FINAL
PROPOSED ACTION MEMORANDUM FOR IHSS 101 AND RCRA CLOSURE OF THE RFETS SOLAR EVAPORATION PONDS

December 2002

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ACRONYMS AND ABBREVIATIONS

AHA	Activity Hazard Analysis
AL	action level
ALARA	As Low As Reasonably Achievable
ALF	Action Levels and Standards Framework
Am	americium
AOC	Area of Concern
AR	Administrative Record
BMP	best management practice
BZ	Buffer Zone
CAD/ROD	Corrective Action Decision/Record of Decision
CCR	Colorado Code of Regulations
CDD	Closure Description Document
CDH	Colorado Department of Public Health
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CHWA	Colorado Hazardous Waste Act
CID	Cumulative Impact Document
COC	contaminant of concern
Cs	Cesium
DOE	U.S. Department of Energy
dpm/kg	disentegrations per minute per kilogram
EDE	effective dose equivalent
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
ER RSOP	Environmental Restoration RFCA Standard Operating Procedure for Routine Soil Remediation
FY	Fiscal Year
GIS	Geographic Information System
GPR	Ground Penetrating Radar
GS	gauging station
HASP	Health and Safety Plan
HHRA	Human Health Risk Assessment
HI	Hazard Index
HRR	Historical Release Report
HSWA	Hazardous and Solid Waste Amendments
HQ	Hazard Quotient
IA	Industrial Area
IAG	Inter-Agency Agreement
IASAP	Industrial Area Sampling and Analysis Plan
IHSS	Individual Hazardous Substance Site
IM/IRA	Interim Measure/Interim Remedial Action
IMP	Integrated Monitoring Program
ISMS	Integrated Safety Management System
ITS	Interceptor Trench System
IWCP	Integrated Work Control Program

ACRONYMS AND ABBREVIATIONS

JHA	Job Hazard Analysis
K-H	Kaiser-Hill Company, L.L.C.
mg/Kg	milligrams per kilogram
mg/L	milligram per liter
mrem	millirem
MSTs	Modular Storage Tanks
NEPA	National Environmental Policy Act
NFA	No Further Action
NPWL	New Process Waste Lines
OPWL	Original Process Waste Lines
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
OU	Operable Unit
PA	Protected Area
PAC	Potential Area of Concern
PAM	Proposed Action Memorandum
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
pCi/L	picocuries per liter
PCOC	potential contaminant of concern
PM_{10}	particulate matter less than 10 micrometers in aerodynamic diameter
ppb	part per billion
PPE	personal protective equipment
ppm	part per million
PRG	preliminary remediation goals
Pu	plutonium
PVC	polyvinyl chloride
Ra	radium
RAAMP	Radioactive Ambient Air Monitoring Program
RCRA	Resource Conservation and Recovery Act
RFCA	Rocky Flats Cleanup Agreement
RfD	Reference Dose
RFETS	Rocky Flats Environmental Technology Site
RFCAB	Rocky Flats Citizen Advisory Board
RFCLOG	Rocky Flats Coalition of Local Governments
RFFO	Rocky Flats Field Office
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RME	reasonable maximum exposure
RMRS	Rocky Mountain Remediation Services
RSOP	RFCA Standard Operating Protocol
SAP	Sampling and Analysis Plan
SEP	Solar Evaporation Ponds
SPP	Solar Ponds Plume
Sr	strontium
SVOC	semivolatile organic compound
SWD	Soil Water Database
SWMU	Solid Waste Management Unit

ACRONYMS AND ABBREVIATIONS

TAL	Target Analyte List
TCLP	Toxicity Characteristic Leaching Procedure
TDS	total dissolved solids
TLL	total long lived
TM	Technical Memorandum
TSP	total suspended particulates
U	uranium
UBC	Under Building Contamination
UHSU	upper hydrostratigraphic unit
VOC	volatile organic compound
WARP	Well Abandonment and Replacement Program
WRW	Wildlife Refuge Worker

EXECUTIVE SUMMARY

Closure of the Solar Evaporation Ponds (SEP), Individual Hazardous Substance Site (IHSS) 101, at Rocky Flats Environmental Technology Site (RFETS), is proposed under alternative Resource Conservation and Recovery Act (RCRA) interim status closure requirements found in 6 Code of Colorado Regulations (CCR) 1007-3, Section 265.110(d). Alternative closure requirements are proposed because a release from the SEP has occurred, resulting in radiological and hazardous constituent contamination. Releases from other units in the area of the SEP have also contributed to the SEP area of contamination. This alternative approach allows contamination from these units within this area to be evaluated as one Area of Concern (AOC), and allows RCRA closure using a risk-based analysis and compliance with the closure performance standards in 6 CCR 1007-3, Section 265.111(a) and (b). A risk assessment was performed based on identified contaminants of concern (COCs) within the AOC, and these findings are included in this Proposed Action Memorandum (PAM). (The AOC is equivalent to IHSS 101 with a few modifications.)

The risk assessment included an evaluation of existing soil and pond liner material analytical data stored in electronic format in the RFETS environmental Soil Water Database (SWD). The data were collected during previous Phase I field investigations and sitewide sampling programs. The data were then screened and COCs were selected and evaluated to determine the risk posed to proposed future human wildlife refuge workers (WRWs) (DOE et al. 2002). Based on the results of the risk assessment, the cumulative Hazard Index (HI)[1] for non-carcinogenic health effects is well below 1 at 0.04. The total cancer risk[2] to a WRW due to RCRA constituents (for purposes of RCRA closure) is less than 1 excess cancer case per 1 million exposed individuals (1E-06) at 3E-07. The total cancer risk to a WRW due to radionuclides (for IHSS 101) is 2E-06, with the major contributors to risk being americium-241 and uranium-235. Therefore, based on achieving protective media cleanup standards for human health at 1E-05[3] risk to a WRW, no action is necessary for either RCRA or radionuclide COCs due to carcinogenic effects. Corrective action of existing groundwater contamination, including treatment, is addressed in a separate Interim Measure/Interim Remedial Action (IM/IRA) decision document.

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[1] The potential for non-carcinogenic effects is evaluated by comparing an exposure level over a specified time period (for example, lifetime) with a reference dose (RfD) derived for a similar exposure period. An RfD represents a level that an individual may be exposed to that is not expected to cause any deleterious effect. The ratio of exposure to toxicity is called a hazard quotient (HQ). An HQ<1 indicates that a receptor's dose of a single contaminant is less than the RfD, and that toxic non-carcinogenic effects from the chemical are unlikely. The Hazard Index (HI) is the sum of the HQs for all chemical(s) of concern that affect the same target organ (for example, liver) or that act through the same mechanism of action within a medium or across all media to which a given individual may reasonably be exposed. An HI<1 indicates that toxic non-carcinogenic effects from all contaminants are unlikely. An HI>1 indicates that site-related exposures may present a risk to human health.

[2] The risk of cancer is described in terms of the probability that an individual will develop cancer by age 70 because of exposure to cancer-causing chemicals. For each chemical of concern, this value is calculated using the daily intake of the chemical from a site (averaged over a lifetime) and the cancer slope factor for the chemical. The resulting value is an estimate of the number of cancer cases expected in excess of those caused by the daily intake of background or non-site related chemical contamination.

[3] A risk level of $1x10^{-5}$ indicates an excess cancer case in 10 out of 1 million individuals exposed to cancer-causing chemicals at the Site, or a 0.001% individual risk of developing cancer from exposure.

Other units within the AOC were removed as a separate action under the Environmental Restoration (ER) Rocky Flats Cleanup Agreement (RFCA) Standard Operating Protocol (RSOP) for Routine Soil Remediation (ER RSOP) (DOE 2002a). (Refer to ER RSOP Fiscal Year [FY]02 Notification #02-08; DOE 2002b.) Specifically, concrete slabs, above-grade lines, segments of belowgrade lines, valve vaults, collection sumps, manholes, electrical control conduit and other utilities, associated support racks, concrete ramps and barriers were removed. To determine whether contamination was present at specific locations where soil or component removal was anticipated, an Industrial Area (IA) Sampling and Analysis Plan (SAP) (IASAP) Addendum was submitted (IASAP Addendum #IA- 02-07) (DOE 2002c). Soil with contaminant concentrations greater than RFCA Tier I Action Levels (ALs) and associated debris were removed in accordance with RFCA and the ER RSOP. In addition, lysimeters and unnecessary monitoring wells were abandoned, and replacement wells installed as a separate action under the Well Abandonment and Replacement Program (WARP) (Kaiser-Hill 2002a).

Based on applying the alternative closure requirements, the results of the risk assessment indicate RCRA constituents pose less than 1E-05 residual risk for a proposed WRW, and with the completion of the actions performed under the ER RSOP and IASAP, the SEP meets the closure performance standards of 6 CCR 1007-3, Section 265.111(a) and (b). After consultation with the regulatory agencies, it was determined that there is one elevated concentration of lead (121 milligrams per kilogram [mg/kg]) above the ecological AL (97.7 mg/kg). It was determined this lead occurrence will not impact target species. In addition, the radiological contaminants remaining within the SEP AOC soil are all below current RFCA Tier I ALs, a 1E-05 risk to a proposed WRW, and proposed soil ALs. Remaining soil contaminant concentrations are also below proposed ecological ALs. Therefore, No Further Action (NFA) is required for the SEP and IHSS 101. As a best management practice (BMP), the pond berms will be pushed into the ponds, clean fill soil will be brought in; and the area will be regraded and revegetated.

1.0 INTRODUCTION

This Proposed Action Memorandum (PAM) decision document serves to close the Solar Evaporation Ponds (SEP), Individual Hazardous Substance Site (IHSS) 101. IHSS accelerated actions and Resource Conservation and Recovery Act (RCRA) unit closures are approved by the U.S. Department of Energy (DOE), Colorado Department of Public Health and Environment (CDPHE) and the U.S. Environmental Protection Agency (EPA) under the Rocky Flats Cleanup Agreement (RFCA) (DOE, et al. 1996). RFCA is both a cleanup agreement under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and a compliance order on consent under RCRA and the Colorado Hazardous Waste Act (CHWA). Therefore, actions associated with IHSS 101 will be completed under RFCA and closure of the SEP will be completed under RCRA.

This PAM also serves as the RCRA/CHWA closure plan for the SEP, which is a RCRA interim status unit. However, since the signing of RFCA in July 1996, EPA amended the RCRA regulations in October 1998 (October 22, 1998, *Federal Register,* 63FR56710), which were adopted by CDPHE in 1999 governing the closure of regulated units (6 Colorado Code of Regulations [CCR] 1007-3, Section 265.110[d]). These new regulations allow regulated units with releases into the environment, such as the SEP, to close under a risk-based approach if other Solid Waste Management Units (SWMUs) have or are likely to have contributed to the release. CDPHE is allowing this flexibility to be used in establishing closure requirements for the SEP, because other units exist in this area, including a portion of IHSS 121 (the Original Process Waste Lines [OPWL]), RCRA Units 21 and 48 (RCRA-stable concrete pads), a portion of the RCRA Permitted New Process Waste Lines [NPWL]; RCRA Unit 374.3), and Potential Area of Concern (PAC) 900-1310 (Interceptor Trench System [ITS] water spill). This alternative approach allows the SEP to be closed under RCRA through the corrective action program, in conjunction with the removal and closure of these other units. This flexibility allows contamination from all of these units to be evaluated as one Area of Concern (AOC) and the removal of contaminated soil to be considered as an alternative to closure by capping the SEP.

Currently, closure-in-place of the SEP is addressed in RFCA Attachment 10, RCRA/CHWA Closure for Interim Status Units, Section I. Closure in place assumes that residual hazardous waste and hazardous waste constituents and liners have not been removed from the interim status unit. Attachment 10 requires closure-in-place using a cap or cover that meets specified design criteria. This PAM proposes to close the SEP in accordance with revised RCRA regulations in 6 CCR 1007, Section 265.110(d) that were promulgated subsequent to the current Attachment 10 (July 1996), which provides for alternative requirements that are protective of human health and the environment. DOE has proposed a modification to Attachment 10 to recognize this regulatory change for other interim status units covered by RFCA as part of a larger package of proposed modifications to several RFCA Attachments (DOE et. al 2002). However, because the proposed modifications to the other RFCA Attachments are still under development, this PAM specifically recognizes the alternative closure method and describes the criteria to be met for SEP closure.

An AOC is defined to include all of these units (as defined above), spills within the SEP area, and the known extent of contamination associated with these units, which becomes the basis for

performing a risk assessment (Appendix A, Figure 1). The AOC is equivalent to IHSS 101 with a few modifications, which are explained further in Sections 2.1.3 and 5.0. Contamination, for purposes of determining risk, takes into account both radiological and nonradiological contaminants. However, for purposes of demonstrating compliance with RCRA closure, only those nonradiological contaminants, which are considered RCRA hazardous constituents, have been considered. All the RCRA units located in this AOC will be closed either by removal or based on risk.

Existing environmental data[4] used in the risk assessment included process knowledge and data collected during previous studies (for example the Phase I RCRA Facility Investigation [RFI]/Remedial Investigation [RI]). A summary of the risk assessment results is presented in Section 5.0, and the risk assessment process is discussed in Appendix A, including data used (Appendix A of the Risk Assessment).

Other units that may have contributed to the release in this AOC are discussed in Section 2.0 of this PAM. However, specific actions associated with these other units have already been addressed under Environmental Restoration (ER) RFCA Standard Operating Protocol (RSOP) Notification #02-08 and Industrial Area (IA) Sampling and Analysis Plan (IASAP) Addendum #IA-02-07. Completion of the closure/remediation of these units will be documented in a separate closeout report. In addition, existing groundwater contamination is briefly discussed in this document for purposes of defining the nature and extent of contamination and to determine whether additional soil removal could reduce the long-term stewardship obligations of the Solar Ponds Plume (SPP) treatment system. However, corrective action of existing groundwater contamination, including treatment, is addressed in a separate Interim Measure/Interim Remedial Action (IM/IRA) decision document. (Refer to the Final Solar Ponds Plume Decision Document, [DOE 1999a], and its Minor Modification [DOE 2002d].)

ER RSOP Notification #02-08 was submitted to the regulatory agencies in July 2002 for the SEP AOC and approved by CDPHE on July 30, 2002. The purpose of the Notification was to invoke the ER RSOP for the various other units, IHSSs, and PACs that exist within the SEP AOC. The Notification indicated that completing closure by removal for RCRA Units 21 and 48 was conducted in accordance with the existing RCRA Closure Description Document (CDD) for Building 788 (RMRS 1999a). Partial closure of NPWL (RCRA Unit 374.3) was conducted in accordance with Section 6.5.3 of the ER RSOP and the ER RSOP Notification #02-08, which is in lieu of a RCRA CDD. Potential contaminants of concern (PCOCs) for these units were identified based on the same data used in the risk assessment, as well as additional data from Historical Release Reports (HRRs) for Rocky Flats Plant from 1992 to 2001 and the Final Closeout Report for Building 788 (RMRS 1999a).

Soil with contaminant concentrations greater than RFCA Tier I action levels (ALs) and associated debris were removed in accordance with RFCA and the ER RSOP. Soil with contaminant concentrations less than RFCA Tier I ALs was evaluated for additional removal through the consultative process based on risk and using Stewardship and As Low As

[4] Data collected in 2002 as a result of the activities identified under ER RSOP Notification #02-08 and IASAP Addendum # IA- 02-07 were not included in the data set used in the risk assessment.

Reasonably Achievable (ALARA) considerations. Actions undertaken will be documented in a closeout report, which includes an estimate of material removed and related risk reduction.

IASAP Addendum #IA-02-07 was submitted to the regulatory agencies in July 2002 and approved by CDPHE on August 1, 2002. The purpose of sampling in the SEP AOC was to determine whether contamination was present at specific locations where soil or component removal occurred and in areas that may be affected by regrading.

1.1 Purpose and Objective

The purpose of this PAM is to serve as the RCRA Closure Plan for the SEP (which supercedes any existing closure plans for the SEP) and propose that No Further Action (NFA) is necessary ant IHSS 101. This proposal for NFA is based on the nature and extent of contamination; previous actions taken including removal of the waste (source of contamination) from the ponds; actions conducted under the ER RSOP; characterization/confirmation sampling conducted under the IASAP; and the results of the risk assessment for the SEP AOC. The objectives of this proposed action are:

- Define the alternative closure requirements and strategy for closing the SEP;
- Evaluate the risks associated with existing contamination within the defined AOC;
- Demonstrate compliance with the RCRA closure performance standards of 6 CCR 1007-3, Section 265.111(a) and (b). (This demonstration includes leaving the asphalt liner material in place.); and
- Propose that no accelerated action is necessary under this PAM and that residual contamination does not pose an unacceptable risk to the anticipated future user, the wildlife refuge worker (WRW). (Closure of the SEP is based on achieving a risk of 2E-06 and a toxicity Hazard Index (HI) of 0.04 [Refer to Section 5.0].)

This PAM discusses the current nature and extent of contamination within this AOC based on existing data, and presents the results of a risk assessment. Results of the risk assessment were used to determine if any actions or if additional sampling was warranted to protect public health and the environment. Actions undertaken under the ER RSOP will be documented in a closeout report.

1.2 RCRA Closure Requirements

The SEP, as a RCRA interim status unit, must comply with the closure requirements of 6 CCR 1007-3 Section 265, Subpart G-Closure and Post-Closure. In general, Subpart G requires the submittal of a closure plan for closure of interim status units. This PAM acts as the closure plan for the SEP. Demonstration of compliance with 6 CCR 1007-3, Section 265, Subpart H-Financial Requirements for Closure, is not required for government-owned facilities (6 CCR 1007-3, Section 265.140[c]).

In addition to the submittal of a closure plan, Subpart G requires a facility to be closed in a specific manner. Closure of the SEP will follow the alternative closure requirements as specified in 6 CCR 1007-3, Section 265.110(d).

This PAM proposes to close the SEP using alternative requirements for closure under 6 CCR 1007-3, Section 265.110(d), which allows all or part of the Subpart G-Closure and Post-Closure requirements for regulated units to be replaced. The alternative closure requirements must protect human health and the environment by meeting the closure performance standards of 265.111(a) and (b). However, three criteria must be met in order to apply these alternative requirements:

1. The regulated unit[5] must be situated among SWMUs;[6]

2. A release has occurred; and

3. Both the regulated unit and one or more SWMUs are likely to have contributed to the release.

Therefore, to demonstrate that the SEP qualifies for closure in accordance with these alternative requirements, the following information is provided:

- The SEP are considered a regulated unit in that the ponds are surface impoundments that received hazardous waste until 1986 (after July 26, 1982).
- Situated among the SEP is a portion of IHSS 121 (OPWL), RCRA Units 21 and 48 (concrete pads brought to RCRA stable), a portion of RCRA Unit 374.3 NPWL, and PAC 900-1310 (ITS water spill).
- OPWL, NPWL, and RCRA Units 21 and 48 qualify as SWMUs.
- A release has occurred in this area.
- The SEP, a portion of OPWL, PAC 900-1310, and RCRA Units 21 and 48 are likely to have contributed to the release in this area.
- It is not necessary to apply the closure requirements of 6 CCR 1007-3, Section 265 Subpart G, because a risk assessment is presented in this PAM to ensure protection of human health and the environment. For purposes of managing risk, additional actions in this area have occurred under the ER RSOP and IASAP to ensure protection of human health and the environment.

[5] A regulated unit is defined as a surface impoundment, waste pile, land treatment unit, or landfill that receives hazardous waste after July 26, 1982 (6 CCR 1007-3, §264.90[a][2]).
[6] SWMUs are defined as any unit at a facility from which hazardous constituents might migrate, irrespective of whether the units were intended for the management of solid and/or hazardous waste. (July 24, 1987, EPA Memorandum Office of Solid Waste and Emergency Response [OSWER] 9502.1987 (07), RCRA/Superfund Hotline Faxback #12984; as explained in the July 15, 1985, Hazardous and Solid Waste Amendments [HSWA] Codification Rule.)

RCRA Unit 48 has interim status and both RCRA Unit 21 and a portion of NPWL are permitted. Each of these units qualifies as a SWMU in that hazardous constituents may have migrated from the units. The definition of a SWMU is intended to include those types of units that have traditionally been subject to regulatory controls under RCRA, such as container storage areas and tanks.[7] Although PAC 900-1310, which is described as a one-time spill of ITS water, does not qualify as a SWMU, this area was evaluated based on risk and the location of the spill within the AOC. (SWMUs and corrective actions were not intended to include one-time accidental spills that cannot be linked to a discernible SWMUs.[4])

Based on the demonstration that the SEP qualify for applying alternative closure requirements, the alternative closure requirements are defined as:

- Achieve protective media cleanup standards for human health at a1E-05 lifetime excess cancer risk for a WRW, and ensure that the concentration of contaminants in soil do not exceed a Hazard Index (HI) of 1 for a WRW;
- Ensure that contaminants that exceed the ecological ALs for target species (listed in Table 3, Attachment 5 of the RFCA Modification [DOE et. al. 2002]) don't pose an unacceptable hazard considering the target species and the exposure unit for that species, and the location, areal extent, and concentration of contamination, and
- Comply with the closure performance standards in 6 CCR 1007-3, Section 265.111(a) and (b)

To demonstrate successful closure of the SEP, Section 6.1 of this PAM discusses the performance standards in relation to the risk assessment (Section 5.0 and Appendix A), and the accelerated actions conducted under the ER RSOP (Section 2.0).

2.0 SITE DESCRIPTION

The Rocky Flats Environmental Technology Site (RFETS) is a government-owned, contractor-operated facility formerly used for the fabrication of special nuclear materials for national defense. The 6,550-acre site is located in Jefferson County, Colorado, approximately 16 miles northwest of Denver. The site occupies approximately 10 square miles.

Centrally located within the RFETS boundary is a 400-acre security area called the IA. A high-security Protected Area (PA) is located within the IA. The IA contains approximately 400 buildings, along with other structures, roads, and utilities, and is where the majority of RFETS mission activities took place between 1951 and 1989. The remaining 6,150 acres consists of undeveloped land used as a buffer zone to further limit access to the operations area.

[7] SWMUs are defined as any unit at a facility from which hazardous constituents might migrate, irrespective of whether the units were intended for the management of solid and/or hazardous waste. (July 24, 1987 EPA Memorandum OSWER 9502.1987 (07), RCRA/Superfund Hotline Faxback #12984; as explained in the July 15, 1985 HSWA Codification Rule.)

2.1 Solar Evaporation Ponds

Operations at the Site resulted in the generation of process wastewater containing radioactive and hazardous waste constituents that were managed in various waste-processing units. The SEP, located in the northeastern portion of the former PA boundary, were used as some of these waste-processing units (Figure 2-1) from 1953 to 1986. The SEP consist of five current or existing surface impoundments designated as Ponds 207-A, 207-B North, 207-B Center, 207-B South, and 207-C, as well as three original surface impoundment cells (DOE 1988). Figure 2-2 shows the locations and relative dimensions of the original and current SEP, as well as the chronological history of pond construction, operation, and removal. The first pond was constructed in 1953, and the last pond (207-C) was placed into service in 1970.

The operational history of the SEP is summarized below. For information regarding the environmental setting, including geologic, hydrogeologic and ecologic settings, review the following documents:

- DOE, 199,9 Final Solar Ponds Plume Decision Document;
- DOE, 1995a, Operable Unit 4 Solar Evaporation Ponds, Interim Measure/Interim Remedial Action Environmental Assessment Decision Document;
- DOE, 1997, Cumulative Impacts Document;
- EG&G, 1995a, Geologic Characterization Report for the Rocky Flats Environmental Technology Site, Volume I of the Sitewide Geoscience Characterization Study; and
- EG&G, 1995b, Hydrogeologic Characterization Report for the Rocky Flats Environmental Technology Site, Volume II of the Sitewide Geoscience Characterization Study.

2.1.1 History

The SEP were operated primarily to store and evaporate radioactive process waste and neutralized acidic process waste containing mostly low concentrations of radionuclides and high concentrations of nitrate and aluminum hydroxide from 1953 to 1986. The SEP were used to manage liquid process waste having less than 100,000 picocuries per liter (pCi/L) total long-lived alpha activity (DOE 1992a). Specific materials placed into the SEP include:

- Radioactively contaminated aluminum scrap;
- Leachate from the sanitary landfill;[8]
- Alcohol wash solutions;

[8] Leachate from the RFETS Sanitary Landfill was placed into the SEP until January 1974 (Rockwell 1988). (The Present Landfill began operations in 1968.) At this time, analysis indicated phenol, tritium, strontium-90, plutonium, americium, total long-lived (TLL) alpha, and nitrate were present in the leachate (DOW 1974). All of these constituents have been included in historical sampling and analysis programs at the SEP. Of these constituents, phenol is the only RCRA constituent and it has never been identified as a PCOC or contaminant of concern (COC) for the SEP.

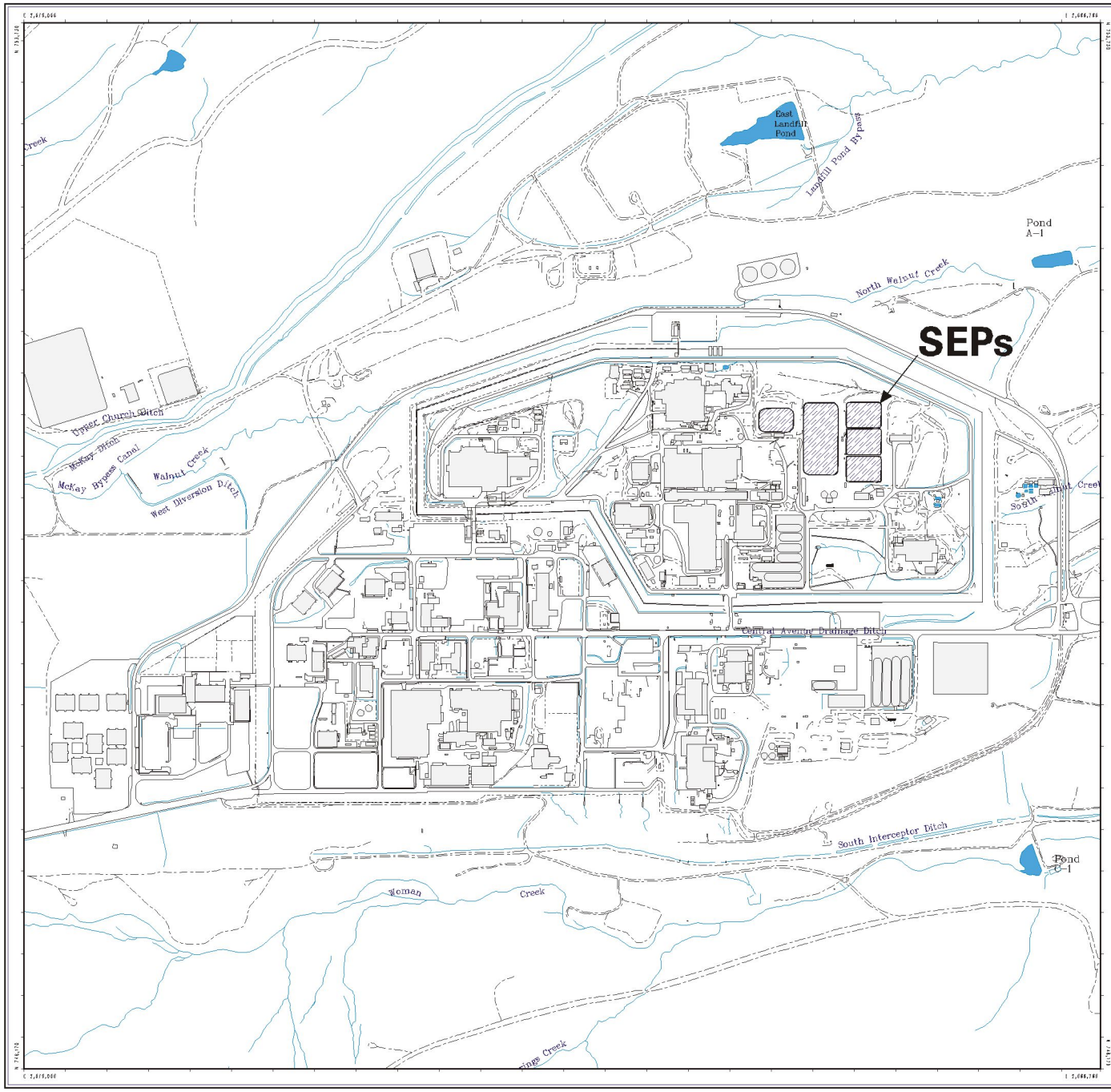

Figure 2-1

Standard Map Features

- Buildings and other structures
- Solar Evaporation Ponds (SEPs)
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Rocky Flats boundary
- Paved roads
- Dirt roads

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrographs, roads and other structures from 1994 aerial fly-over data captured by Eisele Ind., Las Vegas. Digitized from the orthophotographs. 1/95

Scale = 1 : 13340
1 inch represents approximately 1112 feet

250 0 500 1000 ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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

GIS Dept. 303-966-7707

Prepared by: DynCorp THE ART OF TECHNOLOGY

Prepared for: KAISER•HILL COMPANY

September 12, 2002

NT_Svr w:/projects/fy2002/02-0606/fig2-1.aml

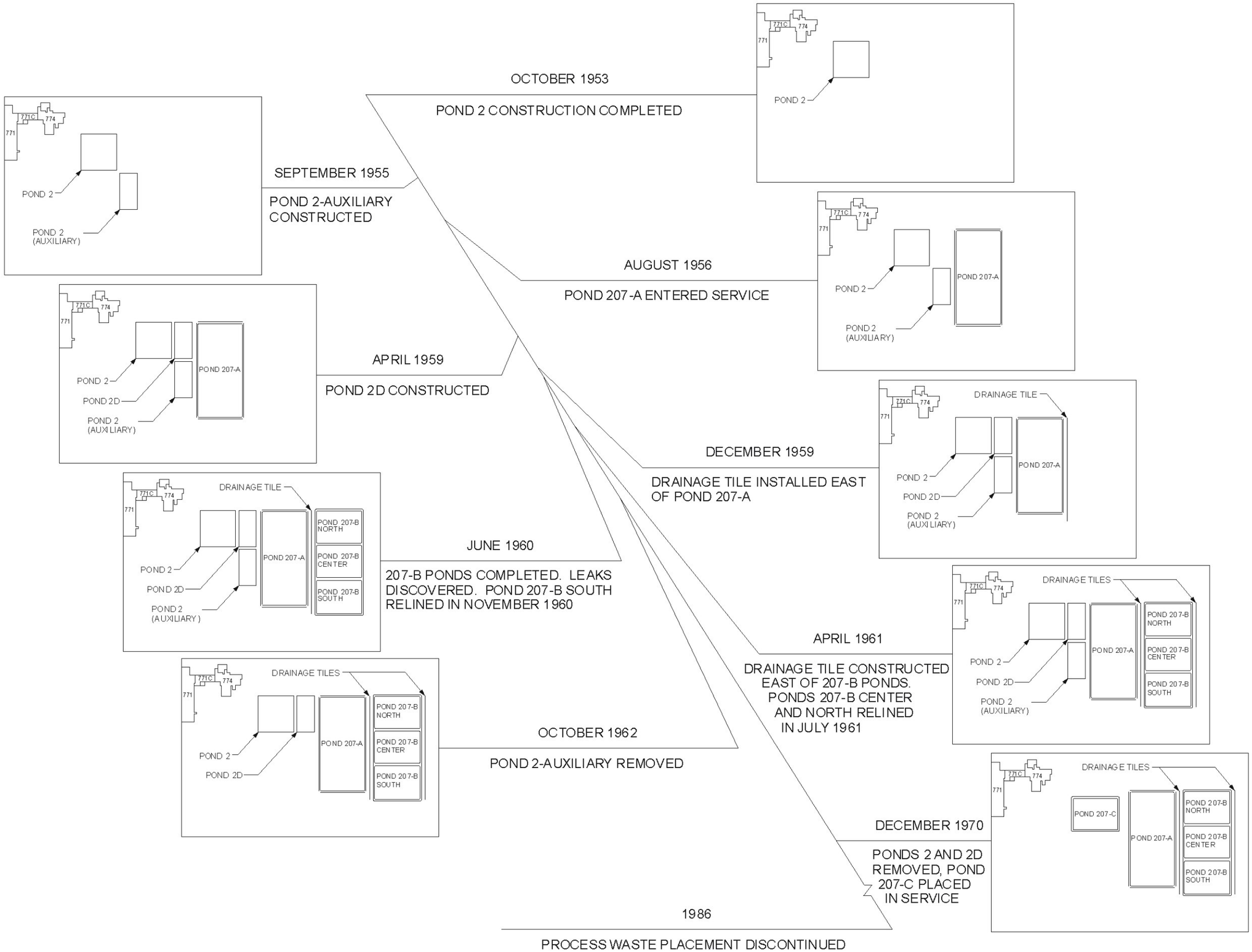

Figure 2-2

Chronological History of Major Pond Construction, Operation and Removal

Source: Solar Evaporation Ponds Operable Unit No. 4, IM/IRA Environmental Assessment Decision Document

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

Prepared by: GIS Dept. 303-966-7707

Prepared for:

DynCorp
THE ART OF TECHNOLOGY

KAISER-HILL COMPANY

MAP ID: 02-0622

Septembe 12, 2002

- Drums of waste radiography solutions;
- Treated sanitary effluent;
- Groundwater collected from the ITS;
- Saltwater solutions;
- Wash water from the decontamination of production personnel;
- Cyanide waste;
- Acid waste; and
- Other compounds such as sodium, cadmium, nitrate, ferric chloride, lithium chloride, sulfuric acid, ammonium persulfate, hydrochloric acid, nitric acid, and hexavalent chromium.

In addition to the above chemicals and compounds, it was reported that lithium scrap was reacted with water adjacent to the SEP, and the solution was transferred to the SEP. Based on these historical records, characteristic (D006) and listed (F00l, F002, F003, F005, F006, F007, and F009) hazardous wastes were placed into the SEP (DOE, 1995a). However, based on additional historical investigation, the following waste codes were potentially received by the SEP: D001, D002, D004,[9] D005, D006, D007, D008, D009, D010, D011, F001 (trichloroethene[10], 1,1,1-Trichloroethane,[7] and Tetrachloroethene[7]), F002 (methylene chloride, and 1,1,2-trichloro-1,2,2-trifluoroethane), F003 (acetone and methanol), F005 (toluene and methyl ethyl ketone), F006, F007, and F009 (RMRS 1996b and 2000).

Routine placement of process wastewater into these ponds ceased in 1986 because of changes in the RFETS waste treatment operations. Leakage from the SEP and related components (for example drainage tiles, leak detection systems, and collection sumps) has contaminated shallow groundwater in the area with uranium and nitrate contaminants. This SPP has migrated down the hillside to the north of the SEP. The primary contaminants in the SPP are uranium and nitrate. (refer to the Final Solar Ponds Plume Decision Document [DOE 1999a]) This decision document was a major modification to the Final Proposed IM/IRA Decision Document for the SEP, OU 4 (DOE 1992a).

Original Solar Evaporation Ponds

The original SEP, also known as Pond 2, was constructed in October 1953 on the existing grade; it measured approximately 200 feet by 200 feet by 6 feet. A clay dike was constructed around the perimeter, and the base of the pond was clay-lined. The operation of Pond 2 commenced in December 1953. Seeps were subsequently discovered along the northern, southern, and eastern dikes. Additional clay was added to the dikes as needed to repair the seeps.

[9] Although historical documents reference this waste code for arsenic, process knowledge and historical documentation also indicate that arsenic was not introduced into any plant process at RFETS.

[10] Although these specific constituents were not listed in the referenced report, the waste codes were identified. Based on the history of processes used at RFETS, it is assumed that these are the applicable constituents associated with this waste code.

In September 1955, a second earthen pond, designated as Pond 2-Auxiliary, measuring 100 feet by 200 feet by 6 feet, was constructed southeast of Pond 2 to maintain operational capacity while plans for a new watertight pond were being finalized. (Pond 2-Auxiliary is referred to as Pond 2C in some documents.) A weir was installed in the southeastern corner of Pond 2 to allow waste to overflow into Pond 2-Auxiliary. The new pond was unlined and leaks were observed along the eastern boundary within the first month of operation.

In August 1956, Ponds 2 and 2-Auxiliary were removed from service upon completion of a new watertight pond (Pond 207-A). These ponds were allowed to dry so that a clay liner could be installed. Completion of the clay liner installation for Pond 2-Auxiliary and Pond 2 occurred in February and March 1957, respectively. The relined ponds were then returned to regular service.

A third clay-lined pond, Pond 2D, was constructed in April 1959 to contain any overflow from Pond 207-A and support denitrification experiments. This third pond was located immediately east of Pond 2, as shown on Figure 2-2.

