather data necessary for a cost-effective sampling design. A study will be performed to confirm waste site boundaries and identify anomalies in the waste site. Project personnel will use the appropriate nonintrusive techniques (e.g., GPR, EMI, radiation surveys, and walkdowns) to identify zones where anomalies may exist. The site will be divided into zones based on the anomalous conditions discovered and additional investigative techniques will be employed where warranted.

D4.1.2 Intrusive Investigation

Phase II requires that each anomaly, as well as the real estate between the anomalies, be intrusively investigated and sampled to ensure that the waste site contains no material above action levels.

In Phase II, intrusive sampling methods will be employed at certain locations and at the anomalies determined in Phase I. Trenching will be used to uncover anomalies for visual inspection. Discernable anomalies, including varying debris, ash layers, etc., will be examined to determine if one of the conceptual models identified in the DQO summary report (BHI 1999) applies. Anomalies that do not conform to the assumptions of the conceptual models identified in the DQO summary report (BHI 1999) will be deferred pending development of the appropriate conceptual model and associated confirmatory sampling techniques. Anomalies that can be assigned a conceptual model will be sampled according to the appropriate guidelines, including the phased sample collection, archiving, and analysis approach discussed in Section 3.2.2.1, as warranted (note that the phased approach sampling contingency is not to be confused with the phased approach to site investigation described for this CSM).

D4.1.3 Sampling of Nonanomalous Conditions (Real Estate Between Anomalies)

The nonanomalous conditions, otherwise referred to as the real estate between anomalies, must also be sampled to determine if the area as a whole meets the RAGs. Unlike anomalies, potential contamination within this portion of the site could be assumed to be homogenous. Furthermore, since it is anticipated that no waste disposal practices actually occurred on these soils, the sampling of the real estate between anomalies will generally be limited to the top undisturbed 15 cm (5.9 in.) of soil; however, sampling at depth will be required where anomalies are indicated (e.g., anomalies detected during nonintrusive field investigation, physical evidence of disturbances on the soil surface, suspect buried material, or as determined from historical information). The soils are considered unimpacted by the site anomalies and will be sampled in a single interval. A grid will be superimposed over the area to be sampled in accordance with EPA's *Methods for Evaluating the Attainment of Cleanup Standards, Volume 1; Soil and Solid Media* (EPA 1989) (refer to Section D4.2 for additional detail). The appropriate number of samples will be collected from grid nodes, the minimum number as determined using the equations in Appendix J (equation J-1), or as determined based on the anticipated size of a likely anomalous condition. For the purpose of estimating required number of samples for nonradionuclides, a Pr(contaminated) of 0.25 should be assumed in lieu of historical or sample data.

D4.2 CONSTRUCTION LAYDOWN YARDS AND DUMPING AREAS, AND HOMOGENOUS PORTIONS OF BURNPITS

As stated previously, although a burn pits may contain many anomalous conditions, the nonanomalous area is considered homogenous. These areas are similar to the laydown areas and surface dumping areas in that contamination, if present, is likely to be surficial in nature. Thus, the approach described below is applicable to the homogenous portions of the burn pit of interest.

Construction laydown areas and surface dumping areas generally have histories of heterogeneous disposals of solid debris that are termed "anomalies" for the purposes of this SAP. The sampling design proposed to identify anomalies in the laydown and dumping areas involves systematic sampling with a grid system arranged in a triangular pattern. Where sufficient data exist concerning contaminant variability, the number of required samples may be computed using equation J-1 of Appendix J. The corresponding grid spacing is then determined with equation J-7 with the grid randomly positioned on the site. If the number of samples is calculated using equation J-1, with the sampling grid determined based on the equation $G=(A/0.866n)^{1/2}$, the size of the corresponding anomaly that can be detected with 95% certainty must be determined and error tolerances must be specified. Also, equation J-1 has an assumption of random sampling, not systematic sampling. The assumptions of the 95% UCL for the mean that will be used for hypothesis testing may be violated. The project statistical lead will be consulted prior to implementing this approach. In cases where the required number of samples cannot be determined, the grid spacing may be determined based on the anticipated size of the expected anomaly. This approach requires the following assumptions:

- The shape (ES) of the anomaly is elliptical and known with a high degree of certainty (S = one-half of the length of short axis of elliptical anomaly, L= one-half of the length of long axis of elliptical hot spot).

- The length (2L) of the smallest anomaly important to detect is known with a high degree of certainty (L = 1/2 [length of long axis of elliptical hot spot]).

- The width (2S) of the smallest anomaly important to detect is known with a high degree of certainty (S = 1/2 [length of short axis of elliptical hot spot]). In lieu of better data, a conservative approach is to assume S=0.5*L; however, if ellipse orientation (north/south, east/west direction) is unknown, assume S=L.

- Samples will be taken on a triangular grid, because the probability of hitting an elliptically shaped anomaly is higher on a triangular grid than on a square or rectangular grid.

- The distance between grid points will be much larger than the size of the sample to be taken at a grid point.

- The definition of an anomaly is a location with concentrations and/or activities of COPCs that exceed two times the associated preliminary action level.

- There are no errors made when deciding if an anomaly has been located.

- The size and shape of an anomaly is independent of the COPC.

D4.2.1 Sampling Design

Where the number of sampling locations (*n*) (assuming one sample per location) cannot be predetermined, the number of sampling locations is dependent on the size of the area (A) to be

sampled and the grid spacing (G), where n is calculated as A/G^2. A grid spacing can be chosen which will allow one to state the probability of hitting an anomaly of the specified shape and size, or conversely, the acceptable probability of hitting an anomaly of a specified shape and size can be set, and the required grid spacing calculated. The probability of missing an anomaly is α, the probability of concluding the site is clean, in error. Thus, the probability of hitting an anomaly is $1-\alpha$. Grid spacing for different sizes and shapes of anomalies and different probabilities of hitting such an anomaly are summarized in Table D-3. Grid spacing becomes smaller as the following occur:

- Desired probability of hitting an anomaly increases
- Shape parameter decreases
- Size parameter decreases.

In other words, for a given waste site size, more samples are required if the following occur:

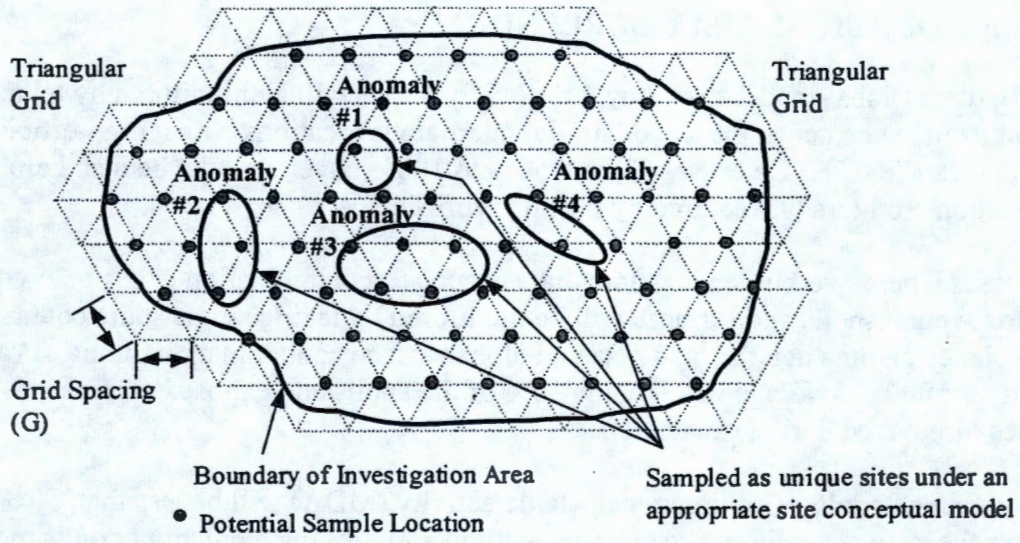
- A higher confidence level for finding an anomaly is desired
- The anomaly has a "skinny" (rather than a "fat") elliptical shape
- The anomaly is small.

Table D-3. Grid Spacing (m), Probability of Hitting Hot Spot = 0.95.

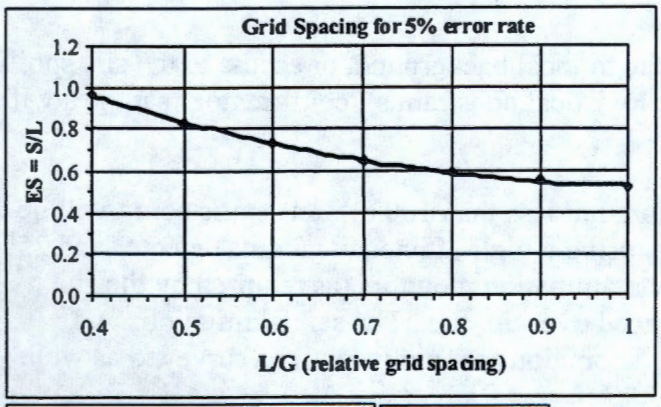
2L = Length of Semi-Major Axis (m)	ES = Shape Parameter, 1 = Circle			
	0.25	0.50	0.75	1.00
1	0.7	1.2	1.6	1.93
2	1.4	2.39	3.2	3.86
3	2.11	3.59	4.81	5.79
4	2.81	4.79	6.41	7.73
5	3.51	5.99	8.01	9.66
6	4.21	7.18	9.61	11.59
7	4.92	8.38	11.21	13.52
8	5.62	9.58	12.81	15.45
9	6.32	10.78	14.42	17.38
10	7.02	11.97	16.02	19.32
25	17.56	29.94	40.05	48.29
50	35.11	59.87	80.09	96.58
75	52.67	89.81	120.14	144.87
100	70.22	119.75	160.18	193.16

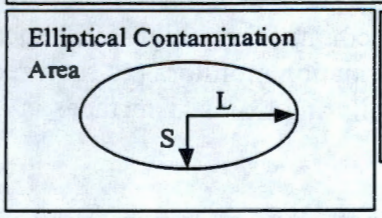
As an example, assume that the theoretical anomaly is elliptical with a shape parameter ES = 0.5 and a size parameter L = 6 m. Given the formulae stated above, this anomaly is a fairly skinny ellipse with a long axis of 12 m and a short axis of 6 m. If the desired probability of detecting a hot spot at least this large is 95%, then the grid spacing (G) from Table D-3 is 7.18 m. If the area of the waste disposal site is 500 m^2, then the sample size $n = 500/7.18^2 = 9.70$. Thus, 10 locations would be sampled. A schematic of an example site is provided in Figure D-1.

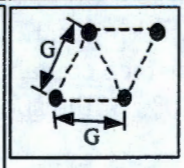
Figure D-1. Schematic of a Typical Burn Pit.



Determination of Grid Spacing Based on Known/Anticipated Anomaly Size







Grid Spacing (m), Probability of Hitting Hot Spot = 0.95

Length of Semi-major Axis (m)	ES=S/L = Shape Parameter, 1 = Circle			
	0.25	0.50	0.75	1.00
1	0.7	1.2	1.6	1.93
2	1.4	2.39	3.2	3.86
3	2.11	3.59	4.81	5.79
4	2.81	4.79	6.41	7.73
5	3.51	5.99	8.01	9.66
6	4.21	7.18	9.61	11.59
7	4.92	8.38	11.21	13.52
8	5.62	9.58	12.81	15.45
9	6.32	10.78	14.42	17.38
10	7.02	11.97	16.02	19.32
25	17.56	29.94	40.05	48.29
50	35.11	59.87	80.09	96.58
75	52.67	89.81	120.14	144.87
100	70.22	119.75	160.18	193.16

D5.0 MINIMUM FIELD SCREENING REQUIREMENTS

D5.1 RADIOLOGICAL FIELD SCREENING

Sites with dimensions smaller than 2 by 2 m (6.5 by 6.5 ft) will be monitored by taking single static counts in the center of the site or similar anomalous locations with a high-efficiency gamma detector (e.g., HPGe or NaI:Tl) and 50% to 100% coverage with beta and alpha surface contamination monitors (as required by the site profile).

In such cases where overburden and potential subsurface contamination exists below the top 15 cm, excavation spoils and surfaces will be monitored by taking single static counts with a high-efficiency gamma detector and beta and alpha surface contamination monitors (as required by the site profile). Coverage will include 50% of the spoils and exposed surfaces, as well as any anomalies discovered during excavation.

The detector/methodology minimum detectable activity (MDA) will be less than 50% of the DCGL for the expected radionuclides. This method assumes that contamination is most likely on the surface. This method will detect high-energy gamma contamination within 15 cm (6 in.) of the survey surface. These field screening methods will not be effective for conditions where the contamination is more than 15 cm below the survey surface (e.g., backfilled or unexposed site).

In cases where the MDA is not achievable due to local background, or access to the site spoils and anomalous surfaces is not feasible (e.g., logistical constraints), confirmatory samples will be taken.

At sites with dimensions greater than 2 by 2 m, but less than 100 m^2, one static count will be taken for every 4 m^2 of exposed surface area, using a high-efficiency gamma detector and 25% to 50% coverage with beta and alpha surface contamination monitors (as required by the site profile). The static counts will be evenly spaced over the site. The same limitations and assumptions used for small sites apply. Any anomalous conditions will be surveyed as well.

Excavation spoils and surfaces will be monitored by taking static counts with a high-efficiency gamma detector and coverage with beta and alpha surface contamination monitors (as required by the site profile). Coverage will include 25% to 50% of the spoils and exposed surfaces, as well as anomalies discovered during excavation.

Sites with surface areas greater than 100 m^2 may employ one of three options.

1. The methodology for medium-sized (4 m^2 to 100 m^2) sites may be employed.

2. Mapping technologies that record radiation levels may be used (e.g., MRDS, Mobile Surface Contamination Monitoring tractor), with limited follow-up static counts. If advanced mapping technologies are used, only contaminants that are not monitored (e.g., alpha) require separate contamination surveys. In this case, 10% coverage surveys would suffice.

3. The third option is to use MARSSIM guidance to locate a statistically generated number of static count locations based on observed sample variance, and scan survey 50% to 100% of the area to a higher MDA, the elevated measurement comparison (EMC). The EMC is a MARSSIM concept where the samples determine the average concentration and variance, and the EMC surveys are designed to demonstrate that no large areas of significantly elevated activity exist. This option is best utilized as verification that the site is clean following the discovery of anomalous conditions.

On sites with backfill material over the site, or sites where the areas of likely contamination cannot be reached, backfill removal and sampling are required to determine if the site is contaminated. In this case, contamination monitoring for interim closure is not possible and will not be considered as a potential release mechanism. Direct measurements and verification samples will be taken for site categorization.

D5.2 NONRADIOLOGICAL FIELD SCREENING

Due to the limited applicability of nonradionuclide field screening methods, it is not practical to specify a percentage of coverage or when or at which sites nonradiological field screening is needed. At sites where nonradiological field screening is warranted, after selection of target field screening compounds (based on site COPCs), a minimum of four samples should be collected from each site component present. Where practical constraints do not limit the umber of field screening samples collected, the minimum should be at least 10.

D6.0 REFERENCES

BHI, 1999, *Data Quality Objectives Summary Report for the 100 Area Remaining Confirmatory Sampling Effort Sites*, BHI 01249, Draft, Bechtel Hanford, Inc., Richland, Washington.

DOE-RL, 1998a, *100 Area Remedial Action Sampling and Analysis Plan*, DOE/RL-96-22, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1998b, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, DOE/RL-96-17, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

EPA, 1999, *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units*, U.S. Environmental Protection Agency, Region X, Richland, Washington.

EPA, 1989, *Methods for Evaluating the Attainment of Cleanup Standards, Volume 1: Soil and Solid Media*, EPA 230/02-89/042, U.S. Environmental Protection Agency, Washington, D.C.

Gilbert, R. O. 1987, *Statistical Methods for Environmental Pollution Monitoring*, Van Nostrand Reinhold, New York, New York.

APPENDIX E

SAMPLING DESIGN FOR POTENTIALLY VOLUMETRICALLY CONTAMINATED CLEARWELLS AND IN SITU DECONTAMINATION AND DECOMMISSIONING SITES CONCEPTUAL SITE MODEL

E1.0 SAMPLING DESIGN FOR POTENTIALLY VOLUMETRICALLY CONTAMINATED CLEARWELLS AND IN SITU DECONTAMINATION AND DECOMMISSIONING SITES

Clearwells and in situ decontamination and decommissioning (D&D) sites are basement structures that received rubble from decommissioning of 100 Areas facilities. Clearwells are different from in situ D&D sites in that clearwells received decommissioning wastes from other facilities, whereas in situ D&D uses the existing facility below-grade structure as a repository for contiguous superstructure demolition rubble. Section E2.0 covers aspects of the conceptual site model (CSM) for clearwells and in situ D&D sites that are specific to these types of waste sites. The error tolerances discussion is presented in Section E3.0. The sampling design is presented in Section E4.0.

E2.0 CONCEPTUAL MODEL AND ASSUMPTIONS FOR CLEARWELLS AND IN SITU DECONTAMINATION AND DECOMMISSIONING SITES

This CSM is defined by the physical configuration and contamination distribution characteristics that affect sampling for interim site closure. The other aspects of conceptual models examined in the data quality objective (DQO) process, including future land use, exposure scenarios, and identification of contaminants of potential concern (COPCs), are found in Sections 1.0 through 5.0 of the DQO summary report (BHI 1999).

Clearwells are assumed to be below-grade concrete structures with walls and a floor. In situ D&D sites are expected to be concrete structures that also extend below grade. The below-grade portion of the decommissioned structures have walls that may not extend to the local grade elevation (e.g., may be entirely below grade), but the structures do have concrete floors. The physical components likely to be present at these sites include the clearwell or below-grade walls and floors, debris or building rubble (inside the clearwell or below-grade structure), inlet and outlet pipe tunnels or ducts, backfill, and surface gravel. It is assumed that all filters from the filter buildings; water, sludge, and asbestos lagging from the wastewater pumping stations; and all fixtures, equipment, hardware, and piping have been removed from the sites. It is assumed that noncontaminated backfill and gravel were deposited at these sites. The sampling media at these sites includes the concrete clearwell structures, below-grade concrete walls and floors, demolition debris and concrete rubble inside the structures, concrete ducts and pipe tunnels, and surrounding and underlying soils.

It is assumed that the locations and dimensions of all sites and associated ductwork and tunnels are known. Assessment of ductwork and tunnels extends only to where these structures meet or used to meet the originating or terminating structure. Lateral boundaries may extend 0.3 m (1 ft) into the native soils on either side of the site component. Vertical boundaries may extend 0.6 m (2 ft) into the underlying soils, whether in shallow or deep zone soils.

Because most of the structures are filled with rubble/debris that cannot be completely removed, the walls and floors of most structures will not be accessible. Vertical core sampling of the soils underlying the below-grade structures also will not be possible due to the constraints mentioned above. If a clearwell is empty, the surface of floors and walls will be assessed by analyzing surface concrete samples collected to a depth of 0.64 cm (0.25 in.). The soils underlying the floor slabs will not be intrusively sampled unless the exposed concrete floor surfaces exceed the shallow zone soil contamination remedial action goals (RAGs) and there is evidence of significant cracks or other breaching that would provide direct leakage paths for contaminated liquids. If the underlying soils must be sampled, concrete coring or jackhammers will be used to obtain the necessary sampling access.

Soils to the sides of site components are assumed accessible by backhoe excavation or core sampling. It is assumed that all ducts and tunnels can be located, unearthed, and the interiors exposed. The exposed concrete surfaces within ducts and tunnels will be sampled to a depth of 0.64 cm (0.25 in.) to assess their contamination status. The soils underlying ducts and tunnels will not be intrusively sampled unless the floor surfaces exceed the shallow zone soil contamination RAGs and there is evidence of significant cracks or other breaching that would provide direct leakage paths for contaminated liquids.

The components most likely to be contaminated are the inlet ducts/tunnels, below-grade floors, below-grade exterior walls, below-grade concrete rubble/debris, soils under below-grade structures, outlet ducts/tunnels, and soils to sides of main structures and soils surrounding ducts/tunnels. This relative scaling of probabilities and the estimates of the probabilities of contamination for one or more of the media lead to the determination of the probability of contamination for all sampling media. The estimates of the probabilities of contamination can be based on historical data or professional judgment.

The probability of contamination will be scaled within a range bounded by the inlet ducts/tunnels (the maximum) and the soils to sides of main structures and soils surrounding ducts/tunnels (the minimum). Scale the probability for the remaining components to values within the range defined by these maximum and minimum values.

E3.0 DECISION ERROR TOLERANCES FOR CLEARWELLS AND IN SITU DECONTAMINATION AND DECOMMISSIONING SITES

This section shows the development of the error tolerances for the clearwells and in situ D&D sites sampling design. This sampling and analysis plan (SAP) makes frequent reference to the generic tables and discussions in Parts I through III of this SAP from which the sampling design was developed.

The number of samples and the sample collection design will be statistically based wherever possible. If the assumptions stated in Section E1.0 are not met, a statistical sampling plan cannot be implemented and regulatory input should be sought for the development of an alternate sample strategy.

Specific waste streams assumed for the clearwells and in situ D&D sites include animal waste, reactor effluent, debris, reactor condensate, and miscellaneous trash. The COPCs associated with these waste streams include radionuclides, metals, and a subset of organic constituents. There are some allowable residual contamination level (ARCL) data associated with these sites. The ranges for the radionuclides presented in the ARCL data are shown in Table E-1.

Table E-1. Contaminants of Potential Concern Range Values. (2 Pages)

WS #	Media	COPCs	Range	
			Lower Limit	Upper Limit
Animal waste, reactor effluent, debris, reactor condensate, and miscellaneous trash	Concrete, debris, and soils	As	N/A	N/A
		Cr^{+6}	N/A	N/A
		Pb	N/A	N/A
		Zn	N/A	N/A
		PCBs	N/A	N/A
		Pesticides	N/A	N/A
		SVOCs	N/A	N/A
		VOCs	N/A	N/A
		Eu-155	N/A	N/A
		I-131	N/A	N/A
		Pu-238	N/A	N/A
		Pu-239/240	N/A	N/A
		Th-232	N/A	N/A
		U-233/234	N/A	N/A
		U-238	N/A	N/A
115-F Building[a] (WIDS No. 132-F-3)	Concrete, debris, and soils	H-3	1.5	570
		C-14	22	8,400
		Co-60	1	20
		Sr-90	1.1	16
		Cs-137	0.32	0.32
		Eu-152	2	7
		Eu-154	1	4
117-H Filter Building[a] (WIDS No. 132-H-2)	Concrete, debris, and soils	H-3	17	17
		C-14	3	3
		Co-60	6	56
		Sr-90	13	45
		Cs-137	22	89
		Eu-152	1	63
		Eu-154	2	8
		Pu-239	5	29

Table E-1. Contaminants of Potential Concern Range Values. (2 Pages)

WS #	Media	COPCs	Range	
			Lower Limit	Upper Limit
1608-F lift station[a] (WIDS No. 132-F-6)	Concrete, debris, and soils	H-3	1.6	888
		C-14	0.13	883
		Co-60	0.151	1,250
		Sr-90	7.77	13,200
		Cs-137	3.48	778
		Eu-152	0.2	2,650
		Eu-154	14.4	461
		Gross alpha	0.21	165.4
1608-H lift station[a] (WIDS No. 132-H-3)	Concrete, debris, and soils	H-3	1.21	1,240
		C-14	0.75	594
		Co-60	1	1,850
		Sr-90	1	667
		Cs-137	1	477
		Eu-152	0.21	136
		Gross alpha	2	29

N/A = not applicable

[a]Data from hot spot (nonremovable contamination) samples taken during building decommissioning effort. Available in ARCL documentation, shown here for information only. Not necessarily indicative of actual site conditions due to the conservatism introduced by sampling hot spots only (e.g., high biased data).

Generic Table 2-1 shows the action levels for the COPCs associated with the Remaining Sites' clearwells and in situ D&D sites. Action levels are provided for each parameter that will be used to support a decision. The derived concentration guideline levels (DCGLs) for radionuclide COPCs will be determined after isotopic distributions have been estimated.

Generic Table 1-7 shows the tolerable decision errors for evaluation of the mean concentration (note: these errors apply to all media identified for the CSM and thus do not require specific identification for use of the table). The false-positive rate is based on the confidence limit for the mean specified in the remedial design report/remedial action work plan for the100 Areas (DOE-RL 1998b) and the *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units* (Remaining Sites ROD) (EPA 1999).. The false-negative error rate follows from the 100 Areas remedial action SAP (DOE-RL 1998a).

Table E-2 specifies the inputs required to determine the number of samples for nonradionuclide COPCs. Because there are no nonradionuclide historical data associated with these sites, the probability that a site component is contaminated is specified as stated in Table E-2. The probabilities are specified by the qualitative ranking of components identified in the CSM.

Table E-2. Inputs for the Number of Samples Calculation When the Sample Maximum Will Be Compared to a Threshold.

DS #	Media	COPCs	Parameter of Interest	Range	Pr (contaminated)
2	Inlet ducts/tunnels	As Cr^{+6} Pb Zn PCBs Pesticides SVOCs VOCs	Population maximum concentration	TBD	0.50
	Below-grade floors				0.30
	Below-grade exterior walls				0.30
	Below-grade rubble/debris				NA
	Soils under below grade structure/clearwell				0.20
	Outlet ducts/tunnels				0.20
	Lateral soils and soils under ducts/tunnels				0.05
4	Inlet ducts/tunnels	As Cr^{+6} Pb Zn PCBs Pesticides SVOCs VOCs	Population maximum concentration	TBD	0.50
	Below-grade floors				0.30
	Below-grade exterior walls				0.30
	Below-grade rubble/debris				NA
	Soils under below grade structure/clearwell				0.20
	Outlet ducts/tunnels				0.20
	Lateral soils and soils under ducts/tunnels				0.05

The bounds of the gray region are presented in a generic format for evaluating the mean concentrations in all of the Remaining Sites in generic Table 1-8 and the associated text.

The bounds of the gray region are based on a DQO established for the analytical laboratory precision (BHI 1999). The laboratory relative percent difference (RPD_{lab}) is required to be equal to or less than 30% to satisfy the established analytical precision DQO. An additional 10% is added to the RPD_{lab} to account for some amount of population variability; the 10% is based solely on judgment. This assumption results in a LBGR default value that is approximately 68.8% of the applicable RAG (where the LBGR is 1-RSD, and RSD is derived from equation J-2 of Appendix J). The LBGR is always 68.8% of the RAG based on the DQO for laboratory precision unless the DQO changes. If the RPD from the laboratory is >30% (the DQO), then a decision has to be made about data usability.

Since there are no historical data associated with most of these sites, the "sampling variability" or the relative standard deviation for the site (RSD_{site}) is determined by equation J-2 in Appendix J. The sampling variability is a combination of all sources of variability: laboratory, site, sample collection, environmental conditions, time of day, etc. In lieu of having sampling variability information at the time of sample planning, a value of 100% is assumed. If the sampling variability (RSD_{site}) is greater than 100%, the original or default number of samples calculated for the site will not be sufficient to meet error tolerances. If the sampling variability (RSD_{site}) is less than 100%, the number of samples should be adequate. The details of proper application of the equations and the assumptions built into the computation of the default number of samples are presented in Appendix J.

E4.0 SAMPLING DESIGN FOR CLEARWELLS AND IN SITU D&D SITES

This section presents guidance for sampling at clearwells and in situ D&D sites. As discussed in Section E2.0, certain components have partial or total sampling access restrictions. It is expected that only the top 2.4 m (8 ft) of debris along the edges of the site will be accessible for sampling. Samples from these areas would not provide a random subset from all possible debris/rubble samples at the site and, therefore, are not representative of the entire debris component.

Thus error tolerances for decisions based on estimates of population maximum, proportions, and means cannot be tested or controlled. However, depending on the type of site (clearwells versus in situ D&D sites) and the type of COPC (radiological versus nonradiological), existing data may be sufficient to make administrative or statistical decisions for specific components. Discussions for the nonstatistical sampling of the components are presented below.

E4.1 DEBRIS/RUBBLE

Waste Information Data System (WIDS) database documentation for the clearwells indicates that one site contains asbestos siding tiles. Another clearwell reportedly received potentially radiologically contaminated debris from the 183-H solar basins. Although this material was radiologically released, concerns were later raised over the data quality used for the release. Consequently, the site has been posted as a "soil contamination" site. It is unlikely that this debris would be located and re-analyzed. Given the potential for hazardous and suspected radiological contamination within these sites, it may be prudent to turn these sites over to the Remedial Action Project.

Release of in situ D&D sites was generally performed through ARCL data. A recent review of the ARCL data (BHI 1999) indicates that these data appear to be defensible and of good quality from a radiological chemistry and risk standpoint. From a statistical standpoint, the ARCL data are much more representative of the site conditions than any data that could be collected in the future, in view of the current access limitations. If nonradiological contaminants can be dealt with on an administrative basis and all other components pass their decision criteria, a proposal for interim closure for these sites may be submitted based on the ARCL data. If the nonradiological COPCs cannot be dealt with administratively, then those sites should be turned over to the Remedial Action Project.

E4.2 EXTERIOR WALLS AND FLOORS

For each pair of clearwells in the Remaining Sites, one clearwell remains at least partially empty. It is assumed that both clearwells, as a pair, received the same water from the same source, thus wall and floor samples from one would be representative of both. A design for the sampling of 6-mm- (0.25-in.) deep concrete chips from the walls and floors in the accessible clearwell is presented in Sections E4.5 and E4.6. If an assessment of the debris/rubble in Section E4.1 leads

to a decision to turn the site over to the Remedial Action Project, there is no need for sampling of the walls and floors.