Routine use of Ponds 2, 2-Auxiliary, and 2D ceased in June 1960 when the B-Series Ponds were placed into service. The only other known discharge to these Ponds after June 1960 occurred in March 1963.

During April 1961, drainage tile was constructed east of the 207-B Ponds to collect and characterize leakage from the ponds. In July 1961, construction activities were implemented to reline the drainage tile associated with Ponds 207-B Center and 207-B North.

In October 1962, the Pond 2-Auxiliary area was regraded for the construction of Building 779. The clay lining and contaminated soil were removed and placed into one of the East Trenches at RFETS. Soil samples collected from the bottom of Pond 2-Auxiliary indicated activities of between 11,000 and 75,000 disintegrations per minute per kilogram (dmp/kg).

The Pond 2 and Pond 2D areas were regraded in 1970 to accommodate construction of Pond 207-C. The soil and dikes from these ponds may have been used in the construction of Pond 207-C. The approximate locations of the original SEP with respect to the existing SEP, are shown on Figure 2-2.

Table 2-1 summarizes the historical information regarding the original ponds. Detailed engineering drawings are presented in the Closure Plan: Solar Evaporation Ponds, Volume I, Appendix I (DOE 1988), as well as the Draft Operable Unit 4 Interim Measure/Interim Remedial Action Environmental Assessment Decision Document (DOE 1995a).

Table 2-l
Solar Evaporation Pond Designations and Status (Source: DOE, 1992a.)

Current Designation	Original Designation	Date Completed	Current Status
Original Clay-Lined Solar Evaporation Pond	Pond 2	October 1953	Regraded in 1970 for construction of Pond207-C.
Pond 2-Auxiliary[a]	Pond 2-Auxiliary[b]	September 1955	Regraded in 1962 for construction of Building 779.
Pond 2D[a]	Pond 2D	April 1959	Regraded in 1970 for construction of Pond 207-C.

[a] This pond could be confused with the original clay-lined solar evaporation pond because it was of earthen construction only.
[b] This pond was also known as Pond 2C. It was originally unlined, but a clay liner was installed in January 1957.

Pond 207-A

SEP 207-A was placed into service in August 1956 to provide additional storage capacity. This pond was originally constructed with a liner consisting of asphalt planks approximately 0.5 inch thick, 3 feet wide, and 14 feet long. The pond measured approximately 250 by 525 feet at the crest with side slopes of 1:2. The maximum operating depth was approximately 7.5 feet, resulting in an impoundment volume of approximately 5 million gallons (DOE 1988). This pond operated with a minimum freeboard of 2 feet. In September 1958, aluminum paint was applied to the exposed surface of Pond 207-A to increase evaporation.

In December 1959, drainage tile was installed along the eastern edge of Pond 207-A to intercept seeps discovered during excavation of the 207-B Ponds. The drainage tile was connected to a sump located northeast of Pond 207-A, and a pump system was installed in April 1970 to return the collected water to Pond 207-A.

In November 1963, modifications were completed to correct problems associated with the liner cracking and slumping, which resulted in leakage of the pond contents. These modifications included replacing the asphalt planking with an asphalt concrete liner, changing the side slopes to 1:3.7, and regrading the base of the pond to drain to a sump at the northeastern end of the pond. The asphalt concrete liner consists of a 4-inch-thick aggregate base placed on top of the subgrade, overlain by an asphalt prime coat, 1.5 inches of asphalt concrete, an asphalt tack coat, 1.5 inches of asphalt concrete, and a catalytically blown asphalt seal coat. Engineering drawings showing construction and liner details are presented in the Closure Plan: Solar Evaporation Ponds (DOE 1988). (It is assumed this closure plan was never approved by the regulatory agencies, because approval documentation could not be located.)

In April 1964, a pump was installed at Pond 207-A to facilitate liquid transfer among the ponds. In 1986, routine placement of waste in Pond 207-A ceased, and dewatering and sludge removal was initiated. Portland cement was mixed with the removed sludge to form pondcrete for offsite disposal. The last of the process water and sludge was removed from this Pond in July 1988.

To minimize the potential leakage of pond water to the underlying soil, the asphalt concrete side slopes of Pond 207-A were relined with a l/8-inch thick (minimum), rubberized, crack-sealing material in the fall of 1988. From 1988 to 1992, a limited amount of precipitation and sediment collected in the Pond. In March 1990, approximately 1.3 million gallons of water was transferred

from the 207-B Ponds to Pond SEP 207-A to prevent the overflow of liquids. The transferred water was removed in fall 1992 prior to the commencement of the RFI/RI drilling program in December 1992.

Ponds 207-B North, Center and South

The 207-B Series Ponds (North, Center, and South) were placed into service in June 1960. These ponds were originally lined with asphalt planking approximately 0.5 inch thick, 3 feet wide, and 14 feet long. Each pond measures approximately 180 by 253 feet. The maximum operating depths were 5.5 feet for Pond 207-B South and 6.5 feet for Pond 207-B Center and North, resulting in an impoundment volume of approximately 1.5 million gallons each.

In June 1960, the transfer of waste from Pond 207-A to Ponds 207-B South and Center was initiated. The transferred waste was acidic and produced gases that lifted the asphalt planking, thus rupturing the liner seams and resulting in leakage from the Ponds. Because of these problems, transfer operations were halted and the waste was returned to Pond 207-A. To return the waste to Pond 207-A, the waste had to be transferred to Pond 207-B North, which resulted in damage to all three of the 207-B Series Ponds. The asphalt planking within Pond 207-B South was covered with asphalt concrete in November 1960. The first six groundwater monitoring wells were installed in the vicinity of the 207-B Series Ponds in November 1960. Repair of Ponds 207-B Center and North was deferred because of funding limitations. Pond 207-B South was returned to service in December 1960.

In April 1961, repairs to the 207-B Series Ponds included installation of a drainage trench along their eastern edge. A sump and pump system was later installed in April 1970 to return the collected water to Pond 207-B North. Ponds 207-B Center and North were relined with asphalt concrete in July 1961. Because of difficulty in laying the asphalt concrete over the asphalt planking, the planking was removed from Pond 207-B North prior to it being relined with asphalt concrete. The two relined Ponds were then returned to service.

In April 1967, an unsuccessful attempt was made to fill cracks on the sidewalls of Pond 207-B North with asphalt mastic. In November 1967, sidewall cracks in Pond 207-B North were successfully repaired with burlap and asphalt. In October 1968, the sidewalls of Pond 207-B Center were successfully repaired with burlap and asphalt covering, and an additional coat of asphalt was applied to Pond 207-B North. Additional coats of burlap and asphalt were applied to Ponds 207-B North and 207-B Center in September and October 1969, respectively. The sidewalls of Pond 207-B South were covered with burlap and asphalt in September 1970. The sidewalls of Ponds 207-B North and Center were covered with Petromat® and hydraulic sealant in October 1971. The sidewalls and bottoms of Ponds207-B South and 207-B North were relined with Petromat® and hydraulic sealant in October 1972 and September 1973, respectively.

The placement of process waste into the 207-B Series Ponds ceased around 1974. A pond clean-out program was initiated in 1974 and extended until 1977, when all process wastes were removed. Since 1977, the B-series SEP were used to hold treated sanitary effluent, treated plant fire water, brine from the Reverse Osmosis Facility, contaminated groundwater from the ITS, and treated wastewater generated during the June-July 1993 hot systems operations testing of the Building 910 evaporators.

In 1978, the Petromat® liners of Ponds 207-B Center and South were removed, bagged, and cemented for offsite disposal. The asphalt concrete liners were not removed. Ponds 207-B Center and South were then relined with a hydraulic sealant. In addition to the sealant, a synthetic 45-mil Hypalon® liner was installed in Pond 207-B South. A leak detection system was installed between the Hypalon® liner and asphalt concrete liner. The leak detection sump is located in the northwestern portion of the SEP, and a pipe extends from the sump to the SEP berm. The lining of Pond 207-B North was not replaced because it held only a minimal amount of sludge, and its residual radioactivity levels were low. Engineering drawings showing the construction and liner details are presented in the Closure Plan: Solar Evaporation Ponds (DOE 1988) (This closure plan was never approved.)

In April 1982, water was removed from Ponds 207-B Center and North for application to the West Spray Field. At the time of the spray field operations, Pond 207-B Center contained treated sanitary effluent and Pond 207-B North contained ITS water. The spray field operations ended in November 1985.

Between 1993 and 1995, wastewater and remaining sludge from 207-A and B-series Ponds were removed by the Accelerated Sludge Removal Project. The sludge was transferred to RCRA-permitted tanks located on the 750 Pad. This sludge was and is currently being shipped to Envirocare of Utah, Inc. for disposal.

Pond 207-C

Pond 207-C was put into service in December 1970 to provide additional process waste storage capacity and provide interim storage for liquid from the other ponds during pond maintenance and repair work. Pond 207-C was constructed in approximately the same location as the original SEP. This pond measures approximately 160 by 250 feet and has a maximum operating depth of 7 feet. The pond has an impoundment waste volume of 1.2 million gallons.

An asphalt concrete liner was originally installed in Pond 207-C, which consisted of a 4-inch aggregate base course, overlain by an asphalt prime coat, 1.5 inches of asphalt concrete, a second asphalt tack coat, 1.5 inches of asphalt concrete, an asphalt tack coat, and a surface of catalytically blown asphalt seal coat. Pond 207-C has not been relined since its construction.

The bottom of the pond slopes to the northeast. Design drawings indicate a leak detection system was installed sometime in the late 1980s. The drawings depict the leak detection system as consisting of a perforated pipe aligned on a north-south axis under the center of the pond with the pipe terminating in a sump at the northern end. Engineering drawings showing the construction and liner details are presented in the Closure Plan: Solar Evaporation Ponds (DOE 1988). Pond 207-C has not received process wastes since 1986.

2.1.2 Actions Taken at the SEP

Various activities and projects have been undertaken to remediate the SEP and the SPP as follows:

1. The Ponds were relined and patched a number of times throughout their history to control leakage (DOE 1992b).

2. Drainage tiles were installed between Ponds 207-A and 207-B, and east of Pond 207-B in 1960 and 1961, respectively, to characterize water in the area (DOE 1992b).

3. Installation of two sumps and six trenches in the area north of the solar ponds allowed collection and return of contaminated groundwater to the ponds. The sumps were installed in April 1970 at the northern end of the drainage tiles. Trenches 1 and 2 were installed in October 1971, Trench 3 in September 1972, Trenches 4 and 5 in April 1974, and Trench 6 in July 1974(DOE 1992b).

4. Construction and utilization of the ITS in 1981 allowed for the collection of surface water runoff and groundwater seepage. (Refer to OU 4 SEP, IM/IRA Environmental Assessment Decision Document [DOE 1995]). The ITS consisted of 18 french drains located on the hillside north of the SEP and a surface water trench, known as the Interceptor Trench. The original configuration of this system has changed. Water collected by the ITS was pumped back uphill from the ITS Pumphouse near Walnut Creek into Pond 207-B North.

5. In 1986, a RCRA Part B operating permit application was submitted to the Colorado Department of Health (CDH) (renamed later as CDPHE). RFETS reported that the SEP were an interim status unit scheduled to be closed. The SEP including surrounding contamination were also identified as a SWMU, which later became IHSS 101. Figure 2-3 delineates the boundary of the SEP RCRA-regulated unit, as well as the boundary of IHSS 101. In 1991, under requirements of the Interagency Agreement (IAG), IHSSs were grouped into single management areas and the SEP area or IHSS 101 also became designated as Operable Unit (OU) 4. IHSS 101 and OU 4 were also later designated as PAC 000-101 for reporting purposes under the HRR. Under RFCA in 1996, OU 4 was combined with other IHSSs into the IA OU.

6. A number of environmental samples were collected from the vicinity of the SEP in 1986, 1987, and 1989 as follows:

   - A program was initiated in 1986 that included installation of 17 RCRA groundwater monitoring wells in the SEP area (designated with an 86 suffix) to expand the ability to monitor subsurface conditions related to the SEP. Hydrogeologic tests were conducted in some of these wells. A draft RCRA Interim Status Closure Plan was submitted for the SEP that summarized the testing results and outlined a method for removing the SEP from service.

   - Eighteen boreholes were drilled in 1987 in the SEP area to collect additional soil chemistry data specific to the SEP (designated with an 87 suffix) and to respond to comments on the draft RCRA Interim Status Closure Plan submitted in 1986 that were directed in part to the collection of additional characterization data. Two of the boreholes were completed as wells for more groundwater monitoring capability and subsurface conditions were evaluated.

   - A draft closure plan was submitted in 1988 that detailed future characterization efforts.

- Thirty-seven monitoring wells (designated with an 89 suffix) were installed in 1989. These additional wells were drilled at locations identified as data gaps in the 1988 characterization.

7. In 1990, a draft Final Phase I RFI/RI Workplan for the SEP, OU 4, was prepared for the purpose of characterizing the physical features of OU 4, identifying potential contaminant sources, and determining the distribution of contaminants in surface and subsurface soil. In 1992, both EPA and CDPHE granted approval of the workplan under the condition that a Technical Memorandum (TM) address vadose zone characterization at OU 4 (CDPHE 1992). TM No. 1 was written in 1992 and approved by both agencies in 1993. In 1993, TM No. 2 was written to document changes required to implement the workplan and was approved by both agencies (CDPHE 1993).

8. During 1992, a brief investigation was performed to determine whether the 207-B series ponds were leaking into the uppermost aquifer. This was accomplished by sampling wells in the vicinity of the SEP for a dye that was placed in the SEP. Based on the study, it was determined that no leakage was occurring from the 207-B series ponds.

9. Construction and utilization of the flash evaporation treatment system in Building 910, as well as three temporary storage tanks and associated piping to contain and transfer water collected by the ITS, began in 1992. The Modular Storage Tanks (MSTs) were located on the hill to the northwest of the SEP and ITS. The water from the MSTs was transferred to Building 374 for flash evaporation. Refer to the Final Proposed IM/IRA Decision Document for the SEP*, OU 4* (DOE 1992a). The MSTs were removed.

10. Removal of liquid and sludge from the SEP began in 1993. The purpose of the removal efforts was to remove the source of nitrate and uranium contamination that exists in soil and groundwater beneath and adjacent to the SEP. The removal (which was completed in 1995), provided access to the ponds for subsurface characterization work as described in the approved RFI/RI Work Plan for OU 4. The work was conducted as a routine operation within a RCRA Interim Status Unit Undergoing Closure. Following removal, the ponds were rinsed (with the possible exception of Pond 207-C, [DOE 1995c]) and the water was pumped to Building 374 for evaporation (CDPHE 1995a). (Consistent with previous actions, Pond 207-C was rinsed and the precipitation removed as part of routine maintenance activities in 2002.) The remaining sludge, stored in tanks on the 750 Pad, are in the process of being removed from the tanks, dewatered, packaged, and shipped to an offsite disposal facility. (Refer to the Draft Operable Unit 4 – Solar Evaporation Ponds Interim Measure/Interim Remedial Action, Environmental Assessment Decision Document [DOE 1995a]).

11. In 1993, investigations pursuant to the approved work plan (DOE 1992d) and TMs were completed. The following investigations and sampling activities were performed:

    - A Ground Penetrating Radar (GPR) survey was completed in the vicinity of the original ponds.

- Six boreholes in or adjacent to the original ponds area were completed. Surface and subsurface soil samples were collected at each borehole and analyzed for suspected contaminants.
- A GPR survey was conducted beneath Pond 207-A.
- An OU 4-wide beta/gamma radiation survey was conducted that consisted of 311 data points.
- A seismic refraction survey was completed to evaluate bedrock topography and the presence of paleochannels.
- Twelve boreholes were completed and subsurface soil samples were collected from within Ponds 207-A, 207-B Center, and 207-B North. Boreholes were placed at locations where breaches in the liners were observed and at locations where the liner was intact (DOE 1995a). It was decided and agreed to in a joint working group meeting with EPA, CDPHE, DOE, and EG&G personnel held February 1, 1995, not to collect core sample beneath Pond 207-B South. Surrounding data from the other 207-B Ponds and Ponds 207-A pond has allowed for adequate characterization of soil associated with pond 207-B South (EG&G 1995c). In addition, comments from CDPHE in 1995 stated "that drilling beneath Pond 207B-South is not planned (the liner of this pond demonstrated integrity that precluded the need for additional RFI/RI investigation)" (CDPHE 1995b).
- Sixteen boreholes were completed between the ponds and around the perimeter of IHSS 101.
- Nineteen boreholes were drilled and sampled in the ITS and surrounding area.
- Twelve samples of asphaltic liner and sub-base material were collected from Ponds 207-A, 207-B Center and 207-B North. (Three additional samples were collected in 1995 from Pond 207-C once the pond was emptied of all liquids and slurried solids. Samples were collected at a depth of 0.5 to 6.5 feet beneath pond 207-C [RMRS 1995]).
- One deep borehole (42193) within Pond 207-A was drilled into bedrock, sampled, and geophysically logged. Subsurface samples were also collected.
- Fifteen lysimeters were installed in the vicinity of IHSS 101.
- Twenty-six random and 10 discrete or "hot spot" surface soil samples were collected and surface soil samples were collected from 36 boreholes.
- Approximately 200 subsurface soil samples were collected from the vadose zone.
- Nine samples were collected for column leaching tests.
- Twenty-five soil samples were collected from boreholes for analysis of physical and hydrogeologic properties.
- Borehole permeability measurements were made.

- Shallow soil permeability was measured at 19 locations using a Guelph permeameter.
- Pore water samples were collected from lysimeters.
- Relative moisture content in the vadose zone was measured using a neutron probe.
- Data loggers and pressure transducers were installed in five wells to measure the response of the water table to precipitation events and evaluate responses attributable to secondary porosities.
- Soil gas samples were collected at 28 locations.

12. As of March 1994, 87 percent of the RFI/RI data had been validated and 1.26 percent of the total validated data had been rejected. DOE, CDPHE, and EPA believed that enough validated data existed to assess and select a closure/remediation general response action and a proposed IM/IRA was written in 1995, which included a baseline risk assessment.

13. RFCA was signed in 1996. Based on the results of the RFI/RI and the risk assessment, ER ranked IHSS 101 number 14.

14. A reactive barrier was installed in 1999 north of the SEP on the northern side of the North Access Road (DOE 1999a). The barrier system consists of a collection system to direct groundwater flow to two passive treatment cells. The collection trench is approximately 1,100 feet long, 2 to 3 feet wide, and 20 to 30 feet deep. The trench extends approximately 10 feet into weathered bedrock to capture both bedrock and alluvial flow. The first treatment cell is filled with a mixture of organic media (sawdust) to act as a carbon source to induce denitrification and zero-valence iron to remove the uranium by chemical reduction. Nutrient mulch, which increases the denitrification rate, can also be added to the iron/sawdust treatment media. The second cell is filled with 100 percent granular activated iron aggregate to remove uranium. The collection trench cuts the ITS, allowing groundwater collected by the ITS upgradient from the reactive barrier to flow into the new collection trench. ITS lines were disrupted where they intersect the new collection system. The installation of a collection sump to increase the volume of groundwater treated was recently approved in the Minor Modification to the Final Solar Ponds Plume Decision Document (2002d).

15. Soil removal for purposes of reducing the long-term stewardship obligations of the SPP treatment system was not necessary because groundwater contaminants are below Tier II ALs in soil (Section 3.1). The groundwater plume present beneath and downgradient of the SEP is being addressed as part of the ongoing SPP IM/IRA. (Refer to the Final Solar Ponds Plume Decision Document (DOE 1999a), and its Minor Modification (DOE 2002d).

16. Environmental monitoring, including downstream surface water and downgradient groundwater monitoring, is being conducted as part of the Sitewide Integrated Monitoring Program (IMP) to ensure that contaminant concentrations are not increasing and that water quality standards are being met. (Refer to the Final Solar Ponds Plume Decision Document [DOE 1999a] and to IMP [DOE 1999b].) The IMP monitors groundwater for volatile organic compounds (VOCs), metals, nitrate, uranium (U), plutonium (Pu), americium (Am),

neptunium and tritium. This is being accomplished by means of a network of eight monitoring wells (four existing wells and four new wells). (Refer to the Well Abandonment and Replacement Program [WARP], Work Plan Addendum for the Solar Evaporation Ponds, [Kaiser-Hill 2002a].) If contaminant concentrations increase, the Site will investigate and implement actions consistent with the overall risk in accordance with RFCA Action Levels and Standards Framework (ALF).

- Surface soil areas exceeding proposed soil ALs (DOE et al.. 2002) for Am-241 and Pu-239/240 were removed in accordance with ER RSOP Notification #02-08. By removing this radiologically contaminated soil, beryllium-impacted soil, which exceeded the ecological receptor action level of 8.71 mg/kg (9.6 milligrams per kilogram [mg/kg]), was also removed. Locations and concentrations removed are documented in the Draft Closeout Report for the SEP AOC (DOE 2002e).

The actions taken are consistent with the RFCA Vision for long-term stewardship in that source removal has been conducted and groundwater treatment has been implemented.

2.1.3 Current Status of the SEP

The five SEP are situated on a large, level parcel of land, except where artificial berms have been built. The existing SEP area covers approximately 6.1 acres determined by Geographic Information System (GIS) analysis, (see risk assessment results in Attachment B) representing the boundary of the interim status RCRA regulated unit.

For purposes of addressing the SEP and associated contamination under this PAM, IHSS 101 has been modified to exclude the following areas that will be included in other onsite investigations:

- The “panhandle” area to the northwest that is associated with Bowman’s pond will be investigated as part of Bowman’s Pond PAC 700-1108.
- The southwester corner of IHSS 101 and directly south of pond 207-C currently includes several buildings (779, 780, 786, 787, and others). This area will be investigated as part of Under Building Contamination (UBC) Site 779 and the demolition or removal of these other buildings.
- Directly east of the B-series ponds and PACs 900-1310 and 1314 is an area that is currently occupied by building 964 and represents IHSSs 176 and 165. This area will be investigated as part of IHSSs 176 and 165.

The ground surface north of the SEP slopes steeply downward toward North Walnut Creek. The ponds are currently roped off and posted as contaminated areas, and all waste has been removed. They currently contain varying amounts of water from precipitation. The existing ponds and major pond components are shown on Figure 2-3.

Subsurface soil and any below-grade ponds and OPWL components located in the area of Pond 2-Auxiliary will be addressed in the future as part of UBC Site 779 (that is when UBC Site 779 is characterized and remediated as necessary).

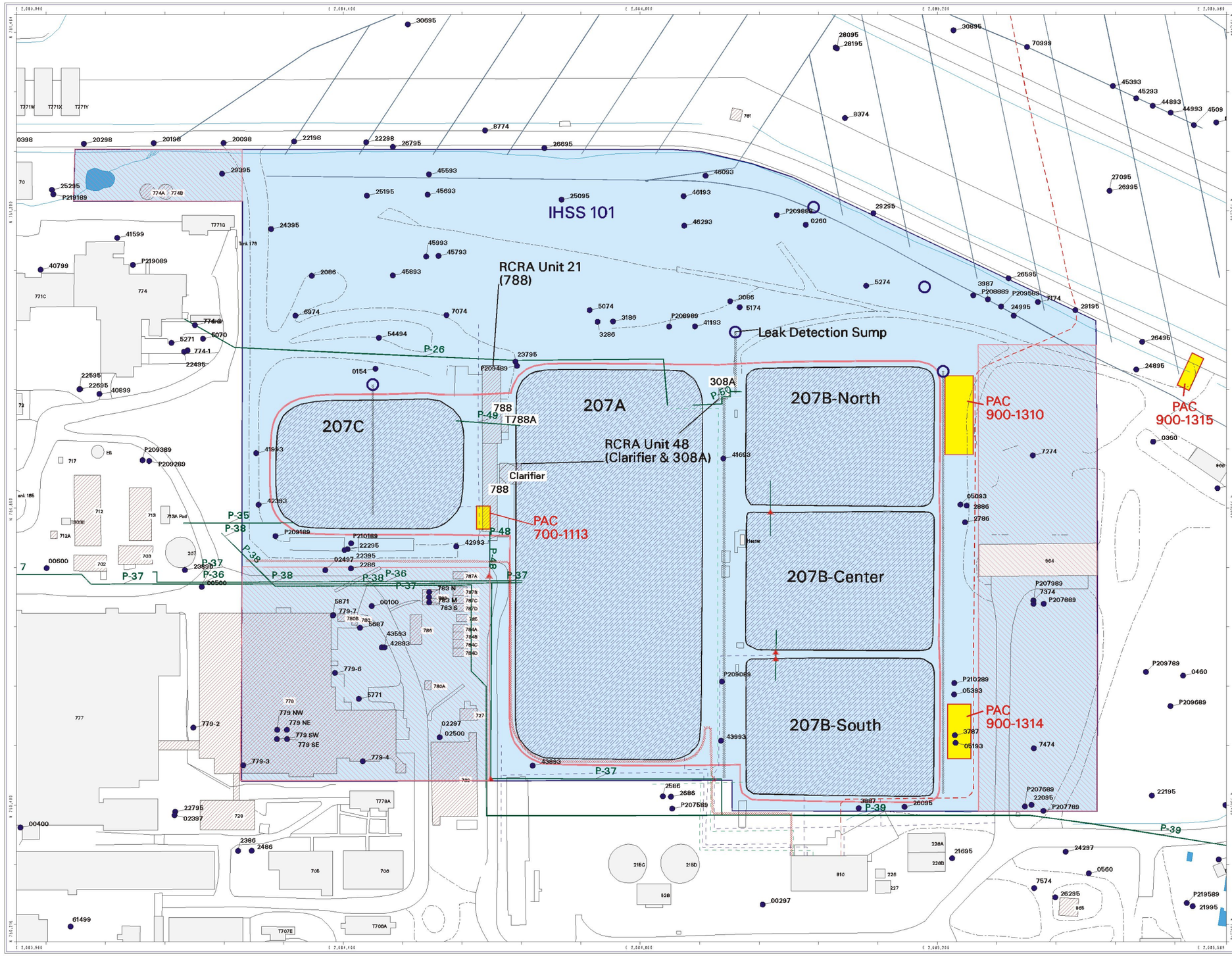

Figure 2-3

Solar Evaporation Ponds and Associated Components

EXPLANATION

- Portions of IHSS 101 managed by other IHSSs, PACs or UBCs
- RCRA Unit Boundary
- Individual Hazardous Substance Site (IHSS)
- Potential Area of Concern (PAC)
- Original Process Waste Line (OPWL) (A portion of IHSS 121)
- Interceptor Trench System (ITS)
- Drainage Tile and Leak Detection Line
- New Process Waste Line (NPWL) (A portion of RCRA Unit 374.3)
- Reverse Osmosis Line (underground)
- Raw Water Line (underground)
- Modular Storage Tank (MST) Return Line
- Valve Pit
- Groundwater Well
- Sumps

Standard Map Features

- Buildings and other structures
- Demolished buildings
- Solar Evaporation Ponds (SEPs)
- Lakes and ponds
- Streams, ditches, or other drainage features
- Paved roads
- Dirt roads

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

Scale = 1 : 1610
1 inch represents approximately 134 feet

25 0 50 100ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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

GIS Dept. 303-966-7707

Prepared by: DynCorp THE ART OF TECHNOLOGY

Prepared for: KAISER•HILL COMPANY

September 20, 2002

NT_Svr w:/projects/fy2002/02-0623/solar_ponds_02-0931.aml

Because the SEP are a RCRA interim status unit and have both an IHSS and PAC number, Table 2-2 identifies the required completion activity, mechanism for completion, and the document used for completion.

Table 2-2
Completion Table for the SEP

Unit Name	RCRA Unit/IHSS/PAC	Required Completion Activity
SEP	RCRA Interim Status Unit (no number), IHSS 101, and PAC 000-101	RCRA Closure for RCRA Unit and NFA for IHSS and PAC
A portion of OPWL, sumps, and valve pits	A portion of IHSS 121 and a portion of IHSS 149.1 (no PAC number)	NFA for IHSSs
A portion of NPWL[11]	A portion (Box 5 at Building 910 to UBC Site 774 fence) of RCRA Unit 374.3 and PAC 000-504 (No IHSS number)	Partial RCRA closure and NFA for PAC
MST line	No specific IHSS or PAC[12] reference	None
Permacon concrete pad	RCRA Permitted Unit 21 (no IHSS or PAC number)	RCRA closure
Clarifier and 308A Pumphouse concrete pads	RCRA Interim Status Unit 48 (no IHSS or PAC number)	RCRA closure
ITS water spill	PAC 900-1310 (no IHSS number)	NFA for PAC

2.2 Other Units, PACs, and IHSSs

Process piping (above- and below-grade waste lines), manholes, electrical control conduit, other utilities, and associated piping support racks are present throughout the SEP area. South of Pond 207-B South, there is a concrete ramp with metal grating for access into the SEP area. The ramp goes over the above-grade NPWL, electrical conduit, and associated support racks. Concrete "jersey" barriers are present to protect the above-grade NPWL. Detailed drawings of utilities, including a portion of the OPWL, valve pits and collection sumps, drainage tiles, and leak detection systems, are presented in the Closure Plan: Solar Evaporation Ponds, Volume I, Appendix 1 (DOE 1988). Also located in the area of the SEP and within the IHSS 101 boundary is an MST line, RCRA Units 21 and 48, and PAC 900-1310. Figure 2-3 highlights these various units and each are discussed below because releases from these units may also have contributed to the contamination present around the SEP. In addition, there are several monitoring wells and lysimeters located in and around the ponds, inside and outside the bermed area.

[11] NPWL has multiple RCRA unit numbers associated with it. RCRA unit 374.3 only represents the portion of NPWL located within IHSS 101.
[12] This line could be associated with Interceptor Trench Pumphouse, PAC NE-1409, which received NFA approval in 2001.

2.2.1 History

OPWL, NPWL, and MST Line

The OPWL functioned as a transfer and storage system for process waste from various facilities onsite to be treated at the process waste treatment facility housed in Building 774 and the SEP. The OPWL is consists of approximately 40 tank locations, which include an assortment of above-, on-, and below-grade tanks; floor sumps; valve vaults; secondary containment structures; and process waste vaults. The OPWL network originally consisted of approximately 35,000 feet of pipeline. Parts of the OPWL were converted to NPWL or other systems (for example, fine plenum deluge system), and the current OPWL system contains approximately 29,000 feet of pipeline. The OPWL transported (or stored in OPWL tanks) various aqueous process waste containing low-level radioactive materials, nitrates, caustics, and acids. The waste managed in the OPWL represents a subset of the total waste managed in the SEP.

Some of the OPWL, including waste lines and valve vaults, are located in the SEP area, and some discharge into the ponds (Figure 2-1). Other lines are used to transfer waste from one pond to another. Most of the lines were installed in the 1950s and 1960s and include P-26 (a portion of IHSS 149.1), P-35, P-36, P-37, P-38, P-48, P-49, and P-50. P-26 is constructed of stainless steel and PVC; P-36 and P-50 are constructed of stainless steel; P-35 is constructed of steel; P-37 is constructed of steel, polyvinyl chloride (PVC), and vitrified clay; P-38 is constructed of vitrified clay; and P-48, and P-49 are constructed of cast iron. Some of these lines (i.e., P-26, P-36, P-37, and P-38) have historically leaked and are part of IHSS 121. (Refer to Operable Unit 9 Technical Memorandum No. 1, Volume IIA – Pipelines, Addendum to Phase I RFI/RI Work Plan [EG&G 1994].)

Two other lines are located in the SEP area. One of the lines is an aboveground line, which is part of the NPWL system and RCRA Unit 374.3 which was used to convey water from the MSTs via Building 910 to Building 374. Typically water transferred from Building 910 to Building. 374 did not contain RCRA-contaminated wastewater. However, in 1999, a temporary authorization was received to transfer decant water from the 750 Pad sludge removal project and cooling tower water from Building 779. The wastewater from the 750 Pad project contained concentrations of metals in the parts per billion (ppb) range and concentrations of methyl ethyl ketone in the parts per million (ppm) range. The cooling water from Building 779 was contaminated with arsenic (11 milligrams per liter [mg/L]). Upon completion of the transfer of this waste to Building 374, the transfer line was to be flushed, rinsed, and sampled and analyzed to ensure no residual contamination remained. However, documentation could not be located to ensure these final activities were conducted. There was no reported release from this line.

The other belowgrade line located in the SEP area was used to convey water from the MSTs to Building 910. Water conveyed was primarily groundwater from the SEP area collected by the ITS. There was no reported release from this line.

RCRA Units

Various structures associated with the removal and processing of pond sludge were located between the ponds, after pond operations ceased; however, all structures have been removed, including Building 788, Trailer 788A, the 207 Clarifier unit, and the 308A Pumphouse (Figure 2-3).

The Permacon within Building 788 was a RCRA-permitted storage unit (RCRA Unit 21) used for the storage of pondcrete waste containers. The 207 Clarifier and 308A Pumphouse were a RCRA interim status unit (Unit 48) used to mix pond sludge and Portland cement to create pondcrete. All that remain are concrete slabs, most of which are probably steel reinforced. Due to radiological concerns, the building and clarifier slabs have been covered with 80-mil plastic and soil. Partial closure was achieved for all of RCRA Unit 21 except for the former Permacon slab. The Permacon slab was rendered RCRA stable by decontamination using chemical cleaning and high-pressure spray methods. Partial closure was achieved for all of RCRA Unit 48 except for the 207 Clarifier and 308A Pumphouse slabs. The Clarifier slab was rendered RCRA stable by the application of acrylic latex spray-on fixative. The Pumphouse slab was rendered RCRA stable by chemical cleaning and high-pressure spray methods. Closure activities are summarized in Section 6.1 and detailed in the Final Closeout Report, Building 788 and Clarifier Tank, RCRA Closure Decommissioning Project Summary Report of RCRA Closure Activities for Units 21 and 48 in Building 788 (RMRS 1999a). The estimated dimensions and areas of the slabs are presented below.

Table 2-3
RCRA Unit Dimensions

Location	Approximate Dimensions (feet)	Approximate Area ($feet^2$)
B788/B788A Slab	220 by 22.5	4950
Former Permacon Area	47 by 10	470
207 Clarifier Slab	30 by 30	900
308A Pumphouse Slab	10 by12	120

All structures associated with RCRA units 21 and 48 have been removed except for the facility pads (RMRS 1999a).

PACs
There are four PACs associated with SEP operations:

- PAC 700-1113, associated with water released from Pond 207-C (DOE 1995c);
- PAC 900-1310, associated with a spill from the ITS (DOE 1994a);
- PAC 900-1314, associated with sludge release from Pond 207-B (DOE 1994b); and
- PAC 900-1315, associated with a release from a tanker truck on the East Patrol Road, north of Spruce Avenue (DOE 1995c).

PACs 700-1113, 900-1314, and 900-1315 have been investigated, and, based on the results, NFA was proposed. (Refer to DOE 1995c for PACs 700-1113 and 900-1315, and DOE 1994b for PAC 900-1314.) CDPHE concurred with the NFA requests on March 13, 2002.

PAC 900-1310 received approximately 490 gallons of water from the ITS on November 30, 1992, when a pipe coupling in the 3 inch transfer line on the eastern slope of the 207-B North berm separated during subzero weather. ITS water consists of collected groundwater from the

SEP area. COCs include U and nitrate. The pipe connection was repaired and the system was placed back into service.

2.2.2 Actions Taken

Various activities and projects have been undertaken that are related to these other units in the area of the SEP. A majority of these other units were removed recently as separate actions in accordance with ER RSOP FY02 Notification #02-08 (DOE 2002b). In addition, sampling was conducted in accordance with IASAP Addendum #IA-02-07 (DOE 2002c). The actions taken include:

- **Portions of OPWL and NPWL*:*** Contaminated above-grade waste lines (NPWL), segments of below-grade lines located less than 3 feet belowgrade and within the berms (OPWL), valve vaults, and collection sumps were removed, characterized, and disposed of in accordance with the ER RSOP. Soil contaminated by known releases (that is, OPWL, valve vaults, and collection sumps) was removed if concentrations were above RFCA Tier I ALs and disposed of. Sampling in the vicinity of suspected areas identified soil contamination. For example, it is known that the valve vault west of Pond 207-A leaked, and, therefore, the area around the valve vault was investigated. All soil removal included confirmatory sampling to ensure that all contaminated soil had been removed. Excavated soil was also characterized for waste management purposes. The leak detection line east of the B-Series Ponds and under Pond 207-C was disrupted and foamed in place.

- **MST Line*:*** The MST line to Building 910 was disrupted that is the line was cut (disrupted) and filled with foam.

- **Various Structures Associated With Pond Cleanout Operations:** Various structures associated with pond cleanout operations were removed, including Building 788/788A, Trailer 788A, the 207 Clarifier unit, and the 308A Pumphouse. Part of Building 788A was a RCRA-permitted unit (Unit 21), and the Clarifier and Pumphouse were part of a RCRA interim status unit (Unit 48). All that remain are concrete slabs. Partial closure was completed for the entire Unit 21 concrete slab except for the area of the former Permacon. The Permacon area was rendered RCRA stable by decontamination using chemical cleaning and high-pressure spray methods. Partial closure was completed for all of Unit 48 except for the 207 Clarifier and 308A Pumphouse slabs. The Clarifier slab was rendered RCRA stable by the application of acrylic latex spray-on fixative. The Pumphouse slab was rendered RCRA stable by chemical cleaning and high-pressure spray methods. Closure activities are presented in the *Final Closeout Report, Building 788 and Clarifier Tank, RCRA Closure Decommissioning Project, and Summary Report of RCRA Closure Activities for Units 21 and 48 in Building 788* (RMRS 1999a).

- **RCRA Units 21 and 48**: The concrete pads remaining for these units were removed and soil samples were collected beneath the pads. Samples were analyzed in accordance with the IASAP Addendum #IA-02-07, results indicated all detected contaminants were below RFCA Tier I ALs. Therefore, the remaining portions of these units were RCRA closed through removal.

- **PAC 900-1310**: Soil from PAC 900-1310 was sampled and characterized. Analytical results indicated radiological contaminants detected were all less than current RFCA Tier II ALs and metal concentrations were all less than current RFCA Tier II ALs except for arsenic, which was below Tier I ALs (Maximum detected concentration of 17 mg/kg compared to the RFCA Tier II AL of 2.99 mg/kg.) Nitrate and nitrite were also well below current RFCA Tier II ALs.

- **Manholes, utilities and piping support racks, and concrete ramps and barriers:** Manholes, utilities and piping support racks, and concrete ramps and barriers were removed, characterized and disposed of in accordance with the ER RSOP.

- **Unnecessary monitoring wells:** Unnecessary monitoring wells were abandoned in accordance with applicable regulations under the Site's well abandonment program (P209089, P209489, 41693, 43893, 43993, 23795, 26095, 2786, 3887, 05093, 05193, and 05393.) (Refer to the Well Abandonment and Replacement Program, Work Plan Addendum for the Solar Evaporation Ponds, [Kaiser-Hill 2002a].) Lysimeters in the area were also removed.

2.2.3 Current Status

The other RCRA units were RCRA closed by removal; these closure activities will be documented in a final closeout report. All aboveground lines, valve pits, sumps, pumps, and associated equipment have been removed. All lines located less than 3 feet belowgrade have also been removed. Lines located more than 3 feet belowgrade have been disrupted by cutting or disconnected and filled with foam. Soil has been sampled in areas around the OPWL that are known to have leaked (for example, around the valve pit) and at PAC 900-1310. Residual soil concentrations present around all these other units are below current RFCA Tier I ALs.

The B-Series ponds are shown on drawings to have leak detection lines; however, this was never verified based on field activities conducted under ER RSOP Notification #02-08.

3.0 NATURE AND EXTENT OF CONTAMINATION

The source of groundwater and soil contamination within the SEP IHSS was process waste managed in the various units and ponds in this area. Contamination resulted from the leakage of the original and existing ponds, and releases from the OPWL and PAC 900-1310 (ITS Water Spill). Process waste has been removed from these units and shipped offsite for disposal. (Refer tothe Final Closeout Report, Building 788 and Clarifier Tank, RCRA Closure Decommissioning Project, and Summary Report of RCRA Closure Activities for Units 21 and 48 in Building 788 (RMRS, 1999a) and Historical Release Report Second Quarterly Update (DOE 1992). Previous investigations have been conducted to characterize the SEP IHSS for purposes of defining the nature and extent of contamination. These investigations are detailed in the following documents:

- DOE, 1995a, OU 4 Solar Evaporation Ponds, Interim Measure/Interim Remedial Action Environmental Assessment Decision Document;

- DOE, 1994c, Final Phase II Resource Conservation and Recovery Act (RCRA) Facility Investigation/Remedial Investigation (RFI/RI) Work Plan, OU 4;
- ERM, 1996, OU 4 SEP, Phase II Ground Water Investigation, Final Field Program Report;
- RMRS, 1996, Management Plan for the ITS Water;
- RMRS, 1997, SPP Remediation and ITS Water Treatment Study;
- DOE, 1992b, Final Phase I RFI/RI Work Plan, Original Process Waste Lines (Operable Unit 9; and
- RMRS, 1995, Solar Evaporation Pond 207C Characterization Report for the Rocky Flats Environmental Technology Site.

Most waste lines, drain tiles, and leak detection lines should not have been a significant contribution to the contamination present within the IHSS. Process waste should have drained to the collection sumps long ago and should no longer be present in the lines. If residual liquid is present, the lines will be drained prior to foaming or removal. Also, it is assumed, based on visual inspection of the lines and composition of the lines, that contaminants should not have significantly penetrated or adhered to the line construction materials. This is based on the knowledge that stainless steel, steel, PVC, cast iron, and vitrified clay[13] lines exist within this IHSS.

It is noted that this section may include possible explanations for the presence of certain contaminants (for example, acetone as a laboratory contaminant) in defining the nature and extent of contamination. However, for purposes of defining risk (as discussed in Section 5.0 and Attachment II) all SEP data were used as defined in Attachment II.

3.1 Groundwater Contamination

Groundwater contamination is discussed briefly for purposes of defining the nature and extent of contamination and to determine whether additional soil remediation could reduce the long-term stewardship obligations of the SPP treatment system. However, corrective action of existing groundwater contamination, including treatment, is addressed in a separate IM/IRA decision document. (Refer to the Final Solar Ponds Plume Decision Document [DOE 1999a], and its Minor Modification [DOE 2002d].)

From previous investigations and as documented in the SPP Decision Document (RMRS 1999c), it is known that the SPP is an area of groundwater contamination that extends from the SEP northeast toward North Walnut Creek and southeast toward South Walnut Creek. It is contained within the upper hydrostratigraphic unit (UHSU).

The groundwater flow path in the area of the SEP is very complex due to the varying thickness of the unconsolidated deposits and weathered bedrock units and the highly variable primary and

[13] Based on technical information associated with the manufacture of clay pipes/lines, when clay pipe is vitrified, the clay mineral particles become infused into an inert, chemically stable compound that is resistant to attack by various chemicals including acid and solvents. (Refer to the National Clay Pipe Institute @ www.ncpi.org.)

secondary permeabilities of the two units. The combination of the varying thickness of the unconsolidated deposits and seasonal water table fluctuations result in large areas of the unconsolidated deposits in the area of the ITS becoming unsaturated. The hydraulic gradient between the unconsolidated deposits and weathered bedrock at the SEP is downward, due to infiltration of rainfall at the ponds. General depth to groundwater beneath the SEP has historically been approximately 10 to 20 feet (DOE 1999a). However, based on the dry conditions during 2002, depth to groundwater is approximately 25 to 30 feet.

Recharge and subsurface inflow to the SEP area originates from both natural and anthropogenic sources. Sources of recharge to the SPP include natural groundwater flow entering the SEP area from the west and southwest, infiltration of precipitation on the SEP and ITS hillside, runoff from the former PA directed to the ITS, and water used for dust suppression at the SEP. (DOE 1999a).

At the SEP, the UHSU groundwater contains high total dissolved solids (TDS) concentrations, most notably in the immediate vicinity of the ponds and the portion of North Walnut Creek located north of the SEP. Leakage of process water concentrated by evaporation from the ponds provided a source of chemically distinct water to groundwater in the IHSS area. Concentrated water is easily distinguished from natural recharge water by its high TDS and major-ion contents (EG&G 1995c).

The primary contaminants in the SPP are various isotopes of U and nitrate (DOE, et al., 1996). Monitoring wells have also indicated detection of lithium, selenium and thallium[14] at concentrations above groundwater ALs. However, an analysis of metals distribution was conducted, and the results indicate there is no metals plume associated with the SEP (DOE 1999a).

Four monitoring wells (1386, 1786, 70099 and 70299) monitor the nitrate- and uranium-contaminated groundwater plume associated with the SEP. Nickel concentrations in well 1386 have increased steadily since spring 1992 and, except for two sampling dates, have been greater than Tier II ALs since spring 1993. Investigation of this upward trend in nickel concentrations in Well 1386 is currently being conducted. Selenium concentrations in Well 1786 have been consistently greater than Tier II ALs since sampling was initiated in February 1990. Nitrate concentrations have declined over time in Well 1786 and have remained essentially unchanged at Well 1386. U activities (U-233/234, U-235) at Well 1386 and Well 1786 exceeded RFCA Tier II groundwater ALs during fourth quarter 2001(Kaiser-Hill, 2002b). However, U activities in these wells are consistently below RFCA Tier I groundwater ALs.

Based on historical data, U and nitrate concentrations in surface soil and subsurface soil are all below RFCA Tier I and Tier II ALs. In addition, lithium, nickel, and selenium concentrations are also below Tier I and Tier II ALs in both surface and subsurface soil. A discrete secondary source of contamination has not been observed in the area of the SEP. Therefore, no additional

[14] The maximum detected concentration of thallium in subsurface soil is 4.2 mg/kg and its maximum detected background concentration is 4.1 mg/kg. Current RFCA ALF does not identify an AL for thallium in surface or subsurface soil. Proposed surface soil Preliminary Remediation Goals (PRGs) do not include thallium as a contaminant. Historical knowledge does not indicate thallium was used in processes that were discharged to the SEP.

soil removal is required for purposes of reducing the long-term stewardship obligations of the SPP treatment system.

The current SPP collection and treatment system was installed as an IM/IRA and placed into operation in 1999. This new system replaced the previous temporary MST storage and Building 374 evaporation treatment systems. The SPP system collects water primarily from the old 1,100-foot-long ITS, passes it through a two-stage treatment cell containing iron filings (to remove U from water) and wood chips, and discharges the effluent to a gallery near Walnut Creek. Groundwater influent concentrations of U are fairly constant at 20 to 30 pCi/L. U effluent concentrations from the SPP treatment system are 0 to 0.96 pCi/L, averaging 0.15 pCi/L (DOE 2001). A minor modification to the 1999 IM/IRA was submitted and approved by CDPHE during Fiscal Year (FY) 02, to increase the amount of water treated by the treatment system, by installing a collection sump in the existing collection trench and pumping groundwater into the existing treatment cell. Gauging Station (GS)d13 is the performance monitoring location for the SPP treatment system.

Tritium has been detected in the vicinity of the SEP in both surface soil and groundwater based on historical sampling conducted in 1991. A signature of tritium was observed around the ponds in groundwater with a maximum concentration of 13,850 pCi/L in 1991. This concentration was below the drinking water standard of 20,000 pCi/L and currently this concentration is approximately 6,300 pCi/L due to radiological decay. Vadose transport and dispersion in saturated zones should further reduce this maximum concentration.

Tritium sampling has also been conducted near the SPP treatment system and the Site boundary to assess possible surface water impacts. The maximum concentration detected near the SPP treatment system in 1991 was 780 pCi/L. This detection was observed in January 1991 and exceeded the surface water standard of 500 pCi/L. Subsequent samples collected from October 1991 to February 1992 had concentrations below the surface water standard. Samples collected after April 1991 had tritium concentrations below detection limits. The overall averaged concentration at this location was 55 pCi/L. Tritium samples collected at the Site boundary from 1991 to 2002 had a maximum reported concentration of 13,400 pCi/L in 1991. Maximum concentrations steadily declined in the following years from 3,310 pCi/L and were below detection limits from 1999 to present day. Detection limits ranged from 150 to180 pCi/L at the Site boundary location.

The activity of tritium in groundwater and surface water near the SEP, and for the Site as a whole, are well below drinking water and surface water standards.

3.2 Soil Contamination

Extensive historical data from analysis of surface and subsurface soil from the SEP area were collected, quantified, and originally stored in electronic format in the RFETS environmental Soil Water Database (SWD). The sampling and analytical programs followed approved work plans, and chemical analytical results were validated in accordance with EPA and RFETS data validation guidelines. All contaminants detected are PCOCs.

In addition, characterization data obtained based upon actions conducted in accordance with the IASAP and the ER RSOP, such as confirmation samples collected after the removal of sumps, have been included in the closeout report and will not be included in this PAM.

3.2.1 Surface Soil Contamination

Surface soil contaminants include metals, nitrates, and radionuclides. The distribution of these contaminants on the SEP berms and nearby indicates that surficial contamination may have resulted primarily from aerosol dispersion of SEP liquids or SEP overtopping. The drainage tile between Pond 207-A and the 207-B Ponds appears to have discharged contaminants to the hillside north of the SEP. The occasional incidence of elevated metals in the seep areas north of the SEP were attributed most likely to the local accumulation of metals transported in groundwater that discharges to the ground surfaces. Although metal concentrations in seeps are occasionally elevated, there is no distinctive metals plume associated with the SEP (DOE 1999a). These fluctuations may be associated with variations in water chemistry such as pH or the concentration of various anions.

The sporadic distribution of semivolatile organic compounds (SVOCs) in surficial soil and their absence in vadose zone soil suggests that these contaminants are not related to waste management practices at the SEP. The SEP have been lined and relined on several occasions with asphaltic material, and the staging of asphaltic construction materials or operation of a “hot-mix” batch plant may have contributed to the isolated sources of polycyclic aromatic hydrocarbon contamination. In addition, the distribution of polychlorinated biphenyl (PCB) Arochlor-1254 does not display a pattern consistent with contamination migration from the SEP. (Refer to OU 4 Solar Evaporation Ponds, Interim Measure/Interim Remedial Action Environmental Assessment Decision Document, Part II, Volume 1, Section 4 [DOE, 1995a].)

All concentrations of contaminants are below RFCA Tier I. In addition, contaminant concentrations are below proposed soil ALs (October 2002), with the exception of manganese, which is discussed further in the risk assessment (Attachment II) for the SEP.

3.2.2 Subsurface Soil Contamination

Subsurface soil samples were collected from within the 0 to 6 foot depth interval, the 6 to12 foot depth interval, and depths greater than 12 feet. (Most samples stopped at the top of bedrock.) Samples outside the SEP were composited over 6-foot intervals, with the exception of samples for VOC analyses, which were collected at discrete 2-foot intervals. The sample intervals for collection of subsurface samples beneath the SEP were specified in TM No. 2 and varied from those subsurface samples collected outside the SEP as follows:

Samples composited over 2 foot intervals:	Radionuclides, Target Analyte List (TAL) metals
Samples collected 2 feet below ground and at every other 2 feet, and one sample from bedrock:	VOCs
Samples composited over 4 foot intervals:	Nitrate
Samples composited over 6 foot intervals:	SVOCs, pesticides, PCBs, cyanide, sulfide

Subsurface contaminants include metals, VOCs, radionuclides, and nitrates. The extent of metals contamination in the subsurface was more limited than in the surficial soil; however, the general distribution was similar. Metal contaminants (barium, cadmium, calcium, potassium, sodium, and zinc identified as PCOCs in the OU 4 IM/IRA) occurred predominantly in the immediate vicinity of and beneath the SEP (in the 0.5 to 4 foot range). With the exception of barium (highest concentration ranged between 3.5 to 9.5 foot range) and zinc (highest concentration ranged between 12.2 and18.2 feet), concentrations of metal contaminants generally decreased with depth. The distribution of metals in the subsurface indicates that metals entered the vadose zone from SEP liner breaches and were subsequently sorbed onto the soil matrix. Elevated metal concentrations also occurred at the outfall of the drainage tile on the hillside north of the SEP (DOE 1995a).

Toluene, acetone, and methylene chloride were the only VOCs detected at significant frequencies. Although toluene was frequently detected, the results of the duplicate sample evaluation indicate that the analyses for toluene were not accurate and precise. The pervasive distribution of toluene in the subsurface at low levels indicates that external factors, such as cross-contamination during sampling or analysis, may have been responsible for the identification of toluene in samples. Acetone and methylene chloride were detected in equipment rinsate and laboratory blanks, which also suggests that these VOCs were introduced during sampling and laboratory activities (DOE 1995a).

The distribution of radionuclides (Am-241, Pu-239/240, U-233/234, U-235, U-238, radium (Ra)-226, strontium (Sr)-89/90, cesium (Cs)-134, Cs-137, gross beta, and tritium were identified as PCOCs in the OU 4 IM/IRA) beneath the SEP indicates that activities generally decreased with depth. With the exception of U-233/235, U-238, gross beta radiation sources, and tritium, the presence of radionuclide contaminants is generally restricted to areas beneath the SEP (0.5 to 6 foot range) and the drainage tile outfall area north of Ponds 207-A and 207-B North. The exceptions listed are found beneath the SEP, and north, downgradient of the SEP at seeps within the former PA and further downslope (north) of the former PA in the Buffer Zone (BZ) (DOE 1995a). U contamination exists as a large dispersed area of very low activities beneath and to the north of the SEP; no discrete secondary source of U is apparent (Kaiser-Hill 2001).

The distribution of nitrate in the subsurface (0.5 to 4 foot range) suggests that nitrate has a distribution pattern similar to that of tritium and that concentrations decrease with depth. Cyanide is present beneath Pond 207-A, north of the drainage tile outfall area, and north of Pond 207-C at shallow depths (0 to 6 feet). Cyanide is also found pervasively throughout the vadose zone beneath the northeastern portion of Pond 207-B North, and at depth (greater than 12 feet) northeast of the SEP in the BZ (DOE 1995a).

All contaminant concentrations are below RFCA Tier I ALs. In addition, all subsurface soil contaminant concentrations are below proposed soil ALs (DOE, et al. 2002), with the exception of arsenic. The maximum detected concentration of arsenic in subsurface soil is 24.6 mg/kg and the proposed action level is 22.2 mg/kg. However, in following the proposed RFCA Attachment 5 soil risk screen process, no further accelerated action is required. (For specific depths and concentrations of contaminants, refer to the various tables in Appendix A.)

3.3 Liner Contamination

Fifteen pond liner material grab samples were collected as part of the OU 4 Phase I RFI/RI activities conducted in 1993; results were summarized in the 1995 proposed IM/IRA Decision Document for OU 4. Six samples were collected from Pond 207-A, and three samples each from Ponds 207-B North, 207-B Center and 207-C. These pond liner material samples were submitted for determination of TAL metals and radiochemical analytes. Cyanide analysis was also included for Ponds 207- B North and Center. Four additional samples were collected in Pond 207-C and analyzed for metals using the Toxicity Characteristic Leaching Procedure (TCLP).

Organic analysis was not conducted on the samples collected from the liner material, because the matrix of the material (asphalt) would interfere significantly with the method of analysis resulting in extremely high detection limits and data that cannot be interpreted. The overall concentration of organic contaminants that may be present in the liner material would be significantly less compared to the concentration of the matrix material. Therefore, because the ponds managed low concentrations of organics in the wastewater and sludge[15], the ponds were designed to evaporate, and asphalt is an impermeable material, it is conservatively assumed that the concentrations of organics detected in subsurface soil (more absorbent than asphalt) are representative of the liner material as well. It is also noted that solvents and other organics were not reported to have been routinely discharged to the SEP (DOE 1995a).

Metals and radionuclides were detected in the liner material samples. The highest concentrations of metals were detected in Ponds 207-A (cadmium and lead) and 207-C (arsenic). Pond 207-A and Pond 207-C historically managed waste with higher concentration of contaminants. However, the TCLP results for the liner material from pond 207C indicate all RCRA metals were below regulatory limits and, therefore, the liner material is not a characteristic hazardous waste due to the presence of metals. These TCLP results are considered representative of all the ponds based on a review of all the pond liner material data, the historical use of the ponds, and a review of historical data associated with wastewater and sludge managed in the ponds.

4.0 FUTURE LAND USE

The current conceptual land use for the IHSS 101 AOC, as shown in RFCA Attachment 5, Figure 1, is a capped area and monitored retrievable storage, surrounded by a larger restricted open space area. Future on-site land use at RFETS includes environmental restoration, decontamination and decommissioning, and transfer of jurisdiction to the U.S. Fish and Wildlife Service for use as a wildlife refuge, in accordance with the Rocky Flats National Wildlife Refuge Act of 2001. The refuge is currently envisioned to require minimal maintenance following remediation, however, wildlife refuge workers (WRWs) are assumed to be present onsite for most of the year and engaged in refuge maintenance and ecological work activities. Ecological surveys performed in compliance with the Threatened and Endangered Species Act indicate the

[15] In accordance with an EPA memorandum to the CDH (February 27, 1989): "After review of the analytical information presented in the solar ponds closure plans, it is apparent that the ponds did not contain listed organic solvents above land ban restrictions levels when analyzed in 1984, 1985 and 1986." (EPA 1989). In addition, analytical data collected in August 1991 indicate that VOCs, SVOCs, and alcohols were not detected in the liquids from Pond 207-A, and the B-series ponds. Parts per billion levels of tetrachloroethene and trichloroethene were detected in the liquids from Pond 207-C (DOE 1995a).

presence of habitat potentially suitable for protected plant and animal species, such as the Preble's Meadow Jumping Mouse. Because of the conceptual land use, residential development is not considered a foreseeable future land use scenario and was not included in the risk assessment.

5.0 EVALUATION OF RISKS

Attachment I presents an evaluation of data adequacy used to support and quantify risk calculations submitted in the human health risk assessment (HHRA) presented in Attachment II. The HHRA estimated health risks for WRW onsite receptors that could be exposed to COCs at the SEP AOC, based on historical data. (Results of this risk assessment do not take into account soil removed in accordance with ER RSOP Notification #02-08.) The AOC covered by the data evaluation and risk assessment is shown in Appendix A, Figure 1.1, and covers approximately 33 acres. The AOC was defined to include the modified IHSS 101, as well as an additional area to the south and north based on existing analytical data. Exposure media evaluated include surface soil, subsurface soil, pond liner material and outdoor air.

Extensive historical data from analysis of surface and subsurface soil and pond liner material from the SEP area were collected, quantified, screened, and then used to select COCs for a risk assessment. (Refer to Appendix A of the risk assessment for a description of the screening process.) These data[16] were filtered and screened to ensure usability for risk assessment purposes. All contaminants detected are considered PCOCs. PCOCs were screened relative to PRGs for an on-site WRW exposure scenario set to a 1E-06 risk level and a HQ hazard quotient of 0.1, given that the target risk level is 1E-05. This ensures that the cumulative effects of PCOCs will be taken into consideration. Based on the risk assessment (Attachment II, the following COCs were identified:

Surface Soil	Liner Material	Subsurface Soil
Cadmium	Am-241	Cadmium
Chromium	U-235	Am-241
Am-241		Pu-239/240
Pu-239/240		U-234
U-234		U-235
U-235		U-238
U-238		

Am-241, Pu-239/240, and U-235 in surface soil are the largest contributors to risk. (Although manganese concentrations were above the proposed soil ALs (DOE, et. al. 2002), it was dropped as a COC because levels were was not statistically above background.) A complete set of the data used in the risk assessment and an evaluation of the data are presented in Appendix A of the risk assessment.

[16] Data collected in 2002 as a result of the activities identified in ER RSOP Notification #02-08 and IASAP Addendum #IA-02-07 were not included in the data set used in the risk assessment.

Results of the risk assessment indicate the cumulative HI for non-carcinogenic health effects for RCRA constituents were well below 1.0 (0.04) for reasonable maximum exposure (RME) conditions. No adverse noncarcinogenic health effects are expected, even for sensitive individuals, because HIs are less than 1.0. Therefore, no action is warranted due to non-carcinogenic effects.

The total cancer risk to a WRW due to RCRA constituents is 3E-07 and 2E-06 for radionuclides. Therefore, based on achieving protective media cleanup standards for human health that support a risk less than 1E-05 for a WRW, no action is necessary for either RCRA or radionuclide COCs due to carcinogenic effects.

With regards to the liner material, the risk assessment identified only radionuclides as COCs. Because the concentration of all metals in the liner material and the concentration of organics present in the subsurface soil (conservatively assumed to be representative of the liner material) were screened to below 1E-06 for a WRW scenario, the liner material is determined not to contain hazardous waste above a 1E-05 risk to a WRW.

6.0 CONCLUSIONS

Based upon the current condition of the SEP area and on previous actions taken the following conclusions are supported:

- The source of the SPP contamination was the waste managed in the ponds; this waste has been removed from the ponds.
- Groundwater contamination is being treated and is addressed under a separate IM/IRA.
- Groundwater contaminants that are also present in soil are all below current RFCA Tier II ALs.
- The liner material was determined not to contain hazardous waste above a 1E-05 risk and is not a characteristic hazardous waste.
- The total carcinogenic risk to a WRW for RCRA constituents is 3E-07. The risk for radiological contaminants is 2E-06. Both of these risks are below the target risk of 1E-05 for a WRW.
- The HIs for non-carcinogenic effects are less than 1.0.
- Concentrations of contaminants in soil do not pose an unacceptable hazard to ecological receptors.
- Other RCRA units in the SEP area have been closed by removal.
- All aboveground structures, including sumps, valve pits, and lines located less than 3 feet belowgrade have been removed.

In addition, separate from RCRA closure, radiological contaminant activities have also been determined to be below both RFCA Tier I ALs and proposed soil ALs (DOE, et al. 2002). Therefore, under CERCLA, no additional action is required for these contaminants.

6.1 RCRA Closure

This section focuses only on RCRA constituents for purposes of demonstrating closure of the SEP and the entire AOC. The alternative closure requirements have been defined as follows:

- Achieve protective media cleanup standards for human health at 10-05 lifetime excess cancer risk for a WRW;
- Provide that the concentration of contaminants in soil do not exceed an HI of 1 for a WRW;
- Ensure that contaminants that exceed the ecological ALs for target species (listed in Table 3 Action Levels, in Attachment 5 of RFCA [DOE, et al. 2002]) do not pose an unacceptable hazard considering the target species and exposure unit for that species, and the location, areal extent and concentration of contamination; and
- Comply with the closure performance standard in 6 CCR 1007-3, Section 265.111(a) and (b).

As previously discussed, the results of the risk assessment indicate that for RCRA constituents the total cancer risk to a WRW is 3E-07, which is well below the closure requirement of 1E-05 for a WRW. The HI is 0.04, which is below 1.0, and contaminant concentrations are below ecological ALs.

The closure performance standard of 6 CCR 1007-3, Section 265.111(a) and (b) is defined as:

- Minimizes the need for further maintenance; and
- Controls, minimizes, or eliminates, to the extent necessary to protect human health and the environment, post-closure escape of hazardous waste, hazardous constituents, leachate, contaminated runoff, or hazardous waste decomposition products to the ground or surface waters or to the atmosphere.

Therefore, to demonstrate compliance with this closure performance standard, the following sections discuss each of these requirements.

6.1.1 Minimize the Need for Further Maintenance

No further maintenance of the SEP AOC is required for the following reasons:

- The concrete pads associated with RCRA Units 21 and 48 were closed by removal.
- Contaminated soil beneath the concrete pads associated with RCRA Units 21 and 48 was removed.
- Segments of the OPWL, valve vaults associated with the OPWL, and collection sumps associated with drainage tiles and the leak detection system were removed.

- Contaminated soil around the OPWL, valve vaults, and collection sumps were removed.
- Contaminated soil from PAC 900-1310 was removed.
- Soil removal was not necessary for purposes of reducing the long-term stewardship obligations of the SPP treatment system.
- No leachate is being generated from the current SEP configuration.
- The SEP liner material at the surface, as it currently exists, does not contribute to risk.
- The concentration of contaminants in soil does not exceed an HI of 1 for a WRW.
- The concentration of contaminants in soil does not pose an unacceptable hazard to ecological receptors.
- All surface and subsurface soil contaminants are below RFCA Tier I ALs.
- Contaminant concentrations are below the proposed soil ALs (DOE, et al. 2002), with the exception of manganese, which was determined not to be statistically above background.
- The total cancer risk to a WRW due to RCRA constituents is 3E-07, which is well below target risk of 1E-05 for a WRW scenario.

6.1.2 Post-Closure Escape of Hazardous Waste

Because the source of contamination associated with the SEP (wastewater and sludge) has been removed, the potential for post-closure escape of hazardous waste has been eliminated. In addition, both the liner material and surrounding soil are determined not to contain hazardous waste above a 1E-05 risk to a WRW. In addition, the liner material does not exhibit the toxicity characteristic for D004-D011 metals and is not considered a D001, D002, or D003 hazardous waste.

6.1.3 Post-Closure Escape of Hazardous Constituents

Because the source of hazardous waste has been removed, and both the liner material and soil do not contain hazardous waste above the 1E-05 risk to a WRW, the potential for post-closure escape of hazardous constituents does not present a situation adverse to the long-term protection of human health and the environment.

6.1.4 Post-Closure Escape of Leachate

Because all hazardous waste has been removed, and remaining constituents are below risk-based levels, the potential for post-closure escape of leachate has been minimized. Currently, no leachate exists from the SEP.

6.1.5 Post-Closure Escape of Contaminated Runoff

Both the liner material and soil have been determined not to contain hazardous waste above the 1E-05 risk to a WRW. Therefore, the potential for post-closure escape of contaminated runoff has been minimized.

6.1.6 Post-Closure Escape of Hazardous Waste Decomposition Products

Because all hazardous waste has been removed, and the liner material and remaining soil do not contain hazardous waste above the 1E-05 risk to a WRW, the potential for post-closure escape of hazardous waste decomposition products has been minimized.

This PAM is proposing a NFA designation for the SEP AOC, because the SEP meet the alternative RCRA closure requirements by achieving cleanup to the 1E-05 risk for a WRW and complies with the closure performance standard in 6 CCR 1007-3, Section 265.111(a) and (b).

6.2 IHSS 101

Without additional remedial action, the SEP area, including IHSS 101, is protective of human health and the environment because the total carcinogenic risk to a WRW for RCRA constituents is 3E-07 and for radiological contaminants is 2E-06. The HI for non-carcinogenic effects is less than 1.0. Contaminant concentrations remaining are below the ecological AL (DOE, et al. 2002) for target species. In addition, all surface and subsurface soil contaminant concentrations are below RFCA Tier I ALs for open space; all surface and subsurface soil contaminant concentrations are below the proposed RFCA ALs (DOE et al. 2002) resulting in a lifetime excess cancer risk of 1E-05 to a WRW. Consequently, no further remedial action is required for IHSS 101.

6.3 Summary

Table 6-1 summarizes the activities required for completion or closure of the SEP and the various other units that exist within IHSS 101.

7.0 ENVIRONMENTAL IMPACTS

Paragraph 95 of RFCA specifies that National Environmental Policy Act (NEPA) values will be included in RFETS decision documents (DOE, et al. 1996). While environmental consequences are addressed in part throughout the decision document, this section of the document specifically examines environmental impacts and satisfies the RFCA requirement for a NEPA-equivalent assessment.

Table 6-1
Completion Table III

Unit Name	RCRA Unit/IHSS/PAC	Required Completion Activity	Mechanism For Completion	Completion Documentation
SEP	RCRA Interim Status Unit (No number), IHSS 101, and PAC 000-101	RCRA Closure for RCRA Unit, and NFA for IHSS and PAC	RCRA Closure using alternative closure requirements, achieving 10^{-5} risk and an HI <1 to a WRW for RCRA constituents. COCs in soil do not pose a hazard to ecological receptors[17]. NFA determination for remaining contaminants using RFCA Tier I ALs, achieving 10^{-5} risk to a WRW, HI <1, and are below proposed soil ALs (October 2002)[18].	PAM and HRR
A portion of OPWL, sumps and valve pits	Portions of IHSSs 121 and 149.1 (no PAC number)	NFA for IHSSs	A portion of the line was removed, remaining lines are > 3 feet belowgrade, and the soil in areas of known releases is below RFCA Tier I ALs.	Closeout Report and HRR for IHSS and PACs
A portion of NPWL[19]	A portion (Box 5 at Building 910 to UBC Site 774 fence) of RCRA Unit 374.3 and PAC 000-504 (no IHSS number)	Partial RCRA closure and NFA for PAC	RCRA closure by removal of the aboveground line.	
MST line	No specific IHSS or PAC[20] No.	None	NA	
Permacon Concrete Pad	RCRA Permitted Unit 21 (no IHSS or PAC number)	RCRA closure	RCRA closure by removal of the concrete pad and soil to RFCA Tier I ALs.	
Clarifier and 308A pumphouse Concrete Pads	RCRA Interim Status Unit 48 (no IHSS or PAC number)	RCRA Closure	RCRA closure by removal of concrete pads and soil to RFCA Tier I ALs.	
ITS Water Spill	PAC 900-1310 (no IHSS No.)	NFA for PAC	Removal of soil to RFCA Tier I ALs. (Recent analytical results indicate radionuclides, nitrate/nitrite and metals < Tier II ALs, except arsenic < Tier I ALs.)	
Entire Area considered SEP AOC			• Risk at 1E-05 and HI <1 to a WRW for all contaminants. • COCs in soil do not pose a hazard to ecological receptors. • Radiological contaminants are below RFCA Tier I ALs. • Groundwater contaminants that are also in soil are below Tier II soil ALs. • Remaining contaminants are below proposed soil ALs (10/2002).[18]	PAM

[17] After consultation with the regulatory agencies, it was determined that there is one elevated concentration of lead (121 mg/kg) above the ecological AL (97.7 mg/kg), which was determined not to be an impact to target species.
[18] The maximum surface soil manganese concentration exceeds the proposed soil ALs (DOE et al. 2002), however manganese was determined not to be statistically above background in the risk assessment and it was not identified as a COC. The maximum subsurface soil arsenic concentration (24.6 mg/kg) exceeds the proposed soil AL (22.2 mg/kg); however, this concentration was detected at a depth of 13 feet, which was, therefore, not included in the risk assessment, and arsenic was not identified as a COC.
[19] The NPWL has multiple RCRA unit numbers associated with it. RCRA Unit 374.3 only represents the portion of the NPWL located within IHSS 101.
[20] This line could be associated with the Interceptor Trench Pumphouse, PAC NE-1409, which received NFA approval in 2001.

In general, this PAM demonstrates that the SEP can be left in their current condition without presenting an unacceptable risk to human health and safety or the environment. Closure of the SEP, without implementing best management practices (BMPs) such as leveling the berms and ponds, will not affect or will have very minor effects on air quality, groundwater, ecological resources, soil and geology, and human health and safety. The visual appearance of the SEP will not match the appearance of a native grassland, and reestablishment and maintenance of native vegetation may be more difficult than on a contoured surface; however, these effects would not be significant. Surface water will collect in the SEP after rains or snowfall; generally, the collected water will evaporate. While sampling of water in Pond 207-A demonstrates that most parameters will pass surface water standards, if activities are planned in or around the SEP, surface water will be removed and managed per existing Site procedures (for example, for incidental water).

Implementation of BMPs will have more notable impacts, which will be both beneficial and adverse. In most aspects, the impacts will be positive and lasting. Positive impacts will occur by reducing or eliminating movement of and exposure to residual contaminants from the SEP, by increasing wildlife habitat, and through an improvement in the appearance of the area. Adverse impacts are limited to temporary effects, such as increased air emissions from the use of heavy equipment, potential erosion during remedial activities, and increased risks to safety during remedial operations. Both social and environmental impacts associated with the BMPs were considered. The following sections discuss the impacts from the BMPS; some issues are briefly discussed in the following paragraphs only.

The SEP project does not affect compliance with the Historic Preservation Act of 1966. Because the project area has been disturbed previously, and most of the subsurface will not be further disturbed, the discovery of archeological or historic artifacts is very unlikely. If such artifacts are encountered, work will be stopped and appropriate RFETS procedures will be followed.

Equipment used and dust generated during the BMP activities will be visible temporarily, and dust-control measures, such as watering, will be used as needed. Long-term, reclamation of the area will provide a more natural appearing landscape. Noise levels will be temporarily elevated during BMP activities, however, they are not expected to exceed levels commonly encountered during highway construction projects. Sensitive human receptors are not found near the SEP; therefore, noise is not a concern.

In accordance with Executive Order 12898, potential impacts on minority and low-income populations were considered. The activities will occur on site away from inhabited areas, and will not lead to offsite indirect effects on nearby populations. Disproportionately high and adverse human health or environmental effects will not be imposed on these populations. The BMP activities will provide short-term employment for a limited number of people (less than 1 percent of currently employed RFETS personnel), and socioeconomic effects of the activities will be minimal.

7.1 Air Quality

Implementation of the BMP will impact air quality; however, the impacts to air quality will be temporary, and will primarily occur from the operation of construction equipment. Fugitive dust,

including total suspended particulates (TSP) and particulate matter less than 10 micrometers in aerodynamic diameter (PM_{10}), is of greatest interest.

Fugitive dust emissions are estimated by identifying the types and capacities of the construction equipment to be used, duration of activities, the area or volume of soil to be disturbed, travel distances, environmental conditions, and use of an emission factor for each category of operations. The estimates use factors and equations for estimating emissions from the Compilation of Air Pollutant Emission Factors, AP-42, 5th Edition, Volumes 1 and 2 (EPA 2000).