The in situ D&D sites have no access to the floors and walls, because of the presence of demolition debris. As noted above, ARCL data exist for the walls and floors, and may be suitable for interim site closure with respect to radionuclides. A definitive data quality assessment should be performed to determine whether these data can be used to support decision making. If these data are not usable to support interim site closure, then these sites are also recommended for remedial action.

E4.3 UNDERLYING SOILS

The soils underlying floor surfaces, ducts, and tunnels will not be intrusively sampled unless the floor surfaces exceed the shallow zone soil contamination RAGs and there is evidence of significant cracks or other breaching that would provide direct leakage paths for contaminated liquids. Soils under the partially empty clearwell may be sampled if access holes may be created in the floor by coring or jackhammering. Because of the sampling access limitations discussed above, soils underlying the in situ D&D sites and the partially filled clearwells are considered inaccessible, except by angled drilling techniques. Angle drilling is not likely a viable approach because of the costs and difficulties that would be encountered retrieving viable samples from depth in the rock-laden Hanford Site soils. Therefore, unless sampling access through the floor of the structure is feasible, the recommendation is to carefully weigh the cost of confirmatory sampling against remedial action prior to commencing any field investigation.

E4.4 OTHER COMPONENTS

All other components (inlet and outlet ducts/tunnels, soil under ducts/tunnels and lateral soils) are assumed to be accessible for sampling. The sampling designs are presented in Section E4.5.

The decision to sample these sites depends on existing data, sampling access, and the administrative decisions reached. For in situ D&D sites, sampling of the accessible components (e.g., inlet and outlet ducts/tunnels, lateral soils, and soils surrounding the ducts/tunnels) should proceed if any of the following occur:

- It is determined that the ARCL data, for below-grade exterior walls and floors and debris in the below-grade structure, are not appropriate to support the decision for interim closure of the site.

- Nonradiological contaminants have been not administratively dealt with by project decisions makers for the below-grade exterior walls and floors and the contained debris.

- Underlying soils are considered in the interim site closure decision, in which case, soil sampling will be performed per Section E4.3 (above).

Sampling of the accessible components at the clearwell sites should proceed if any of the following occur:

- The documented disposal data are deemed unreliable.
- Asbestos tiling is considered hazardous.
- Data from the potentially radiologically contaminated debris from the 183-H solar basins are deemed unacceptable.
- The walls, floors, and underlying soils of one clearwell are considered unrepresentative of both clearwells at a given site.

E4.5 STEP I SAMPLING

The Step I sampling design determines the number of samples collected (sampling frequency) within each backhoe bucket or the number of corings required.

The minimum sample grid will be based on the volume and/or area of soil (or other material) that a single sample will represent (width of a backhoe bucket) and will follow a line consistent with site coordinates, or will follow a line dictated by site limitations on backhoe access. Table E-3 summarizes the Step I sampling requirements for the clearwells and in situ D&D sites.

The required number of sampling locations is calculated for each nonradiological COPC and the most conservative number (the largest) is chosen. If a site has both types of COPCs, the number of sampling locations will be the maximum number calculated for radiological COPCs and nonradiological COPCs.

After the number of samples is determined, the locations of these samples will be randomly selected from the grid covering the surface area for the specific component. The grid coverages will include the following:

- The bottom half of the inside surface of the inlet and outlet ducts/tunnels (i.e., the lower half of the walls and the entire floor).
- The entire clearwell floor, if empty; otherwise the portion that is not covered and is accessible. If more than 50% of the floor is covered with debris, then it is considered inaccessible for statistical sampling.
- All four clearwell walls, if the clearwell is empty; otherwise the walls that are accessible for sampling. Again, if approximately 50% or more of the clearwell is filled with debris, then it is not considered accessible for statistical sampling.
- Sampling locations for soils (if sampled) underlying the clearwell floor will be randomly selected from those chosen for the floor.

Table E-3. Sampling Requirements for Clearwells and In Situ D&D Sites. (2 Pages)

Site Component	COPCs [a]	Parameter of Interest	Statistic of Interest	RSD_{site} [b]	RPD_{lab} [b]	LBGR [b] (% of RAG)	Alpha	Beta	Pr (contaminated)	Relative Error Consequence Ratio	Default # of Lateral Sampling Locations in (X-Y) Plane	Number of Lateral Sampling Locations in (X-Y) Plane Based on Analogous Site Data	Calculated # of Lateral Sampling Locations in (X-Y) Plane
Inlet ducts and tunnels	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	0.50	N/A	64	Computed from analogous data	Site-specific computation
	Non-radionuclides	Maximum	Maximum Concentration	1.00	0.30	68.8%	0.05	0.20	0.50	2	3[c]	Computed from analogous data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	Computed from analogous data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A
Below grade floors[c]	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	0.30	N/A	64	Computed from analogous data	Site-specific computation
	Non-radionuclides	Maximum	Maximum Concentration	1.00	0.30	68.8%	0.05	0.20	0.30	2	3[c]	Computed from analogous data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	Computed from analogous data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A
Below grade exterior walls[c]	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	0.30	N/A	64	Computed from analogous data	Site-specific computation
	Non-radionuclides	Maximum	Maximum Concentration	1.00	0.30	68.8%	0.05	0.20	0.30	2	3[c]	Computed from analogous data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	Computed from analogous data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A
Below grade rubble/debris	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	N/A	N/A	64	Computed from analogous data	Site-specific computation
	Non-radionuclides	Maximum	Maximum Concentration	1.00	0.30	68.8%	0.05	0.20	N/A	2	3[c]	Computed from analogous data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	Computed from analogous data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A
Soils under below grade structure/ clearwell[d]	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	0.20	N/A	64	Computed from analogous data	Site-specific computation
	Non-radionuclides	Maximum	Maximum Concentration	1.00	0.30	68.8%	0.05	0.20	0.20	2	3[c]	Computed from analogous data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	Computed from analogous data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A

Table E-3. Sampling Requirements for Clearwells and In Situ D&D Sites. (2 Pages)

Site Component	COPCs [a]	Parameter of Interest	Statistic of Interest	RSD_{site} [b]	RPD_{lab} [b]	LBGR [b] (% of RAG)	Alpha	Beta	Pr (contaminated)	Relative Error Consequence Ratio	Default # of Lateral Sampling Locations in (X-Y) Plane	Number of Lateral Sampling Locations in (X-Y) Plane Based on Analogous Site Data	Calculated # of Lateral Sampling Locations in (X-Y) Plane
Outlet ducts/tunnels	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	0.20	N/A	64	Computed from analogous data	Site-specific computation
	Non-radionuclides	Maximum	Maximum Concentration	1.00	0.30	68.8%	0.05	0.20	0.20	2	3[c]	Computed from analogous data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	Computed from analogous data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A

[a] For deep zone nonradionuclides, the 95% UCL for the mean is the only statistic of interest.

[b] Default value:

In lieu of having a RSD_{site} at the time of sample planning, a value of 100% is assumed.

In lieu of having a RPD_{lab} at the time of sample planning, a value of 30% is assumed.

In lieu of analytical data or field screening results, the LBGR may be taken at 68.8% of the RAG based on RPDs established above.

[c] Per the lookup table, n=3; however, 4 samples is the minimum number of samples that should be collected if n<4.

[d] These components are inaccessible for sampling at in situ D&D sites.

N/A = not applicable

- A single line of the grid squares will be placed to either side of the inlet and outlet ducts/tunnels and around the perimeters of the in situ D&D sites and the clearwells.

- Sampling locations for soils (if sampled) underlying the inlet and outlet ducts/tunnels will be randomly selected from those chosen for the ducts/tunnels.

If a specific site does not meet the general construction assumptions, the sampling frequency and/or locations will be modified to allow for sample coverage of the lateral and vertical dimensions of each sampling media present at the site.

E4.6 STEP II SAMPLING

Step II sampling requirements are shown in Table E-4.

Table E-4. Step II Sampling Frequency and Requirements for Clearwells and In Situ D&D Sites.

Component	Sampling Frequency/Requirements
Concrete surfaces	Radiologically field screen concrete surface prior to sampling.
	The number of samples collected is equal to the number of sampling locations because only surface samples will be collected.
Soils under concrete floor (if sampled)	Soils underlying the concrete slab will only be sampled if there are significant cracks in the slab. If significant cracks are detected, at least one sample will be collected beneath the crack at the onset of the native soils. The underlying soils will not be sampled at depth unless it is determined that the COPCs for the site are extremely mobile.

E5.0 MINIMUM FIELD SCREENING REQUIREMENTS

E5.1 RADIOLOGICAL FIELD SCREENING

One static count will be taken for every 4 m^2 of exposed concrete surface area, using a high-efficiency gamma detector and 25% to 50% coverage with beta and alpha surface contamination monitors (as required by the site profile). The static counts will be evenly spaced over the exposed surface area. Any anomalous conditions will be surveyed as well. In cases where overburden and potential subsurface contamination exists below the top 15 cm, excavation spoils (including exhumed rubblized material) and surfaces will be will be monitored by taking single static counts with a high-efficiency gamma detector and beta and alpha surface contamination monitors (as required by the site profile).

The detector/methodology minimum detectable activity (MDA) will be less than 50% of the DCGL for the expected radionuclides. This method assumes that contamination is most likely on the surface of the material surveyed. This method will detect high-energy gamma

contamination within 15 cm (6 in.) of the survey surface. These field screening methods will not be effective for conditions where the contamination is more than 15 cm below the exposed survey surface.

In cases where the MDA is not achievable due to local background, or access to the site spoils and anomalous surfaces is not feasible (e.g., logistical constraints), confirmatory samples will be taken on the basic assumption that the site is clean.

E5.2 NONRADIOLOGICAL FIELD SCREENING

Due to the limited applicability of nonradionuclide field screening methods, it is not practical to specify a percentage of coverage. After selection of target field screening compounds (based on site COPCs), a minimum of four samples should be collected from each site component present. Where practical constraints do not limit the number of field screening samples collected, the minimum should be at least 10.

In addition, key to application of the field screening approach is the proper application of the observational approach. All anomalous conditions identified should be field screened for elevated COPC levels.

E5.0 REFERENCES

BHI, 1999, *Data Quality Objectives Summary Report for the 100 Area Remaining Confirmatory Sampling Effort Sites*, BHI 01249, Draft, Bechtel Hanford, Inc., Richland, Washington.

DOE-RL, 1998a, *100 Area Remedial Action Sampling and Analysis Plan*, DOE/RL-96-22, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1998b, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, DOE/RL-96-17, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

EPA, 1999, *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units*, U.S. Environmental Protection Agency, Region X, Richland, Washington.

APPENDIX F

SAMPLING DESIGN FOR POTENTIALLY VOLUMETRICALLY CONTAMINATED INTACT CONCRETE SLABS CONCEPTUAL SITE MODEL

F1.0 SAMPLING DESIGN FOR POTENTIALLY VOLUMETRICALLY CONTAMINATED INTACT CONCRETE SLABS

Intact concrete slabs include grade-level concrete structures that remain after some degree of decommissioning or demolition has been performed. The conceptual site model (CSM) for these slabs in Section F2.0 are specific to these types of waste disposal sites. A discussion of error tolerances is presented in Section F3.0. The sampling design is presented in Section F4.0.

F2.0 CONCEPTUAL MODEL AND ASSUMPTIONS FOR INTACT CONCRETE SLABS

This CSM is defined by the physical configuration and contamination distribution characteristics that affect sampling for interim site closure. The other aspects of conceptual models examined in the data quality objectives (DQO) process, including future land use, exposure scenarios, and identification of contaminants of potential concern (COPCs), are found in Sections 1.0 through 5.0 of the DQO summary report (BHI 1999).

The physical components likely to be present at these sites include concrete slabs, U-supports for storage tanks, and residual piping associated with the tanks. The original storage tanks have been removed from these sites. Remaining slabs are assumed to be concrete, in place, intact, and visible. Tank supports may be in place and intact or may exist as visible rubble on the surface of the site. The associated piping is assumed to have been above ground or within the slab during the period of operation and detached from associated structures and lying on the surface at the present. The sampling media at these sites include the concrete (i.e., slabs and supports, if intact), debris (i.e., piping and supports, if rubbleized), adjacent surface soils, and underlying soils.

Because slabs and supports are assumed to be intact or rubblized and visible, the spatial boundaries of these components will be clearly delineated on inspection. Spills onto the surrounding soils and into underlying soils were possible either when filling or draining the tanks. These spill areas are addressed under a separate CSM sampling design, as are associated pipelines. Any contaminants that have come into contact with concrete are assumed to have penetrated no more than 0.64 cm (0.25 in.) into the concrete surface. It is assumed that spill boundaries are clearly defined. The subsurface soil boundary is 0.6 m (2 ft) below the concrete slab. Because these sites have been exposed to weather over time, some transport into subsurface soil may have occurred. The soils beneath the concrete slabs (if they are intact) are assumed to be uncontaminated. If there are visible cracks in the concrete that could result in contaminants reaching the underlying soils, the underlying soils are assumed to be potentially contaminated and will be sampled.

Access to all sampling media is assumed to be unimpeded. The concrete slab and supports will be sampled by removing 0.64-cm (0.25-in.)-deep surface chips. Debris at the site may be surveyed for radiological contamination and may be sampled for constituents with land disposal

restrictions (LDRs). Based on the results of the debris sampling, it is assumed that the debris will be removed to as necessary to facilitate soil sampling, where required. All surface and subsurface soils are assumed suitable for sampling by excavation, coring, augering, or jackhammering. Within the delineated site boundaries, the surface and subsurface soils will be sampled under the protocols presented in Appendix B and will not be discussed further in this appendix.

Concrete slab sampling will be performed in two phases:

- Characterize potentially contaminated debris, including rubblized concrete supports and piping
- Characterize intact/upright tank supports and concrete slabs.

Debris will be screened for radiological contamination according to MARSSIM guidance. In addition, debris with potential for volumetric contamination will be analyzed for LDR constituents (note that waste designation is beyond the scope of this document and will be addressed in a separate effort). The results of the screening and fixed laboratory analyses will determine the disposition of the debris.

The assumed ranking of components in order of probability of contamination is concrete slab under tank piping, other concrete slab areas, and concrete tank supports. The relative scaling of probabilities and the estimates of the contamination probabilities lead to the determination of the probability of contamination for the sampling media in Section F4.0. The estimates of the probabilities of contamination can be based on historical data or professional judgment.

The probability of contamination will be scaled within a range bounded by the concrete slab under inlet/outlet pipes (the assumed maximum) and the concrete supports (the assumed minimum). Scale the probability for the remaining concrete slab to a value within the range defined by these maximum and minimum values.

F3.0 DECISION ERROR TOLERANCES FOR INTACT CONCRETE SLABS

This section shows the development of the error tolerances for the intact concrete slabs sampling design. This SAP makes frequent reference to the generic tables and discussions in Parts I through III of this SAP from which the sampling design was developed.

Specific waste streams assumed for the intact concrete slabs include debris, hexavalent chromium, and spent acid/caustics. The COPCs associated with these waste streams include only inorganic constituents. As needed, future sites may be identified where radiological COPCs are suspected; thus, contingencies for radionuclides are presented in the following discussion. Because there are no historical data associated with these sites, the concentration ranges of the COPCs are unknown at this time; thus, upper and lower range limits associated with the Remaining Sites' slabs have not yet been established.