Fugitive dust emissions were estimated using factors for bulldozers, graders, and scrapers for the purpose of moving berms and importing 35,000 cubic yards of soil. The work includes contouring the entire site, and is estimated to last for 6 weeks at 40 hours per week.

Total projected emissions are 5.5 tons TSP, and 2.3 tons PM_{10} (AQM 2002). The fugitive dust quantities are total amounts for the entire project. Most fugitive dust emissions will fall back to the ground at the SEP. The fugitive dust will include several nonradiological components that are specifically estimated. The following emissions are total amounts for the entire project on an annual basis: arsenic (6E-03 pounds); cadmium (3E-01 pounds); chromium (10E-02 pounds); and manganese (6E+00 pounds). Monitoring these emissions is conducted with special attention to a specified level of concern of 250 pounds per year; therefore, these emissions are not significant.

Radiological emissions are based on the initial surface soil screening. The modeled result for the SEP activities is 2.9E-03 mrem per year effective dose equivalent (EDE) to the maximally exposed individual (person most greatly impacted by the activities). The modeled EDE is well below the threshold monitoring level of 0.1 mrem per year, and radiological emissions are not significant.

7.2 Surface Water

The SEP are situated on a level area and cover about six acres. The entire SEP AOC covers approximately 33 acres. Surface water consists of small amounts of water in the ponds; water in the ponds will be removed prior to the berms being pushed in. Surface water concerns are related to runoff and the effects on nearby drainages.

During contouring of the area, soil can be transported by runoff from precipitation events. The ground surface north of the SEP slopes steeply downward toward North Walnut Creek; however, surface water flow is intercepted by open channels and stormwater culverts.

Surface water monitoring will be conducted as part of the Sitewide IMP to ensure that contaminant concentrations are not increasing, and that water quality standards are met.

7.3 Groundwater

Groundwater quality in the area of the SEP will not be directly affected by BMP activities. Groundwater is not directly addressed by this PAM; remedial actions for groundwater are

considered in other plans. For example, the groundwater plume under and downgradient of the SEP is being addressed as part of the ongoing SPP IM/IRA.

The long-term indirect effect of the BMPs will be to direct water away from the area of the SEP, and allow greater volumes of water to be captured by plants growing on the site and released through the evapotranspiration process.

7.4 Ecological Resources

As currently configured, the SEP have little ecological value, and activities to cover and contour the SEP will have little short-term impact on ecological resources. The finished site will provide 33 acres of revegetated open space that will have value for small mammals, songbirds, and similar species. The ecological value of the SEP area should increase over time, as the surrounding area is also revegetated, and animal species are better able to use the site. The area is to be revegetated with native plant species, which will be beneficial; however, but adverse impacts could occur if weed species are allowed to infest the area. The controls to ensure that a natural vegetative cover is established, and weed growth is prevented, will be identified and implemented in the Final Site Corrective Action Document/Record of Decision (CAD/ROD).

7.5 Soil and Geology

The ponds will be filled with material from the berms (material originally excavated from the site) and additional soil will be brought in as fill and topsoil. Contaminated soil within the SEP was removed prior to implementing the BMP. Removal of contaminated soil will benefit the area as a whole. The use of mixed soil to change the area from an industrial pond use to a more natural prairie setting will also be beneficial in terms of soil and soil productivity in the remediated SEP area.

In the borrow site east of the ponds, where fill materials will be obtained, surface soil will be removed and soil productivity will be reduced.

Subsurface geological resources would not be affected. Prime or unique farmlands would not be affected.

7.6 Human Health and Safety

Closure of the SEP is being approached in a manner that identifies and evaluates cumulative risks to human health and safety. To ensure protection of human health and the environment, a risk assessment was performed based on COCs within the AOC. In particular, this PAM reviews the long-term risk to a hypothetical person subject to the greatest exposure (i.e., a future WRW). Short-term construction activities, which can pose a direct risk of injury to workers, are also evaluated in this PAM.

BMP activities in the area of the SEP are comparable to typical construction activities (for example, operation of heavy equipment); unique or unusual activities are not associated with the closure. The activities will be short-term, lasting days to months, and will pose safety risks for workers that are similar to other demolition and construction operations. These risks are addressed through various controls required at the Site. For example, a project-specific Health

and Safety Plan (HASP) will address the entire scope of the project. As part of the HASP, a Job Hazard Analysis (JHA) will be prepared that will address each task, the hazards associated with that task, and the controls (for example, the use of personal protective equipment [PPE]) needed to minimize the risk inherent in that task. These controls and the focus on safety minimize the short-term risk associated with the project.

The long-term health and safety risk associated with the closed SEP is the focus of this document. As a primary requirement to closing the SEP, this document looks at future risks to a hypothetical most highly impacted person (i.e., WRW). The risks are based on an evaluation of COCs, which could have non-carcinogenic and carcinogenic effects on WRWs. This conservative approach bounds the maximum impact for offsite receptors or future visitors, because the risks to a WRW will be much higher than to any other person.

Non-radiological health effects from exposure to chemicals using an HI. An HI greater than 1 is considered to be a basis for concern. The risk assessment in this PAM finds that the HI for non-carcinogenic health effects is well below 1 (0.04). The total cancer risk to a WRW, due to exposure to RCRA constituents left at the SEP, is less than 1 excess cancer case per 1 million exposed individuals (3E-07), and the total cancer risk to a WRW due to radionuclides (principally Am-241 and U-235) is 2E-06. These risks are well below the RCRA closure requirements for non-radiological contaminants and below the RFCA Tier I ALs for radiological contaminants. Therefore, the potential impact to the long-term health and safety of WRWs (and other persons) is insignificant.

7.7 Irreversible and Irretrievable Commitment of Resources

Irreversible and irretrievable resources are resources that are consumed, committed, or lost. Activities discussed in the PAM will irreversibly and irretrievably use or commit resources, but will not result in a significant loss of resources. Committed resources include the consumptive use of geologic resources and fuel use during construction activities. Fill, clay, sand, and gravel will be needed; the proposed approach requires a permanent commitment of approximately 35,000 cubic yards of these materials. Adequate supplies are available locally without affecting local demand for these products. Fuel will be consumed by construction equipment and vehicles performing the construction, and will not be recovered.

7.8 Cumulative Impacts

Cumulative impacts may result from the combination of incremental impacts from past, present, and reasonably foreseeable future actions. Cumulative impacts could have the potential of being more significant than individual impacts due to synergism between types and areas of impacts or the individual impacts collectively resulting in significant effects to the environment.

The Rocky Flats Environmental Technology Site Cumulative Impacts Document (CID) (DOE 1997) provides a broad-scope environmental impact analysis of activities planned to achieve the current RFETS mission of site cleanup and closure. Environmental issues related to closure in general are addressed in that document. Specific activities, such as remediation of the SEP, may have cumulative effects, although at this time there are no other activities planned in the vicinity of the SEP that are expected to have significant cumulative environmental impacts.

Likely activities that would occur in the vicinity of the SEP would include the removal of SEP components. Components removed would include, for example, contaminated facility slabs, abovegrade waste lines, valve vaults, collection sumps, manholes, utilities and support racks, concrete ramps and barriers, soil contaminated by known releases (that is, OPWL, valve vaults, and collection sumps), unnecessary groundwater monitoring wells, and lysimeters. Decommissioning and demolition activities throughout the Site would continue, and trucking of waste and materials would be cumulative with the SEP closure.

The following types of cumulative impacts may occur:

- Implementing the BMP means that approximately 35,000 cubic yards of soil will be brought in to this area. While traffic generated by the project will occur at the same time as other activities, the vehicle travel will occur on RFETS, and the impact will be temporary and insignificant.

- Water erosion of the SEP berms could occur if substantial rainfall occurs during remedial activities; other projects with exposed soil would also be eroded. Given the generally flat area of the SEP, and mandatory erosion controls at RFETS, significant cumulative erosion would not be expected.

- Along with the rest of the IA, the revegetated SEP will provide additional habitat for wildlife. The effect will be beneficial as long as weed growth is prevented.

- The visual impact of the remediated area will be enhanced as other parts of the Site are also remediated.

8.0 LONG TERM STEWARDSHIP

This stewardship evaluation describes current site conditions, proposed actions and the anticipated effect on current site conditions, and stewardship recommendations.

8.1 Current Site Conditions

Based on previous studies and removal actions at the SEP (Sections 2.0 and 3.0), all contaminant concentrations are less than RFCA ALs in surface and subsurface soil with the exception of manganese, which was eliminated as a COC at this site. Radionuclides (Am, Pu, and U) and metals (cadmium and chromium) are found in concentrations greater than background in surface soil. Radionuclides (Am, Pu, and U) and cadmium are found in concentrations greater than background in subsurface soil. Am and U are found in concentrations greater than background in the liner material.

Results of the risk assessment (Section 5.0 and Attachment II) indicate the cumulative HI for non-carcinogenic health effects was well below 1.0 (0.04) for RME conditions. The total cancer risk to a WRW was 3E-07 and 2E-06 for radionuclides before removal of hot spots. Total cancer risk to a WRW following removal of hot spots is 1E-06.

Surface soil areas exceeding proposed soil ALs (DOE, et al. 2002) for Am-241 and Pu-239/240 were removed in accordance with ER RSOP Notification #02-08 (DOE 2002b). These removals also resulted in removing soil with beryllium and cadmium concentrations greater than ecological receptor ALs. Lead concentrations were determined to be significantly lower than background values and was eliminated as an ecological COC.

An evaluation of contaminant concentrations present in surface and subsurface soil associated with the ponds indicated there is no source term present that could impact surface water by leaching and transport mechanisms. A reactive barrier treatment system is in place north of the SEP that collects and directs SEP groundwater flow to two passive treatment cells. The treatment system is designed to treat U and nitrate, but is also effective at capturing metals and VOCs.

8.2 Proposed Action Memorandum Measures

NFA is required at SEP; however, several BMPs will be implemented including the following:

- Remove standing water within the ponds;
- Sample and analyze the liner material and soil beneath Pond 207-B South;
- Collect additional samples of the liner material and soil beneath Pond 207-C;
- Push in pond berms;
- Add clean fill to create a level area; and
- Regrade and revegetate.

It is anticipated that after the BMPs are completed the risks to receptors will be eliminated because surface soil and liner materials will be covered, and contact via inhalation, ingestion, and external exposure to radionuclides and metals will be prevented.

8.3 Monitoring

Environmental monitoring, including downstream surface water and downgradient groundwater monitoring is being conducted as part of the Sitewide IMP. There are currently eight monitoring wells and five surface water-monitoring stations. Additionally, groundwater is monitored to measure the effectiveness of the treatment system.

8.4 Stewardship Actions and Recommendations

Near- and long-term stewardship requirements are based on residual contamination at the SEP AOC. Because the risk assessment results indicate environmental risks are below regulatory requirements and potential groundwater impacts are mitigated by the treatment system, near-term stewardship actions for the SEP AOC consist of the following:

- Control excavations through the Site Soil Disturbance Permit process;
- Control access to groundwater; and
- Install fencing and post signs restricting access to the site.

Because the risk assessment results indicate environmental risks are below regulatory requirements and potential groundwater impacts are mitigated by the treatment system, the long-term stewardship actions and recommendations for the SEP AOC are as follows:

- Continue Federal ownership and control over the site;
- Implement land use restrictions to prevent soil excavation that could access or disturb residual contamination. Specific land use restrictions will be discussed in the Site Long-Term Stewardship Plan and evaluated along with other institutional controls for implementation in the final remedy selection process;
- Maintain the groundwater treatment system;
- Restrict groundwater use;
- Review groundwater and surface water monitoring stations near the SEP when long-term monitoring options are evaluated; and
- Maintain environmental data and other relevant data.

These recommendations may change based upon other future Site remedial activities.

9.0 BEST MANAGEMENT PRACTICE ACTIONS

Because no additional actions are needed for purposes of demonstrating closure under RCRA, the berms will be pushed into the ponds, and the area will be graded and vegetated as a BMP.

The BMPs will involve removing any standing water within the ponds, pushing in the berms, adding clean fill to create a level area, and grading and vegetating the area. These actions will commence as a BMP, after completion of activities described under the ER RSOP notification. This includes removal of SEP components (for example, facility slabs, abovegrade waste lines, valve vaults, collection sumps, manholes, and other utilities), contaminated soil, lysimeters, and unnecessary groundwater monitoring wells that were abandoned. Contaminated soil associated with PAC 900-1310 has also been removed. Pond liners, the OPWL, drainage tiles, and leak detection lines will remain, as well as some groundwater monitoring wells. Water within the ponds will be sampled and managed based on analytical results (for example, use for dust suppression or transported to the Building 891 wastewater treatment facility). Clean fill dirt (approximately 12,000 cubic yards) and topsoil will be brought in to create a level area. The source of the fill may be an area between IHSS 165 and the North Perimeter Road. Grading will be performed to conform to the topography of the surrounding area (that is, tied in uniformly with existing contours) and provide adequate site drainage. Slopes will be kept to a minimum to

reduce erosion. The area will be vegetated with native grass species. All work will be performed to comply with Site Environment, Safety and Health requirements, including ALARA and stewardship requirements. Long-term adverse impacts from the activities are not expected.

When pushing in the berms, the bottom liner material will not be breached. Perching of groundwater in this area is not anticipated because a few of the ponds have cracks in the liners, some of the ponds will contain a few additional holes from lysimeters previously located within the ponds and from recent samples taken through the liners, the bottoms of the ponds are sloped to one corner, and a sandy fill material exists beneath the ponds. (The B-series ponds slope toward the northwestern corner. The A and C ponds slope toward the northeastern corner.) In addition, a majority of the sidewalls will be removed after the berms are pushed in, which will allow precipitation to flow out laterally. If, after the area is regraded and revegetated, water is observed to be perching in this area, equipment will be brought in (for example, GeoProbe ™) for purposes of breaching the liner material in additional locations.

Environmental monitoring, including downstream surface water and downgradient groundwater monitoring, will also be conducted as part of the Sitewide IMP to ensure that contaminant concentrations are not increasing and that water quality standards are being met. (Refer to IMP [DOE 199_] and Final Solar Ponds Plume Decision Document [DOE 1999a].) Monitoring results will be used to determine whether additional remediation is warranted.

9.1 Worker Health and Safety

All work under this proposed action will be controlled using the Site Integrated Safety Management System (ISMS) and the Integrated Work Control Program (IWCP). A project-specific HASP will be developed to address the safety and health hazards of project execution and specify the requirements and procedures for employee protection. The Occupational Safety and Health Administration (OSHA) construction standard for Hazardous Waste Operations and Emergency Response, 29 Code of Federal Regulations (CFR) 1926.65 will be used as the basis for the HASP. In addition, DOE Order 5480.9A, Construction Project Safety and Health Management, applies to this project. This Order requires preparation of an Activity Hazard Analyses (AHA) for each task, which includes identifying each task, the hazards associated with each task, and the controls necessary to eliminate or mitigate the hazards. The AHAs will be included in the HASP.

Data and controls will be continually evaluated. If field conditions were to vary from the planned approach (for example, when unanticipated hazards are encountered, such as contaminated debris and airborne contamination), an AHA would be prepared for the new conditions, and work would proceed according to the appropriate control measures.

9.2 Water Management

If belowgrade lines are encountered when pushing in the berms, special care will be taken to ensure that no liquids remaining in waste lines are released to the environment. Lines will be flushed into drums and then plugged.

During construction activities, silt fences will be used to minimize soil transport. Temporary berms could also be used to control stormwater runon and runoff and related erosion. If water were to accumulate in the ponds during backfilling operations, the water will be handled according to the practices specified in the Control and Disposition of Incidental Waters (Kaiser-Hill 1998). However, work will be conducted during the dry season; as such storm events are not expected to generate significant runoff and water accumulation problems.

9.3 Air Quality Management and Monitoring

Routine sitewide monitoring will be conducted during project execution. The Kaiser-Hill, L.L.C. Air Quality Management group maintains the RFETS Radioactive Ambient Air Monitoring Program (RAAMP), which monitors the perimeter of RFETS continuously with samples collected and analyzed on a monthly basis. The RAAMP sampling network also includes monitoring stations inside the perimeter of RFETS, from where samples are collected but not analyzed unless conditions warrant additional analysis.

Dust suppression will be performed to minimize the potential for particulate dispersion. Wind speed and direction are monitored continuously at RFETS, and these data are available through the shift superintendent.

9.4 Waste Management

Very little waste (e.g., PPE) will be generated during the backfilling and seeding operations. The existing berms and liners will not be removed, but instead will be pushed into the ponds. Almost all of the waste will be generated under other actions (Section 3.0). All waste generated will be managed according to Site procedures and regulations.

10.0 ADMINISTRATIVE RECORD

This section identifies the documents that constitute the Administrative Record (AR) file for this decision. After completion of the public comment period, all comments received from the public, the responsiveness summary, and the approval letter will be incorporated into the AR file. Approval of this decision document approval by the regulatory agencies of the projects's AR file. The following documents constitute the AR file:

- CDPHE, 1995, CDPHE Letter to DOE regarding comments on the Proposed OU 4, SEP, IM/IRA Decision Document, February 1995; (Administrative Record # I101-A-000289).
- DOE, CDPHE, and EPA, 1996, Rocky Flats Cleanup Agreement, July 19, 1996 (as updated).
- DOE, 1991 – 2001, Historical Release Reports and Annual Updates.
- DOE, 1992, Final Proposed IM/IRA Decision Document for the SEP, OU 4, DOE, February.
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- DOE, 1993, Final TM 4 to Final Phase I RFI/RI Workplan, Modifications to Field Activities, SEP, OU 4, June.
- DOE, 1993, Historical Release Report for the Rocky Flats Plant, Second Quarterly Update, October 1, 1992 to January 1, 1993, Rocky Flats Plant, Golden, Colorado.
- DOE, 1994, Final Phase II RFI/RI Work Plan, SEP, September.
- DOE, 1995, OU 4 SEP IM/IRA Environmental Assessment Decision Document, DOE February.
- DOE, 1997, Cumulative Impacts Document.
- DOE, 1999, Final Solar Ponds Plume Decision Document.
- DOE, 2001, Industrial Area Sampling and Analysis Plan.
- DOE, 2002, Final ER RSOP for Routine Soil Remediation.
- DPE, 1998, Solar Evaporation Ponds Closure Plan, July.
- DOE, 2002, ER RSOP for Routine Soil Remediation Notification # 02-08.
- DOE, 2002, IASAP Addendum # 02-07.
- DOE, 2002, Minor Modification for the Final Solar Ponds Plume Decision Document.
- DOE 2002, Draft Closeout Report for SEP AOC.
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- DOW, 1974, External Letter from DOW to RFAO regarding Disposition of Water from Sanitary Landfill.
- EG&G, 1995, EG&G Letter to DOE regarding reminder of decision not to core sample 207B South-SRK-026-95,(Administrative Record # 1101-A-00007).
- EG&G, 1993, Background Geochemical Characterization Report.
- EG&G 1995, Geologic Characterization Report for RFETS, Volume I.

- EPA, 1989, EPA Letter to Colorado Department of Health regarding the transfer of liquids between the solar ponds, February (Administrative Record # A-OU04-000180).
- Kaiser-Hill, 2002, WARP Work Plan Addendum for SEP.
- RMRS 1995, Solar Evaporation Pond 207C Characterization Report for RFETS.
- RMRS 1999, Final Closeout Report, Building 788 and Clarifier Tank.
- RMRS 1999, Final Solar Ponds Plume Decision Document.
- RMRS 1996, Management Plan for ITS Water.

11.0 RESPONSIVENESS SUMMARY

Responses to comments are included in Attachment III of this document. Specific responses address the following comments:

- Rocky Flats Coalition of Local Governments (RFCLOG) Comments dated October 15, 2002;
- CDPHE Comments dated October 9, 2002; and
- Rocky Flats Citizen Advisory Board (RFCAB) Comments dated November 7, 2002

12.0 REFERENCES

AQM, 2002, Solar Pond Remediation PAM Calculations, RFETS, September 19.

CDPHE, 1992, May 8, 1992, letter to DOE regarding conditional approval of Final Phase I RFI/RI Workplan, Solar Evaporation Ponds (OU 4), Rocky Flats Plant, Golden, Colorado, January.

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CDPHE, 1995a, January 4, 1995, letter to DOE regarding the determination of "empty" status for OU-4 Solar Evaporation Ponds (Administrative Record # I101-A-000288) January.

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DOE, 1995c, Historical Release Report for the Rocky Flats Plant, Eleventh Quarterly Update, January 1, 1995, to March 31, 1991, Rocky Flats Plant, Golden, Colorado.

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DOE, 2002b, Environmental Restoration RFCA Standard Operating Protocol for Routine Soil Remediation Notification # 02-08, Rocky Flats Environmental Technology Site, Golden, Colorado, July.

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DOE, 2002e, Draft Closeout Report Solar Evaporation Ponds Area of Concern, Rocky Flats Environmental Technology Site, Golden, Colorado, December.

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ATTACHMENT I
DATA ADEQUACY EVALUATION

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DATA ADEQUACY EVALUATION

Attachment I presents an evaluation of data adequacy used to support and quantify risk calculations submitted for the Solar Ponds. The evaluation includes a lognormal power calculation, distributional testing, geostatistics, derivation and comparison of upper 95 % UCLs, and assessment of the impact that hot spot removal has on reported risk results. A spatial analysis and evaluation of the Bootstrap technique are also provided.

Data evaluation was focused on those contaminants that dominated risk. Receptor exposure to nonradiological noncarcinogens present in surface soils resulted in a relatively low hazard index of only 0.04 and was, therefore, not of concern. Exposure to nonradiological carcinogenic COCs resulted in a total risk associated with surface soils of 2.7E-07 and 2.9E-09 in subsurface soils for a total of 3E-07 risk to a wildlife refuge worker. Exposure to radiological carcinogenic radionuclides dominated risk with individual risks for surface soil (2E-06), liner (1E-07), and subsurface soils (3.9E-08) and a total risk of 2E-06. Total risk was primarily due to external exposure and ingestion pathways to surface soils. Total risk for surface soil was the only observed risk to exceed 1E-06. Accordingly, the data adequacy evaluation was focused on the radionuclides present in surface soils.

1.0 Power Calculation

A power calculation was performed for surface soil radionuclides using Sum of Ratios (SOR) data. Various distributional tests were used to demonstrate lognormality of the data. The Coefficient of Variation, Filliben, Geary, Skewness/Kutosis tests all confirmed lognormality at an alpha level of 0.05. Only the Studentized Range Test failed lognormality.

The Gilbert (1987) Equation 13.23 was then used to estimate the number of samples required at the 95% confidence level. A relative error of 10% was assumed for a 1-Tailed test. Results indicated that 66 samples would be required for radionuclides present in surface soil. The existing risk assessment used 69 to 72 samples to determine risk estimates for radionuclides. This calculation was performed to support a determination of sample adequacy and not to quantify risk based on a UCL of a median concentration.

2.0 Distributional Testing

DOE has performed both normality and lognormality checks for surface radionuclide, surface nonradionuclide, subsurface radionuclide, and subsurface nonradionuclide SOR data using EPA's Quality Assurance Management Staff's DataQuest statistical software. DataQuest is the companion software to the EPA's QA/G-9 guidance document on Data Quality Assessment and performs quantitative tests on data. This quantitative method is preferable to and compliments qualitative approaches such as histograms, probability plots, and quantile plots. Table 1 presents the results.

Table 1. Summary of Distributional Testing

Strata & COC Group	Distribution Test (alpha = 0.05)									
	Normality Test					Lognormality Test				
	CV	Filliben	Geary	S/K	S.R.	CV	Filliben	Geary	S/K	S.R.
Surface Rads	Fail	Fail	Fail	Fail	Fail	Pass	Pass	Pass	Pass	Fail
Surface Non-Rads	Fail	Fail	Fail	Fail	Fail	Pass	Fail	Fail	Fail	Pass
Subsurface Rads	Fail	Fail	Fail	Fail	Fail	Pass	Fail	Fail	Pass	Fail
Subsurface Non-Rads	Fail	Fail	Fail	Fail	Fail	Pass	Fail	Fail	Fail	Fail

CV = Coefficient of Variation test
S/K = Skewness/Kurtosis test
S.R. – Studentized Range test

Table 1 indicates that the data are not normally distributed for any strata or COC group. In addition, most data were also not lognormally distributed. Surface radionuclides faired best, passing four of the five tests for lognormality using an alpha of 0.05. Based on this, DOE considers using lognormal statistics for the surface radionuclide data to be acceptable. However, the other three strata/COC groups failed multiple tests for normality and lognormality. Therefore, these data are neither normal nor lognormal at an alpha of 0.05 and require the use of non-parametric testing. Histograms for these Ln-transformed data sets appear below in Figures 1 through 4. Figures were created using EPA's GeoEAS software.

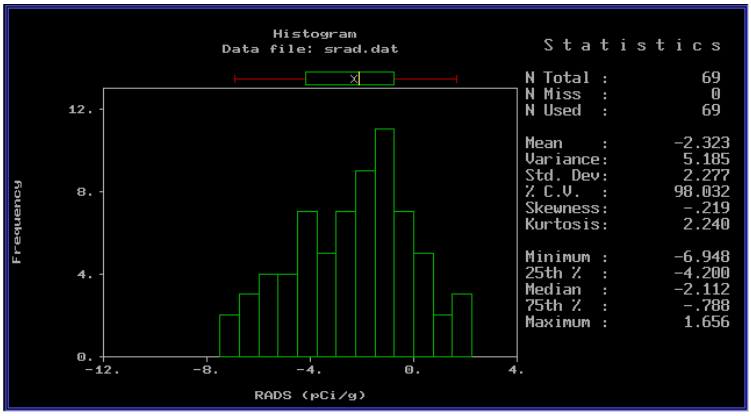

Figure 1. Surface Soil Rads

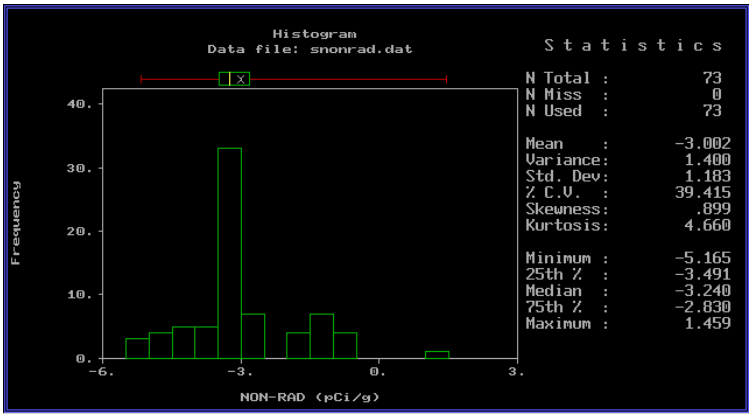

Figure 2. Surface Soil Non-Rads

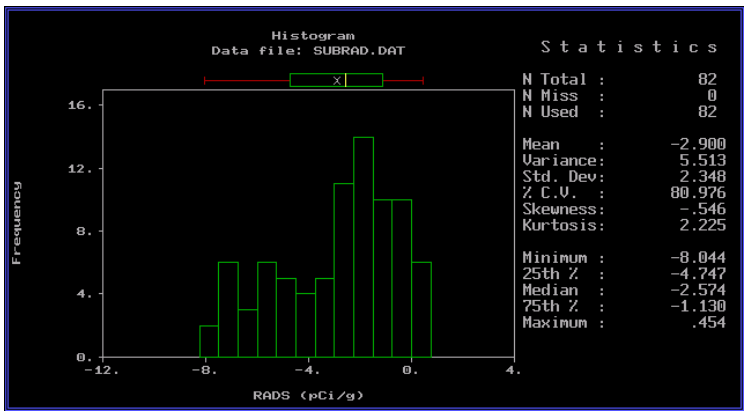

Figure 3. Subsurface Soil Rads

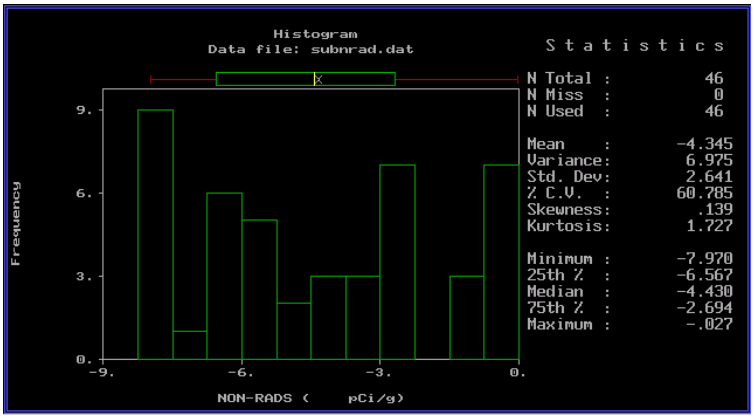

Figure 4. Subsurface Soil Non-Rads

EPA recommends using the Bootstrap approach to UCL calculation when data distributions are neither normal nor lognormal. The SEP Risk Assessment used the Bootstrap method to quantify UCLs. This position is stated in EPA technical paper "The Lognormal Distribution in Environmental Applications" by Singh, et al. (1997). Use of

the Bootstrap methodology is also supported in the User's Guide to EPA's PRO-UCL software released in April of 2002. The Bootstrap method is bounded by the minimum and maximum values observed in the data set. However, virtually all statistical tests are limited by this constraint. Use of lognormal statistics can create data values that are outside the bounds of those values actually observed.

In addition, use of lognormal statistics is limited when data have outliers, non-detects, small sample size, and the presence of multiple populations (EPA, 1997). A data set might appear lognormal due to these constraints and estimates assuming lognormality will overestimate the uncertainty term for concentration and therefore overestimate risk. Radiological data have negative concentrations and relatively large variances that can present technical difficulties in using lognormal statistics.

Distributional testing was also conducted for individual surface soil COCs. Data normality and lognormality were tested using the Shapiro-Wilks test on the raw data and Ln-transformed data. Results are presented in Table 2 and Attachment A. All individual COCs were not normally distributed. Am-241, Pu-239, and U-235 were lognormally distributed and all other surface soil COCs were neither normally nor lognormally distributed. Graphical results for each COC are shown in Attachment A.

Table 2. Shapiro-Wilks Test Results

Radionuclide	Normality P(0.05)	Lognormality P(0.05)
Cadmium	<0.0001	<0.0001
Chromium	<0.0001	<0.0001
Am-241	<0.0001	0.209
Pu-239	<0.0001	0.201
U-238	<0.0001	<0.0001
U-235	<0.0001	0.04
U-234	<0.0001	<0.0001

3.0 Geostatistical Spatial Analysis

The distributional assumption of lognormality holds for the surface radiological data set. In fact, only Am-241, Pu-239, and U-235 were lognormally distributed. However, this does not solve the problem of how to calculate UCLs in the other data sets. An approach that could be used consistently for each type is desirable. DOE investigated the use of geostatistical methodologies to determine if they could provide such a consistent method. Variograms were run on COCs in the SEP area. Results indicated that good spatial correlation was observed, based on the variograms. The observed data started at the origin and then demonstrated a steady and continuous rise to the maximum sill. No "nugget" effects were apparent in the variogram data. This was true for both individual COCs (e.g. Am-241, Pu-239/240, Cd, etc.) and aggregated variables (SOR values). Resulting variances from the variograms were then used to conduct polygonal kriging. An example variogram for Am-241 is shown below in Figure 5. Variograms for all COCs in surface soils are shown in Attachment B. Polygonal kriging was also conducted

for all COCs and the observed mean (Vlu) and variance (Kv) were used to directly calculate UCLs assuming that kriging errors are normally distributed. Standard UCL calculations were performed using an estimate of the variance of the mean from polygonal kriging and $t_{0.05,\ n-1}$ degrees of freedom. An example polygonal kriging map for Am-241 is shown in Figure 6. All other kriging maps for other COCs are shown in Attachment C.

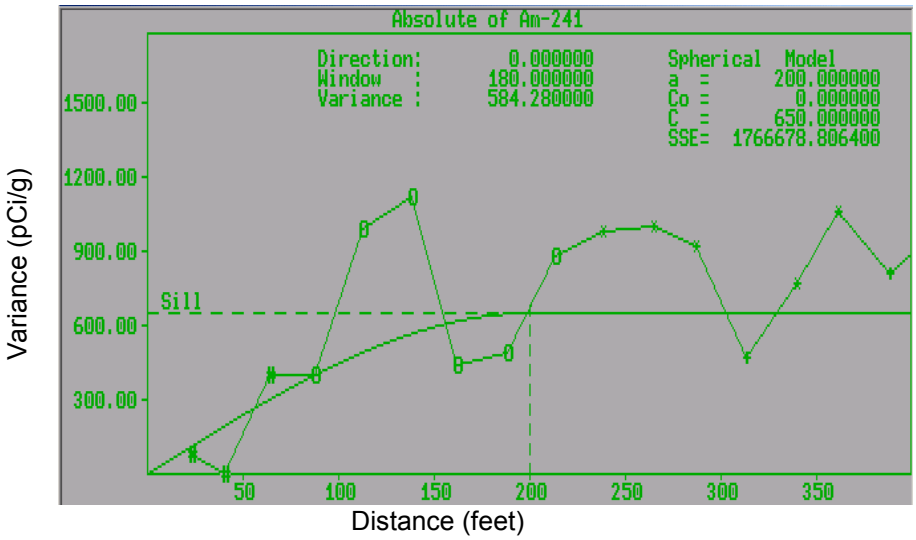

Figure 5. Am-241 in Surface Soil

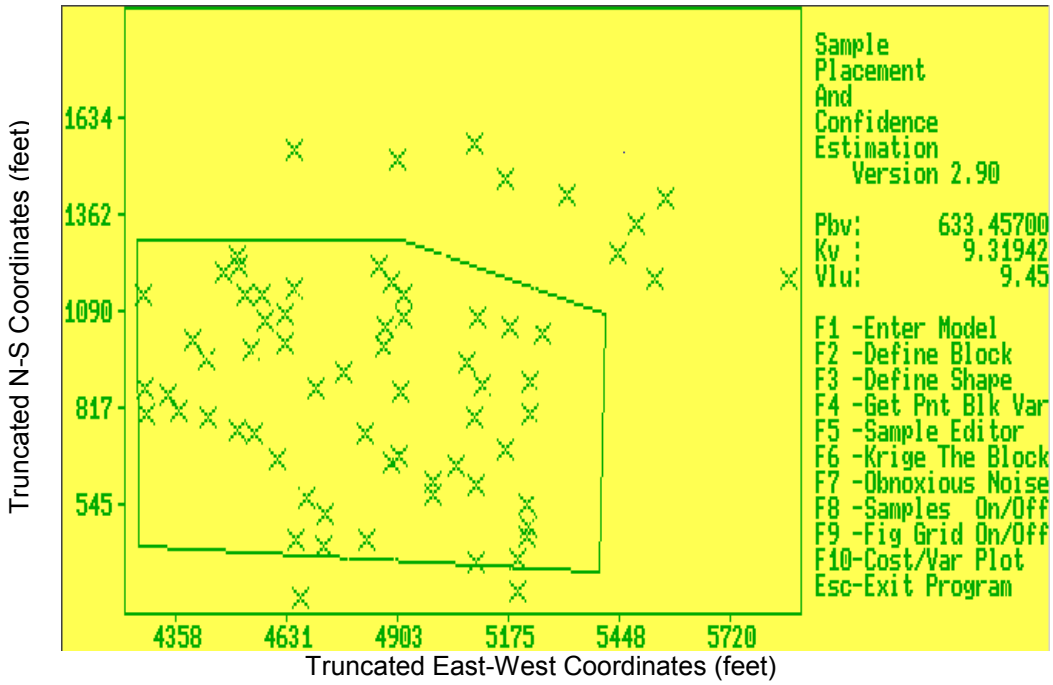

Figure 6. Polygonal Kriging for Am-241 Showing Sampling Locations and Resulting Statistics

Identification of spatial correlation in a data set immediately indicates that use of classical statistical methods for characterizing the 95% UCL for the arithmetic mean concentration should be avoided. Such classical methods include the Student's t-statistic for normal distributions and the Land H-statistic for lognormal distributions. These methodologies quantify uncertainty in the long-term concentration term without consideration of spatial variability present in data derived from environmental sampling (EPA 2001). These techniques assume that collected data are randomly and independently distributed. However, the SEP data indicate that there is a pattern of contamination resulting from release mechanisms and down-wind deposition. Therefore, autocorrelation between sample points is present at the site. Because the variogram shows that the SEP data are not independent, using classical statistics would violate basic fundamental assumptions for the tests, unless the correlations can be accounted for. Independent data would show a variogram pattern that starts up the y-axis near the sill maximum and randomly varies about the sill as a function of distance.

Geostatistical methods are specifically designed to incorporate the correlations found in the variogram analysis directly into statistical analysis and UCL calculations. In addition, the geostatistical estimation technique of kriging does not make any distributional assumptions about the data. This technique is also a "best" approach with minimum error and "declusters" data that are grouped in close spatial proximity to provide the most appropriate estimates of average concentrations within the entire area.

Based on the success of variogram analyses and the strong theoretical basis, kriging of the data in the surface soils in the SEP was conducted. Data were kriged using two different methods. The first method kriged the SEP data COC-by-COC using a polygonal kriging approach. Polygonal kriging estimates the average concentration within single non-rectangular polygonal shapes across the site using a type of "horizontal" approach. Using the kriging mean and kriging standard deviation, a 95% UCL was calculated for each COC using a standard formula for classical statistics. Each UCL was then divided by the corresponding action level for a target risk of 1E-05 to derive an SOR for the SEP. The sum of the Surface Rad SORs using polygonal kriging was 1.09. The 95% UCLs for individual COCs developed using polygonal kriging were higher than those calculated using the Student's t classical statistical approach.

The second approach aggregated SORs for COC concentrations at individual sample locations. Compared to the first method, this is a more "vertical" approach. These SOR values were then kriged across the SEP area using polygonal kriging. Results indicated a 95% UCL on the SOR of 0.98, slightly less than the UCL for the horizontal approach. The IASAP uses the more conservative "horizontal" approach.

Both results for the "horizontal" and "vertical" UCL calculations were derived using the same existing action levels as used in the SEP Risk Assessment. However, the existing action levels are based on an exposure scenario that includes indoor air exposure and continuous external gamma exposure for the wildlife refuge worker. If indoor air and continuous gamma exposure are corrected, observed UCLs are reduced by a factor of approximately 6. The sum of 95% UCLs/ALs would, therefore, be 1.09/6 = 0.18 and the

95% UCL associated with the aggregated SORs would be 0.98/6 = 0.16. Both resulting SOR 95% UCLs are well below the limit of 1.0.

To assess the removal of hot spots, the five highest concentrations were replaced with approximate background values. The data were then re-kriged using the same variograms and new 95% UCLs were recalculated. This approach represents a type of "virtual remediation" of the site to demonstrate risk reduction in a post-remediation scenario. Results of the horizontal kriging provided a 95% UCL of 0.66 for the SOR and a 95% UCL of 0.64 using the vertical approach. Correcting these UCL values for exposure assumptions discussed above results in a horizontal and vertical estimate of 0.11 for both approaches. The results, therefore, indicate that the SEP risk is well below concern at the 95% level of confidence, before hot spot removal. The resulting SOR 95% UCLs following hot spot removal are approximately equivalent to a 1E-06 risk.

The results indicate that kriging is the most conservative of all the approaches to calculating UCLs, with the exception of lognormal UCLs for Pu239 and Am-241. Kriging is also, by far the most defensible from a theoretical standpoint. Of the two variations on kriging, the horizontal approach (COC-by-COC and corresponding to risk) is the most conservative method. The vertical method, however, provides an excellent surrogate estimate of total risk and can be used for screening and remediation purposes. The horizontal and vertical kriging techniques described are also robust approaches. The testing characteristics identified will remain even if Action Levels or if a combination of Action Levels is applied to SOR calculations.

In terms of data sufficiency, the fact that data are spaced closely enough to observe spatial correlations on a consistent basis indicates that enough data have already been collected to calculate valid mean and UCL estimates. Using a statistical method (Gilbert 1987) and a lognormal distribution for surface soil SOR data, approximately 66 samples would be required as previously discussed (Section 1.0). Using DOE's Visual Sample Plan software to calculate the number of samples by means of EPA's decision performance goal diagram (DPGD), a total of seven samples is required following removal of the five highest concentrations present in hot spots (Figure 7). The DPGD assumes normal data, so the number of samples recommended (7) must be considered low (alpha = 0.05, beta = 0.05). However, approximately 70 samples currently exist in the SEP surface soil data set. Even accounting for low bias in the DPGD calculation, an order of magnitude should conservatively adjust for the assumption of normality.

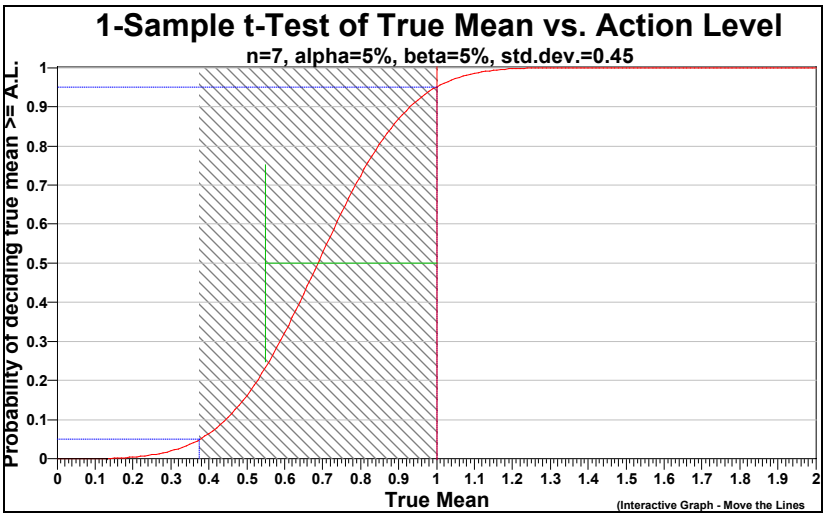

Figure 7. EPA Performance Curve

4.0 Impacts to Risk

The resulting impact of removing identified hot spots and use of alternative statistical methods to derive UCLs are discussed in this Section.

4.1 Hot Spot Removal

The following confirmation sample results were reported as gamma-spec measurements for Am-241, U-238, and U-235 at hot spot locations. Five samples were collected at each hot spot location on a one-meter quadrant. Results are reported as the arithmetic means for each location and radionuclide in Table 3 as follows:

Table 3. Confirmation Sample Results

Location	Sample #	Am-241	U-235	U-238
SS400693	CJ46-DR02	0.0	0.16	2.4
SS400593	CK46-DR01	1.6	0.3	7.4
43793	CK46-DR02	25.4	0.22	4.4
SS402893	CK48-DR01	5.3	0.08	3.5
SS403093	CK48-DR02	0.22	0.87	2.8

To assess residual risk following removal of hot spots, the above average concentrations were used to replace original hot spot concentrations. The 95 percent upper confidence limits (95 UCL) of the mean concentrations were then recalculated for use as exposure point concentrations. Table 4 below shows the pre- and post-removal means and 95 UCLs as determined by the Bootstrap method.

Table 4. Mean and UCLs Concentrations Before and After Hot Spot Remediation

Radionuclide	Pre-removal		Post-removal	
	Mean	95% UCL	Mean	95% UCL
Americium-241	9.11	14.7	3.08	5.06
Uranium-235	0.186	0.289	0.144	0.217
Uranium-238	2.73	3.77	2.23	3.31

The removal reduced the mean and 95 UCL of Am-241 by a factor of almost three. The two uranium isotopes were less affected. The total radiological risk was reduced from 2E-06 before the removals to 1E-06 after the removals.

4.1 Comparison of UCLs

Table 5 compares UCLs derived from various statistical methods. UCLs computed by Bootstrap and Geostatistics were consistently higher than UCLs derived from normal t-statistical methods. These two methods therefore do not underestimate the UCL for the SEP surface soil data. The Bootstrap method was used to calculate UCLs for the SEP Risk Assessment.

However, lognormal statistics using Land H produced UCLs for Am-241 and Pu-239 that were more then twice all other UCL estimates. At the same time, lognormal statistics produced a UCL estimate for U-235 that was even below the t-statistic estimate. Lognormal statistics therefore produced UCL estimates that were inconsistent and outside the range of all other estimates. EPA has discussed this problem in a Technical Document (EPA 1997)

Table 5. Comparison of 95% UCLs by Statistical Method

COC	Normal t-Statistics	Lognormal Land(H)	Geostatistics	Bootstrap
Cadmium	32.8	na	35.3	38.1
Chromium	23.8	na	25.1	24.8
Am-241	13.4	34.2	14.5	14.7
Pu-239	5.47	16.5	6.40	6.06
U-238	3.46	na	3.55	3.77
U-235	0.24	0.21	0.25	0.29
U-234	5.70	na	6.38	6.53

na = Not applicable, distribution not lognormal at the 0.05 level.

4.2 Impact on Risk

The impact of using lognormal, bootstrap, and geostatistics on risk estimates is discussed in this section. In addition, the impact on total risk following hot spot removal is also addressed. Table 6 shows the existing risk estimates compared to those derived from different statistical assumptions and hot spot removal. Surface soil risk dominates the estimates of total risk. Use of lognormal statistics increases the estimate of total risk by a

factor of two. Risk estimates using Bootstrap (existing risk) and geostatistics are consistent for total risk and for individual COCs. Hot spot removal decreases total risk by a factor of two as expected.

Table 6. Summary of Worker Risk by Assumption

Worker Carcinogenic Total Risk				
Medium	**Radiological**			
	Existing Risk	**Lognormal UCLs**	**Geostistical UCLs**	**Hot Spot Removal**
Surface Soil	2.0E-06	4.2E-06	2.1E-06	1.2E-06
Total Risk	2E-06	4E-06	2E-06	1E-06

5.0 Summary and Conclusions

- Statistical and spatial analyses both indicate that sampling at the SEPs is adequate, especially in view of the low estimated risk observed.
- Surface Soil Radionuclides dominate total risk to the worker.
- Radionuclides have both lognormal and non-parametric distributions.
- Metal COCs have non-parametric distributions.
- Lognormal power calculation for surface radionuclides (Am-241, Pu-239, U-235) is valid and indicates that 66 samples are required vs 69 already collected.
- UCLs derived from Bootstrap and Geostatistics are comparable and consistently greater than UCLs from statistics assuming a normal distribution.
- UCLs derived from lognormal statistics were inconsistent. Many were higher than all other calculation methods, but one was lower than UCLs derived from normal distributions for U-235.
- Geostatistics and Bootstrap methodologies are both technically sound, have no distributional assumptions, and adequately support risk quantification.
- Geostatistical methodologies address environmental data with spatial correlation such as the data present at the SEPs.
- Use of lognormal statistics increases risk by a factor of two and has the potential to quantify risk based on UCLs outside the range of observed concentrations.
- Hot Spot removal decreases risk by a factor of approximately two.
- Non-parametric statistical testing should be conducted for environmental data to incorporate observed spatial information and ensure that the best estimates of uncertainty for the concentration term are determined.
- SORs should be assessed on a point-by-point screening basis to guide remediation. If exceedances are observed above 1.0, then UCLs for individual COCs should be determined to calculate risk for the aggregated data.

ATTACHMENT II
HUMAN HEALTH RISK ASSESSMENT
SOLAR EVAPORATION PONDS

DRAFT FINAL
HUMAN HEALTH RISK ASSESSMENT
FOR THE SOLAR EVAPORATION PONDS

U.S. DEPARTMENT OF ENERGY

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

GOLDEN, COLORADO

Environmental Restoration

Kaiser-Hill Company, L.L.C.

December 2002

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ACRONYMS AND ABBREVIATIONS

AI	adequate intake
ALF	Action Levels and Standards Framework for Surface Water, Ground Water, and Soil
AOC	Area of Concern
ASD	Analytical Services Division
AUF	area use factor
AWF	area weighting factor
BZ	Buffer Zone
CCR	Code of Colorado Regulations
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	contaminant of concern
CRA	Comprehensive Risk Assessment
DAF	dermal absorption factor
DOE	U.S. Department of Energy
DQA	Data Quality Assessment
EDD	electronic data deliverable
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
EU	exposure unit
GIS	Geographic Information System
HEAST	Health Effects Assessment Summary Tables
HHRA	Human Health Risk Assessment
HI	hazard index
HQ	hazard quotient
IA	Industrial Area
IASAP	Industrial Area Sampling and Analysis Plan
IHSS	Individual Hazardous Substance Site
IM/IRA	Interim Measure/Interim Remedial Action
IRIS	Integrated Risk Information System
ITS	Interceptor Trench System
K-H	Kaiser-Hill Company, L.L.C.
LCS	laboratory control sample
µg/kg	micrograms per kilogram
$\mu g/m^3$	micrograms per cubic meter
mg	milligram
mg/kg	milligrams per kilogram
mg/kg-day	milligrams per kilogram per day
ML	mass loading
MS	matrix spike
MSD	matrix spike duplicate
NCEA	National Center for Environmental Assessment

OPWL	Original Process Waste Lines
OU	Operable Unit
PAC	Potential Area of Concern
PAH	polyaromatic hydrocarbon
PARCCS	precision, accuracy, representativeness, completeness, comparability, and sensitivity
PCB	polychlorinated biphenyl
pCi	picocurie
pCi/g	picocuries per gram
PCOC	potential contaminant of concern
ppb	parts per billion
ppm	parts per million
PRG	preliminary remediation goal
QA	quality assurance
QC	quality control
RADMS	Remedial Action Decision Management System
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
RDA	recommended daily allowance
RfC	reference concentration
RFCA	Rocky Flats Cleanup Agreement
RfD	reference dose
RFETS (or Site)	Rocky Flats Environmental Technology Site
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RFP	Rocky Flats Plant
RL	reporting limit
RIN	report identification number
RME	reasonable maximum exposure
RPD	relative percent difference
RSAL	radionuclide soil action level
SAP	Sampling and Analysis Plan
SEP	Solar Evaporation Ponds
SF	slope factor
SOP	standard operating procedure
SVOC	semivolatile organic compound
SWD	Soil Water Database
TCLP	Toxicity Characteristic Leaching Procedure
UCL	upper confidence limit
UL	upper limit
V&V	verification and validation
VOC	volatile organic compound
WRW	wildlife refuge worker

1.0 INTRODUCTION AND PURPOSE

The Human Health Risk Assessment (HHRA) was performed for Individual Hazardous Substance Site (IHSS) 101, the Solar Evaporation Ponds (SEP), effluent pipe, a portion of IHSS 121, the Original Process Waste Lines (OPWL) Resource Conservation and Recovery Act (RCRA), Units 21 and 48, and Potential Area of Concern (PAC) 900-1310 (the Interceptor Trench System [ITS] water spill) at the Rocky Flats Environmental Technology Site (RFETS).[1] This assessment of health risks can be used as a tool in the evaluation of appropriate and necessary remedial actions or implementation of other risk management measures to ensure protection of human individuals and populations following site closure. The HHRA was conducted in accordance with anticipated future land use, a wildlife refuge. Adverse health risks to wildlife refuge workers (WRWs) resulting from potential exposures to chemicals and radionuclides at or released from source term areas within the SEP area of concern (AOC) are quantified. Health risks are estimated for the reasonable maximum exposure (RME) conditions as defined by the U.S. Environmental Protection Agency (EPA) guidance (EPA 1989; 1992a).

Two HHRAs have previously been prepared for the SEP. The first was performed for the 1995 Interim Measure/Interim Remedial Action (IM/IRA), which was never approved. In response to deficiencies in the IM/IRA HHRA, Environmental Restoration (ER) completed a draft of a second HHRA in late 1995. The second HHRA was executed in close consultation with Colorado Department of Public Health and Environment (CDPHE) but was never finalized. There have been several significant changes in anticipated land use since 1995. The changes in land use impact all phases of the risk assessment process including receptors, exposure scenarios, exposure factors; screening values (preliminary remediation goals [PRGs]), and contaminant of concern (COC) selection. There have also been many updates of the toxicity factors used to calculate risks and health hazards since 1995.

The current HHRA incorporates much of the same data used in the earlier HHRAs, plus any that have become available since 1995. All methods and information used in the HHRA have been updated to those currently approved or that are in the approval process for RFETS. The final HHRA has been completed in close consultation with CDPHE. Ecological risk is

[1] Although a portion of the New Process Waste Lines (NPWL), RCRA Unit 374.3, exists within this area, the line was not included in this risk assessment because it is an aboveground line with no soil contamination expected.

not addressed in this risk assessment. Ecological risk will be assessed in the Sitewide Comprehensive Risk Assessment (CRA).

1.1 SITE DESCRIPTION

RFETS consists of an industrialized area of approximately 400 acres surrounded by an undeveloped Buffer Zone (BZ) of about 6,150 acres. The SEP is located in the central portion of the Site on the northeastern side of the Industrial Area (IA) and consists of five dry (empty) solar evaporation ponds (Pond 207-A, 207-B North, 207-B Center, 207-B South, and Pond 207-C). The SEP AOC includes adjacent soils within the IA and outside the IA fence, as well as a portion of IHSS 121, RCRA Units 21 and 48, and PAC 900-1310 (Figure 1.1). A field investigation was performed for the SEP and adjacent areas (results are presented in Appendix A). Any releases of contaminants into the environment that may have occurred from these units are within the AOC. The total AOC area is approximately 33.3 acres with a SEP area of 6.1 acres (determined by Geographic Information System [GIS] analysis, see Appendix B, Table 3).

The SEP was constructed primarily to store and evaporate radioactive process wastes containing high nitrates, and neutralized acidic process wastes containing aluminum hydroxide. In addition, these ponds have historically received wastes such as sanitary sewage sludge, lithium metal, sodium nitrate, ferric chloride, lithium chloride, sulfuric acid, ammonium persulfates, hydrochloric acid, nitric acid, hexavalent chromium, and cyanide solutions.

The ponds were initially constructed to contain wastewater with a liner inside of a bermed area. Contaminated liquids apparently infiltrated into subsurface soil. Currently, a groundwater barrier and treatment system is in place to protect an adjacent watershed area. A detailed description of the site location and general condition of the ponds is included in Sections 1.0 and 3.0 of the Phase I RCRA Facility Investigation/Remedial Investigation (RFI/RI) Report for the SEPs.

1.2 REPORT ORGANIZATION

This document consists of the following sections and appendices that provide detailed information on various aspects of the HHRA:

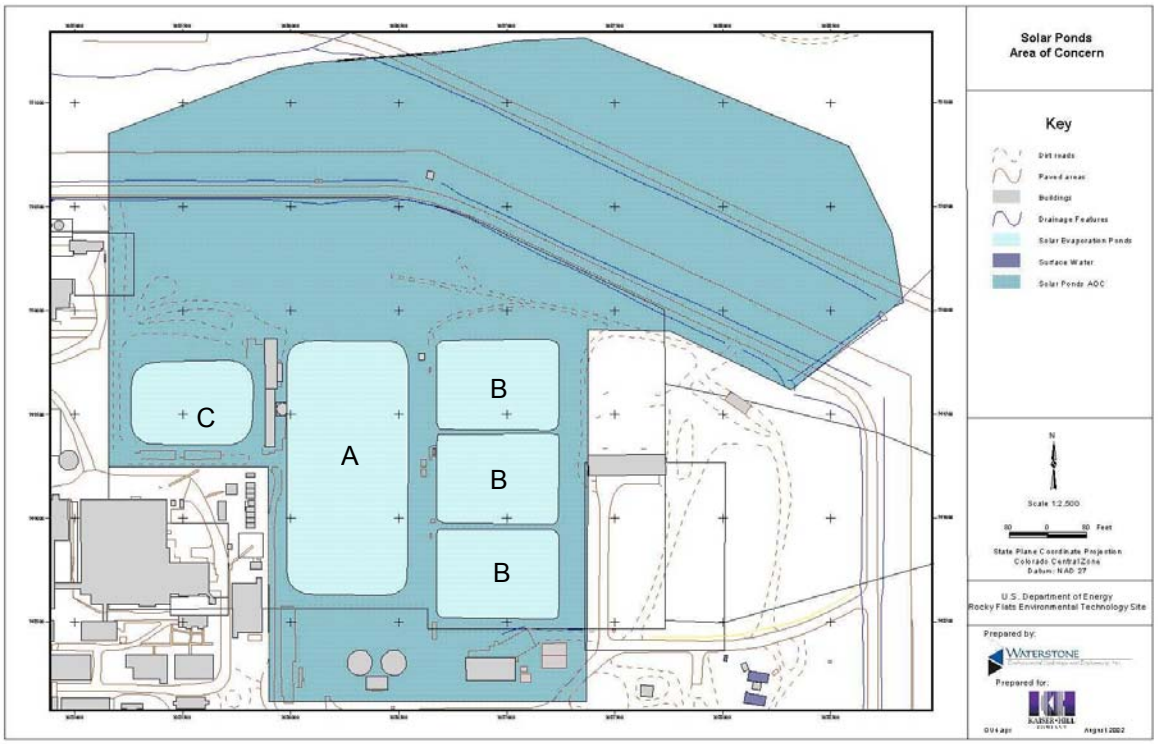

Figure 1.1. Solar Evaporation Ponds Area of Concern

Section 2.0, Selection of Contaminants of Concern: Describes the approach taken to screen and identify COCs for quantitative evaluation in the HHRA, including a summary of the analytical data used and how the data were aggregated.

Section 3.0, Exposure Assessment: Discusses the exposure scenarios evaluated in the HHRA, presents the exposure point concentrations calculated for each COC in each exposure medium and exposure area, and describes the methodology and exposure parameters used to quantify intake from each exposure pathway to each receptor.

Section 4.0, Toxicity Assessment: Describes the chemical-specific toxicity factors used in estimating noncarcinogenic and carcinogenic health risk resulting from exposure to chemicals and radionuclides.

Section 5.0, Risk Characterization and Uncertainty: Presents the results of the quantitative risk assessment for each exposure scenario, including hazard index (HI)/hazard quotient (HQ) estimates and dose calculations for each receptor, and identifies the primary sources of uncertainty associated with the resulting risk estimates.

Section 6.0, Summary and Conclusions: Summarizes and draws conclusions from the evaluation of risk assessment results and primary findings.

Section 7.0, References: Lists the literature cited in the HHRA.

Appendix A, Data Evaluation: Documents data management and all chemical and radionuclide data used in the HHRA. Data are presented in tables by media, with table of detection frequency and summary statistics, and tables and figures for the background comparisons.

Appendix B, AOC Area and Exposure Unit (EU) Size: Presents data on the development of exposure unit size and AOC area.

Appendix C, Risk Calculations: Presents risk calculation results by chemical and percent of total risk by media, pathway, and chemical.

2.0 SELECTION OF CONTAMINANTS OF CONCERN

Analytical data, data aggregation, the screening of potential contaminants of concern (PCOCs), and identification of COCs for quantitative evaluation in the HHRA are summarized. COCs in surface soil, subsurface soil, and pond liner material were selected on an AOC-wide basis.

2.1 ANALYTICAL DATA ASSESSMENT

Analytical data from analysis of environmental samples collected during previous Phase I field investigations and sitewide sampling programs were used to quantify contaminant concentrations present in the SEP AOC, and select the COCs for risk assessment. The sampling and analytical programs followed approved work plans, and chemical analytical results were validated in accordance with EPA and RFETS data validation guidelines.

SEP data used in the risk assessment are a compilation of analytical results generated by on-site and off-site laboratories. These data were originally stored in electronic format in the RFETS environmental Soil Water Database (SWD). The majority of these data were further processed through a series of data quality filters to ensure usability for risk assessment purposes. Data quality filters were based on the data quality objectives (DQOs) for the IA Sampling and Analysis (SAP) (IASAP) (DOE 2000). Approximately 36 percent of the data were taken directly from SWD. Appendix A describes the data preparation for the final database used in the HHRA. The data sets used for evaluation of surface soil, subsurface soil, and pond liner material are described below and presented in Appendix A, Tables A-1 through A-12.

2.1.1 DATA QUALITY ASSESSMENT (DQA)

This Data Quality Assessment (DQA), performed on the solar ponds data set, is based on various criteria derived from EPA Guidance, particularly those related to data verification and validation (V&V). A detailed DQA was also performed on the Operable Unit (OU) 4 IM/IRA data sets in 1995 (DOE 1995), and those results are summarized herein. References are listed at the end of the report. Quality Control (QC) evaluations performed on the current solar ponds data set are documented within the Microsoft (MS) ACCESS database "OU4 RA-DQA.mdb."

Verification and Validation of Results

Verification ensures that data produced and used by a project are documented and traceable per quality requirements. Validation consists of a technical review of data that directly support project decisions, such that any limitations of the data relative to project goals are stated. V&V criteria include:

- Chain-of-custody;
- Preservation and hold times;
- Instrument calibrations;
- Preparation blanks;
- Interference check samples (metals);
- Matrix spikes/matrix spike duplicates (MS/MSDs);
- Laboratory control samples (LCSs);
- Field duplicate measurements;
- Chemical yield (radiochemistry);
- Required quantitation limits/minimum detectable activities (MDAs) (sensitivity of chemical and radiochemical measurements, respectively); and
- Sample analysis and preparation methods.

Evaluation of V&V criteria ensures that precision, accuracy, representativeness, completeness, comparability, and sensitivity (PARCCS) parameters are satisfactory, that is, within tolerances acceptable to the project. Satisfactory V&V of laboratory quality controls are captured through application of validation "flags," or qualifiers, applied to individual records. Satisfactory V&V are indicated by a 10% (or greater) validation frequency of all results by method and matrix-type, and <10% rejection of those records validated. Validation results are summarized in Table 2.1, and indicate that data quality for the project is excellent. The validation frequencies shown range from 53% to 86% per analytical suite and far exceed the present DQO at RFETS of >10%. Rejected records (R validation code) ranged from 0.5% to 2.5% of the total records for each analyte group. All analytical categories represented in the tables are self-explanatory except for "Organics-misc," which are nontarget compounds not readily classified within the suites given.

Field sampling conducted for the OU 4 RFI/RI was performed under an approved Quality Assurance (QA) Plan (EG&G 1993), including standard operating procedures (SOPs), QA

addenda, and work plans. Several deficiency reports and associated corrective action plans were produced and implemented during the course of the project as an integral part of the Quality program. None of the deficiencies compromised data quality (DOE 1995a, §II.3.6.1).

Table 2.1 OU-4 Risk Assessment Data Set, Summary of Validated Records in the RFETS SWD

VAL_QUAL	Total Of CAS Number	Number of Validated Records							
		Organics-misc.	Anions	Metals	PCBs	Pesticides	Rads	SVOCs	VOCs
Null	4,410	121	73	519	126	258	649	1,523	1,141
Y	141	35					106		
Z	3,458	349	40	682	28	80	223	1,623	433
N	553			24			529		
A	2,228	63	18	343	2		976	501	325
J	3,720	168	29	2,430	53	100	59	623	258
V	20,383	306	273	4,345	715	2,000	1,159	5,493	6,092
R	605	40	2	154	21	60	71	46	211
Total Records	35,498	1,082	435	8,497	945	2,498	3,772	9,809	8,460
% Validated	76%	53%	74%	86%	84%	86%	60%	68%	81%
% Rejected	1.7%	3.7%	0.5%	1.8%	2.2%	2.4%	1.9%	0.5%	2.5%

V = Valid without qualification
J = Estimated (semiquantitative) value
A = Acceptable with qualification
Null, N, Y, Z = Not validated
R = Rejected, do not use

Hard-copy records of previous OU 4 (SEP) reports can be found in the RFETS Comprehensive Environmental Response Compensation and Liability Act (CERCLA) Administrative Record. Raw data, including V&V results and individual (analytical) data packages are currently filed by report identification number (RIN) and are maintained by Kaiser-Hill Company, L.L.C. (K-H) Analytical Services Division (ASD); older hard copies reside in the Federal Center (Lakewood, Colorado, [NARA]).

Precision and Accuracy

Overall precision and accuracy for the solar pond data sets were evaluated and documented in the SEP IM/IRA (DOE 1995), and are summarized in this section.

Precision of field sampling was adequate based on measurement of relative percent difference (RPDs) between duplicate and real samples. A collection frequency of 10% was originally established for the project, although >5% is generally considered adequate. The actual collection frequency was 1:14, or approximately 7%. An RPD of <40% was the RPD DQO for soil matrices; that goal was achieved for all analytical suites, including radionuclides, over 75% of the time.

Field blanks collected during the project indicated no false positives were present in the data set due to equipment cross-contamination.

Representativeness

Samples acquired for the project are representative based on their type, number, and location relative to the site-specific history (DOE 1995a). Other criteria that corroborate representativeness include:

- Implementation of industry-standard chain-of-custody protocols;
- Compliance with sample preservation and hold times; and
- Compliance with documented and Site-approved sampling plans and procedures, including SW-846 analytical methods.

Completeness

Sampling completeness was evaluated through the number and types of samples acquired relative to the project DQOs. Specifically, were samples collected to meet established goals, and valid results produced, to make project decisions?

The following number of asphalt liner samples were collected, relative to the analytical suites:

Metals:	15	Volatile Organic Compounds (VOCs):	0
Radionuclides:	15	Semivolatile Organic Compounds (SVOCs)	67
Polychlorinated biphenyls (PCBs):	0	Organics (miscellaneous):	0
Pesticides:	0		

The following number of surface soil (SS) samples were collected, relative to the analytical suites:

Metals	73	VOCs	68
Radionuclides	72	SVOCs	67
PCBs	66	Organics (misc.)	71
Pesticides	61		

The following number of subsurface (BH) soil samples from 0-to-6-foot depth were collected, relative to the analytical suites:

Metals	103	VOCs	98
Radionuclides	118	SVOCs	27
PCBs	17	Organics (misc.)	101
Pesticides	17	Anions	72

The following number of subsurface (BH) soil samples from greater than 6-foot depth were collected, relative to the analytical suites:

Metals	72	VOCs	102
Radionuclides	133	SVOCs	14
PCBs	14	Organics (misc.)	72
Pesticides	14	Anions	59

A summary of the V&V for all electronic data deliverable (EDD) records (in the current data sets) is provided in Table 2-1 and indicates that the minimum required percentages of validation for current projects, >10% and typically greater than 90%, were achieved for all sample types and methods. Of the percentages validated, <4% were rejected for any given analytical method; this is well below the maximum allowable rejection rate of 10% considered acceptable based on current RFETS DQOs. All rejected records were disqualified from use in the SEP risk assessment.

Comparability

All results presented are comparable with nation-wide CERCLA data and U.S. Department of Energy (DOE) complex-wide environmental data. This comparability is based on:

- Use of standardized engineering units in the reporting of measurement results;
- Consistent sensitivities of measurements (generally ≤ ½ corresponding action levels); and
- Use of Site-approved procedures, work plans, and quality controls (for example, Contractual Statements of Work for lab analyses; DOE 1995a).

Sensitivity

Adequate sensitivities of analytical methods were attained for all results. Reporting limits (and nondetect values), in units of micrograms per kilogram (µg/kg) (parts per billion [ppb]) for organics, milligrams per kilogram (mg/kg) (parts per million [ppm]) for metals, and picocuries per gram (pCi/g) for radionuclides, were compared with PRG action levels (10^{-5} WRW scenario) on a record-by-record basis. All results were less than <1/2 the PRG value. Adequate sensitivity is defined as a reporting limit (RL) that is less than the analyte's associated action level; ideally, it is <1/2 the action level.

Summary

Data quantity and quality are acceptable for risk assessment purposes, with the qualifications given, and based on the V&V criteria cited.

2.1.2 Power Calculations

Sampling power was evaluated to statistically determine if sufficient samples were collected to adequately characterize analyte concentrations within the AOC to support the risk assessment. It was assumed that samples were collected independently across the AOC for all sampled media, including liner materials, surface soils, and subsurface soils.

Three methodologies were used to conduct power calculations that are specific to the type of concentration distributions observed:

- Parametric: EPA (1994). QA/G-4 Report for normally distributed results.
- Lognormal: Gilbert (1987). Equation 13.23 for lognormally distributed results.
- Non-parametric: NRC/EPA/DOE/DOD (1997). MARSSIM Report §5.5.2.3 for non-parametric distributions.

The QA/G-4 model is only appropriate for normally distributed data and, therefore, used the arithmetic average and standard deviation to estimate the variance and construct 95UCLs.

The EPA QA/G-9 model is used to estimate numbers of required samples for analytes with lognormal distributions. Accordingly, the data were log-transformed to estimate the variance and lognormal UCLs. The Gilbert (1987) equation 13.23 is used for all analytes with lognormal distributions. The MARSSIM model (1997) is used for all analytes with observed non-parametric distributions. This model uses normal data or non-parametric data to estimate the variance and UCLs. Non-parametric estimates are derived from the re-sampling Bootstrap methodology (EPA, 1997; EPA, 2001: EPA, 2002).

Relative errors are derived primarily from the difference between the PRG or Action Level and the mean. Secondary relative errors are determined based on the difference between the PRG and the upper 95% confidence limit. A target risk of 1E-05 and HQ = 1.0 are used to select the appropriate PRGs to derive relative errors. The relative errors are constructed to bound sampling error due to inherent heterogeneity of analytes in soils and, therefore, the number of predicted samples required.

Statistical testing for distributions is conducted at the 95% confidence level using EPA (2000) QA/G-9 guidance and the associated DataQuest software. Graphical output is also evaluated, including histograms and frequency distributions. Tables 2.2a through 2.2c present the power calculations.

Liner Material

Radiological results appear to be lognormal with leptokurtic, skewed-right distributions clustering about zero. However, statistical testing did not confirm lognormality for americium-241 and uranium-238. Uranium-235 had a lognormal distribution. Both lognormal and non-parametric methods were employed to evaluate sample power for this reason. Table 2.2a presents the power calculation for the liner material.

The minimum number of required samples at 95% confidence level for PRGs at the 1E-06 and HQ = 1.0 levels are summarized below for all PCOC and the statistical methods employed.

Table 2.2a Power Calculations for Liner PCOCs.

PCOC-Dist	Number of Required Samples (n)			
	MARSSIM	MARSSIM	Lognormal	Lognormal
Chromium-NP	13	13	1	1
Am-241-NP	13	13	2	2
U-235-Log	13	13	1	1
U-238-NP	13	13	1	1

Power calculation results indicated that sufficient samples have been collected for all liner analytes. The results indicated that the difference between the mean or 95UCL and the respective PRGs is so great, that no additional samples would have to be collected. The value of 13 for the MARSSIM test is the default when the relative shift is greater than 3.0.

Surface Soils

Actual sample sizes for surface soil analytes ranged from 60 for Pu-239 to the low seventies for all other radionuclides and inorganics. Arsenic had a normal distribution and all other analytes in surface soil exhibited non-parametric distributions. Table 2.2b shows the power calculation results. Due to the relative large difference between the PRGs and the analyte mean or 95UCLs, predicted sample numbers were all at 1 to 2 for lognormal and 13 for the MARSSIM non-parametric test. A power calculation was conducted for arsenic assuming a normal distribution. These results predicted that one additional sample was required.

Table 2.2b Power Calculations for Surface Soil PCOCs.

PCOC-Dist	Number of Required Samples (n)			
	MARSSIM	MARSSIM	Lognormal	Lognormal
Aluminum-NP	13	13	1	1
Arsenic-Nor	13	13	1	1
Cadmium-NP	13	13	1	1
Chromium-NP	13	13	1	1
Manganese-NP	13	13	1	1
Am-241-NP	13	13	1	2
Pu-239-NP	13	13	1	1
U-238-NP	13	13	1	1
U-235-NP	13	13	1	1
U-234-NP	13	13	1	1

Subsurface Soils

Subsurface soils were evaluated for adequate samples using both lognormal and non-parametric power calculations. Actual samples sizes for analytes ranged from 95 for americium-241 to 188 for uranium-238. All predicted sample sizes for all analytes in Table 2.2c were below the actual sample sizes collected. The low results for all lognormal analytes indicates that the means and upper 95% confidence levels are well below the respective PRGs. Non-parametric results were all at the default of 13 when the relative difference over the standard deviation is greater than 3.0.

Table 2.2c Power Calculations for Subsurface Soil PCOCs.

PCOC-Dist	Number of Required Samples (n)			
	MARSSIM	MARSSIM	Lognormal	Lognormal
Aluminum-Log	13	13	1	1
Arsenic-Log	13	13	1	1
Barium-Log	13	13	1	1
Cadmium-Log	13	13	1	1
Chromium-Log	13	13	1	1
Iron-NP	13	13	1	1
Manganese-Log	13	13	1	1
Am-241-NP	13	13	1	1
Pu-239-NP	13	13	1	1
U-238-Log	13	13	1	1
U-235-NP	13	13	2	2

nc = Not Calculated because the mean and confidence levels are above the PRG.

Based on the results of the power calculations for all analytes in all SEP media, it is concluded that a sufficient number of samples have been collected from the AOC to adequately quantify risk at the 1E-05 level using estimates of uncertainty associated with the concentration terms.

2.2 SEGREGATION OF SAMPLES BY MEDIA

2.2.1 Liner Materials

A total of 15 pond liner material samples were collected in 1993 and 1995. These samples were analyzed for only metals and radionuclides; no analyses for organics were requested because the liners are made of asphalt. Sampling locations for the collection of pond liner materials are shown on Figure 2.1. All ponds were sampled, except the southernmost B-Series ponds; however, all B-Series ponds received similar waste streams.