Refer to generic Table 2-1 for the action levels for the COPCs associated with the Remaining Sites slabs. Action levels are provided for each parameter that will be used to support a decision. The DCGLs for radionuclide COPCs will be determined after isotopic distributions have been estimated.

Generic Table 1-7 shows the tolerable decision errors for evaluation of the mean concentration (note: these errors apply to all media identified for the CSM and thus do not require specific identification for use of the table). The false-positive rate (5%) is based on the confidence limit for the mean specified in the remedial design report/remedial action work plan (RDR/RAWP) for the 100 Areas (DOE-RL 1998b) and the *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units* (Remaining Sites ROD) (EPA 1999). The false-negative error rate (20% for the mean) follows from the 100 Area remedial action sampling and analysis plan (SAP) (DOE-RL 1998a).

Table F-1 specifies the inputs required to determine the number of samples for nonradionuclide COPCs. Because there are no historical data associated with these sites, the probability that a site component is contaminated is specified as stated in Table F-1. The probabilities are specified by the qualitative ranking of components identified in the CSM. The lower limit for the probability of assuming a component is contaminated is 0.05. The component with the highest probability of contamination, the concrete, is specified as 0.50.

Table F-1. Inputs for the Number of Samples Calculation When the Sample Maximum Will Be Compared to a Threshold.

DS #	Media	COPCs	Parameter of Interest	Range	Pr(contaminated)
2	Concrete under inlet/outlet pipes	As, Ag, Ba, Cd, Cr^{+6}, Cr, Hg, Pb, Se, and sulfate	Population maximum concentration	TBD	0.50
	Remaining concrete slab				0.30
	Concrete supports				0.20
4	Concrete under inlet/outlet pipes	As, Ag, Ba, Cd, Cr^{+6}, Cr, Hg, Pb, Se., and sulfate	Population maximum concentration	TBD	0.50
	Remaining concrete slab				0.30
	Concrete supports				0.20

TBD = deep zone RAGs to be determined

The bounds of the gray region are presented in a generic format for evaluating the mean concentrations in all of the Remaining Sites in generic Table 1-8 and the associated text.

The bounds of the gray region are based on a DQO established for the analytical laboratory precision (BHI 1999). The laboratory relative percent difference (RPD_{lab}) is required to be equal to or less than 30% to satisfy the established analytical precision DQO. An additional 10% is added to the RPD_{lab} to account for some amount of population variability; the 10% is based solely on judgment. This assumption results in a LBGR default value that is approximately 68.8% of the applicable remedial action goal (RAG) (where the LBGR is 1-RSD, and RSD is derived from equation J-2 of Appendix J). The LBGR is always 68.8% of the RAG based on the

DQO for laboratory precision unless the DQO changes. If the RPD from the laboratory is >30% (the DQO), then a decision has to be made about data usability.

Since there are no historical data associated with most of these sites, the "sampling variability" or the relative standard deviation for the site (RSD_{site}) is determined by equation J-2 in Appendix J. The sampling variability is a combination of all sources of variability: laboratory, site, sample collection, environmental conditions, time of day, etc. In lieu of having sampling variability information at the time of sample planning, a value of 100% is assumed. If the sampling variability (RSD_{site}) is greater than 100%, the original or default number of samples calculated for the site will not be sufficient to meet error tolerances. If the sampling variability (RSD_{site}) is less than 100%, the number of samples should be adequate. The details of proper application of the equations and the assumptions built into the computation of the default number of samples are presented in Appendix J.

F4.0 SAMPLING DESIGN

This section presents guidance for sampling at sites with intact concrete slabs. The term "component" is used to denote both physical components and sampling media.

F4.1 STEP I SAMPLE DESIGN

The Step I sample design establishes the number of sampling locations at which samples will be collected for intact concrete slabs.

Sampling of radiological contaminants is performed to estimate mean activity for each radiological COPC so the sample mean can be compared with the RAG. Sampling of the nonradiological contaminants is performed to collect data sufficient to satisfy the three-part *Model Toxics Control Act* (MTCA) evaluation criteria regarding the sample maximum, the proportion of sample results exceeding the RAG and the single-tailed 95% upper confidence limit of the sample data (95% UCL).

The required number of samples is calculated for each COPC. The most conservative number (i.e., the largest) is chosen. If intact foundations or concrete slabs have both types of COPCs, the number of sampling locations will be the maximum number calculated for either the radiological or nonradiological COPCs. Table F-2 summarizes the Step I sampling requirements for the intact concrete slabs sites. This table shows the components and assumed RSD_{site}, RPD_{lab} (which is used to calculate the RSD_{lab}), LBGR, alpha, beta, Pr(contaminated), and default number of lateral sampling locations in the X-Y plane for each component. The number of samples may be approximated using the analogous site approach (e.g., using analogous site data in equation J.1 of Appendix J). This must be done of a case-by-case basis to ensure applicability of the analogous site to the CSM of the site to be sampled. The site-specific calculated number of samples in Table F-2 will be completed after field screening results have been obtained and used to support variability analyses per Appendix J.

Table F-2. Step I Sampling Requirements for Intact Foundations and Concrete Slabs Sites.

Site Component	COPCs [a]	Parameter of Interest	Statistic of Interest	RSD_{site} [b]	RPD_{lab} [b]	LBGR [b] (% of RAG)	Alpha	Beta	Pr (contaminated)	Relative Error Consequence Ratio	Default # of Lateral Sampling Locations in (X-Y) Plane	Number of Lateral Sampling Locations in (X-Y) Plane Based on Analogous Site Data	Calculated # of Lateral Sampling Locations in (X-Y) Plane
Concrete slab under inlet/outlet pipes	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	0.50	N/A	64	Computed from analogous data	Site-specific computation
	Non-radionuclides	Maximum	Maximum Concentration	1.00	0.30	68.8%	0.05	0.20	0.50	2	3[c]	Computed from analogous data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	Computed from analogous data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A
Remaining concrete slab	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	0.30	N/A	64	Computed from analogous data	Site-specific computation
	Non-radionuclides	Maximum	Maximum Concentration	1.00	0.30	68.8%	0.05	0.20	0.30	2	3[c]	Computed from analogous data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	Computed from analogous data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A
Concrete supports	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	0.20	N/A	64	Computed from analogous data	Site-specific computation
	Non-radionuclides	Maximum	Maximum Concentration	1.00	0.30	68.8%	0.05	0.20	0.20	2	3[c]	Computed from analogous data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	Computed from analogous data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A

[a] For deep zone nonradionuclides, the 95% UCL for the mean is the only statistic of interest.

[b] Default value:
In lieu of having a RSD_{site} at the time of sample planning, a value of 100% is assumed.
In lieu of having a RPD_{lab} at the time of sample planning, a value of 30% is assumed.
In lieu of analytical data or field screening results, the LBGR may be taken at 68.8% of the RAG based on RPDs established above.

[c] Per the lookup table, n=3; however, 4 samples is the minimum number of samples that should be collected if n<4.

N/A = not applicable

After the number of samples is determined, the locations of these samples will be randomly selected from a 1-ft grid covering the surface area for the specific component. Three grids will be used for the tank supports: one on each of the broad sides of the support and one in the tank cradle. In addition, certain biased locations will be sampled if they were not selected randomly:

- Locations below the junction of the tank and the inlet and outlet pipes
- Locations with visible staining or evidence of a spill
- Soil beneath significant cracks in the concrete slab.

If the number of samples required is greater than the number of grid squares, the size of the grid may be decreased.

F4.2 STEP II SAMPLING DESIGN

Concrete is assumed to be contaminated to a maximum depth of 0.62 cm (0.25 in.), so the number of samples will equal the number of sampling locations for concrete samples. Table F-3 provides the Step II sampling requirements.

Table F-3. Step II Sampling Frequency and Requirements for Intact Foundations and Concrete Slabs Sites.

Component	Sampling Frequency/Requirements
Concrete surfaces	Radiologically field screen concrete surface prior to sampling.
	The number of samples collected is equal to the number of sampling locations because only surface samples will be collected.
Soils underlying the concrete slab (if sampled)	Soils underlying the concrete slab will only be sampled if there are significant cracks in the slab. If significant cracks are detected, at least one sample will be collected beneath the crack at the onset of the native soils. The underlying soils will not be sampled at depth unless it is determined that the COPCs for the site are extremely mobile.

F5.0 MINIMUM FIELD SCREENING REQUIREMENTS

F5.1 RADIOLOGICAL FIELD SCREENING

One static count will be taken for every 4 m^2 of exposed concrete surface area, using a high-efficiency gamma detector and 25 to 50% coverage with beta and alpha surface contamination monitors (as required by the site profile). The static counts will be evenly spaced over the exposed surface area. Any anomalous conditions will be surveyed as well.

The detector/methodology minimum detectable activity (MDA) will be less than 50% of the DCGL for the expected radionuclides. This method assumes that contamination is most likely on the surface of the material surveyed. This method will detect high-energy gamma contamination within 15 cm (6 in.) of the survey surface.

In cases where the MDA is not achievable due to local background, confirmatory samples will be taken on the basic assumption that the site is clean.

F5.2 NONRADIOLOGICAL FIELD SCREENING

Due to the limited applicability of nonradionuclide field screening methods, it is not practical to specify a percentage of coverage or when or at which sites nonradiological field screening is needed. At sites where nonradiological field screening is warranted, after selection of target field screening compounds (based on site COPCs), a minimum of four samples should be collected from each site component present. Where practical constraints do not limit the number of field screening samples collected, the minimum should be at least 10.

In addition, key to application of the field screening approach is the proper application of the observational approach. Anomalous conditions identified should be field screened for elevated COPC levels.

F6.0 REFERENCES

BHI, 1999, *Data Quality Objectives Summary Report for the 100 Area Remaining Confirmatory Sampling Effort Sites*, BHI 01249, Draft, Bechtel Hanford, Inc., Richland, Washington.

DOE-RL, 1998a, *100 Area Remedial Action Sampling and Analysis Plan*, DOE/RL-96-22, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1998b, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, DOE/RL-96-17, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

EPA, 1999, *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units*, U.S. Environmental Protection Agency, Region X, Richland, Washington.

APPENDIX G

SAMPLING DESIGN FOR SEPTIC SYSTEMS AND ASSOCIATED PIPING CONCEPTUAL SITE MODEL

G1.0 SAMPLING DESIGN FOR SEPTIC SYSTEMS AND ASSOCIATED PIPING

Septic systems are waste sites where sanitary wastes and facility discharges were deliberately released to a drain field for evaporation and dispersal through the vadose zone. Section G2.0 provides details of the conceptual site model for septic systems that are not included in the previous sections of the workbook. Section G3.0 discusses decision error tolerances. The sampling design is presented in Section G4.0.

Like underground confining structures, septic tanks and sewer piping are unique in that they were designed to hold wastes as opposed to dispersal or release of the waste material. These two components are more likely to contain raw residual waste material (e.g., sludge and scale) than the tile field. Because of their nature, if the septic tank or associated piping contains sludge and/or scale, and that material is determined to be contaminated at some point during the field investigation or in evaluation of the analytical results, then the site should be deferred to remedial action. This gives the project flexibility, in that prior to analysis of other site components, the sludge or scale may be analyzed first to determine if the site will even remain a candidate for interim closure. This strategy should be implemented whenever feasible in an effort to minimize analytical costs.

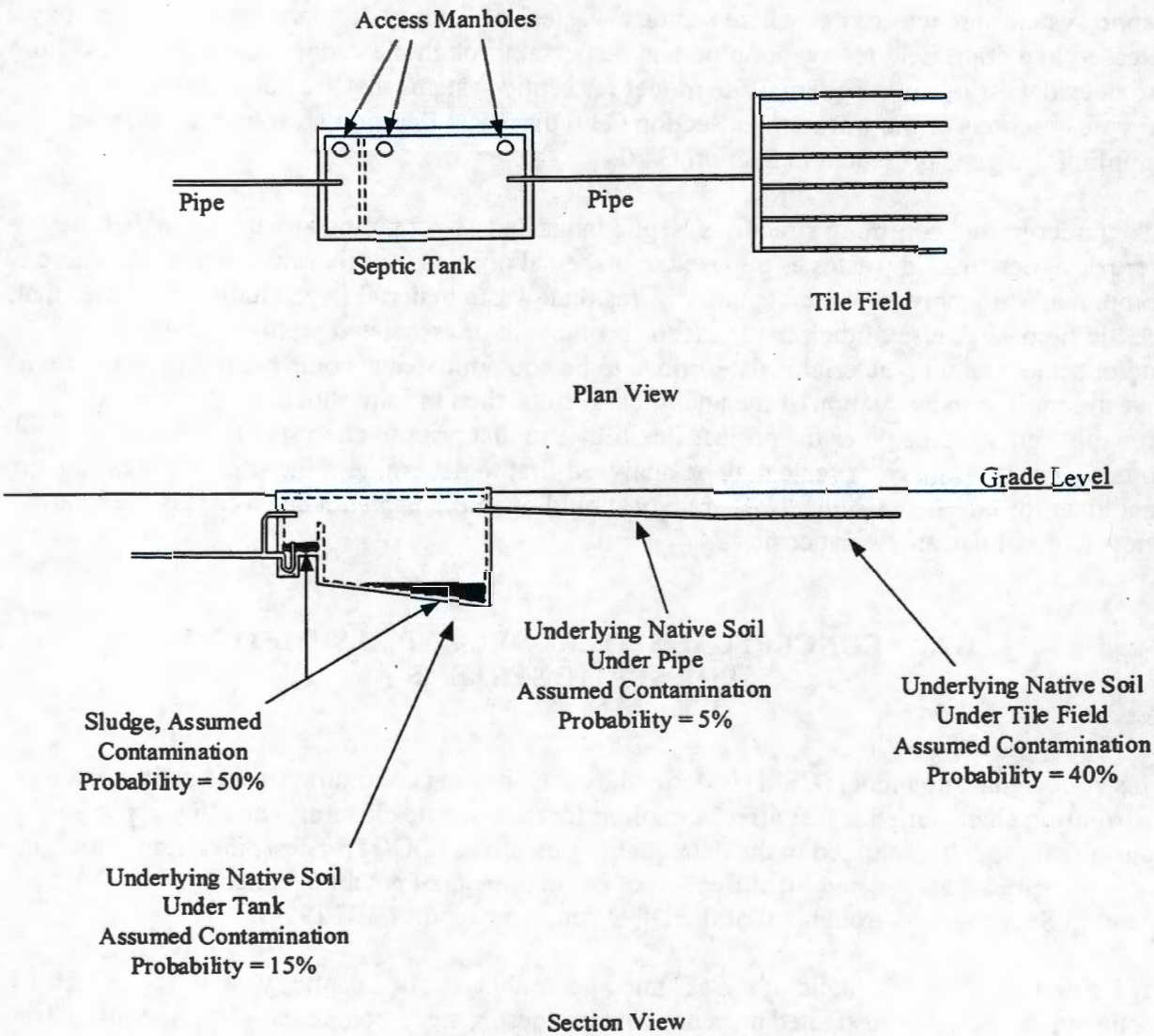
G2.0 CONCEPTUAL SITE MODEL AND ASSUMPTIONS FOR SEPTIC SYSTEMS

This conceptual site model (CSM) is defined by the physical configuration and contamination distribution characteristics that affect sampling for interim site closure. The other aspects of conceptual models examined in the data quality objectives (DQO) process, including future land use, exposure scenarios, and identification of contaminants of potential concern (COPCs), are found in Sections 1.0 through 5.0 of the DQO summary report (BHI 1999).

Figure G-1 shows a schematic of the assumed general layout of a septic system. If a specific septic system being investigated does not contain these general components, the sampling design will be updated to reflect the appropriate design features.

The septic tank is assumed to be below grade and constructed of concrete, either a one-piece design or a separate tank and cover. Regardless of tank design, it is assumed that the most likely area for tank leakage is the junction of the tank walls with the tank bottom. An additional assumption is that the tank did not overflow through the top into the surrounding soils. If liquid did seep through the concrete walls, it is assumed that the seepage was insignificant relative to tank contents potential or soil contamination around the tank.

Figure G-1. Schematic of a Typical Septic System.



For septic systems, there are two sampling access assumptions. The first is that the contents of the tank are accessible, either by removing the top of the tank or through access ports. It is also assumed that an appropriate sample collection technique can be employed to collect sludge samples from the entire sludge profile. A final assumption concerning sample access for septic systems is that depth sampling is possible for other components of the system (i.e., the aggregate and surrounding soils, both lateral and adjacent, are accessible for each of the components).

The following areas are identified as being the most likely to contain detectable COPC concentrations:

- Septic tank sludge
- Sludge within piping or tile field (if present)
- Native soil interface beneath the septic tank, near the junction of walls and tank bottom
- Native soil interface beneath the tile field aggregate
- Native soil interface under the inlet/outlet pipes.

The probability of contamination will be scaled within a range bounded by the tank contents (the maximum) and the soil beneath the inlet/outlet pipes (the minimum). Additional discussion on how to estimate this probability for when historical data and/or field screening data are available is presented in Section G3.0.

G3.0 DECISION ERROR TOLERANCES FOR SEPTIC SYSTEMS

This section discusses the development of the error tolerances for the septic system sampling design. This sampling and analysis plan (SAP) makes frequent reference to the generic tables and discussions in Parts I through III of this SAP from which the sampling design was developed.

The number of samples and the sample collection design will be statistically based wherever possible.

Specific waste streams are assumed to include animal waste, reactor effluent, and sewage. The COPCs associated with these waste streams include radionuclides, metals, and a subset of organic constituents. Because there are no historical data associated with these sites, the concentration ranges of the COPCs are unknown at this time, thus, upper and lower range limits associated with the Remaining Sites' septic systems have not yet been established. Analogous site data may be available from septic system removal actions of the past (e.g., 1607-D2); however, the site and data must still be evaluated for suitability prior to implementing the analogous site approach to support sample design.

Refer to generic Table 2-1 for the action levels for the COPCs associated with the Remaining Sites septic systems. Action levels are provided for each parameter that will be used to support a decision. The derived concentration guideline levels (DCGLs) for radionuclide COPCs will be determined after isotopic distributions have been estimated.

Generic Table 1-7 shows the tolerable decision errors for evaluation of the mean concentration (note: these errors apply to all media identified for the CSM and thus do not require specific identification for use of the table). The false-positive rate is based on the confidence limit for the mean specified in the remedial design report/remedial action work plan for the 100 Areas (DOE-RL 1998b) and the *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units* (Remaining Sites ROD) (EPA 1999). The false-negative error rate follows from the 100 Areas remedial action SAP (DOE-RL 1998a).

Table G-1 specifies the inputs required to determine the number of samples for nonradionuclide COPCs. Because there are no historical data associated with these sites, the probability that a site component is contaminated is specified as stated in Table G-1. The probabilities are specified by the qualitative ranking of components identified in the conceptual site model. The lower limit for the probability of assuming a component is contaminated is 0.05. The component with the highest probability of contamination, the tank contents, is specified as 0.50.

Table G-1. Inputs for the Number of Samples Calculation When the Sample Maximum Will Be Compared to a Threshold.

DS #	Media	COPCs	Parameter of Interest	Range	Pr (contaminated)[a]
2	Tank sludge or sludge (if present) within piping or tile field	As, Cd, Hg, Pb, Cr^{+3}, Cr^{+6}, Zn, SVOCs, pesticides, PCBs	Population maximum concentration	TBD	0.50
	Native soil interface				
	- Under septic tank				0.15
	- Under tile field				0.40
	- Under pipes				0.05
4	Tank sludge or sludge (if present) within piping or tile field	As, Cd, Hg, Pb, Cr^{+3}, Cr^{+6}, Zn, SVOCs, pesticides, PCBs	Population maximum concentration	TBD	0.50
	Native soil interface				
	- Under septic tank				0.15
	- Under tile field				0.40
	- Under pipes				0.05

[a] Because there are no historical data for these sites, the probability of contamination has been estimated based on Section 6.3.
PCB = polychlorinated biphenyl
SVOC = semi-volatile organic compound
TBD = to be determined (on a site-specific basis)

The bounds of the gray region are presented in a generic format for evaluating the mean concentrations in all of the Remaining Sites in generic Table 1-8 and the associated text.

The bounds of the gray region are based on a DQO established for the analytical laboratory precision (BHI 1999). The laboratory relative percent difference (RPD_{lab}) is required to be equal to or less than 30% to satisfy the established analytical precision DQO. An additional 10% is added to the RPD_{lab} to account for some amount of population variability; the 10% is based solely on judgment. This assumption results in a LBGR default value that is approximately 68.8% of the applicable remedial action goal (RAG) (where the LBGR is 1-RSD, and RSD is derived from equation J-2 of Appendix J). The LBGR is always 68.8% of the RAG based on the DQO for laboratory precision unless the DQO changes. If the RPD from the laboratory is >30% (the DQO), then a decision has to be made about data usability.

Since there are no historical data associated with most of these sites, the "sampling variability" or the relative standard deviation for the site (RSD_{site}) is determined by equation J-2 in Appendix J. The sampling variability is a combination of all sources of variability: laboratory, site, sample collection, environmental conditions, time of day, etc. In lieu of having sampling variability information at the time of sample planning, a value of 100% is assumed. If the sampling variability (RSD_{site}) is greater than 100%, the original or default number of samples calculated for the site will not be sufficient to meet error tolerances. If the sampling variability (RSD_{site}) is less than 100%, the number of samples should be adequate. The details of proper application of the equations and the assumptions built into the computation of the default number of samples are presented in Appendix J.

G4.0 SAMPLING DESIGN FOR SEPTIC SYSTEMS

This section presents guidance for sampling the Remaining Sites' septic systems. Section G4.1 discusses the number of sampling locations, and Section G4.2 discusses the depth intervals at which samples will be collected.

G4.1 STEP I SAMPLING

Backhoe excavation is the preferred sample collection method for septic sites. The Step I sample design establishes the number of lateral sampling locations in the X-Y plane.

Sampling of radiological contaminants is performed to estimate mean activity for each radiological COPC so the sample mean can be compared with the RAG. Sampling of the nonradiological contaminants is performed to collect data sufficient to satisfy the three-part *Model Toxics Control Act* (MTCA) evaluation criteria regarding the sample maximum, the proportion of sample results exceeding the RAG and the single-tailed 95% upper confidence limit of the sample data (95% UCL).

The required number of lateral sampling locations in the X-Y plane is calculated for each COPC. The most conservative number (the largest) is chosen. If septic sites have both types of COPCs, the number of sampling locations will be the maximum number calculated for either the radiological or nonradiological COPCs.

Table G-2 summarizes the Step I sampling requirements for french drain sites. This table shows the components and assumed RSD_{site}, RPD_{lab} (which is used to calculate the RSD_{lab}), LBGR, alpha, beta, Pr(contaminated), and default number of lateral sampling locations in the X-Y plane for each component. Components with an expected probability of contamination that is equal to or less than 0.10 are not shown in this table and will not be sampled. The number of samples may be approximated using the analogous site approach (e.g., using analogous site data in equation J.1 of Appendix J). This must be done of a case-by-case basis to ensure applicability of the analogous site to the CSM of the site to be sampled. The site-specific calculated number of samples in Table G-2 will be completed after field screening results have been obtained and used to support variability analyses per Appendix J.

G4.2 STEP II SAMPLING DESIGN

The Step II sampling design determines the sampling requirements at each depth interval below the grade elevation. The sampling locations for each component will be randomly selected from a grid covering a surface area that is specific to the septic system component:

- Tank contents: footprint of bottom of tank
- Native soil underlying the tile field: width of tile field, plus 0.3 m (1 ft) to each side
- Native soil underlying the tank: footprint of bottom of tank plus 0.3 m (1 ft) to each side.

Access to tank contents may be limited to access ports. If the number of access ports is less than the number of samples required, then one sample will be collected from each access port, in addition to the required number of quality assurance samples.

Samples collected from the soils surrounding the tank will be limited to the depth intervals starting at the bottom of the tank due to assumptions made in the conceptual model regarding transport. All samples, regardless of medium, will be taken at 1-ft intervals. The Step II sampling requirements are provided in Table G-3.

G5.0 MINIMUM FIELD SCREENING REQUIREMENTS

G5.1 RADIOLOGICAL FIELD SCREENING

Septic systems are largely buried systems that cannot be tested using conventional surface-measurement methodologies. In each case, a specific sampling and testing plan must be constructed.

Table G-2. Step I Sampling Requirements for Septic Systems.

Site Component	COPCs [a]	Parameter of Interest	Statistic of Interest	RSD_{site} [b]	RPD_{lab} [b]	LBGR [b] (% of RAG)	Alpha	Beta	Pr (contaminated)	Relative Error Consequence Ratio	Default # of Lateral Sampling Locations in (X-Y) Plane	Number of Lateral Sampling Locations in (X-Y) Plane Based on Analogous Site Data	Calculated # of Lateral Sampling Locations in (X-Y) Plane
Septic tank contents and/or sludge within piping of tile field (if present)	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	0.50	N/A	64	Computed from analogous data	Site-specific computation
	Nonradionuclides	Maximum	Maximum Concentration	1.00	0.30	68.8%	0.05	0.20	0.50	2	3[c]	Computed from analogous data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	Computed from analogous data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A
Native soil under septic tank	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	0.15	N/A	64	Computed from analogous data	Site-specific computation
	Nonradionuclides	Maximum	Maximum Concentration	1.00	0.30	68.8%	0.05	0.20	0.15	2	3[c]	Computed from analogous data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	Computed from analogous data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A
Native soil under tile field	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	0.40	N/A	64	Computed from analogous data	Site-specific computation
	Nonradionuclides	Maximum	Maximum Concentration	1.00	0.30	68.8%	0.05	0.20	0.40	2	3[c]	Computed from analogous data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	Computed from analogous data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A

[a] For deep zone nonradionuclides, the 95% UCL for the mean is the only statistic of interest.

[b] Default value:
In lieu of having a RSD_{site} at the time of sample planning, a value of 100% is assumed.
In lieu of having a RPD_{lab} at the time of sample planning, a value of 30% is assumed.
In lieu of analytical data or field screening results, the LBGR may be taken at 68.8% of the RAG based on RPDs established above.

[c] Per the lookup table, n=3; however, 4 samples is the minimum number of samples that should be collected if n<4.

N/A = not applicable

Table G-3. Step II Sampling Frequency and Requirements for Septic Systems.

Component	Sampling Frequency/Requirements per Backhoe Pit
Sludge material (if present) from the septic tank, piping, or tile field	Radiological field screen each sludge sample collected with sodium iodide detector.
	Radiological field screening of piping and tile field aggregate during excavation.
	From every 0.3-m thickness of component, collect a minimum of one sample. If sampling media is less than 0.3 m thick, collect at least one sample per designated lateral sample location.
Native soil under septic tank or tile field	Radiological field screen each bucket (or auger sample) used for sample collection with sodium iodide detector.
	Native soil is considered to be 0.3 m thick. Collect a minimum of two samples from this stratum per septic tank, piping, and tile field (six samples total minimum). One sample to be taken from a suspect area under a tank seam, pipe fitting, and tile field pipe discharge point, and one sample from an adjacent location at the same depth.

Two stages of surveying are recommended. Surface measurements are suggested to determine if a large quantity of radioactive contamination is below the surface. In such cases where overburden and potential subsurface contamination exists below the top 15 cm, excavation spoils and surfaces will be will be monitored by taking single static counts with a high-efficiency gamma detector and beta and alpha surface contamination monitors (as required by the site profile). Coverage will include 25% to 50% of the spoils and exposed surfaces, as well as any anomalies discovered during excavation.

Excavation spoils and surfaces will be monitored by taking static counts with a high-efficiency gamma detector and coverage with beta and alpha surface contamination monitors (as required by the site profile). Coverage will include 25% to 50% of the spoils and exposed surfaces, as well as anomalies discovered during excavation.

All samples of dry sludge shall be surveyed with a high-efficiency gamma detector and beta and alpha surface contamination monitors. Moist sludge will only have to be surveyed for sample shipping purposes. It is anticipated that the presence of moisture in wet septic sludge will shield low-energy beta particles and alpha particles. In cases where analysis to the MDA is not achievable due to moisture, or access to the site spoils and anomalous surfaces is not feasible (e.g., logistical constraints), confirmatory samples will be taken.

The detector/methodology minimum detectable activity (MDA) will be less than 50% of the DCGL for the expected radionuclides. This method assumes that contamination is most likely on the surface. This method will detect high-energy gamma contamination within 15 cm (6 in.) of the survey surface. These field screening methods will not be effective for conditions where the contamination is more than 15 cm below the survey surface (e.g., backfilled or unexposed site).

In cases where the MDA is not achievable due to local background, or access to the site spoils and anomalous surfaces is not feasible (e.g., logistical constraints), confirmatory samples will be taken.

G5.2 NONRADIOLOGICAL FIELD SCREENING

Due to the limited applicability of nonradionuclide field screening methods, it is not practical to specify a percentage of coverage or when or at which sites nonradiological field screening is needed. At sites where nonradiological field screening is warranted, after selection of target field screening compounds (based on site COPCs), a minimum of four samples should be collected from each site component present. The exception is wet sludge. Due to the potential biological hazards associated with handling this material, only one field measurement may be required assuming uniform contaminant concentration. Where safety considerations dictate, this sample may be eliminated altogether. Where practical and safety constraints do not limit the number of field screening samples collected, the minimum should be at least 10.

In addition, key to application of the field screening approach is the proper application of the observational approach. All anomalous conditions identified should be field screened for elevated COPC levels.

G6.0 REFERENCES

DOE-RL, 1998a, *100 Area Remedial Action Sampling and Analysis Plan*, DOE/RL-96-22, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1998b, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, DOE/RL-96-17, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

EPA, 1999, *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units*, U.S. Environmental Protection Agency, Region X, Richland, Washington.