The pond liner data were aggregated separately and assessed using surface soil pathways. The inhalation pathway was not assessed due to the cohesive nature of the liners. No allowance was made for additions of clean fill over the liners.

Four asphalt samples from Pond 207-C were collected and tested for the RCRA toxicity characteristic for metals using the Toxicity Characteristic Leaching Procedure (TCLP) (Test Method 1311, specified by EPA in SW-846 ([EPA 1996]). Observed concentrations for arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver were well below regulatory limits. Therefore, the SEP liner material is not classified as characteristic hazardous waste and is not subject to regulation under RCRA, Code of Colorado Regulations (CCR) 1007-3, Subpart C.

2.2.2 Surface Soil

Most surface soil samples were collected using the Rocky Flats Plant (RFP) method, in which the top 2 inches (5 centimeters) of soil are collected in several locations within a plot and then composited. Other samples were collected from the first interval of borehole sampling. All samples having a beginning and ending depth between 0 and 6 inches were retained in the surface soil data set. Surface soil for the ponds is considered to be within 0 to 6 inches of soil below the liners. The majority of surface soil samples were collected from May through July 1994. The analytical parameters varied by location, but generally included metals, radionuclides, nitrates, VOCs, SVOCs, pesticides, and PCBs. Surface soil sampling locations are shown on Figure 2.2.

2.2.3 Subsurface Soil

Subsurface soil samples were collected from October 1987 through November 1993. Subsurface soil samples were collected in 2-to-6-foot composites, depending on sampling location. Laboratory analyses of subsurface soil samples generally included the following analytical groups: VOCs, SVOCs, metals, pesticides, PCBs, and radionuclides. All data available for the AOC were reviewed. The subsurface data were divided into three categories: (1) samples with beginning depths less than 6 feet and ending depths greater than 0.5 feet (Figure 2.3); (2) samples with beginning depths greater than 6 feet (Figure 2.4); and (3) samples with no depth data in the database (Figure 2.5). Only samples with starting depths less than 6 feet were used in the HHRA. Receptors are unlikely to come in contact with soil below six feet. Subsurface data with no depths were not used due to the uncertainty of the samples' vertical location. These data are summarized in Section 2.3.8.

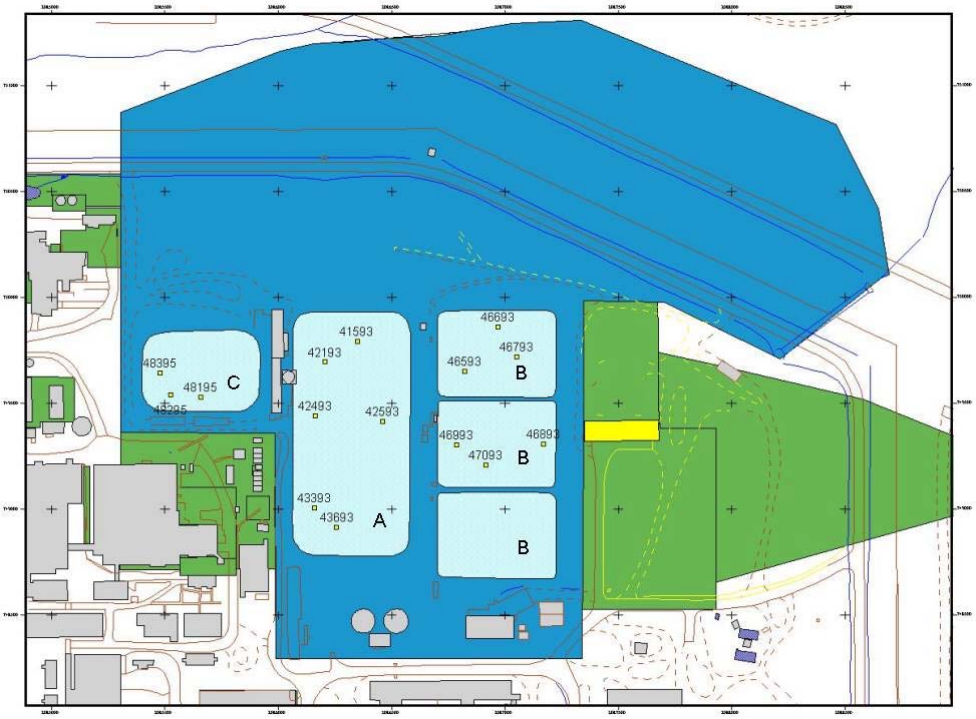

Figure 2.1 Solar Ponds Liner Sampling

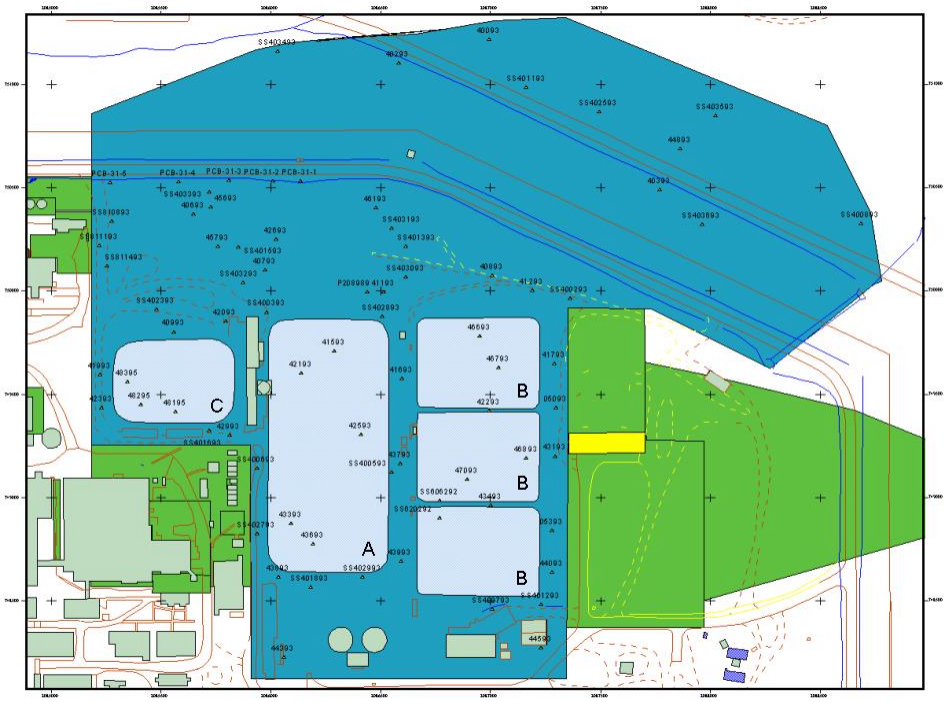

Figure 2.2 Surface Soil Sampling Locations

Figure 2.3 Subsurface Sampling Locations (Beginning Depths Less Than 6 Feet)

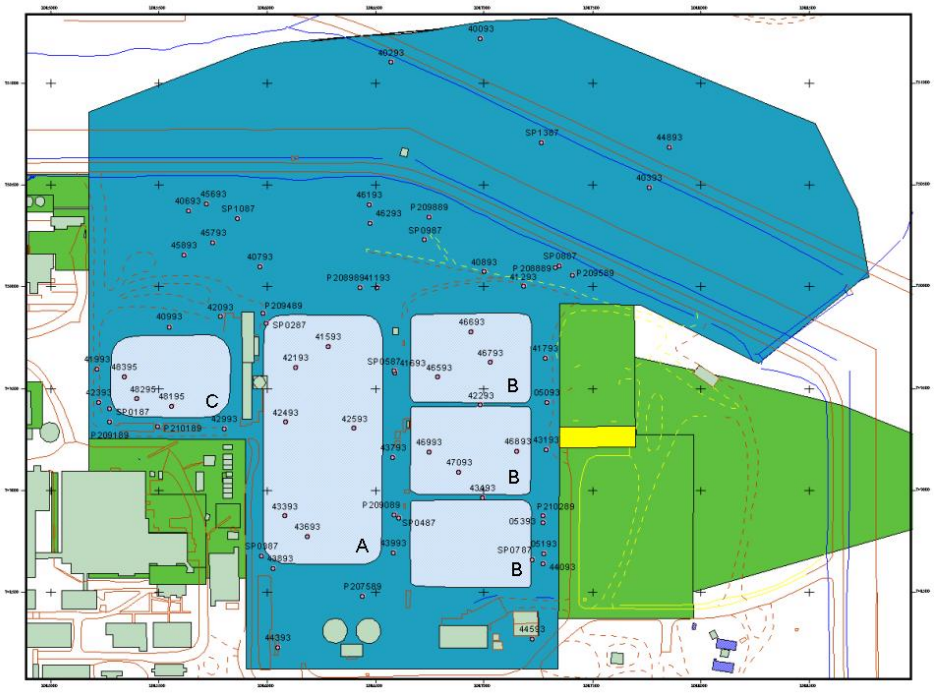

Figure 2.4 Subsurface Sampling Locations (Beginning Depths Greater Than 6 Feet)

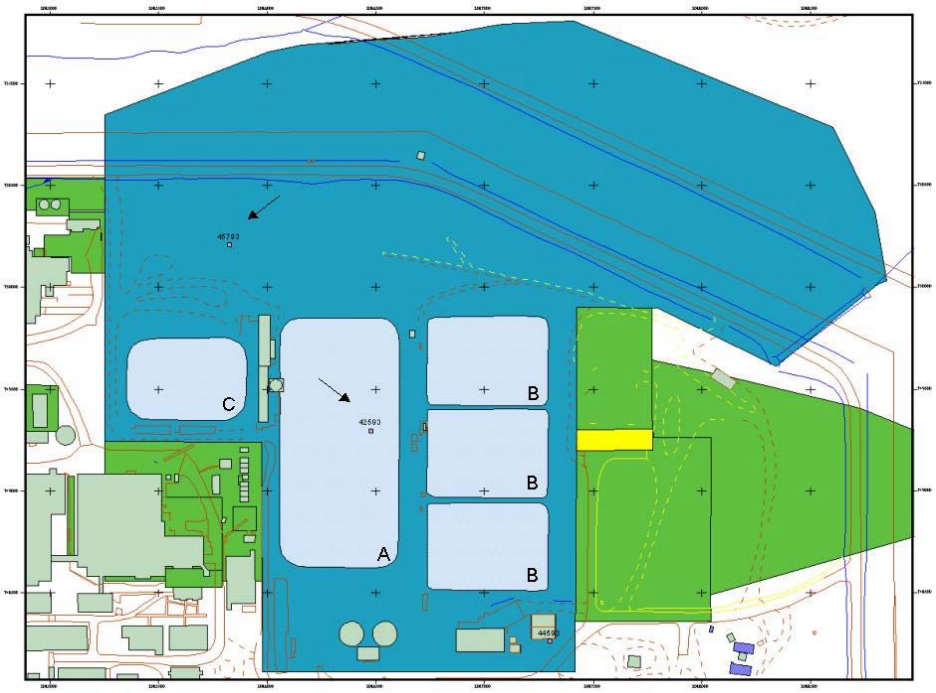

Figure 2.5 Subsurface Soil Sampling Locations (No Depths)

2.3 SELECTION OF CONTAMINANTS OF CONCERN

Samples within the AOC for surface soil, subsurface soil, and liner material were selected for use in the HHRA. The constituents in these media are the result of natural processes, precipitation of particulates and aerosols from the solar ponds, anthropogenic background (including pond liner materials), leakage of fluids from the solar ponds and surrounding lines, and accidental releases of site-specific chemicals. All analytes listed in the Action Levels and Standards Framework for Surface Water, Groundwater, and Soil (ALF) are considered PCOCs (DOE et al. 1996). Tables with summary information for all PCOCs are presented in Appendix A, Tables A-13 through A-20. All sample results from the AOC were pooled for each medium and the COCs selected. The procedure used to screen the data and select COCs is documented below and shown on Figure 2.6.

2.3.1 Essential Nutrients and Major Cations/Anions

Essential nutrients with no toxicity values in Iris or HEAST were compared to recommended daily allowances (RDA), recommended daily intakes (RDI), adequate intakes (AI) or upper limit daily nutrient intakes (UL) in accordance with EPA guidance (EPA, 1989a). Results are shown in Table 2.3. Essential nutrients with toxicity values were taken through the COC selection process.

Table 2.3 Comparison of intakes and daily allowances for essential elements without toxicity values[1]

	Intake from Ingestion of 200 mg of Soil per Day				Soil Concentrations	
Element	Max	Mean	RDA/RDI/AI	UL2	SEP Maximum	Western US Background Range[1]
	(mg/day)	(mg/day)	(mg/day)	(mg/day)	(mg/kg)	(mg/kg)
Calcium	49.6	4.34	500-1,200	2,500	248,000	600 – 32,000
Magnesium	1.3	0.51	80-420	65-110	6,500	300-<100,000
Potassium	1.66	0.51	2,000-3,500	ND	8,310	1,900-63,000
Silicon	2.26	0.71	ND	ND	11,300	150,000-440,000
Sodium	0.7	0.11	500-2,400	ND	3,660	500-100,000

1. Shaklette and Boerngen, 1984

2.3.2 Data Aggregation and Calculation of Statistics

Data aggregation for the HHRA was performed in accordance with guidelines developed by CDPHE, EPA Region VIII, and DOE. The SEP AOC was delineated on the basis of the spatial extent of potential contaminants and known historical use. The AOC encompasses the SEP and contaminated adjacent soil (Figure 1.1).

Sample concentrations for surface soil and the bermed soil surrounding the SEP were aggregated. Liner sample data were aggregated separately from surface soil so that risks could be estimated for both media. Subsurface soil data were aggregated for use in the risk assessment for samples with beginning depths at less than 6 feet. Summary statistics are also shown for samples with beginning depths below 6 feet and for those with no depth data. These samples were not used in the risk assessment.

Summary statistics were calculated for each data group, and that included detection frequency, mean contaminant concentrations, minimum concentrations, maximum concentrations, and standard deviation. Summary statistics are presented in Tables A-13 to A-20. A summary of samples found to have irregular units and therefore, excluded from the risk assessment is shown for each medium in Tables A-21 to A-23 in Appendix A. The upper 95 percent confidence limit of the mean concentration (95UCL) was only calculated for COCs. More details on calculating the exposure concentrations are provided in Section 3.0.

2.3.3 Comparison to PRGs

PCOCs were screened relative to PRGs for the on-site WRW exposure scenario set to a 1E-06 risk level and an HQ of 0.1 (Appendix A, Tables A-13 to A-20). This was done because the target risk level for the Site is 1E-05 and this ensures that cumulative effects of PCOCs will be taken into consideration. The draft WRW PRGs developed by CDPHE using the radionuclide soil action level (RSALS) exposure assumptions and parameters were used for the screen. This is a conservative screen because the PRGs assume an office on the site, whereas the risk assessment does not (see Section 3.0).

Hexavalent chromium was deposited in the SEP. It is unlikely that the chromium has remained in the oxidized state due to its instability in the soil environment; however, for this risk assessment, the PRG value for chromium VI was used for conservatism. The maximum values observed from site samples, as reported in Appendix A, Tables A-13 to A-20, were directly compared to PRGs. Those PCOCs with maximums below the corresponding PRGs were eliminated from further consideration. The data are also shown for subsurface soil below 6 feet, so they may be compared to shallow subsurface soil. PCOCs with maximum values above the PRGs are shown in Tables 2.3 through 2.6.

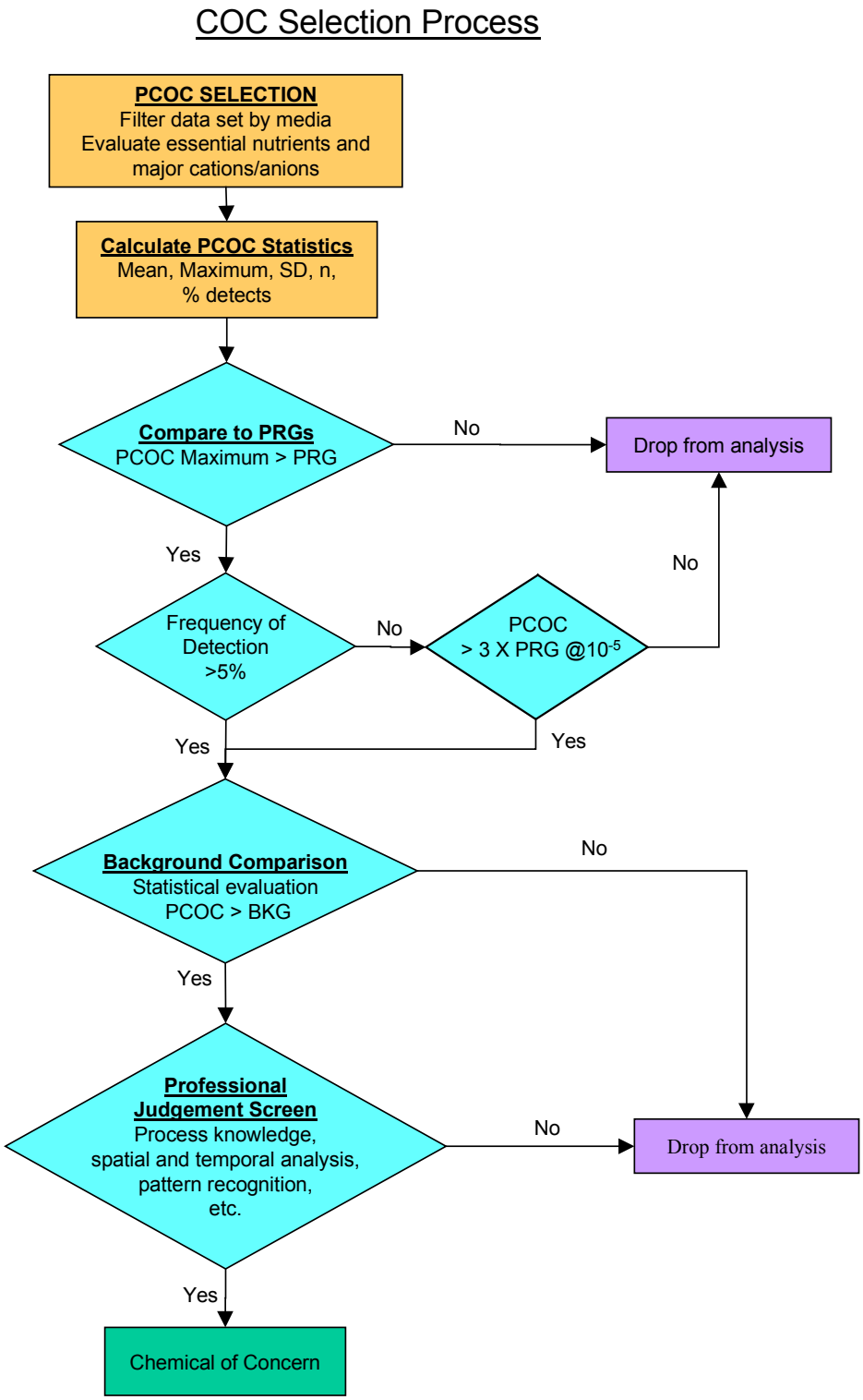

Figure 2.6 IHSS PCOC Screening Process

Table 2.4 PRG Screen for Surface Soil

ANALYTE	Minimum	Maximum	Total Samples	Number Detects	Detection Frequency	PRG @ 10-6 or HQ=0.1	Max/PRG
	mg/kg	mg/kg			%	mg/kg	
Aluminum	5.45	32500	73	72	99	14763	2.20
Arsenic	0.31	7.5	72	70	97	2.17	3.46
Cadmium	0.135	382	73	43	59	95.5	4
Chromium	0.47	120	73	71	97	15.1	7.95
Manganese	1.1	7650	73	72	99	220	34.8
	µg/kg	µg/kg	µg/kg			µg/kg	
Benzo(a)pyrene	36	1700	67	37	55	349	4.87
Dibenz(a,h)anthracene	38	370	66	9	14	348	1.06
	pCi/g	pCi/g				pCi/g	
Americium-241	0.011	130	69	69	100	3	44.6
Plutonium-239/240	0.013	56	60	60	100	7	8.42
Uranium-234	0.51	63.4	71	71	100	17.4	3.64
Uranium-235	-0.008	2.3	71	54	76	0.226	10.2
Uranium-238	0.31	27	72	72	100	1.03	26.1

Table 2.5 PRG Screen for Liner Materials

ANALYTE	Minimum	Maximum	Total Samples	Number Detects	Detection Frequency	PRG @ 10-6 or HQ=0.1	Max/PRG
	mg/kg	mg/kg			%	mg/kg	
Chromium	5.7	37.5	15	15	100%	15.1	2.483
	pCi/g	pCi/g				pCi/g	
Americium-241	0.003	8.188	15	9	60%	2.91	2.814
Uranium-235	0.018	0.27	15	10	67%	0.236	1.144
Uranium-238	0.52	2.68	15	15	100%	1.03	2.602

Table 2.6 PRG Screen for Subsurface Soil Above 6 feet

ANALYTE	Minimum	Maximum	Total Samples	Number Detects	Detection Frequency	PRG @ 10-6 or HQ=0.1	Max/PRG
	mg/kg	mg/kg			%	mg/kg	
Aluminum	2250	39100	102	102	100	14763	2.65
Arsenic	0.295	15.5	103	97	94	2.17	7.14
Barium	13.45	11600	102	101	99	1833	6.33
Cadmium	0.1	547	97	29	30	95.5	5.73
CHROMIUM	3.8	56.9	102	102	100	15.1	3.77
Iron	3210	31100	102	102	100	30660	1.01
Manganese	43.6	1220	102	102	100	220	5.55
	µg/kg	µg/kg				µg/kg	
Benzo(a)pyrene	34	405	26	1	4	349	1.16
	pCi/g	pCi/g				pCi/g	
Americium-241	-0.04	6.1	95	82	86	2.91	2.09
Plutonium-239/240	-0.06	19.78	98	81	83	6.65	2.97
Uranium-234	0	21	118	117	99	17.4	1.21
Uranium-235	0	0.87	99	71	72	0.226	3.86
Uranium-238	0.1	11.46	118	114	97	1.03	11.1

Table 2.7 PRG Screen for Subsurface Soil Below 6 feet

ANALYTE	Minimum	Maximum	Total Samples	Number Detects	Detection Frequency	PRG @ 10-6 or HQ=0.1	Max/PRG
	mg/kg	mg/kg			%	mg/kg	
Aluminum	2160	42400	72	72	100	14763	2.872
Arsenic	0.19	24.6	72	67	93	2.17	11.336
Barium	9.7	4150	72	65	90	1833	2.264
Iron	1060	50800	72	71	99	30660	1.657
Manganese	21.5	3140	72	72	100	220	14.274
	pCi/g	pCi/g				pCi/g	
Uranium-235	-0.005	0.383	71	43	61	0.226	1.698
Uranium-238	0.19	9.29	132	128	97	1.03	8.987

2.3.4 Frequency of Detection

All contaminants were evaluated for frequency of detection. Rarely detected PCOCs with detection frequencies < 5 % and chemicals with no detections were screened relative to the PRG to be sure the detection limits were not set too high to detect potentially hazardous concentrations. Benzo(a)pyrene had a detection frequency of 4%(one detect, Table 2.6) in shallow subsurface soil. It will not be carried on as a PCOC because the ratio of the maximum detect to the PRG is less than 3, and the detection frequency is less than 5%. Nondetected contaminants were not observed in the surface soil or liner material with elevated detection limits greater than the PRG at 1E-06 or the HQ of 0.1 (Appendix A Tables A-13-A-20).

2.3.5 Data Distribution Testing

Distributional testing was performed for all the PCOCs from liner material, surface soil, and subsurface soil retained following the PRG Screen. Testing was conducted following EPA guidance and EPA QA/G-9 methods using the Data Quest Program (EPA 1992; EPA 1996; EPA 1997; EPA 2002). Data Quest includes six statistical tests for determining data distributions. These are:

- Shapiro-Wilk Test (S-W, test limited to n < or = 50);
- Fillibens Test (Filliben, test limited to n < or = 100);
- Coefficient of Variation Test (CV);
- Skewness and Kertosis Tests (S/K, n > 50);
- Studentized Range Test (S.R, n < 1,000); and
- Geary Test (Geary, verify with other test if n > 50).

Not all tests were applied to each data set due to sample number limitations. Filliben's test was included for sample sizes less than 50 and results verified by other tests. The results of the distribution testing were evaluated using specific decision rules and a final distribution type of normal, lognormal, or non-parametric was assigned for each PCOC. The assigned distribution was then utilized to quantify the appropriate upper 95% UCL. Test results were also compared to background distribution test results to determine the appropriate statistical test to compare Site data to background data.

The decision rules to assign distribution types were the following:

- A yes result indicates that the data do conform to the assumed distribution at the alpha = 0.05 level for an individual test.
- Two or more "no" results for the tests shown in Tables 2.8 to 2.13 indicates that the data did not conform to the distribution being tested.
- If results lead to a yes decision for both normal and lognormal distributions the data are treated non-parametrically.
- Radiological data with zero and negative concentrations cannot be log-transformed and are considered normal or non-parametric.

Statistical comparisons to background were conducted using a non-parametric Mann-Whitney Rank Sum Test when Site and background data had different assigned distributions or were neither normally or lognormally distributed. If Site and background data had the same normal or lognormal distributions, then a Student's T-Test was used to compare PCOCs to background. Overlap of 95% lognormal confidence limits was also considered to indicate that that site data was within the range of background.

Liner Data Evaluation

Fifteen liner samples were evaluated for each PCOC with a maximum above the WRW PRG, chromium, americium-241, uranium-235, and uranium -238. All other PCOCs were eliminated in the PRG Screen. Table 2.8 presents test results.

Chromium, americium-241, uranium-238were classified as having neither normal nor lognormal distributions. Uranium-235 exhibits a lognormal distribution. Table 2.9 presents distributional testing results for background surface soil. Background distributions for the PCOCs were very similar to site data distributions. However, background americium-241 was assigned a normal distribution. Background and site PCOCs were assigned the same or different final distributions as shown in Tables 2.8 and 2.9.

Table 2.8 Summary of Distribution Testing for Liner PCOCs

PCOC(n)	Distribution Test Result (alpha = 0.05)										
	Normality Test					Lognormality Test					Final Dist
	S-W	Filliben	CV	S.R.	Geary	S-W	Filliben	CV	S.R.	Geary	
Cr(15)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NP
Am-241(15)	No	No	No	Yes	Yes	No	No	No	No	No	NP
U-235(15)	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Log
U-238(15)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	NP

NP = Non-Parametric Distribution.
Log = Lognormal Distribution.

Table 2.9. Summary of Distribution Testing for Background Surface Soil PCOCs

PCOC(n)	Distribution Test Result (alpha = 0.05)										
	Normality Test					Lognormality Test					Final Dist
	S-W	Filliben	CV	S.R.	Geary	S-W	Filliben	CV	S.R.	Geary	
Cr(15)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NP
Am-241(15)	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No	Nor
U-235(15)	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Log
U-238(15)	No	No	Yes	Yes	No	No	No	No	Yes	No	NP

NP = Non-Parametric Distribution.
Log = Lognormal Distribution.
Nor = Normal Distribution.

Surface Soil Data Evaluation

Surface soil data were evaluated for each PCOC with a maximum above the WRW PRG, aluminum, arsenic, cadmium, chromium, manganese, americium-241, uranium-235, and uranium-238. All other PCOCs were eliminated in the PRG Screen. Table 2.10 presents test results.

None of the surface soil PCOCs was classified as normally or lognormally distributed. Table 2.11 presents distribution testing results for background surface soil. Background distributions for the PCOCs were similar to site data distributions. However, background americium-241 was assigned a normal distribution and plutonium-239/240 and uranium-235 were found to be lognormal. Background and site PCOCs were assigned the same or different final distributions as shown in Tables 2.10 and 2.11.

Table 2.10 Summary of Distribution Testing for Surface PCOCs

PCOC (n)	Distribution Test Results (alpha = 0.05)										
	Normality Test					Lognormality Test					Final Dist
	Fillbens	CV	S/K	S.R.	Geary	Fillbens	CV	S/K	S.R.	Geary	
Al (73)	No	Yes	No	Yes	No	No	Yes	Yes	No	No	NP
As (72)	No	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Nor
Cd (73)	No	No	No	No	No	No	No	No	Yes	Yes	NP
Cr (73)	No	Yes	No	No	No	No	Yes	No	No	No	NP
Mn (73)	No	No	No	No	No	No	Yes	No	No	No	NP
Am-241(69)	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	NP
Pu-239 (60)	No	No	No	No	No	Yes	No	Yes	Yes	No	NP
U-234 (72)	No	No	No	No	No	No	No	No	Yes	Yes	NP
U-235 (70)	No	No	No	No	No	No	Yes	Yes	Yes	No	NP
U-238 (71)	No	No	No	No	No	No	No	No	Yes	Yes	NP

NP = Non-Parametric Distribution.

Table 2.11 Summary of Distribution Testing for Background Surface Soil PCOCs

PCOC (n)	Distribution Test Result (alpha = 0.05)										
	Normality Test					Lognormality Test					Final Dist
	S-W	Fillibens	CV	S.R.	Geary	S-W	Fillibens	CV	S.R.	Geary	
Al (20)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NP
As (20)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NP
Cd (20)	No	No	Yes	Yes	No	No	No	No	Yes	Yes	NP
Cr (20)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NP
Mn (20)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NP
Am-241 (50)	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No	Nor
Pu-239 (50)	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Log
U-234 (20)	No	No	Yes	Yes	No	No	No	No	Yes	No	NP
U-235 (20)	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Log
U-238 (20)	No	No	Yes	Yes	No	No	No	No	Yes	No	NP

NP = Non-Parametric Distribution.
Nor = Normal Distribution
Log = Lognormal Distribution.

Subsurface Soils Data Evaluation

Subsurface soil samples ranging in sample size from 95 to 118 were evaluated for distribution type as shown in Table 2.12 for all PCOCs retained in the PRG screen. Metals, with the exception of iron are lognormally distributed. However, all radionuclides, with the exception of uranium-238, were not evaluated, due to the presence of zero and negative concentrations which can not be evaluated using log transformations.

Table 2.13 presents the test results for background analytes corresponding to the PCOCs in subsurface soils collected from the SEPs. Aluminum, arsenic, and barium had lognormal distributions in both background and SEP data. All other background analytes in Table 2.13 are neither normally nor lognormally distributed, or could not be log-transformed due to the presence of zero and negative concentrations.

Subsurface PCOC exhibited mostly lognormal distributions compared to surface and liner PCOCs that were primarily non-parametric. This could be due to the presence of contamination mixed with background concentrations in surface media as opposed to a predominant background population in the subsurface soils.

Table 2.12 Summary of Distribution Testing for Subsurface PCOCs

PCOC (n)	Distribution Test Result (alpha = 0.05)										
	Normality Test					Lognormality Test					Final Dist
	Fillbens	CV	S/K	S.R.	Geary	Fillbens	CV	S/K	S.R.	Geary	
Al (102)	na	Yes	No	Yes	No	na	Yes	Yes	Yes	Yes	Log
As (103)	na	Yes	No	Yes	No	na	Yes	Yes	Yes	Yes	Log
Ba (102)	na	No	No	No	No	na	Yes	Yes	Yes	Yes	Log
Cd (97)	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Log
Cr (102)	na	Yes	No	Yes	No	na	Yes	Yes	Yes	Yes	Log
Fe (102)	na	Yes	No	Yes	Yes	na	Yes	Yes	Yes	Yes	NP
Mn (102)	na	Yes	No	No	No	na	Yes	Yes	Yes	Yes	Log
Am-241 (95)	No	No	No	No	No	nc	nc	nc	nc	nc	NP
Pu-239 (98)	No	No	No	No	No	nc	nc	nc	nc	nc	NP
U-234 (118)	na	No	No	Yes	No	na, nc	nc	nc	nc	nc	NP
U-235 (99)	No	No	No	Yes	No	nc	nc	nc	nc	nc	NP
U-238 (118)	na	No	No	Yes	No	na	Yes	Yes	Yes	Yes	Log

na = Fillbens Test limited to n < or = 100.
nc = Not Calculated Due to Zero and Negative Concentrations.
NP = Non-Parametric Distribution.
Log = Lognormal Distribution.

Table 2.13. Summary of Distribution Testing for Background Subsurface Soil PCOCs[1]

PCOC (n)	Distribution Test Result (alpha = 0.05)										
	Normality Test					Lognormality Test					Final Dist
	Fillbens	CV	S/K	S.R.	Geary	Fillbens	CV	S/K	S.R.	Geary	
Al (98)	No	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Log
As (99)	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Log
Ba (99)	No	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Log
Cd (81)	No	Yes	No	Yes	No	Yes	No	No	Yes	No	NP
Cr (99)	No	No	No	No	No	No	Yes	No	No	No	NP
Fe (99)	No	Yes	No	No	No	No	Yes	No	No	No	NP
Mn (99)	No	No	No	No	No	No	Yes	No	No	Yes	NP
Am-241 (28)	No	No	na	Yes	Yes	nc	nc	nc	nc	nc	NP
Pu-239 (99)	No	No	No	Yes	Yes	nc	nc	nc	nc	nc	NP
U-234 (99)	No	No	No	No	No	No	No	No	No	No	NP
U-235 (99)	No	No	No	Yes	No	nc	nc	nc	nc	nc	NP
U-238 (99)	No	Yes	No	No	No	No	No	No	No	No	NP

nc = Not Calculated Due to Zero and Negative Concentrations.
NP = Non-Parametric Distribution.
Log = Lognormal Distribution.
(1) Subsurface Soil Data from upper stratigraphic unit.

2.3.6 Background Comparison – Statistical Testing

Analytical results for metals and radionuclides above the WRW PRGs in surface soil, subsurface soil, and liner material at the SEP were compared to background concentrations. Background data were from DOE (1995b and 1993) for local surface and subsurface soil, respectively. Pond liner material was compared to background surface soils for determination of PCOCs, because no specific background data are available for liner materials.

Data distribution testing was discussed in Section 2.3.5 for all PCOCs retained after the PRG Screen for all SEP media. Statistical comparison of SEP media data to background data was then conducted, based on the results of the distribution testing, to ascertain the possible presence of SEP analyte concentrations above natural background. If SEP media data and background data had different distributions or both had non-parametric distributions, then a non-parametric Mann-Whitney U-test was used for the comparison. If both background and SEP media data had normal or lognormal distributions, then a specific t-test and a comparison of lognormal 90% confidence intervals were used, respectively. The comparison of lognormal 90% confidence intervals for SEP analyte data compared to background data was conducted to evaluate if SEP data were within the range of background. However, this test was not considered conclusive and was used in conjunction with the Mann-Whitney U-test and the t test to screen PCOCs in the Background Comparison Screen.

Statistical testing versus background was performed for all PCOCs with maximum concentrations above PRGs (Tables 2.4 to 2.6). Comparative statistics were run, using the Excel^{tm} add-in program Analyze-it^{tm}, for the AOC and background data for each analyte and each medium (Appendix A). A box plot comparison was completed to visually compare each pair of populations. The nonparametric Mann-Whitney U test was used to test for differences between the medians of the two independent samples with an Alternative Hypothesis: Site > Background, p-value = 0.05. Detailed results are shown in Appendix Tables A-24 through A-76. Results of the analysis are summarized in Table 2.14, and discussed below.

Liner Material: Non-parametric tests were completed for chromium, americium-241, uranium-235, and uranium-238 in liner materials. In addition, a comparison of lognormal confidence intervals was conducted for U-235. Chromium and uranium-238 were eliminated as PCOCs and americium-241 and uranium-235 were both retained as shown in Table 2.8. The geometric means and respective lognormal confidence intervals for uranium-235 SEP

(0.095 to 0.206) vs. background (0.048 to 0.062) were shown to overlap. In addition, the site and background uranium-235 data were log-transformed and subjected to an independent sample t-test. The results indicated that the site uranium-235 mean was significant greater than background with a P=0.0004, alpha = 0.05. Uranium-235 was therefore retained as a PCOC due to highly significant results of P=0.0003 from the Mann-Whitney U-test and P=0.0004 from the t-test, coupled with the large degree of variability associated with the lognormal 95UCLs.

Surface Soil: All PCOCs from SEP surface soil was evaluated and found to have different distribution relative to background distributions (Section 2.3.5). Therefore, statistical comparisons to background were conducted using the non-parametric Mann-Whitney U-test. Aluminum, arsenic, and manganese were determined not to be greater than background at the 0.05 level of significance (Table 2.14). Aluminum, arsenic, and manganese were therefore eliminated from further consideration as PCOCs.

Subsurface Soils:

Chromium, iron, and manganese were determined to not be greater than background using the Mann-Whitney U-test (Table 2.14) and will be not be considered further. Aluminum, arsenic, and barium exhibited lognormal distributions for both SEP subsurface soil and background data. The non-parametric Mann-Whitney test indicates that aluminum and barium are not greater than background at the 95% confidence level. The lognormal 90 % confidence intervals for SEP subsurface soil and background data for these three analytes are as follows:

PCOC	SEP Soils	Background Soils
Aluminum	11619 to 14010	11484 to 14708
Arsenic	4.38 to 5.86	3.56 to 4.50
Barium	102 to 138	85.2 to 107

Table 2.14 Summary of Statistical Comparison of Sep and Background Data

Analyte	AOC (n)	BKG (n)	Mann-Whitney One tailed p-value	AOC>BKG @ 0.05 Level?
Liner[1]				
Chromium	15	20	0.1118	No
Americium-241	**15**	**50**	**0.001**	**Yes**
Uranium-235	**15**	**20**	**0.0003**	**Yes**
Uranium-238	15	20	0.0966	No
Surface Soil				
Aluminum	73	20	0.541	No
Arsenic	72	20	1.000	No
Cadmium	**73**	**20**	**0.0009**	**Yes**
Chromium	**73**	**20**	**0.0017**	**Yes**
Manganese	73	20	0.9932	No
Americium-241	**69**	**50**	**<0.0001**	**Yes**
Plutonium-239/240	**60**	**50**	**<0.0001**	**Yes**
Uranium-234	**71**	**60**	**0.0002**	**Yes**
Uranium-235	**71**	**20**	**0.0028**	**Yes**
Uranium-238	**72**	**20**	**0.0014**	**Yes**
Subsurface Soil				
Aluminum	102	98	0.1594	No
Arsenic	**103**	**99**	**0.0003**	**Yes**
Barium	102	99	0.0677	No
Cadmium	**97**	**81**	**0.0284**	**Yes**
Chromium	102	99	0.5645	No
Iron	102	99	0.9470	No
Manganese	102	99	0.6043	No
Americium-241	**95**	**28**	**<0.0001**	**Yes**
Plutonium-239/240	**98**	**99**	**<0.0001**	**Yes**
Uranium-234	**118**	**99**	**<0.0001**	**Yes**
Uranium-235	**99**	**99**	**<0.0001**	**Yes**
Uranium-238	**118**	**99**	**<0.0001**	**Yes**

1. Liner material was compared to surface soil background levels.

All 90% confidence intervals overlapped and support the decision to eliminate aluminum, arsenic, and barium as PCOCs. T-tests were also conducted for these three analytes using the log-transformed data. Results indicate that aluminum (P=0.199) and barium (P= 0.073) are not greater than background at the 95 % confidence level. However, arsenic was

significantly higher than background, with P=0.0012. Arsenic was retained as a PCOC, and will be discussed in Section 2.8, Professional Judgement.

Cadmium and all radionuclides were also retained based on significant results greater than background using the non-parametric Mann-Whitney U-test. All other PCOCs were eliminated as PCOCs.

2.3.6 Application of Professional Judgement

The maximum concentrations for dibenz(a,h)anthracene and benzo(a)pyrene in surface soil are above the PRG screening levels for the WRW (Table 2.3). Table A-2 shows that there were 0 unqualified detections, 9 "J" qualified detections (estimated values), and 57 "U" qualified nondetections for dibenz(a,h)anthracene. Benzo(a)pyrene had 5 unqualified detections, 32 "J" results below the detection limit, and 30 nondetections. Figure 2.7 shows the box plots for these compounds. These compounds are members of the group of ubiquitous polyaromatic hydrocarbons (PAHs) that occur due to combustion, in engine exhaust and asphalt. There is no information suggesting that either compound was released due to activities at the SEP site.

The WRW PRG at 1E-06 for dibenz(a,h)anthracene is 0.348 mg/kg. The detection limit ranged from 0.330 to 0.740 mg/kg, with a mean of 0.413 mg/kg. The nine J-qualified (estimated) values were below the detection limit and ranged from 0.038 to 0.21 mg/kg. The estimated values are all well below the PRG.

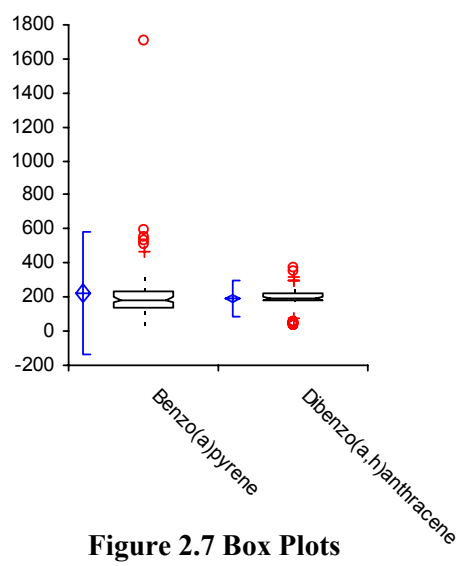

Figure 2.7 Box Plots

The WRW PRG at 1E-06 for benzo(a)pyrene is 0.348 mg/kg. The detection limit ranged from 0.330 to 0.740 mg/kg, with a mean of 0.411 mg/kg. The four detections ranged from 0.47 to 1.7 mg/kg. The 95UCL for benzo(a)pyrene, calculated using the bootstrap methodology discussed in Section 3.0, is 0.290 mg/kg, well below the PRG.

There is no pattern of contamination that suggests

these compounds are a result of a waste release; therefore, dibenz(a,h)anthracene and benzo(a)pyrene are not considered COCs.

Arsenic was determined to be significantly (0.05 level) greater than background in the 0.5-to-6-foot layer of subsurface soil by the nonparametric Mann-Whitney test and by an independent t-test on the log transformed data. A comparison of the 90% confidence limits indicated the populations overlap. Figure A-55 shows that the AOC results are all well below the maximum background result. The range for surficial soils of the western United States is 0.1 to 97 mg/kg with a geometric mean of 5.5 mg/kg and an arithmetic mean of 7 mg/kg (Shacklette and Boerngen 1984). The arithmetic means for subsurface soil in the SEP AOC and the background are 4.7 mg/kg and 3.6 mg/kg, respectively. Both are below the geometric and arithmetic means for the western US. The arithmetic 95UCLs are 5.3 mg/kg for the AOC and 4.9 mg/kg for background. The lognormal 95UCLs are 5.9 mg/kg for the AOC and 4.5 mg/kg for background. Arsenic concentrations in the surface soil and the liner materials were below background levels. The arsenic concentrations in the subsurface soil are considered to be well within the natural variation in soils and arsenic will not be carried on as a COC.

2.3.7 Data not Included in the COC Selection Process and Chemicals not in ALF or Without EPA Toxicity Values

Three data types included in the master data set were not used in the COC selection process as follows.

- Subsurface soil data with beginning depths greater than 6 feet (Tables A-9 to A-11, A-14, and A18);
- Subsurface soil data with null depth fields (Tables A-12, A-16, and A-20); and
- Data for all media that had irregular units (Tables A-21 to A-23).

The summary statistics table for data from greater than 6 feet (Table A-15) shows that the maximum values for the PCOCs aluminum, arsenic, iron, and manganese were higher than for the data from less than 6 feet. It is likely that this is due to geologic and soil weathering processes because the increases include the major soil constituents aluminum, iron, and, manganese. The maximum for arsenic increases from 15.5 mg/kg to 24.6 mg/kg. Both levels are much lower than the background maximum of 41.8 mg/kg. No organics in the greater-than-6-foot data had values greater than the PRG values.

The data with null depth fields were from only two locations (Figure 2.5) and included only organic analytes. No maximum values for this data exceeded the PRGs.

The third type of data excluded from the assessment was data with irregular units. Rather than make arbitrary changes to the units to what appear to be appropriate, it was decided to censor the data. The data do not indicate that any significantly high values are included (Tables A-21 to A-23).

Only compounds listed in ALF were assessed for the risk assessment, per agreement (DOE, EPA and CDPHE, 1996). All analytes listed in ALF (DOE, EPA, and CDPHE, 2000) had toxicity factors. Tables 2.15 through 2.17 list analyte with no PRGs in ALF.

Table 2.15. Solar Evaporation Ponds AOC Analytes in Liner Material With No PRG in ALF

Analyte	CAS Number	Mean	Min	Max	Total Samples	Detection Frequency
		mg/kg	mg/kg	mg/kg		%
Calcium	7440-70-2	1,832.80	832.00	2,660.00	15	100
Cesium	7440-46-2	2.06	0.43	7.70	15	80
Magnesium	7439-95-4	2,087.33	1,320.00	2,750.00	15	100
Potassium	7440-09-7	1,878.67	1,010.00	3,110.00	15	100
Sodium	7440-23-5	674.13	135.00	1,540.00	15	100
Thallium	7440-28-0	0.48	0.37	0.96	15	7
Titanium	7440-32-6	407.00	322.00	468.00	3	100
		pCi/g	pCi/g	pCi/g		
Cesium-134	13967-70-9	0.18	0.02	0.25	12	100
Cesium-137	10045-97-3	0.12	0.07	0.17	12	100
Plutonium-238	13981-16-3	0.01	0.01	0.02	6	100
Strontium-89	14158-27-1	0.26	0.00	0.50	12	100
Strontium-90	10098-97-2	0.01	-0.10	0.20	12	100

Table 2.16. Solar Evaporation Ponds AOC Analytes in Surface Soils With No PRG in ALF

ANALYTE NAME	CAS NO	Mean	Min	Max	Total Samples	Detection Frequency
		mg/kg	mg/kg	mg/kg		%
Calcium	7440-70-2	21691	109	248000	73	99
Cesium	7440-46-2	54.2	1.25	123.5	72	3
Magnesium	7439-95-4	2567	109	6500	73	99
Potassium	7440-09-7	2544	109	8310	73	99
Silicon	7440-21-3	3529	10.9	11300	61	98
Sodium	7440-23-5	525	46.7	3660	73	37
Thallium	7440-28-0	0.24	0.08	0.81	70	9
Titanium	7440-32-6	407	322	468	3	100
		µg/kg	µg/kg	µg/kg		
9-Octadecenoic Acid (Z)-	112-80-1	740	640	840	2	100
1,3-Dioxolane, 2,2-Dimethyl-	2916-31-6	320	320	320	1	100
1-Methyl Naphthalene	90-12-0	80	80	80	1	100
2,6-Di-Tert-Butyl-4-Methyl Phenol	128-37-0	205	190	220	2	100
3-Penten-2-One	625-33-2	6100	6100	6100	1	100
9,10-Anthraquinone	84-65-1	210	210	210	1	100
9-Hexadecenoic Acid	2091-29-4	2000	2000	2000	1	100
Benzo(Ghi)Perylene	191-24-2	190	38	680	67	45
Carbazole	86-74-8	204	140	410	7	29
Heptane, 2,5-Dimethyl-	2216-30-0	150	150	150	1	100
Hexatriacontane	630-06-8	650	650	650	2	50
N-Octacosane	630-02-4	2300	2300	2300	1	100
Nonacosane	630-03-5	1100	1100	1100	1	100
Octane, 4-Methyl-	2216-34-4	190	190	190	1	100
O-Fluorophenol	367-12-4	1200	1200	1200	1	100
Palmitic Acid	57-10-3	833	260	1500	10	80
Pentadecane	629-62-9	170	170	170	1	100
Pentatriacontane	630-07-9	1800	1800	1800	1	100
Phenanthrene	85-01-8	282	37	2700	67	66
Propanoic Acid, 2-Hydroxy-2-	594-61-6	1100	1100	1100	1	100
Tetratetracontane	7098-22-8	1667	1600	1700	3	67
		pCi/g	pCi/g	pCi/g		
Cesium-134	13967-70-9	0.02	-0.239	0.15	55	18
Cesium-137	10045-97-3	0.15	-0.0323	0.79	67	40
Radium-226	13982-63-3	1.14	0.32	10.76	47	94
Radium-228	15262-20-1	1.77	0.49	16	51	94
Strontium-89,90	11-10-9	0.36	-0.16	1.5	63	63

Table 2.17 Solar Evaporation Ponds Subsurface Analytes With No PRG in ALF

Analyte Name	CAS NO	Mean	Min	Max	Total Samples	Detection Frequency (%)
		mg/kg	mg/kg	mg/kg		%
Calcium	7440-70-2	38,220	706	32,5000	102	100
Magnesium	7439-95-4	2,587	703	6,460	102	100
Potassium	7440-09-7	2,711	66	21,100	103	92
Silicon	7440-21-3	2,608	360	14,000	55	98
Sodium	7440-23-5	1,466	100.5	10,200	102	61
Sulfide	18496-25-8	5.5	1	18.6	61	8
Thallium	7440-28-0	0.28	0.024	1.25	98	4
Titanium	7440-32-6	258	118	464	7	100
		ug/kg	ug/kg	ug/kg		
1,2,3-Trimethylbenzene	526-73-8	700	700	700	1	100
1-Octanol	111-87-5	600	600	600	1	100
2-Pentanone, 4-Hydroxy-4-Methyl	123-42-2	77,143	10,000	100,000	7	86
Ethyl Acetate	141-78-6	1,000	1,000	1,000	1	100
Lauric Diathanolamide	120-40-1	5,125	1,000	8,000	8	100
Myristic Acid	544-63-8	900	900	900	1	100
N-Dodecane	112-40-3	1,260	300	2,000	5	80
N-Hexadecane	544-76-3	700	400	1,000	2	100
N-Tetradecane	629-59-4	2,750	2,000	3,000	4	75
N-Undecane	1120-21-4	1,667	1,000	2,000	3	100
Octametylcylotetrasiloxane	556-67-2	1,567	400	2,000	6	83
Palmitic Acid	57-10-3	290	290	290	1	100
Pentadecane	629-62-9	1,350	300	2000	6	83
Phenanthrene	85-01-8	211	25	395	27	11
Sec-Octylbromide	557-35-7	2,000	2,000	2000	1	100
Tridecane	629-50-5	4,000	4,000	4000	1	100
Undecane, 2,6-Dimethyl-	17301-23-4	1,000	1,000	1000	1	100
		pCi/g	pCi/g	pCi/g		
Cesium-134	13967-70-9	0.04	-0.04	0.15	61	34
Cesium-137	10045-97-3	0.03	-0.018	0.42	82	11
Radium-226	13982-63-3	1.57	0.48	9.28	73	96
Radium-228	15262-20-1	1.53	0.6438	3.9	77	95
Strontium-89,90	11-10-9	0.18	-0.6	0.74	88	69
Strontium-90	10098-97-2	0.14	-0.5	2.6	11	9
Tritium	10028-17-8	0.81	0.58	3	18	72

2.3.8 Contaminants of Concern

Final COCs were selected for the SEP based on all previously discussed data evaluation and screening processes. The final COCs were evaluated in the quantitative risk assessment to determine the potential impacts to receptors in each exposure scenario. Results of the COC screening for organics, metals, and radionuclides are summarized in Tables 2.18 through 2.20.

Surface Soil
Table 2. 18 summarizes COCs selected for surface soil. Selected COCs are, cadmium, chromium, americium-241, plutonium-239/240, uranium-234, uranium-235, and uranium-238.

Liner Materials
Table 2.19 summarizes COCs in liner material. All metals were eliminated as COCs. The selected COCs are americium-241, and uranium-235. The COCs had lower concentrations than the surface and subsurface soils.

Subsurface Soils
Table 2.11 summarizes COCs selected for subsurface soils. Selected COCs were cadmium, americium-241, plutonium-239/240, uranium-234, uranium-235, and uranium-238.

Table 2.18 COC for Surface Soil

ANALYTE	CAS NO	Total Samples	Detection Frequency (%)
Cadmium	7440-43-9	73	59
Chromium	7440-47-3	73	97
Americium-241	14596-10-2	69	100
Plutonium-239/240	10-12-8	60	100
Uranium-234	11-08-5	71	100
Uranium-235	15117-96-1	71	76
Uranium-238	7440-61-1	72	100

Note:

1. Calculated using bootstrap resampling methodology.

Table 2.19. COC Liner Material

ANALYTE	CAS NO	Total Samples	Detection Frequency (%)
Americium-241	14596-10-2	15	60
Uranium-235	15117-96-1	15	67

Note:

1. Calculated using bootstrap resampling methodology.

Table 2.20. COC for Subsurface Soil

ANALYTE	CAS NO	Total Samples	Detection Frequency (%)
Cadmium	7440-43-9	97	30
Americium-241	14596-10-2	95	86
Plutonium-239/240	10-12-8	98	83
Uranium-234	11-08-5	236	50
Uranium-235	15117-96-1	99	72
Uranium-238	7440-61-1	118	97

Note: 1. Calculated using bootstrap resampling methodology.

3.0 EXPOSURE ASSESSMENT

This section discusses the exposure scenarios evaluated in the HHRA; presents exposure point concentrations, calculated for each COC in each exposure medium and exposure area; and describes the methodology and exposure parameters used to quantify contaminant intake for each exposure pathway.

3.1 FUTURE ON-SITE LAND USE

Future on-site land use at RFETS includes environmental restoration, decontamination and decommissioning, and transfer of jurisdiction to the U.S. Fish and Wildlife Service for use as a wildlife refuge, in accordance with the Rocky Flats National Wildlife Refuge Act of 2001. The federal government will be responsible for conducting future environmental monitoring activities at the site. The refuge is currently envisioned to have minimal maintenance following remediation, but; however, refuge workers are assumed to be present on-site for most of the year and engaged in refuge maintenance and ecological work activities. Ecological surveys performed in compliance with the Threatened and Endangered Species Act indicate the presence of habitat that is potentially suitable for protected plant and animal species, such as the Preble's Meadow Jumping Mouse. Residential development is not considered a foreseeable future land use scenario and was not included in the risk assessment.

3.2 EXPOSURE PATHWAYS AND RECEPTORS

A complete exposure pathway requires a chemical source, chemical release mechanism, environmental transport medium, exposure point, and human intake route. If one of these elements is lacking, the pathway is incomplete and no human exposures can occur. Exposure to groundwater is an example of an incomplete pathway for the WRW. Incomplete pathways were not evaluated in the HHRA. Exposure pathways selected for quantitative evaluation in the HHRA are listed below.

Future On-Site WRW

This WRW is primarily exposed to incidental ingestion of surface water, soil, and sediments; inhalation of volatiles and particulates; and external exposure to beta and gamma radiations from radionuclides present in surface soil. The worker is also exposed to subsurface materials during limited digging activities and dermal contact with surface and subsurface soil.

The scenario assumes that the WRW will be located in an office on an uncontaminated site 50 percent of each day during a standard work week of 5 days per week. The remaining time will be spent outdoors across the Site with an emphasis near the watershed areas. It is assumed that this receptor will be exposed to residual contaminants in the IA as well as all other on-site locations following remediation. The WRW will conduct some percentage of fieldwork that will result in exposure to residual contaminated surface soil, subsurface soil, sediments, and surface water. Figure 3-1 shows the site conceptual model of potential human exposure pathways for the WRW. The site conceptual model is a schematic representation of the chemical sources, chemical release mechanisms, environmental transport media, human intake routes, and human receptors for the SEPs. The site conceptual model is used to identify the complete exposure pathways for quantitative risk assessment and to identify pathways that are incomplete or do not warrant quantitative assessment because they would not contribute measurably to the estimate of overall risk. Significant complete exposure pathways identified that apply to the SEP AOC are[2]:

- Inhalation of airborne surface soil particulates
- Incidental ingestion of surface soils
- Incidental ingestion of subsurface soils
- Dermal exposure to surface soils
- External radiation exposure

Insignificant Pathways

The following exposure pathways are incomplete for the SEP AOC, and were not quantitatively addressed in this risk assessment:

- Ingestion of fish in RFETS surface waters is an incomplete exposure pathway; there are no surface waters at SEPs, and because fishing is prohibited;
- Ingestion of livestock is an incomplete pathway; beef ingestion will not occur under the wildlife refuge land use;
- Groundwater direct exposure pathways are incomplete; the shallow groundwater is not sufficiently productive for domestic well production;
- Inhalation of VOCs released to outdoor air through volatilization from soil is an incomplete pathway; no VOCs were included as COCs;

[2] Incidental ingestion of surface water and incidental ingestion of sediments are not complete pathways in the SEP AOC, but are in other areas of RFETS.

- Ingestion of homegrown produce is an incomplete pathway; gardening will not occur under wildlife refuge land use; and
- Dermal contact with surface water and sediments are considered complete for other areas of RFETS, but are not significant in the SEP AOC.

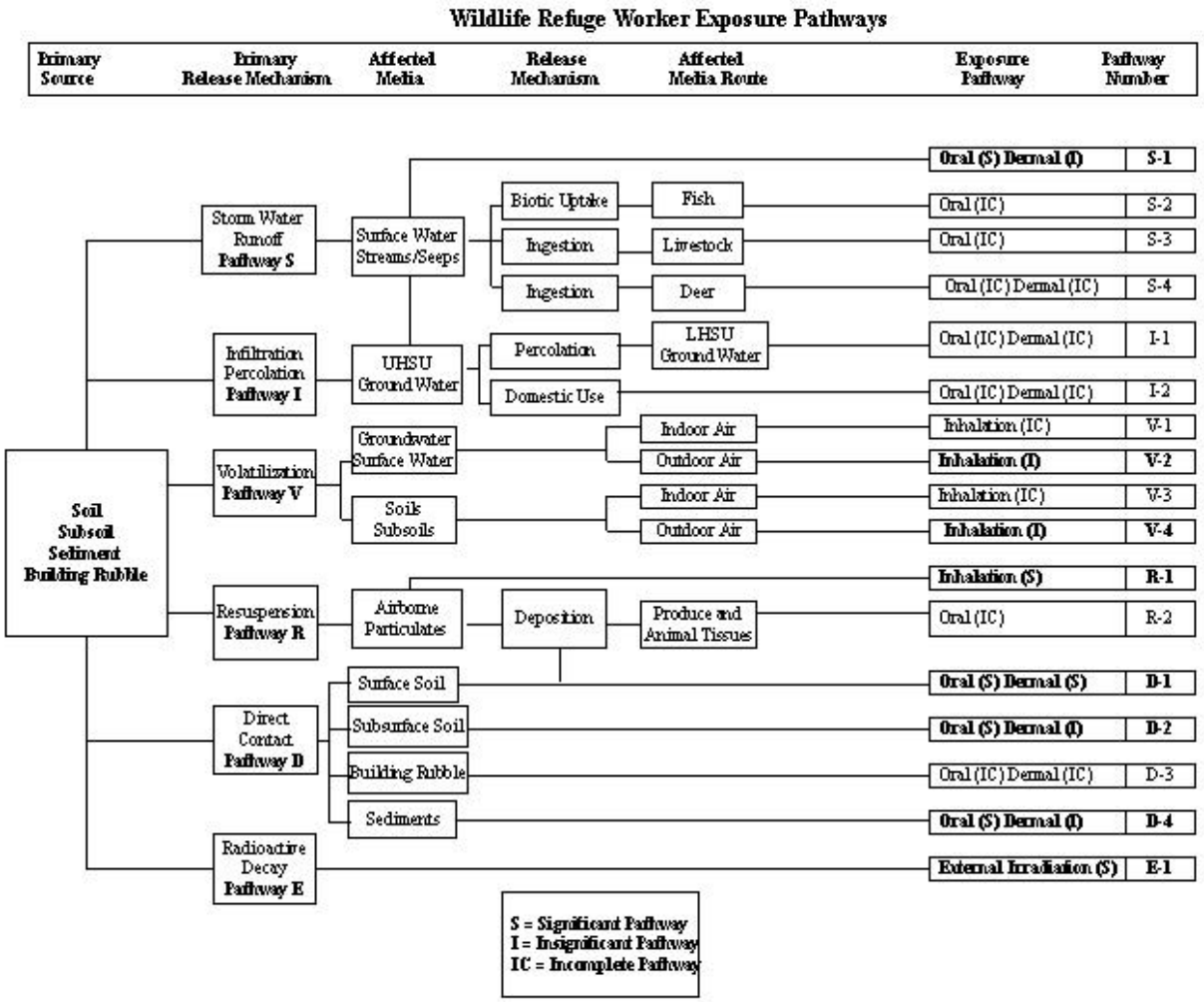

Figure 3.1 WRW Site Conceptual Model

3.3 EXPOSURE SCENARIOS

The WRW exposure scenario was used in this risk assessment based on identification of likely long-term on-site land use, potential receptors, and the site conceptual model. The site conceptual model (Figure 3.1) includes surface exposure via inhalation, ingestion, dermal contact, and external radiation exposure, and exposure to ingestion of potentially contaminated surface water resulting from sediment transport and groundwater transport. Off-site receptors were not evaluated in this HHRA, but will be addressed in the Site CRA that will evaluate potential cumulative impacts to offsite receptors from all sources at RFETS. Specific scenario parameters used in this HHRA are listed in Tables 3.1 and 3.2. Exposure parameters and assumptions are similar to RSALS Task 3 with the exceptions discussed below.

The WRW scenario has no indoor component. This is consistent with statements by DOE and the U.S Fish and Wildlife Service that no office buildings will be built in contaminated areas. It is assumed that workers will spend 50 percent of their work time (4 hours per day) outdoors on the Site. The other 50 percent of their work time will be spent in an office in an uncontaminated area. Select WRW exposure variables are described as follows:

- It has been agreed with the regulatory agencies to use an area use factor (AUF) of 1 for the main risk assessment. Alternative risk estimates will be presented in Section 5.4 on uncertainties influencing the risk estimates. The risk managers can use this discussion in the decision-making process.

Table 3.1. Surface Soil Exposure Factors for the Wildlife Refuge Worker

Exposure Variable	Acronym	Units	Point Estimate	Sources
Body Weight	BW	kg	70	EPA default
Exposure time	ET	hr/day	4	RSALS Task
Exposure time fraction, outdoors	ETo	unitless	1	No Building
Area Use Factor	AUF	unitless	1	AOC area/EU area
Exposure frequency	EF	day/yr	230	EPA default: 250 d/yr - 20 d/yr for subsurface exp.
Exposure duration	ED	yr	18.7	RSALS Task 3
Events per day	EV	er/d	1	Unit correction
Carcinogenic Averaging Time	ATc	days	25550	70 yr. x 365 days/yr
Noncarcinogenic Averaging Time	ATn	days	6826	18.7 yr. x 365 days/yr
Hourly inhalation rate	IR_h	m3/hr	1.3	RSALS Task 3
Mass loading	ML	kg/m3	2.12E-08	50th percentile of RSALS distibution
Site-specific PEF based on ML	PEF	m3/kg	47169811	1/ML
Soil ingestion rate	IR_s	mg/day	100	EPA default
Dermal Adherance Factor	AF_d	mg/cm2	0.1	EPA, 2001
Surface Area of Exposed Skin - Soil	SA_s	cm2	4260	EPA, 1997
Area Weighting Factor-Pond liners	AWFpl	unitless	0.2	SEP area/AOC area
Area Weighting Factor-Soils	AWFs	unitless	0.8	Surface soil area/AOC area
Gamma exposure factor (annual)	EF/365	unitless	0.63	EF/365
Gamma exposure factor (daily)	ET/24	unitless	0.17	ET/24 per Rags Part B (EPA, 1991)
Gamma shielding factor	(1 - Se)	unitless	1	EPA, 1991, set to 1

Table 3.2. Subsurface Soil Exposure Factors for the Wildlife Refuge Worker

Wildlife Refuge Worker Exposure Variable	Acronym	Units	Point Estimate	Sources
Body Weight	BW	kg	70	EPA default
Exposure time outdoors	ET	hr/day	4	RSALS Task 3
Area Use Factor	AUF	unitless	1	AOC area/EU area
Exposure frequency	EF	day/yr	20	WLRWs in RMA survey, 1990.
Exposure duration	ED	yr	18.7	RSALS Task 3
Events per day	EV	er/d	1	Unit correction
Carcinogenic Averaging Time	ATc	days	25550	70 yr. x 365 days/yr
Noncarcinogenic Averaging Time	ATn	days	6826	18.7 yr. x 365 days/yr
Hourly inhalation rate	IR_h	m3/hr	1.3	RSALS Task 3
Mass loading	ML	kg/m3	2.12E-08	50th percentile of RSALS distibution
Site-specific PEF based on ML	PEF	m3/kg	47169811	1/ML
Soil ingestion rate	IR_s	mg/day	100	EPA default
Dermal Adherance Factor	AF_d	mg/cm2	0.1	EPA, 2001
Surface Area of Exposed Skin - Soil	SA_s	cm2	4260	EPA, 1997
Gamma exposure factor (annual)	EF/365	unitless	0.05	EF/365
Gamma exposure factor (daily)	ET/24	unitless	0.17	ET/24 per Rags Part B (EPA, 1991)
Gamma shielding factor	(1 - Se)	unitless	1	EPA, 1991

The AUF is the ratio of the AOC area to the minimum anticipated area of the WRW EU for the CRA. WRWs are expected to spend 100 percent of their time in an area equal to the EU area. If the AOC has an area less than the EU, equal to B, then workers will spend a portion of their time in the AOC, which will be equal to B/EU. The AUF is used to normalize exposure based on area.

In discussions with the regulatory agencies, it was agreed that the smallest EU size to be used in the CRA would be 133 acres, based on data from a survey conducted for the

Rocky Mountain Arsenal (Appendix B, Table B-1). This is a conservative estimate of the EU area. Other estimates from the survey data are approximately 450 acres and the area used for the RSALS was 300 acres. The area for the AOC is 33.3 acres. Therefore, the AUF equals 33.3/133 or 0.25, representing the approximate portion of the WRW's outdoor worktime that would be spent in the AOC. That this factor significantly affects the risk estimates. Risk calculations using this AUF are presented in the uncertainty section (Section 5.4).

- A central tendency mass loading (ML) value was used to estimate risk via inhalation over the 18.7-year exposure period. The RSALS Task 3 calculations used an upper 95th percentile value. This is appropriate for conservative action levels or PRGs. Risk assessments are forward-looking, long-term evaluations of risk and are based on a mixture of high-end and central tendency factors. The site average annual ML from CDPHE monitoring data is 11.8 micrograms per cubic meter ($\mu g/m^3$). The 95th percentile value for the distribution developed for the RSALS Task 3 is 67 $\mu g/m^3$. This value is extremely high for use in a long-term exposure assessment. Therefore, the 50th percentile value, 21.2 $\mu g/m^3$, from the same distribution was chosen for this risk assessment. Alternative risk estimates will be presented in the uncertainty section, including all three ML estimates for use by the risk managers.
- The same ML factor was used for subsurface exposures due to small excavations such as posthole digging or tail improvement. This is a reasonable estimate, considering the expected level of activities. A specific factor will be developed for the CRA through the consultative process with the regulatory agencies.
- An area weighting factor (AWF) was used for the calculation of exposures to the pond liners and surface soil in the AOC. The AWF is based on the surficial area of the AOC covered by the liners and surface soil. WRWs will be exposed to the entire surface area of the AOC. Their exposure to the liners and surface soil will be proportional to the area covered by each. Use of the AWF allows the apportionment of risk between the soil and liners. This information will be helpful to the risk managers in making informed decisions. If the AWF is not used it must be assumed that the WRWs will spend 100 percent of their time on the soil and 100 percent on the liners, which is not possible. The area of the AOC is 33.3 acres, and the areas of the surface soil and liners are 27.2 and 6.1 acres respectively (Appendix B, Table B-2). The AWF for surface soil is 27.2/33.3 = 0.817, and the AWF for the liner is 6.1/33.3 = 0.183. These values were rounded to 0.8 and 0.2, respectively, for the risk assessment (Table 3.1).
- The value for the daily gamma-exposure time factor, often abbreviated as Te_d, was calculated as exposure time (ET)/24 based on EPA guidance (EPA 1991). In revisions to Chapter 4 of Risk Assessment Guidance for Superfund (RAGS) Part B (EPA 1993), it is stated that, "The default value for workers discussed in Section 4.4.2 and used in Equation (13) under commercial/industrial soil exposure scenario, has been changed from 1 to 0.3. Te is the ratio of the number of hours an individual is exposed to an external gamma radiation source per day to the total hours in a day, 24. This is the result of the external slope factors being calculated for a 24- hour per day residential exposure. For workers, the exposure time is assumed to be 8 hours each day, resulting in a Te value of

8/24 = 0.3." The value for the WRW is ET/24 = 4/24 = 0.17. This factor has been used in the risk calculations for the WRW.

- The gamma-shielding factor was set to 1 for calculation of external radiation risks to the WRW. Federal Guidance Report No. 12 (EPA 1993) recommends the use of a shielding factor for outdoor exposures. The effect of the use of a shielding factor is shown and discussed in the uncertainty section (Section 5.4).
- Based on EPA 2001 guidance, a weighted soil dermal adherence factor (AF_d) of 0.1 was used. This was based on the upper 95% value for a groundskeeper and a geometric mean for a commercial gardener.

3.4 EXPOSURE POINT CONCENTRATIONS

The exposure point concentration of a COC in a sampled medium is usually the 95UCL on the arithmetic mean, assuming normality. The arithmetic mean is a statistically robust estimator, even when normality assumptions are not met (Gilbert 1987). The 95UCL on the mean is a conservative estimate of the average concentration to which people would be exposed over time in the exposure area. If the maximum detected COC value is below the 95UCL, the maximum concentration is usually used as the exposure point concentration. When data distributions are demonstrated to be lognormal, a geometric mean and 95UCL are calculated using log-transformed data. When distributions are found to be neither normal nor lognormal, lognormality is often assumed and the data transformed to calculate the exposure concentration. Problems arise with this procedure when data are not lognormally distributed. In addition, contaminant concentrations in soil at contaminated sites can often appear to be lognormally distributed due to non-detections and outliers or the data may be from more than one population (EPA 1997, State of Alaska 2001).

Guidance and literature for calculating exposure point concentrations have been reviewed. A methodology has been adopted for this HHRA to determine 95UCLs using a nonparametric probabilistic resampling methodology when data are not normally or lognormally distributed. The bootstrap method has been used to calculate the concentration term for estimating risk as presented in EPA guidance, Calculating Exposure Point Concentrations at Hazardous Waste Sites (EPA 2002a). This method was chosen because some SEP data have unknown distributions and lognormal distributions for radionuclides have inherent technical difficulties due to zero and negative concentrations and large variances.

The commercially available statistics program S-Plus^{tm} was used for the bootstrap calculations. The technique avoids difficulties associated with empirically determining the shape of the observed distribution because it has no distributional assumptions. Resampling

techniques provide estimates of the mean and variance for any distribution regardless of the specific shape. The method is discussed in detail in Appendix D of EPA's Process for Conducting Probabilistic Risk Assessment (1999). It has been shown that bootstrap methods "…perform substantially better, sometimes orders of magnitude better, in estimating the 95UCL of the mean from positively skewed datasets…" than other methods (EPA, 1999). Estimates derived for this risk assessment were developed using 1,000 resampling events.

Distributions for all PCOCs were discussed previously in Section 2.3.5. Most liner and surface soil PCOCs had non-parametric distributions. However, most non-radiological subsurface soil distributions were lognormal. All PCOCs were compared to background by using the appropriate test based on evaluation of both SEP and background distributions. Following the background comparison and professional judgement screens, final COCs were selected to quantify risk to the WRW. Some COCs had lognormal distributions and UCLs were calculated based on standard lognormal statistical methods (Gilbert 1987; EPA 2002). Arsenic in surface soil was the only COC with an observed distribution assigned as normal. Lognormality was assumed for all final COCs in liner material based on direction from EPA, Region 9 and CDPHE to assume lognormality for all data sets with less than 30 samples. This assumption also applies to the surface soil background data set that currently contains 20 observations. Statistical testing of final COC distributions showed that many are actually neither normal nor lognormal and non-parametric methods are appropriate (EPA 2002).

The exposure point concentrations for COCs in surface soils, liner materials, and subsurface soils are presented in Table 3.3. The exposure concentrations in surface soil were used to estimate health risks associated with soil ingestion, inhalation of particulates, external irradiation, and dermal contact by a WRW. Subsurface soil concentrations were used to estimate health risks as a result of digging activities.

Americium-241 and uranium-235 are final COCs present in liner materials (Table 3.3). A lognormal distribution was assumed for americum-241 due to a small sample size. Test results for americum-241 indicated a non-parametric distribution based on mixed positive results for normality and consistent negative results for lognormality. The resulting lognormal UCLf or americium 241 was 10,633 pCi/g, greatly exceeding the maximum detected concentration of 8.1 pCi/g by orders of magnitude. The extreme exceedance of the americum-241 UCL above the maximum detected concentration indicated that the assumption of lognormality is not valid. The sensitivity of the H Land statistic to assumptions of lognormality has been widely documented (Gilbert, 1987; EPA, 1997; EPA,

2002). The maximum concentration of 8.1 pCi/g was therefore used to calculate risk. The remaining COC in liner material was uranium-235, which did exhibit a lognormal distribution and the resulting UCL of 0.21 pCi/g was below the maximum detected concentration of 0.27 pCi/g, as expected. The lognormal UCL for uranium-235 was therefore used to quantify risk estimates.