APPENDIX H

SAMPLING DESIGN FOR REACTOR STACK DEMOLITION SITES CONCEPTUAL SITE MODEL

H1.0 SAMPLING DESIGN FOR REACTOR STACK DEMOLITION SITES

Plant stacks were employed at all of the Hanford Site reactors to release plant airborne emissions. The stacks have been decommissioned at the Hanford Site by detonating explosive charges and dropping the demolished stacks into a trench, which was covered with soil. Section H2.0 includes aspects of the conceptual site model (CSM) for reactor stack demolition sites that are specific to these types of waste disposal sites. A discussion of error tolerances for these sites is presented in Section H3.0. The sampling design is presented in Section H4.0.

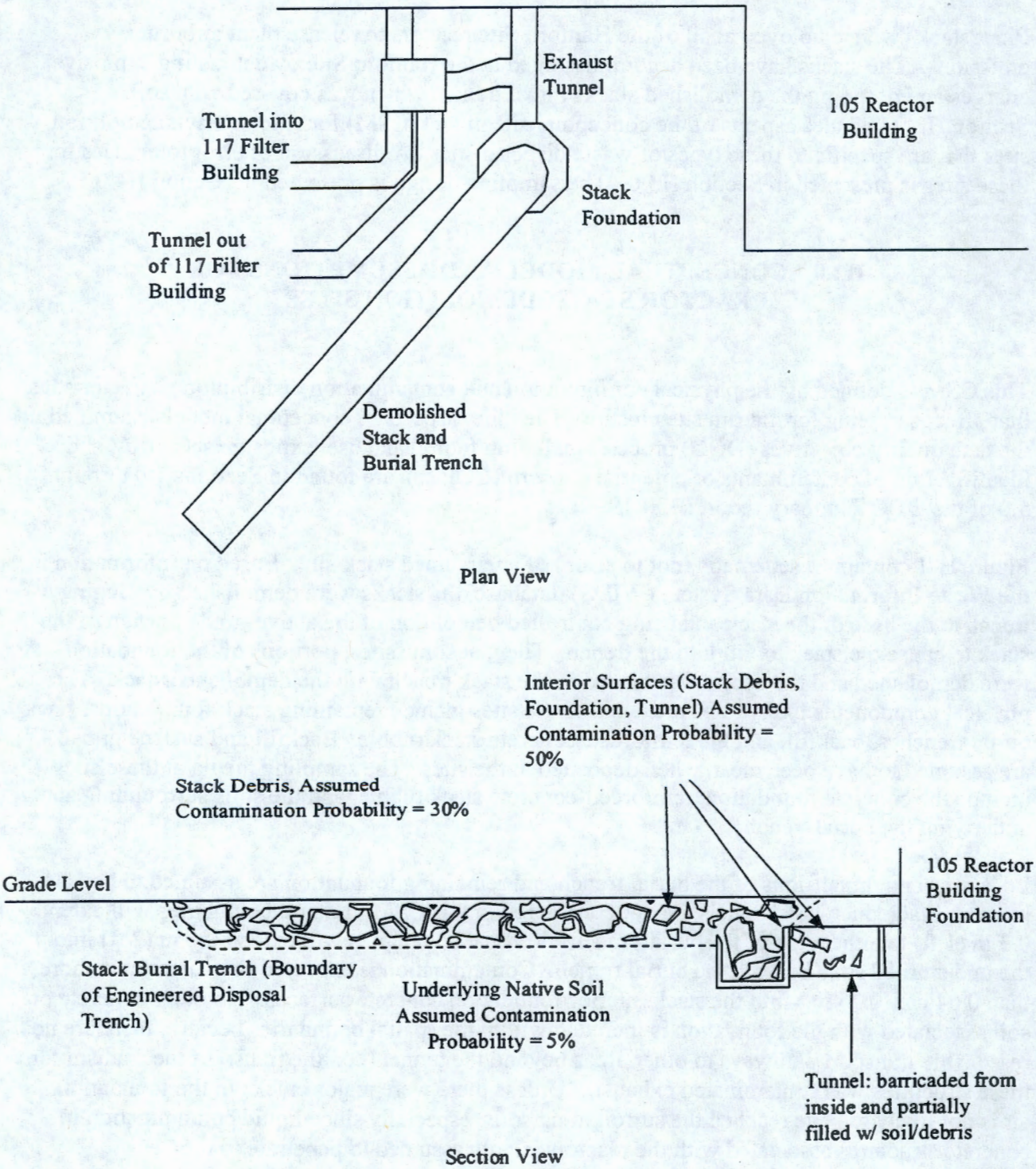
H2.0 CONCEPTUAL MODEL AND ASSUMPTIONS FOR REACTOR STACK DEMOLITION SITES

This CSM is defined by the physical configuration and contamination distribution characteristics that affect sampling for interim site closure. The other aspects of conceptual models examined in the data quality objectives (DQO) process, including future land use, exposure scenarios, and identification of contaminants of potential concern (COPCs), are found in Sections 1.0 through 5.0 of the DQO summary report (BHI 1999).

Figure H-1 contains a schematic (not to scale) of an assumed stack site. Based on information in the Waste Information Data System (WIDS) database, the stacks were demolished by digging a trench at the base of the stack and using controlled demolition of the above-grade portion of the stack to cause the stack to fall into the trench. Then, at some sites, portions of the foundation were demolished and the debris was placed in the stack trench with the demolished stack. The physical components likely to be present at these sites include remaining stack foundations, stack burial trenches, backfill, and the reinforced-concrete stack rubble. Backfill and surface gravel are assumed to have been clean when deposited at the sites. The sampling media at these sites include the concrete foundation, reinforced-concrete stack rubble, and the soils surrounding and underlying the burial trench.

Locations and dimensions of the burial trench and remaining foundation are assumed to be known. Stack ductwork/tunnels are not considered in this CSM. Lateral boundaries will extend 0.3 m (1 ft) to either side of the burial trench. Vertical boundaries will extend 0.6 m (2 ft) into the undisturbed soils beneath the burial trench. Contamination is expected to penetrate no more than 0.64 cm (0.25 in.) into the stack interior/foundation concrete surfaces. No other concrete or soil associated with the foundation is included within the spatial boundaries because there are no reasonable transport pathways to other areas beyond the tunnel (i.e., the transport mechanism for these structures was contaminated exhaust). Unless there were major cracks in the foundation, air is not likely to have reached the surrounding soils, especially since liquid contamination in concrete structures associated with the reactors is only assumed to penetrate to 0.64 cm (0.25 in.).

Figure H-1. Schematic of a Stack Site.



It is assumed that sampling of the soils under the trench will be performed by backhoe excavator with thumb assembly if needed. Soils to the sides of the trench are also assumed to be accessible for sampling. The intact foundation was backfilled with clean soil and the maximum depth of the foundation is known. It is assumed that all backfill can be removed to expose all wall and floor surfaces of the interior foundation tunnel.

The assumed ranking of components in order of probability of contamination is inside surface of the foundation tunnel, concrete stack rubble in the trench (stack interior), and the soils surrounding and under the trench. This relative scaling of probabilities, along with estimates of the probabilities of contamination for one or more of the media, lead to the determination of the probability of contamination for all sampling media in Section H4.0. The estimates of the probabilities of contamination can be based on historical data or professional judgment.

The probability of contamination will be scaled within a range bounded by the inside surface of the foundation tunnel (the maximum) and the soils surrounding and under the trench (the minimum). Scale the probability for the remaining components to a value within the range defined by these maximum and minimum values.

H3.0 DECISION ERROR TOLERANCES FOR REACTOR STACK DEMOLITION SITES

This section discusses the development of the error tolerances for the reactor stacks conceptual model. This SAP makes frequent reference to the generic tables and discussions Parts I through III of this SAP from which the sampling design was developed.

The number of samples and the sample collection design will be statistically based wherever possible. If the assumptions stated in Section H2.0 are not met, a statistical sampling plan cannot be and regulatory input should be sought for the development of an alternate sample strategy.

Specific waste streams for the Remaining Sites' reactor stacks are assumed to include reactor condensate and debris. The COPCs associated with these waste streams include radionuclides and metals. There are some data associated with these sites, namely allowable residual contamination level (ARCL) data. The ranges for the radionuclides presented in the ARCL data are shown in Table H-1.

Generic Table 2-1 shows the action levels for the COPCs associated with the Remaining Sites' reactor stacks. Action levels are provided for each parameter that will be used to support a decision. The derived concentration guideline levels (DCGLs) for radionuclide COPCs will be determined after isotopic distributions can be estimated.

Table H-1. Contaminants of Potential Concern Range Values

WS #	Media	COPCs	Range	
			Lower Limit	Upper Limit
Reactor condensate and debris	Concrete, concrete rubble, and soil	As	N/A	N/A
		Cr^{+6}	N/A	N/A
		Pb	N/A	N/A
		Zn	N/A	N/A
		Co-60	N/A	N/A
		Cs-137	N/A	N/A
		Eu-152	N/A	N/A
		Eu-154	N/A	N/A
		Eu-155	N/A	N/A
		Pu-238	N/A	N/A
		Pu-239/240	N/A	N/A
		Sr-90	N/A	N/A
		U-238	N/A	N/A
116-F stack[a] (WIDS No. 132-F-4)	Concrete, debris, and soils	H-3	11	11
		C-14	140	140
		Co-60	10	10
		Sr-90	26	26
		Cs-137	64	64
		Eu-152	8	8
		Pu-239	1	1
116-H stack[a] (WIDS No. 132-H-1)	Concrete, debris, and soils	H-3	15	22.4
		C-14	207	231
		Co-60	0.055	4.07
		Sr-90	0.16	9.49
		Cs-137	0.314	0.314
		Eu-152	0.637	5.77
		Gross alpha	0.2	27.2

N/A = not available

[a] Data from hot spot (nonremovable contamination) samples taken during building demolition effort. Available in ARCL documentation, shown here for information only. Not necessarily indicative of actual site conditions due to the conservatism introduced by sampling hot spots only (e.g., high biased data).

Generic Table 1-7 shows the tolerable decision errors for evaluation of the mean concentration (note: these errors apply to all media identified for the CSM and thus do not require specific identification for use of the table). The false-positive rate is based on the confidence limit for the mean specified in the *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2,*

100-IU-6, and 200-CW-3 Operable Units (Remaining Sites ROD) (EPA 1999). The false-negative error rate follows from the 100 Areas remedial action sampling and analysis plan (SAP) (DOE-RL 1998a).

Table H-2 specifies the inputs required to determine the number of samples for nonradionuclide COPCs. Because there are no nonradionuclide historical data associated with these sites, the probability that a site component is contaminated is specified as stated in Table H-2. The probabilities are specified by the qualitative ranking of components identified in the CSM.

Table H-2. Inputs for the Number of Samples Calculation When the Sample Maximum Will Be Compared to a Threshold.

DS #	Media	COPCs	Parameter of Interest	Range	Pr (contaminated)
2	Concrete on interior surface of tunnel through stack foundation or stack interior	As Cr^{+6} Pb Zn	Population maximum concentration	TBD	0.50
	Reinforced-concrete rubble from demolition of foundation and/or stack				0.30
	Lateral soils and soils under the burial trench				0.05
4	Concrete on interior surface of tunnel through stack foundation or stack interior	As Cr^{+6} Pb Zn	Population maximum concentration	TBD	0.50
	Reinforced-concrete rubble from demolition of foundation and/or stack				0.30
	Lateral soils and soils under the burial trench				0.05

TBD = deep zone remedial action goals to be determined

The bounds of the gray region are presented in a generic format for evaluating the mean concentrations in all of the Remaining Sites in generic Table 1-8 and the associated text.

The bounds of the gray region are based on a data quality objective established for the analytical laboratory precision (BHI 1999). The laboratory relative percent difference (RPD_{lab}) is required to be equal to or less than 30% to satisfy the established analytical precision DQO. An additional 10% is added to the RPD_{lab} to account for some amount of population variability; the 10% is based solely on judgment. This assumption results in a LBGR default value that is approximately 68.8% of the applicable remedial action goal (RAG) (where the LBGR is 1-RSD, and RSD is derived from equation J-2 of Appendix J). The LBGR is always 68.8% of the RAG based on the DQO for laboratory precision unless the DQO changes. If the RPD from the laboratory is >30% (the DQO), then a decision has to be made about data usability.

Since there are no historical data associated with most of these sites, the "sampling variability" or the relative standard deviation for the site (RSD_{site}) is determined by equation J-2 in Appendix J. The sampling variability is a combination of all sources of variability: laboratory, site, sample collection, environmental conditions, time of day, etc. In lieu of having sampling variability information at the time of sample planning, a value of 100% is assumed. If the sampling variability (RSD_{site}) is greater than 100%, the original or default number of samples calculated for the site will not be sufficient to meet error tolerances. If the sampling variability

(RSD_{site}) is less than 100%, the number of samples should be adequate. The details of proper application of the equations and the assumptions built into the computation of the default number of samples are presented in Appendix J.

H4.0 SAMPLING DESIGN FOR REACTOR STACKS DEMOLITION SITES

This section presents guidance for sampling at reactor stack demolition sites. The term "component" will be used to denote both physical components and sampling media.

Certain components may have partial or total sampling access restrictions. The largest access problems are associated with the concrete rubble in the burial trench. Samples from these areas would not be a random subset from all possible rubble samples at the site and, therefore, would not be representative of the entire component. Thus, error tolerances for decisions based on estimates of population maximum, proportions, and means cannot be tested or controlled. However, depending on the type of COPC (radiological versus nonradiological), existing data may be sufficient to make administrative or statistical decisions for specific components with restricted sampling access (e.g., rubble and underlying soils).

Reactor stack demolition sites are known to contain stack and foundation rubble only. These site components generally have associated ARCL data that were used to release the site prior to decontamination and decommissioning (D&D). From a radiological chemistry and risk standpoint, these data are considered to be defensible and of good quality. If nonradiological contaminants can be administratively eliminated as COPCs and all other components pass their decision criteria, a proposal for interim closure for these sites may be submitted based on ARCL data only. If nonradiological COPCs cannot be administratively accounted for, then the recommendation is that the site be evaluated for sampling as opposed to remedial action.

Soils under the buried debris may also be potentially contaminated with concrete dust as a result of stack demolition. Soils surrounding the stack foundation are not considered because there are no reasonable transport pathways from this structure to this medium.

The decision to implement a sampling plan will depend on existing data, sampling access and administrative decisions. Sampling of the assumed accessible components (i.e., tunnel through the foundation and the soils to the sides of the trench) should proceed in the following instances:

- Project personnel determine that the ARCL data, for the rubble contained in the trench, are not appropriate to support the decision for interim closure of the site based on these components.

- Nonradiological contaminants are considered to be of concern.

Potential contamination of soils underlying the trench is not a factor that will be used in the interim site closure decision, or alternate sampling techniques are technically and financially

feasible to sample the underlying soils. In the event that sampling is the chosen alternative over administrative interim closure using ARCL data or remedial action, the following guidelines shall be used for sample planning.

H4.1 STEP I SAMPLING DESIGN

Backhoe excavation is the preferred sample collection method for reactor stack demolition sites. The Step I sample design establishes the number of backhoe test pit sampling locations.

The tunnel through the foundation that connects the inlet duct/tunnel and the stack, the demolition debris (reactor stack), and the soils adjacent to the burial trench are the components at these sites with sampling access. The inside walls and floor of the foundation tunnel are assumed to be accessible for sampling and assumed to be least disturbed relative to demolition debris. Since this component has been backfilled, the foundation will have to be located and the backfill removed in order for concrete foundation samples to be collected. The burial trench will be exhumed and the debris shall be sampled by grinding away the top 0.5 to 1 cm of surface material. To the extent possible, efforts should be made to get at least one sample representative of the stack interior. The soils of the burial trench are assumed suitable for sampling.

Sampling of radiological contaminants is performed to estimate mean activity for each radiological COPC so the sample mean can be compared with the RAG. Sampling of the nonradiological contaminants is performed to collect data sufficient to satisfy the three-part *Model Toxics Control Act* (MTCA) evaluation criteria regarding the sample maximum, the proportion of sample results exceeding the RAG, and the single-tailed 95% upper confidence limit of the sample data (95% UCL).

The required number of samples is calculated for each COPC. The most conservative number (the largest) is chosen. If reactor stacks have both types of COPCs, the number of sampling locations will be the maximum number calculated for either the radiological or nonradiological COPCs. Table H-3 summarizes the Step I sampling requirements for the reactor stacks sites.

After the number of samples is determined, the locations of these samples will be randomly selected from a grid covering the surface area for the specific component. The grid coverage will include the following:

- The entire inner surface of the foundation tunnel
- The burial trench.

Sampling of the soil underlying the tunnel will not be performed as there was not a hydraulic driver for the COPCs.

Table H-3. Step I Sampling Requirements for Reactor Stack Demolition Sites.

Site Component	COPCs [a]	Parameter of Interest	Statistic of Interest	RSD_{site} [b]	RPD_{lab} [b]	LBGR [b] (% of RAG)	Alpha	Beta	Pr (contaminated)	Relative Error Consequence Ratio	Default # of Lateral Sampling Locations in (X-Y) Plane	Number of Lateral Sampling Locations in (X-Y) Plane Based on Analogous Site Data	Calculated # of Lateral Sampling Locations in (X-Y) Plane
Concrete on interior surface of tunnel through stack foundation or stack interior surface	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	0.50	N/A	64	Computed from analogous data	Site-specific computation
	Non-radionuclides	Maximum	Maximum Concentration	1.00	0.30	68.8%	0.05	0.20	0.50	2	3[c]	Computed from analogous data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	Computed from analogous data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A
Reinforced-concrete rubble from demolition of foundation and/or stack	Radionuclides	Mean	95% UCL for the mean	1.00	0.30	68.8%	0.05	0.20	0.30	N/A	64	Computed from analogous data	Site-specific computation
	Non-radionuclides	Maximum	Maximum Concentration	1.00	0.30	68.8%	0.05	0.20	0.30	2	3[c]	Computed from analogous data	Site-specific computation
		Mean	95% UCL for the mean							N/A	64	Computed from analogous data	Site-specific computation
		Proportion	% > RAG							N/A	N/A	N/A	N/A

[a] For deep zone nonradionuclides, the 95% UCL for the mean is the only statistic of interest.

[b] Default value:
In lieu of having a RSD_{site} at the time of sample planning, a value of 100% is assumed.
In lieu of having a RPD_{lab} at the time of sample planning, a value of 30% is assumed.
In lieu of analytical data or field screening results, the LBGR may be taken at 68.8% of the RAG based on RPDs established above.

[c] Per the lookup table, n=3; however, 4 samples is the minimum number of samples that should be collected if n<4.

N/A = not applicable

H4.2 STEP II SAMPLING DESIGN

Concrete is assumed to be contaminated to a maximum depth of 0.62 cm (0.25 in.); therefore, the number of samples will equal the number of sampling locations for concrete samples. The Step II sampling requirements are provided in Table H-4.

Table H-4. Step II Sampling Frequency and Requirements for Reactor Stack Demolition Sites.

Component	Sampling Frequency/Requirements
Concrete on interior surface of tunnel through stack foundation or stack interior surface	Radiologically field screen concrete surface prior to sampling.
	The number of samples collected is equal to the number of sampling locations because only surface samples will be collected.
Reinforced-concrete rubble from demolition of foundation and/or stack	Radiologically field screen concrete surface prior to sampling.
	The number of samples collected is equal to the number of sampling locations because only surface samples will be collected.

The soils are not anticipated to be contaminated (Pr[contaminated]<10%) and will not be sampled unless field reading indicate anomalous conditions. In that case, the soil will be sampled at the trench/native material interface.

Additional samples at other depths may be collected as conditions warrant. However, this will not be the common practice, as there are no known hydraulic drivers that mobilize contaminants.

H5.0 MINIMUM FIELD SCREENING REQUIREMENTS

H5.1 RADIOLOGICAL FIELD SCREENING

One static count will be taken for every 4 m^2 of exposed concrete surface area, using a high-efficiency gamma detector and 25% to 50% coverage with beta and alpha surface contamination monitors (as required by the site profile). The static counts will be evenly spaced over the exposed surface area. Any anomalous conditions will be surveyed as well. In cases where overburden and potential subsurface contamination exists below the top 15 cm, excavation spoils (including exhumed rubblized material) and surfaces will be will be monitored by taking single static counts with a high-efficiency gamma detector and beta and alpha surface contamination monitors (as required by the site profile).

The detector/methodology minimum detectable activity (MDA) will be less than 50% of the DCGL for the expected radionuclides. This method assumes that contamination is most likely on the surface of the material surveyed. This method will detect high-energy gamma contamination within 15 cm (6 in.) of the survey surface. These field screening methods will not be effective for conditions where the contamination is more than 15 cm below the exposed survey surface.

In cases where the MDA is not achievable due to local background, or access to the site spoils and anomalous surfaces is not feasible (e.g., logistical constraints), confirmatory samples will be taken.

H5.2 NONRADIOLOGICAL FIELD SCREENING

Due to the limited applicability of nonradionuclide field screening methods, it is not practical to specify a percentage of coverage or when or at which sites nonradiological field screening is needed. At sites where nonradiological field screening is warranted, after selection of target field screening compounds (based on site COPCs), a minimum of four samples should be collected from each site component present. Where practical constraints do not limit the number of field screening samples collected, the minimum should be at least 10.

In addition, key to application of the field screening approach is the proper application of the observational approach. Anomalous conditions identified should be field screened for elevated COPC levels.

H6.0 REFERENCES

BHI, 1999, *Data Quality Objectives Summary Report for the 100 Area Remaining Confirmatory Sampling Effort Sites*, BHI 01249, Draft, Bechtel Hanford, Inc., Richland, Washington.

DOE-RL, 1998, *Sampling and Analysis Plan for Release of the 105-C Below-Grade Structures and Underlying Soils*, DOE/RL-97-37, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

EPA, 1999, *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units*, U.S. Environmental Protection Agency, Region X, Richland, Washington.

APPENDIX I

RATIONALE FOR SURVEY AREA DIMENSIONS AND CALCULATIONS OF MINIMUM DETECTABLE ACTIVITY

I1.0 RADIOLOGICAL SURVEY

For purposes of calculation of the minimum detectable concentration (MDC), it is necessary to define three key parameters: background count rate, static count time (or survey scan rate), and size of the sampled area (as defined by shield configuration and distance from the surface scanned). The establishment of an appropriate statistically based background level should include considerations of the variances in background caused by man-made or natural effects (including radon) that may be prevalent in subsurface structures. The acceptable surface static count time or scan rates determine dwell time (count time) over the hypothetical contaminated area, and the sampled area size determines the magnitude of the source term that is being detected, as well as the counting geometry that directly affects the overall counting efficiency.

I1.1 CONCRETE SURFACE SCANS

The sample grid size for the survey of each site is based on the size of the site. Small sites will have essentially 100% sampling per strata for gamma-emitting isotopes, while larger sites have grid-based surveys. The grid size selected for each site is consistent with recommendations in NUREG/CR 1500, 5512, and 5849, as well as the *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) (NRC 1997). No area will have less than 10% coverage.

I1.2 CALCULATION OF MINIMUM DETECTABLE CONCENTRATION

The MDC of the instrument is based on instrument performance in near-background conditions. As the expected condition of the sites is at or near background, and the release criteria are established on a radionuclide concentration basis, the MDC will be iteratively calculated to provide a result that is below the release criteria for the site in question.

The survey approach is to perform a static count at the approximate center of each small site, or at each survey location identified for larger sites. Using these guidelines, MDC calculations were performed to determine the estimated detection level that will be required, using the equation is shown below:

$$MDA = \frac{2.71 + 3.29\sqrt{T_S B\left(1 + \frac{T_S}{T_B}\right)}}{2.22 \times (E)(T_S) \times c}$$

where:

MDA = minimum detectable activity, at the 95% confidence level (dpm/100 cm^2)

B = background count rate (cpm)

T_S = sample counting time (min)

T_B = background count time

E = efficiency of instrument

c = grams of dirt or material in the modeled area interrogated by detector (an 80-cm x 15-cm disk of soil weighs approximately 1.2×10^5 g)

2.22 = conversion factor from dpm to units of pCig.

Following of site background conditions and the characteristics of the material sampled, the MDA can be calculated.

I2.0 SITE MATERIAL VERIFICATION SAMPLES

As discussed in Section 1.4.4, samples will be taken to provide final verification that the cleanup standards are met. Verification samples will be analyzed for the applicable contaminants of concern.

I3.0 REFERENCES

BHI, 1996, *Instrumental Basis Utilizing Sodium Iodide Detector for Radioactive Soil Evaluations for Site Remediation*, BHI-00885, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

BHI, 1997, *Instruction Guide for Remediation of the 100 Areas Waste Sites*, 0100X-IG-G0001, Rev. 2, Bechtel Hanford, Inc., Richland, Washington.

Currie, L. A., 1968, "Limits for Qualitative Detection and Quantitative Determination," *Analytical Chemistry*, Vol. 40, No. 3, pp. 586-593.

DOE-RL, 1998, *100 Area Remedial Action Sampling and Analysis Plan*, DOE/RL-96-22, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

NRC, 1997, *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM),. NUREG 1575, EPA 402-R-97-106, U.S. Nuclear Regulatory Commission, Washington, D.C.

APPENDIX J

STATISTICAL FORMULAS

J1.0 CALCULATING THE NUMBER OF SAMPLING LOCATIONS FOR RADIONUCLIDE CONTAMINANTS OF POTENTIAL CONCERN

The formula for estimating the number of samples when radionuclides are considered contaminants of potential concern (COPCs) for a site is as follows:

$$n = RSD^2 \bar{x}^2 \frac{\left(z_{1-\alpha} + z_{1-\beta}\right)^2}{\left(LBGR - RAG\right)^2} \quad \text{or} \quad n = s^2 \frac{\left(z_{1-\alpha} + z_{1-\beta}\right)^2}{\left(LBGR - RAG\right)^2} \qquad \text{(Equation J-1)}$$

where:

RSD	=	relative standard deviation, determined from historical or field screening data, if available, or set at 100% if no data are available (see Section 1.4.2 for discussion)
$\bar{x}$	=	average concentration, determined from historical or field screening data, if available, or set at the remedial action goal (RAG) if no data are available (see Section 6.0 for discussion)
α	=	tolerable decision error for mistakenly concluding the site is clean
$z_{1-\alpha}$	=	the quantile from the standard normal distribution such that $Pr(z > Z_{1-\alpha}) = \alpha$; = 1.645 for $\alpha = 5\%$
β	=	tolerable decision error for mistakenly concluding the site is dirty
$z_{1-\beta}$	=	the quantile from the standard normal distribution such that $Pr(z > Z_{1-\beta}) = \beta$; = 0.842 for $\beta = 20\%$
RAG	=	the remedial action goal, shown in Table 1-7
$LBGR$	=	the lower bound of the gray region (68.8% of the action level, as described in Section 6.0)
s	=	standard deviation of site.

This formula is an adaptation of equation 6.6 in the U.S. Environmental Protection Agency's (EPA's) *Methods for Evaluating the Attainment of Cleanup Standards, Volume 1: Soils and Solid Media* (EPA 1989). The formula is adapted to use the RSD instead of the standard deviation, because the variability associated with most field screening results is reported in terms of the RSD.

The spreadsheet setup for computing the required number of samples per equation J-1 is as follows:

= ROUNDUP(**A1**^2***B1**^2*((1.645+0.842)^2/(**C1-D1**)^2),0)
(for α= 5%, β = 20%) or
=ROUNDUP(**E1**^2((1.645+0.842)^2/(**C1-D1**)^2),0)

where:

cell **A1** = the RSD for the COPC of interest for the site (assumed=100%, or determined for historical or analytical data)

cell **B1** = the average concentration for the COPC of interest for the site (assumed = RAG [cell D1], or determined for historical or analytical data)

cell **C1** = the LBGR, which is equal to 1-RSD for the confirmation sample analysis, as derived from the analytical RPD (below)

cell **D1** = the RAG for the COPC of interest

cell **E1** = the standard deviation for the COPC of interest for the site as determined from historical or analytical data.

J2.0 CONVERTING RPD TO RSD

The relative percent difference (RPD) is determined by the accuracy requirement given in Table 2-7. This RPD is the data quality objective (DQO) for analytical precision. If the laboratory is unable to achieve the DQOs presented in Table 2-7, then a qualitative decision regarding data usability must be made. When the power computation is performed, the laboratory matrix spike (MS) and matrix spike duplicate (MSD) sample RPD should be computed and used to determine the actual RPD for the analysis of interest for computing the LBRG. Where MS and MSD values approach the MDA or PQL (e.g., within analytical error range), the RPD for those samples should be computed using the MDA or PQL (instead of the reported value) to minimize bias introduced by error associated with the analytical method. To convert RPD to RSD, use equations J-2 through J-4 and follow steps 1 through 7 below. This is an estimate of the variability attributed strictly to analytical error.

$$RPD = \frac{x_1 - x_2}{\bar{x}} \qquad \text{(Equation J-2)}$$

$$RPD \times \bar{x} = x_1 - x_2 \qquad \text{(Equation J-3)}$$

$$RPD\left(\frac{x_1 + x_2}{2}\right) = x_1 - x_2 \qquad \text{(Equation J-4)}$$

1. Set $x_1 - x_2$.

$$x_1 - x_2 = RPD\left(\frac{x_1 + x_2}{2}\right)$$

2. Plug in *RPD* from analytical requirements (Table 2-2).

$$x_1 - x_2 = 0.30 \times \left(\frac{x_1 + x_2}{2}\right)$$

3. Solve for x_1.

$$x_1 - x_2 = \frac{0.30}{2} \times (x_1 + x_2) = 0.15 \times (x_1 + x_2)$$

4. Solve for x_2, given x_1.

$$x_1 - x_2 = 0.15x_1 + 0.15x_2 \Rightarrow 1.15x_2 = 0.85x_1 \Rightarrow x_2 = 0.7391x_1$$

5. Calculate $\bar{x}$, the arithmetic mean of x_1 and x_2.

$$\bar{x} = \left(\frac{x_1 + x_2}{2}\right) = \left(\frac{x_1 + 0.7391x_1}{2}\right) = 0.8696x_1$$

6. Calculate s, the standard deviation of x_1 and x_2.

$$s = \sqrt{\sum_{i=1}^{n} \frac{(x_i - \bar{x})^2}{n-1}} = \sqrt{\frac{(x_1 - 0.8696x_1)^2 + (0.7391x_1 - 0.8696x_1)^2}{2-1}} = \sqrt{(0.1304x_1)^2 + (-0.1304x_1)^2}$$
$$= \sqrt{0.01700x_1^2 + 0.01700x_1^2} = \sqrt{0.03400x_1^2} = 0.1844x_1$$

7. Calculate $RSD = \frac{s}{\bar{x}}$.

$$RSD = \frac{s}{\bar{x}} = \frac{0.1844x_1}{0.8696x_1} = 0.2121 \text{ (or 21.2\% [for an RPD=30\%])}.$$

The spreadsheet setup for computing an RSD for RPD is:

	A	B	C	D	E	F	G
1	RPD	X_1	X_2	Average	St. Dev.	RSD	RSD+10%
2	Manually input	Manually input	=B2* (1-0.5*A2)/(1+0.5*A2)	=AVERAGE (B2:C2)	=STDEV (B2:C2)	=E2/D2	=0.1+F2

where the input to cell A2 is the RPD as determined by analytical data, and the input to cell B2 is any value greater than zero (algebraically, this value drops out of the final equation). Note that when computing an RSD from MS and MSD sample results, set cell **A2**=ABS**(B2-C2)/D2**, and manually input MS and MSD results in cells **B2** and **C2**.

J3.0 LOOKUP TABLE FOR DETERMINING THE NUMBER OF SAMPLES FOR NONRADIONUCLIDE CONTAMINANTS OF POTENTIAL CONCERN

Table J-1 uses Bayesian statistical methods (Berger 1985). The table indicates that the higher the probability that contamination exists, the more samples are required to prove that the expected contamination is not present.

Table J-1. Lookup Table for Determining the Number of Samples for Nonradionuclide COPCs. (2 Pages)

Pr(contaminated)	*n* Consequence Ratio = 2	*n* Consequence Ratio = 3	*n* Consequence Ratio = 4
5%	2	2	2
10%	2	2	2
15%	2	2	2
20%	2	2	2
25%	2	2	2
30%	2	2	2
35%	2	2	3
40%	2	3	4
45%	2	4	5
50%	3	5	7
55%	4	7	9
60%	5	7	11
65%	7	10	14

Table J-1. Lookup Table for Determining the Number of Samples for Nonradionuclide COPCs. (2 Pages)

Pr(contaminated)	*n* Consequence Ratio = 2	*n* Consequence Ratio = 3	*n* Consequence Ratio = 4
70%	8	13	18
75%	11	17	25
80%	16	25	31
85%	21	33	44
90%	35	53	71
95%	75	100	100

The consequence ratio is the ratio of the relative severity of the consequences of a false-positive (incorrectly conclude no contamination) to false-negative (incorrectly conclude contamination) decision errors.

J4.0 CALCULATING THE NUMBER OF SAMPLING LOCATIONS FOR NONRADIONUCLIDE CONTAMINANTS OF POTENTIAL CONCERN

Calculation of the number of sampling locations for nonradionuclide COPCs is based on a screening assessment of the maximum concentration for a COPC. The procedure employed combines the binomial probability of the maximum concentration being above the RAG, initial site knowledge regarding the likelihood that the site is contaminated, and the relative ratio of the consequences of the decision errors. To arrive at the optimal sample size the following function is minimized with respect to *n*

$$abs\left[1-\frac{\alpha}{\beta}\frac{(1-p_n)}{p_n}\right] \qquad \text{(Equation J-5)}$$

where:

$$p_n = \frac{p\prod_{i=1}^{n}\frac{\omega+i-1}{\nu+\omega+i-1}}{1-p+p\prod_{i=1}^{n}\frac{\omega+i-1}{\nu+\omega+i-1}} \qquad \text{(Equation J-6)}$$

p = initial probability of observing contamination
ν = 1, $\omega = 2$ are shape parameters of the beta distribution
β = false-negative decision error consequence
α = false-positive decision error consequence.

This procedure is based on the approach outlined in "Professional Judgement in the Data Quality Objectives Process: A Bayesian Approach to Screening Assessment" (Black et al. 1994).

There are two approaches for using a spreadsheet to compute the required number of sample based on the equation above. The first approach requires the user to transfer the above data to a worksheet for reference as a lookup table. The following command line is then used in the cell in which the number of nonradioactive COPC samples is to be displayed:

=IF(**B2/A2**=2,LOOKUP(**C2**,'Lookup Table'!**D2:D20**,'Lookup Table'!**E2:E20**),IF(**B2/A2**=3,LOOKUP(**C2**,'Lookup Table'!**D2:D20**,'Lookup Table '!**F2:F20**),LOOKUP(**C2**,'Lookup Table'!**D2:D20**,'Lookup Table'!**G2:G20**)))

where:

cell **A2** = Tolerable decision error for mistakenly concluding the site is clean (α), 0.05

cell **B2** = tolerable decision error for mistakenly concluding the site in dirty (β), 0.10 to 0.20

cell **B2/A2** = Ratio of tolerable errors (β/α). This ratio is used in a nested IF/THEN command to execute the correct LOOKUP command using the appropriate values and vector.

cell **C2** = The probability that the component of interest is contaminated, or Pr(contaminated). Within the LOOKUP function, this is the *Lookup_value* used to specify which row in the table will be used.

'Lookup Table'!**D2:D20** = the worksheet (worksheet title: "Lookup Table") and cell range used as the *Lookup_vector* in the LOOKUP function. The LOOKUP function will find a value that equals the value in cell C2 within the cell range (*Lookup_vector*) D2:D20. One of the values within the range D2:D20 should contain a number equal to C2.

'Lookup Table'!**E2:E20** = the worksheet (worksheet title: "Lookup Table") and cell range used as the *Result_vector* in the LOOKUP function, IF the ratio of cells B2/A2=2. The LOOKUP function will display the value from the table that corresponds to the value in cell **C2** (which is also within the range 'Lookup Table'!D2:D20) with the appropriate value from the cell range 'Lookup Table'!E2:E20. For example, if C2=20%, the Lookup function will find the row in the cell range 'Lookup Table'!D2:D20 that equals 20%, then it will display the value (e.g., 2) from 'Lookup Table'!E2:E20 that is from the same row and that corresponds to 20%.

'Lookup Table '!**F2:F20** = the worksheet (worksheet title: "Lookup Table") and cell range used as the *Result_vector* in the LOOKUP function, IF the ratio of cells B2/A2=3.

'Lookup Table'!**G2:G20** = the worksheet (worksheet title: "Lookup Table") and cell range used as the *Result_vector* in the LOOKUP function, IF the ratio of cells B2/A2=4.

J5.0 SYSTEMATIC SAMPLING EQUATIONS, TABLES, AND GRAPHS

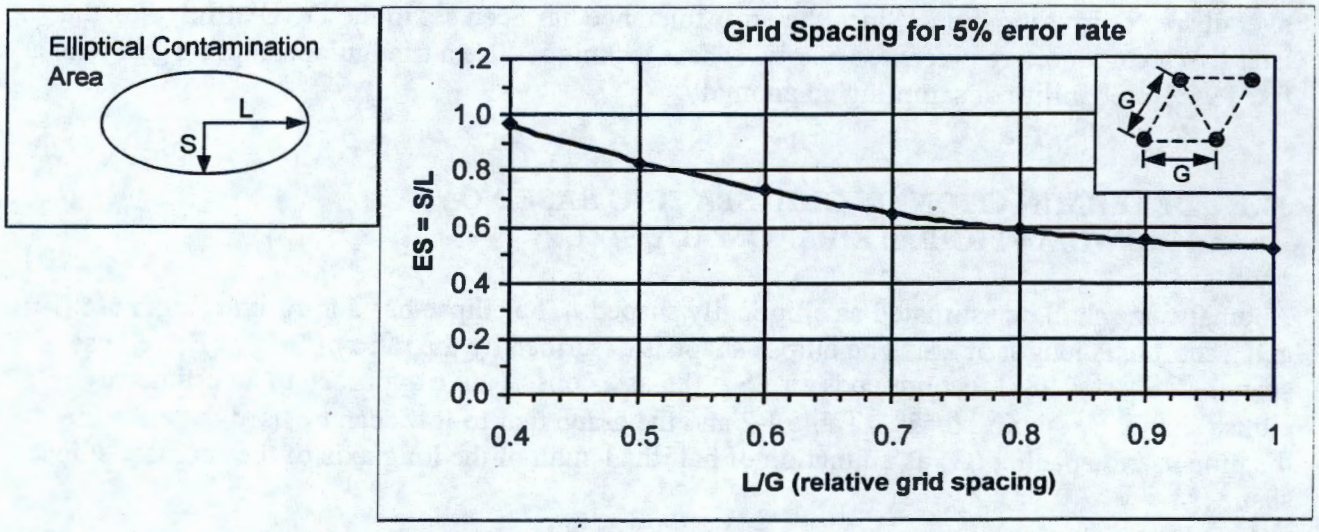
The *Model Toxics Control Act* (MTCA) presents an approach for systematic sample designs for large sites that is based on the sampling design presented by Gilbert's *Statistical Methods for Environmental Pollution Monitoring* (Gilbert 1987) as the "hot spot approach." There are three methods for establishing a sample grid presented: (1) establishing grid spacing based on probability of sampling anomaly, (2) establishing grid spacing based on known or anticipated anomaly size, or (3) establishing grid spacing based on required number of samples for the overall area of investigation. Since the error tolerance has been set in the DQO effort, only the later two techniques are presented below. These techniques use a triangular sampling grid with a fixed 95% probability of sampling an anomaly.

J5.1 DETERMINATION OF GRID SPACING BASED ON KNOWN/ANTICIPATED ANOMALY SIZE

Anomaly size shall be estimated as elliptically shaped. The ellipse has a long axis length of 2L and a short axis length of 2S. The ellipse shape is described by the ratio of S/L, or ES (ellipse shape). Gilbert (1987) recommends an ES = 0.5 as a conservative approach to an estimated ellipse shape. Assuming α=5%, Table J-2 and the graph that follows can be used to determine the proper grid spacing (G) as a function of half the length of the long axis of the anomaly ellipse shape (L).

Table J-2. Grid Spacing (m), Probability of Hitting Hot Spot = 0.95.

L = Length of Semi-Major Axis (m)	ES = Shape Parameter, 1 = Circle			
	0.25	0.50	0.75	1.00
1	0.7	1.2	1.6	1.93
2	1.4	2.39	3.2	3.86
3	2.11	3.59	4.81	5.79
4	2.81	4.79	6.41	7.73
5	3.51	5.99	8.01	9.66
6	4.21	7.18	9.61	11.59
7	4.92	8.38	11.21	13.52
8	5.62	9.58	12.81	15.45
9	6.32	10.78	14.42	17.38
10	7.02	11.97	16.02	19.32
25	17.56	29.94	40.05	48.29
50	35.11	59.87	80.09	96.58
75	52.67	89.81	120.14	144.87
100	70.22	119.75	160.18	193.16



J5.2 DETERMINATION OF GRID SPACING BASED ON REQUIRED NUMBER OF SAMPLES

The alternate method for determining the required grid spacing is based on the number of samples required for the site (entire area to be investigated) as calculated using equation J-1. The outcome (n) from calculation equation J-1 and the area of the entire site (A) are then used in the following equation to determine the grid spacing (G) requirements. Use of this approach requires that the size of the corresponding anomaly that can be detected with a 95% certainty, along with associated error tolerances, be specified. The project statistical lead should be consulted when implementing this approach.

$$G = \sqrt{\frac{A}{0.866n}} \qquad \text{(Equation J-7)}$$

J6.0 CALCULATING STATISTICAL POWER AND EVALUATING FALSE-NEGATIVE ERROR RATES

Equation J-8 is used to calculate the statistical power associated with the samples that are collected and analyzed from a site. The statistical power will be calculated when the 95% upper confidence limit (UCL) for the mean concentration exceeds the RAG (the null hypothesis is not rejected), as discussed in Part I through Part III.

Statistical power is equal to (1- false-negative error rate) and is used to evaluate whether the false-negative error rate specified in the DQO has been met. In this project, the false-negative error rate is set at 20%. Therefore, the statistical power associated with the data must be greater than or equal to 80%, otherwise the false-negative DQO error rate has not been achieved.

The statistical power is calculated using the statistics (average, standard deviation) from the sample data. It is assumed that the sample data are usable from QA, risk, and statistical perspectives. In particular, the statistical assumptions of normality must hold to use equation J-8, because it is the power equation used when the 95% UCL for the mean is calculated as $\bar{x} + t^{*}_{(\alpha,n-1)} s/\sqrt{n}$.

$$Power = \Pr\left(\frac{\bar{x} - LBGR}{s/\sqrt{n}} > T_{(\alpha,n-1)} \right), \qquad \text{Equation J-8}$$

where:

$\bar{x}$	= the sample average
$LBGR$	= the lower bound of the gray region
s	= the sample standard deviation
n	= the number of samples collected and analyzed
$T_{(\alpha,n-1)}$	= the Student's t random variable with $(n-1)$ degrees of freedom such that
$\Pr(t > T_{(\alpha,n-1)})$	$= \alpha$

The following equation can be used in a spreadsheet to compute the power per equation J-8 above:

tquan=((A1-A2)/(A3/SQRT(A4))-TINV(2*0.05,A4-1))
Power=1-TDIST(ABS(tquan),A4-1,1)

where:

cell **A1**	=	$\bar{x}$, the sample average, =AVERAGE(data range)
cell **A2**	=	LBGR, lower bound of the gray region, or $(1\text{-}RSD_{lab})$*RAG where RSD_{lab} is determined from the analytical RPD for the COPC of interest
cell **A3**	=	*s*, the sample standard deviation, =STDEV(data range)
cell **A4**	=	*n*, the number of samples collected and analyzed, which can be determined using =COUNTA(data range)

The "TINV(2*0.05,A4-1)" function returns the inverse of the Student's T-distribution for a probability of 0.05 (α, false-positive error rate), and *n*-1 degrees of freedom.

The equations presented above are for normally distributed data. Equations for calculating the power for lognormal and nonparametric data are too extensive for discussion here. Due to the complexity of the power analysis for lognormal and nonparametric data, the project statistical lead should be consulted for direction concerning the proper power computation for lognormal and nonparametric distributions.

J7.0 REFERENCES

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