Table 3.3. Exposure Point Concentrations for Solar Evaporation Ponds Human Health Risk Assessment[1].

Analyte	Maximum	Mean	95% UCL[2]	95% UCL
	Detect			
	mg/kg or	mg/kg or	mg/kg	pCi/g
	pCi/g	pCi/g		
Pond Liner Material				
Americium-241	8.19	0.16		10,633
Uranium-235	0.27	0.101	0.095	0.21
Surface Soil				
Cadmium	382	20.1	38.1	
Chromium	120	20.3	24.8	
Americum-241	130	9.11		14.7
Plutonium-239/240	56	4.19		6.1
Uranium-234	63.4	4.16	0.001	6.5
Uranium-235	2.3	0.19	0.13	0.29
Uranium-238	27	2.73	11.3	3.77
Subsurface Soil				
Cadmium	547	1.11	9.6	
Americum-241	6.1	0.487		0.69
Plutonium-239/240	19.78	0.639		1.20
Uranium-234	21	2.92	0.0006	3.65
Uranium-235	0.87	0.125	0.071	0.153
Uranium-238	11.46	1.36	0.99	2.14
(1) The 95% UCL was used as the exposure point concentration for all COCs, except for americium-241 in the pond liner for which the maximum was used.				
(2) The 95UCL concentrations for mineral uranium were calculated from the 95UCL for the isotopes.				

All COCs in surface soil had non-parametric distributions and therefore these UCLs were calculated using the non-parametric Bootstrap method as reported in Table 3.3.

Final COCs in subsurface soils included cadmium, americum-241, plutonium-239, uranium-238, uranium-235, and uranium-234 (Table 3.1). Cadmium and uranium-238 both exhibited lognormal distributions and log-transformed data was used to derive UCLs of 9.6 ppm and 2.1 pCi/g respectively. Both log UCLs were well below maximum detected concentrations and were used to calculate risk estimates. All other COCs in subsurface soils were radionuclides with non-parametric distributions. The Bootstrap method was used to derive UCL estimates for COCs with non-parametric distributions reported in Table 3.1.

3.5 INTAKE CALCULATIONS

Intake is a measure of exposure expressed as the mass of a substance in contact with the exchange boundary per unit body weight per unit time (EPA 1989a). Chemical intake is expressed in terms of milligram (mg) chemical ingested, inhaled, or dermally absorbed per kilogram of body weight per day (mg/kg-day). Intake of radionuclides is expressed in units of picocuries (pCi) total intake to the receptor. Intakes are estimated following EPA RAGS (1989) and are based on reasonable estimates of body weight, inhalation volume, ingestion rates, soil matrix effects, frequency and duration of exposure, and estimated contaminant concentrations. Exposure factors are presented in Tables 3.1 and 3.2 for workers exposed to surface and subsurface soil, respectively.

The general equation for calculating chemical intake, in terms of mg/kg-day, is:

$$\text{Intake} = \frac{(\text{chemical concentration})(\text{contact rate})(\text{exposure frequency})(\text{exposure duration})}{(\text{body weight})(\text{averaging time})} \qquad \text{(Equation 3.1)}$$

With units of: $$\text{mg/kg-day} = \frac{(\text{mg/volume or mass})(\text{volume or mass/day})(\text{day/year})(\text{year})}{(\text{kg})(\text{day})}$$

Intake of radionuclides was calculated using equations similar to those for calculating intake of chemicals. Intake of radionuclides by either ingestion or inhalation is a function of radionuclide concentration, intake rate (or the amount of potentially contaminated medium contacted per unit time or event), and exposure frequency and duration. However, for radionuclides, averaging time and body weight are excluded from intake equations.

Table 3.4 presents the intake equations for each pathway evaluated in the risk assessment. The equations are based on standard EPA guidance. Tables 3.5 and 3.6 present the chemical intakes for all COCs, media, and exposure pathways.

Table 3.4 Intake equations for the WRW

Wildlife Refuge Worker Scenario[1]

Risk Equations - Radionuclides

Inhalation Risk = CSs x IR_h x ET x ETo x EF x ED x AWF x AUF x (1/PEF) x 1000 x SFi

Ingestion Risk = CSs x IR_s x EF x ED x AWF x AUF x 0.001 x SFo

External Radiation Risk = CSs x ED x EF/365 x ET/24 x AWF x AUF x SFe

Risk Equations - Inorganics and Organics

Inhalation Risk = [(CSs x IR_h x ET x ETo x EF x ED x AWF x AUF x (1/PEF))/(BW x ATc)] x SFinh

Ingestion Risk = [(CSs x IR_s x EF x ED x AWF x AUF x 0.000001)/(BW*ATc)] x SFo

Dermal Risk = [(CSs x EF x ED x AWF x AUF x EV x SA_s x AF_d x DAF x 0.000001)/(BW x ATc)] x SFo

Noncarcinogenic Hazard Quotient Equations - Inorganics and Organics

Inhalation HQ = (CSs x IR_h x ET x EF x ED x ETo x AWF x AUF x (1/PEF))/(BW x ATn x RfDi)

Ingestion HQ =(CSs x IR_s x ED x EF x AWF x AUF x 0.000001)/(BW x ATn x RfDo)

Dermal HQ = (CSs x EF x ED x AWF x AUF x EV x SA_s x AF_d x DAF x 0.000001)/(BW x ATn x RfDo)

CSs	Concentration in soil	mg/kg or pCi/g	
IR_h	Hourly inhalation rate	m3/hr	
IR_s	Soil ingestion rate	mg/day	
ET	Exposure time	hr/day	
EF	Exposure frequency	day/yr	
ED	Exposure duration	yr	
ETo	Exposure time fraction, outdoors	unitless	Set to 1
EV	Events per day	ev/d	Set to 1
AWF	Area Weighting Factor	unitless	
AUF	Area Use Factor	unitless	Set to 1
EF/365	Gamma exposure factor (annual)	unitless	
ET/24	Gamma exposure factor (daily)	unitless	
PEF	Site-specific PEF based on ML	m3/kg	
SA_s	Surface Area of Exposed Skin - Soil	cm^2	
AF_d	Dermal Adherance Factor	mg/cm^2-ev	
DAF	Dermal Absorption Fraction	unitless	
SFinh	Inhalation slope factor	(2)	
SFo	Oral slope factor	(2)	
SFe	External radiation slope factor	(2)	
BW	Body Weight	kg	
ATc	Carcinogenic Averaging Time	days	
ATn	Noncarcinogenic Averaging Time	days	
RfDi	Inhalation reference dose	(mg/kg-day)	
RfDo	Inhalation reference dose	(mg/kg-day)	
ACF	Area correction factor	unitless	
(1 - Se)	Gamma shielding factor	unitless	Set to 1

1. Based on the wildlife refuge worker scenario developed by the RSALS Working Group.

2. Slope factors for inorganic and organic COCs are in units of $(mg/kgday)^{-1}$.
Slope factors for radionuclides inhalation and ingestion exposures are in units of risk/pCi.
Slope factors for External Exposures are in units of risk/yr per pCi/g.

Table 3.5 Intakes for the Wildlife Refuge Worker from Surface Soil and Liner Material at the SEPs

COC	Carcinogenic Intakes from Surface Soil (mg/kg-day)				Total Intake[c]
	Inhalation	Ingestion	Dermal	External	
Cadmium	8.07E-09	a	a	NA	8.1E-09
Chromium	5.27E-09	a	a	NA	5.3E-09
	Non-Carcinogenic Intakes from Surface Soil (mg/kg-day)				
Cadmium	3.02E-08	2.74E-05	1.17E-04	NA	1.44E-04
Chromium	1.97E-08	1.79E-05	7.62E-05	NA	9.41E-05
Uranium-234	a	7.54E-10	3.21E-09	NA	3.97E-09
Uranium-235	a	9.62E-08	4.10E-07	NA	5.06E-07
Uranium-238	a	8.11E-06	3.46E-05	NA	4.27E-05
	Radiation Intakes from Surface Soil (pCl/g or yr-pCi/g)				
Americium-241	5.59E+00	5.07E+03	NA	2.32E+01	5.1E+03
Plutonium-239/240	2.30E+00	2.09E+03	NA	9.53E+00	2.1E+03
Uranium-234	2.48E+00	2.25E+03	NA	1.03E+01	2.3E+03
Uranium-235	1.09E-01	9.93E+01	NA	4.53E-01	9.9E+01
Uranium-238	1.43E+00	1.30E+03	NA	5.93E+00	1.3E+03
	Carcinogenic Intakes from Pond Liner (mg/kg-day)				
b	b	b	b	b	b
	Non-Carcinogenic Intakes from Pond Liner (mg/kg-day)				
Uranium-235	a	1.40E-08	1.39E-11	NA	1.40E-08
	Radiation Intakes from Pond Liner (pCl/g or yr-pCi/g)				
Americium-241	2.93E-01	2.66E+02	NA	1.21E+00	2.7E+02
Uranium-235	1.59E-02	1.44E+01	NA	6.58E-02	1.4E+01

Notes
a. No toxicity factor available for this exposure pathway.
b. No non-radionuclide carcinogenic COCs for the pond liner material.
c. External exposure is not included for theradionuclides.
NA. Not applicable

Table 3.6 Intakes for Wildlife Refuge Worker Exposure to Subsurface Soil and Liner Material at Solar Ponds

COC	Carcinogenic Intakes from Subsurface Soil (mg/kg-day)				Total Intake
	Inhalation	Ingestion	Dermal	External	
Cadmium	4.65E-10	a	a	NA	4.6E-10
	Non-Carcinogenic Intakes from Subsurface Soil (mg/kg-day)				
Cadmium	1.74E-09	1.58E-06	6.72E-06	NA	8.30E-06
Uranium-234	a	4.57E-11	1.95E-10	NA	2.41E-10
Uranium-235	a	5.55E-09	2.36E-08	NA	2.92E-08
Uranium-238	a	8.46E-08	3.60E-07	NA	4.45E-07
	Radiation Intakes from Subsurface Soil (pCi/g or yr-pCi/g)				
Americium-241	2.85E-02	2.59E+01	NA	1.18E-01	2.6E+01
Plutonium-239/240	4.96E-02	4.50E+01	NA	2.06E-01	4.5E+01
Uranium-234	1.50E-01	1.36E+02	NA	6.23E-01	1.4E+02
Uranium-235	6.32E-03	5.73E+00	NA	2.62E-02	5.8E+00

a. No toxicity factor available for this exposure pathway.
NA Not applicable

4.0 TOXICITY ASSESSMENT

This section describes toxicity factors that are combined with estimated intakes of COCs to estimate potential risk associated with exposure. Toxicity factors used in the HHRA are EPA-verified or provisional carcinogenic slope factors (SFs) and noncarcinogenic reference doses (RfDs) or air reference concentrations (RfCs) for COCs in the SEP. Toxicity factors are presented in Table 4.1. Toxicity factors for radionuclides are taken from Federal Guidance Report 13.

The principal indices of toxicity for chemicals with noncarcinogenic effects are the oral RfD and inhalation RfD. RfDs can be considered threshold doses or exposure levels. At chemical doses or exposures below threshold values, adverse effects are not expected to occur. RfDs incorporate a number of safety factors to ensure that they are health-protective for all human populations, including sensitive subgroups (for example, children and the elderly).

Oral and inhalation SFs are used to characterize the potency of carcinogens. A SF is a dose-response factor used to relate carcinogenic response to chemical dose. SFs are used to estimate the upper-bound probability of an individual developing cancer as a result of exposure to a potential carcinogen. EPA policy assumes that carcinogenic responses have no threshold, and that exposure to a carcinogen may result in some finite cancer risk at any dose, no matter how small (EPA 1989).

SFs for radionuclides are derived considering radionuclide emissions and their relative biological damage to exposed tissues, residence time of radionuclide in various body tissues, and duration of exposure. Radionuclide dose is calculated as a yearly intake followed by a 50-year dose commitment period. SFs for radionuclides are presented for external exposure, inhalation, and ingestion of radioactive materials.

EPA assumes that any dose of a radionuclide has the potential to produce carcinogenic effects in a linear, no threshold model. However, EPA does not recommend the evaluation of noncarcinogenic effects of radionuclides, with the exception of uranium, because these impacts have been shown to be insignificant compared to carcinogenic effects at most Superfund sites with potential radionuclide contamination (EPA 1989). EPA has developed both internal (inhalation and ingestion) and external SFs for the carcinogenic response to radionuclide exposure (EPA 1999).

The RfDs and SFs used in the HHRA were obtained from the following sources:

- EPA's Integrated Risk Information System (IRIS) online database (EPA 2002b);
- EPA's Health Effects Assessment Summary Tables and Supplements (HEAST) (EPA 1997); and
- EPA's National Center for Environmental Assessment (NCEA) for interim and provisional values.

4.1 DERMAL EXPOSURE TO CHEMICALS

EPA recommends using oral toxicity factors, adjusted if possible by a gastrointestinal absorption fraction, to evaluate toxic effects from dermal contact with potentially contaminated media (EPA 1989; 1992b, 2001a). The oral toxicity factor relates the toxic response to an administered intake dose of contaminant, which may be only partially absorbed by the body. Intake from dermal contact is estimated as an absorbed dose. Therefore, EPA (2001a) suggests adjusting some oral toxicity factors by contaminant-specific gastrointestinal absorption rates, if available, to yield toxicity factors for contaminants absorbed via the dermal pathway. When specific gastrointestinal absorption rates are not available, gastrointestinal absorption is assumed to be 100 percent and the unadjusted oral toxicity factor is used to assess the response to dermal absorption. Adjustments were made to the oral toxicity factors for cadmium and chromium RfDs for this risk assessment.

Table 4.1. Toxicity Factors

Analyte	CAS Number	DAF Fraction[1]	Oral RfD (mg/kg-day)		Dermal Adjusted RfD	Inhalation RfD (mg/kg-day)		Oral Slope Factor (mg/kg-day)$^{-1}$		Inhalation Slope Factor (mg/kg-day)$^{-1}$						External Slope Factor	
Cadmium	7440-43-9	0.001	1.00E-03	I	2.50E-05	5.70E-05	E	--		6.30E+00	I						
Chromium	7440-47-3	0.001	3.00E-03	I	7.50E-05	3.00E-05	I	--		4.10E+01	H						
			Oral RfD (mg/kg-day)					Oral/Ingestion Slope Factors (f)									
								(risk/pCi) Water Ingestion		Food Ingestion		Soil Ingestion		(risk/pCi)		(risk/yr/pCi/g)	
Am-241	14596-10-2							1.04E-10	E	1.34 E-10	E	9.1E-11	R	2.78E-08	E	2.76E-08	E
Pu-239	15117-48-3							1.35E-10	E	1.74E-10	E	1.21E-10	R	3.33E-08	E	2.00E-10	E
U-234	13966-29-5	0.001	3.00E-03	I				7.07E-11	E	9.55E-11	E	5.11E-11	R	1.14E-08	E	2.52E-10	E
U-235	15117-96-1	0.001	3.00E-03	I				6.96E-11	E	9.44E-11	E	4.92E-11	R	1.01E-08	E	5.18E-07	E
U-238	7440-61-1	0.001	3.00E-03	I				6.4E-11	E	8.66E-11	E	4.66E-11	R	9.35E-09	E	4.99E-11	E

Notes:

1. Values for dermal adsorption factor (DAF) are from EPA (2001). Values for chromium are default values based on the value

2. Assessed as chromium (VI).

I = IRIS

E = NCEA provisional value

H = HEAST

R = RSALS PPRG tables

References:

2001b, Integrated Risk Information System (IRIS), On-line database, Office of Research and Development, Cincinnati, OH, June.

1997, Health Effects Assessment Summary Tables (HEAST).

HEAST 2001b = U.S. Environmental Protection Agency. 2001. Health Effects Assessment Summary Tables, Radionuclide Table, EPA, Office of Radiation and Indoor Air (ORIA), April.

EPA, 2001a, Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Interim, EPA/540/R/99/005, OSWER 9285.7-02EP, PB99-963312, September.

5.0 RISK CHARACTERIZATION AND UNCERTAINTY ANALYSIS

Risk characterization is the final step of the risk assessment process. In this step, toxicity factors, noncarcinogenic RfDs and carcinogenic SFs for COCs are applied, in conjunction with estimated chemical intakes, to predict potential noncarcinogenic and carcinogenic health risks to exposed receptors. Spreadsheets with calculations are presented in Appendix C.

5.1 NONCARCINOGENIC HEALTH EFFECTS

The potential for noncarcinogenic effects is characterized by comparing estimated contaminant intakes (Section 3.5) with contaminant-specific RfDs (Table 4.1). The resulting ratio is the HQ. It is derived in the following manner:

$$\text{Noncarcinogenic HQ} = \frac{\text{Chemical Intake (mg/kg-day)}}{\text{RfD (mg/kg-day)}} \qquad \text{(Equation 5.1)}$$

The RfD concept assumes that there is a level of intake (the RfD) below which it is unlikely that even sensitive individuals will experience adverse health effects over a lifetime of exposure. If the average daily intake exceeds the RfD and the HQ is above 1.0, concern for potential noncarcinogenic effects may increase (EPA 1989). It should be noted, however, that the level of concern does not increase linearly as the RfD is approached or exceeded. This is because all RfDs are not assessed equally or based on the same severity of toxic effects. Because the HQ does not define a dose-response relationship, the numeric value is not a direct estimate of risk (EPA, 1989a), but rather an indicator that adverse health effects are more likely to occur as the HQ increases.

To assess exposure to multiple contaminants, HQs are summed to yield an HI for each pathway and receptor. The assumption of additive effects reflected in the HI is most properly applied to substances that induce the same effect by the same mechanism (EPA 1989). Consequently, summing HQs for substances that are not expected to induce the same type of effect will likely overestimate potential adverse health effects. The HI, therefore, provides a conservative measure of potential adverse health effects and is dependent on the quality of experimentally derived evidence.

HIs from all relevant pathways are summed to obtain the total HI for that receptor. If the total HI is less than or equal to 1, multiple-pathway exposures to COCs at the site are judged

unlikely to result in any adverse health effects. If the sum is greater than 1, further evaluation of exposure assumptions and toxicity, including consideration of specific target organs affected and mechanisms of toxic actions of COCs, is warranted to ascertain whether cumulative exposure would be likely to harm exposed receptors.

5.2 CARCINOGENIC RISK

Potential carcinogenic effects are characterized in terms of incremental probability of an individual developing cancer over a lifetime (70 years) as a result of exposure to a potential carcinogen. Known as the excess lifetime cancer risk, it is an estimate of the increased risk of developing cancer above the background rate for the general population. Excess lifetime cancer risk is estimated from the projected lifetime average daily intake and the cancer SF, which represents an estimate of the dose-response relationship. Excess lifetime cancer risk is calculated by multiplying the average daily chemical intake by the cancer SF as follows:

Cancer risk = (Average daily intake)(SF) (Equation 5.2)

Units: (mg/kg-day)(mg/kg-day)$^{-1}$ or (pCi)(Risk/pCi)

Carcinogenic risks estimated using SFs are upper-bound estimates. This means that the actual risk is likely less than the estimated risk (EPA 1989). RME cancer risks may be significantly overestimated because they are calculated by multiplying 95th percentile estimates of cancer potency, 95UCLs of concentrations, and high-end estimates of several exposure parameters.

The risks resulting from exposure to multiple carcinogens are assumed to be additive (EPA 1989). The total cancer risk is estimated by summing the risks estimated for each COC for each pathway. This is a highly conservative approach that results in an artificially elevated estimate of cancer risk, especially if several carcinogens are present, because 95th percentile estimates are not strictly additive (EPA 1989).

In accordance with EPA guidance (EPA 1989) radionuclide risks were calculated separately for each exposure pathway. Carcinogenic risks for each pathway due to radionuclides are presented in Appendix C. Chemical and radiological risks were summed by media to determine the overall potential human health hazard at the site, as shown in Tables 5.1 and 5.2.

EPA policy must be considered in order to interpret the significance of cancer risk estimates. The National Oil and Hazardous Substances Pollution Contingency Plan (EPA 1990) states that: "For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk of between 10^{-4} and 10^{-6}." When cumulative carcinogenic risk to an individual, based on RME exposure, does not exceed 10^{-4} and the total HI does not exceed 1, action is generally not warranted for protection of public health (EPA 1991).

5.3 SEP AOC

The receptor evaluated in the SEP AOC was a WRW. One scenario was assessed for the WRW receptor with the liner materials on the surface. Health risks and hazards were found to be low for the Solar Ponds AOC. The results are presented and discussed below.

5.3.1 Noncarcinogenic Hazard Index

The cumulative HI for noncarcinogenic health effects is 0.04 (Table 5.1). The surface soil dominates the results. No adverse non-cancer health effects are expected, even for sensitive individuals, because HIs are much less than 1.0 for all media and pathways. The HQs for each COC and pathway are shown in Table5.2.

5.3.2 Carcinogenic Risk

Excess lifetime cancer risk estimates for the WRW receptor are summarized in Table 5.3 by medium and in Table 5.4 by pathway and COC. No nonradiological carcinogenic COCs were present in liner materials and no estimate for risk is presented Table 5.3.

The total risk for RCRA constituents (cadmium and chromium) is 3E-07, well below the 1E-06 level of concern. The highest cancer risk estimate is for radionuclides in surface soil at 2E-06 (2 excess cancer cases per 1,000,000 exposed individuals). The risk levels are driven

Table 5.1. Hazard Indices for Wildlife Refuge Worker Receptors

Hazard Index Summary for the Solar Evaporation Ponds				
WRW Hazard Index by Medium and Exposure Pathway				Medium
Medium	Inhalation	Ingestion	Dermal	HI
Surface Soil	0.001	0.03	0.008	0.04
Liner Material	a	0.00002	0.00000000002	0.00002
Subsurface Soil	0.00001	0.001	0.0001	0.001
Total HI				0.04

a. No toxicity factor available.

Table 5.2 HQs and HIs by COC, Media, and Pathway

COC	Surface Soil			HI
	Inhalation	Ingestion	Dermal	
Cadmium	0.0005	0.03	0.005	0.03
Chromium	0.0007	0.006	0.001	0.007
Uranium-234	a	0.0000003	0.000000001	0.0000003
Uranium-235	a	0.00003	0.0000001	0.00003
Uranium-238	a	0.003	0.00001	0.003
HI	0.001	0.04	0.006	0.04
	Pond Liners			**HI**
Uranium-235	a	0.00002	0.00000000002	0.00002
	Suburface Soil			**HI**
Cadmium	0.00001	0.0008	0.0001	0.0009
Uranium-234	a	0.00000002	0.0000000001	0.00000002
Uranium-235	a	0.000002	0.00000000002	0.000002
Uranium-238	a	0.00003	0.0000000003	0.00003
HI	0.00001	0.0008	0.0001	0.0009

a. No toxicity factor available.

by the inhalation pathway for chromium VI for metal COCs and by the external radiation pathway for americium-241 and uranium-235 in the surface soil (see Appendix C).

The estimated excess lifetime risks for a WRW due to RCRA listed constituents are well below the 1E-06 level of concern. Approximately 80 percent of the nonradiological risk are due to chromium in the surface soil. Chromium was conservatively assessed as chromium VI, actual risks are likely to be lower due to the presence of chromium III.

Table 5.3. Summary of WRW Carcinogenic Risks for the Solar Ponds AOC

WRW Risk by Medium and Exposure Pathway				
Medium	**Nonradiological**			**Total Risk**
	Inhalation	**Ingestion**	**Dermal**	
Surface Soil	2.7E-07	a	a	2.7E-07
Liner	NA	NA	NA	NA
Subsurface Soil	1.4E-09	a	a	1.4E-09
Total Nonradiological Risk				3E-07
	Radiological			
	Inhalation	**Ingestion**	**External**	
Surface Soil	2.7E-07	8.9E-07	8.8E-07	2.0E-06
Liner on Surface	2.2E-08	6.5E-08	1.3E-07	2.2E-07
Subsurface Soil	5.0E-09	1.6E-08	1.8E-08	3.9E-08
Total Radiological Risk				2E-06

a. No toxicity factor available
NA. No nonradiological COCs present in liner materials.

The total radiological risk to the worker is 2E-06. Americium-241, plutonium-239/240, and uranium-235 are the major contributors to risk (see Table 5.4 and Appendix C). Americium dominates all pathways, plutonium is a significant contributor to the inhalation and ingestion pathways, and uranium-235 is significant for the external pathway.

5.4 UNCERTAINTIES AND LIMITATIONS

This section discusses major uncertainties and limitations of the HHRA and how the results and conclusions might be affected. Uncertainties and limitations are inherent in the risk assessment process. The level of certainty associated with the conclusions of the risk assessment are conditional upon the data quality, methods used to identify COCs, estimates of chemical concentrations, assumptions made in estimating exposure conditions, conservatism of methods used to develop exposure factors, and toxicity values used to characterize risk.

Table 5.4. Summary of WRW Carcinogenic Risks by COC, Media and Pathway

COC	Inhalation	Ingestion	Dermal	External	Total Risk By COC
	Pond Liner				
Americium-241	2.16E-08	6.41E-08	NA	8.88E-08	1.7E-07
Uranium-235	1.97E-10	8.72E-10	NA	4.19E-08	4.3E-08
Surface Soil					
Cadmium	5.09E-08	a	a	NA	5.1E-08
Chromium	2.16E-07	a	a	NA	2.2E-07
Americium-241	1.55E-07	4.60E-07	NA	6.37E-07	1.3E-06
Plutonium-239/240	7.65E-08	2.52E-07	NA	1.90E-09	3.3E-07
Uranium-234	2.83E-08	1.15E-07	NA	2.59E-09	1.5E-07
Uranium-235	1.11E-09	4.89E-09	NA	2.35E-07	2.4E-07
Uranium-238	1.34E-08	6.05E-08	NA	2.96E-10	7.4E-08
Subsurface Soil					
Cadmium	1.40E-09	a	a	NA	1.40E-09
Americium-241	7.94E-10	2.36E-09	NA	3.26E-09	6.4E-09
Plutonium-239/240	1.65E-09	5.45E-09	NA	4.11E-11	7.1E-09
Uranium-234	1.71E-09	6.97E-09	NA	1.57E-10	8.8E-09
Uranium-235	6.38E-11	2.82E-10	NA	1.35E-08	1.4E-08
Uranium-238	8.23E-10	3.72E-09	NA	1.82E-11	4.6E-09

a. No toxicity factor available
NA. Not applicable.

Conservative assumptions were made at all stages of this risk assessment to prevent underestimating potential health risk. Carcinogenic risks were estimated using upper-bound SFs and conservative exposure assumptions. Estimates of noncarcinogenic toxicity values (RfDs) are also very conservative and may result in an overestimate of noncarcinogenic health hazards. RME estimates of potential health risks associated with potential exposures at the SEP should be considered upper bounds. This means that actual risks are likely to be less than estimated risk (EPA 1989). Although point estimates of risk are made, it should be recognized that each estimate represents a range of possible risk and is only an indicator of the actual risk.

Uncertainties in the HHRA for the SEP lie chiefly in sampling limitations, the identification of COCs, estimation of exposure point concentrations, exposure assumptions and factors, and the assessment of chemical toxicity. Each of these is discussed below.

5.4.1 Sampling and Identification of COCs

Samples of surface soil, subsurface soil, and pond liner materials were collected in accordance with approved work plans, and most of the chemical analytical results were validated in accordance with EPA and RFETS data validation guidelines. Work plans were presented in the Final Phase I RFI/RI Work Plan for OU 4 (DOE 1992), and the chemical analytical database and data review are described in Appendix A. It can be seen from Figures 2.1 through 2.3 that sampling was performed in a nonsystematic, random fashion. There are areas that were more or less densely sampled than others. The overall quality of the data was determined to be sufficient for risk assessment purposes (Section 2.0).

The identification of COCs is dependent on the quality of the sampling, analysis, and database management. Data were retrieved from both the SWD and the Remedial Action Decision Management System (RADMS). The data are considered representative of the SEP AOC and retrieval is considered to be complete. The elimination of PCOCs and selection of COCs are documented in Section 2.0.

5.4.2 Exposure Point Concentrations and Exposure Factors

Concentration Term

The 95UCL of the mean concentration is used as a conservative estimate of exposure concentrations. The 95UCL is used rather than the arithmetic mean concentration to provide an additional level of conservatism and limit uncertainties involved in estimating the true mean from a relatively small data set. Small sample size, variability in sample results, inclusion of extreme values, and negative or zero values add to the uncertainty in estimating the mean. However, these uncertainties usually result in a high, rather than low, bias to the estimate.

Attachment I presents a detailed evaluation of data adequacy used to support and quantify risk calculations submitted for the Solar Ponds. The evaluation included determination of mean, variance, and 95UCLs estimates using Bootstrap resampling and geostatistical methods. A spatial analysis and evaluation of the Bootstrap technique were also provided. Comparison of upper 95UCLs from all statistical methods was included, and their impact on the reported risk results evaluated. The data adequacy evaluation focused on the radionuclides present in surface soils. The results are summarized below and discussed in relation to the methods used in the HHRA.

Distributional testing was conducted and reported in Section 2.3.6 of the risk assessment. A normal, lognormal, or non-parametric distribution was assign to each analyte in liner material, surface soil, and subsurface soil. Most liner material and surface soil analytes had non-parametric distributions, while subsurface analytes had lognormal distributions. Distributional testing was also conducted for individual surface soil COCs using the Shapiro-Wilk test on the data and Ln-transformed data. The Bootstrap approach was then used to estimate UCLs for distributions that were neither normal nor lognormal.

In addition, a Geostatistical Spatial Analysis was conducted for surface soil radionuclides that dominated risk. Results indicated good spatial correlation based on observed variograms. Evidence of a spatial pattern indicates that the use of classical statistical methods for characterizing the 95% UCLs should be avoided and geostatistics are appropriate to properly assess SEP contaminants and quantify UCLs to support risk calculations. The classical methodologies quantify uncertainty in the exposure concentration term without consideration of spatial variability present in data derived from environmental sampling (EPA 2001).

The Bootstrap method was used to calculate UCLs for the SEP Risk Assessment. Table 5.5 compares UCLs derived from the statistical methods evaluated. UCLs computed by Bootstrap and geostatistical methods were consistently higher than UCLs derived from normal t-statistic methods. These two methods therefore do not underestimate the UCL for the SEP surface soil data. Bootstrap and geostatistics are therefore unlikely to underestimate the true UCLs and risk.

Table 5.5 Comparison of 95% UCLs in Surface Soils by Statistical Method

COC	Normal	Lognormal	Geostatistics	Bootstrap
Cadmium	32.8	na	35.3	38.1
Chromium	23.8	na	25.1	24.8
Am-241	13.4	34.2	14.5	14.7
Pu-239	5.47	16.5	6.40	6.06
U-238	3.46	na	3.55	3.77
U-235	0.24	0.21	0.25	0.29
U-234	5.70	na	6.38	6.53

na = Not applicable, distribution not lognormal at the 0.05 level.

However, lognormal statistics using Land H produced UCLs for americium-241 and plutonium-239 that were more then twice all other UCL estimates and a UCL estimate for

uraniium-235 that was below the t-statistic estimate. Lognormal statistics therefore produced UCL estimates that were inconsistent and outside the range of the other estimates. EPA has discussed this problem in a Technical Document (EPA 1997). EPA concludes that lognormal statistics are likely to overestimate UCLs and risk. The current evaluation supports this conclusion.

Both statistical and spatial analyses indicate that sampling at the SEPs is adequate, especially in view of the low estimated risk. Geostatistics and Bootstrap methodologies are both technically sound; have no distributional assumptions; and adequately support risk quantification. Use of either Bootstrap or geostatistical methods do not underestimate true risk. The 95UCLs derived from lognormal statistics were inconsistent and greatly overestimated the 95UCLs when actual analyte distributions deviated from lognormality. For example, the lognormal 95UCL for Americum-241 in the liner (n=15) was 10,633 compared to a maximum of 8.1 pCi/g. Use of lognormal statistics increases risk by a factor of two and often results in the use of maximum values to quantify risk due to 95UCLs falling outside the range of observed concentrations. Geostatistical methodologies address environmental data with spatial correlation such as the data present at the SEPs.

Mass Loading and Air Exposure Concentrations

There is uncertainty associated with the ML factor used to estimate contaminant concentrations in air. A 50th percentile estimate developed by the RSALS Working Group was used (21.2 $\mu g/m^3$) in the risk assessment. This figure is approximately twice the documented site average (11.8 $\mu g/m^3$), but 30 percent of the 95th percentile figure used by the working group for the RSALS action levels (67 $\mu g/m^3$). The 95th percentile value is appropriate for action levels to be used for screening, but is too conservative for a forward-looking, long-term risk assessment. The effect of using multiple high-end factors in a risk assessment quickly leads to unrealistically high estimates of risk. EPA guidance (1989) recommends using a balance of high-end and central tendency estimates to avoid this problem. The effect of the three MLs on inhalation risk is shown in Table 5.6.

Table 5.6 Effect of Using Different Mass Loading Factors on Inhalation Risk

	ML = 11.8	ML = 21.2	ML = 67
	μg/m^3	μg/m^3	μg/m^3
Nonradiological Risk			
Medium	Inhalation	Inhalation	Inhalation
Surface Soil	1.5E-07	2.7E-07	8.4E-07
Liner Material	NA	NA	NA
Subsurface Soil	7.8E-10	1.4E-09	4.4E-09
Total Risk	1E-07	3E-07	9E-07
Radiological Risk			
Surface Soil	1.9E-06	2.0E-06	2.6E-06
Liner Material	2.1E-07	2.2E-07	2.6E-07
Subsurface Soil	3.6E-08	3.9E-08	5.3E-08
Total Risk	2E-06	2E-06	3E-06

NA. Not applicable.

The effect on total inhalation risk of moving the ML from the Site average to the RSALS 50th percentile and then to the RSALS 90th percentile is almost one order of magnitude for nonradiologicals. There is little effect for the radionuclides. These uncertainties associated with the exposure point concentrations and the ML factor are likely to result in an overestimate of risks in the long term.

Area Use Factor and Gamma Shielding Factor

The AUF is the ratio of the AOC to the minimum anticipated size of the EU for the WRW. The AUF is used to normalize exposure based on area. In discussions with the regulatory agencies it was agreed that the smallest EU size used in the CRA would be 133 acres, based on data from a survey conducted for the Rocky Mountain Arsenal (Appendix B, Table B-1). The area for the AOC is 33.3 acres. Therefore, the AUF equals 33.3/133 = 0.25. This is a conservative estimate of the amount of time a WRW will spend in the SEP AOC over an 18.7-year exposure period. It was agreed with the agencies to use an AUF of 1 for the risk assessment. This means that the hypothetical WRW will spend 4 hours a day, 5 days a week for 18.7 years in the SEP AOC. This is an extremely conservative assumption that a WRW will spend 20 hours a week for 18.7 years on such a very small portion of the total area of the

Site. Therefore, risks have been calculated for the conservative assumption of a 0.25 AUF to aid in the risk managers' decision-making process (Table 5.7).

It was also agreed with the regulatory agencies that a gamma shielding factor would not be used to account for the effects of surface geometry and contaminant depth. The effect of incorporating a gamma shielding factor of 0.7, as calculated in Federal Guidance Report No. 12 (EPA 1993) for radionuclides of similar energies as present at RFETS, is shown in Table 5.7.

Table 5.7 demonstrates that the effect of the AUF is greater than that of the gamma shielding factor. The AUF has a greater influence because it affects all pathways, whereas

Table 5.7 Effects of the AUF and the Gamma-shielding Factor (1-Se) on Total Risk

	AUF = 1	AUF = 1	AUF = 0.25	AUF = 0.25
Medium	(1 - Se) = 1	(1 - Se) = 0.7	(1 - Se) = 1	(1 - Se) = 0.7
Nonradiological Risk				
Surface Soil	2.7E-07	2.7E-07	6.7E-08	6.7E-08
Subsurface Soil	1.4E-09	1.4E-09	3.5E-10	3.1E-09
Total Risk	3E-07	3E-07	7E-08	7E-08
Radiological Risk				
Surface Soil	2.1E-06	1.8E-06	5.1E-07	4.5E-07
Liner	2.2E-07	1.8E-07	5.4E-08	4.5E-08
Subsurface Soil	3.9E-08	3.4E-08	9.7E-09	8.4E-09
Total Risk	2E-06	2E-06	6E-07	5E-07

the gamma-shielding factor only affects the external radiation pathway. Using the 0.25 AUF instead of the very conservative AUF of 1.0, reduces the estimated radiological risk from 2E-06 to 6E-07 and nonradiological risk from 3E-07 to 7E-08.

5.4.3 Toxicity Assessment

Toxicity values (RfDs and cancer SFs) derived by EPA are conservative, upper-bound estimates of potential toxicity or carcinogenicity of chemicals and central tendency estimates for radionuclides. They are designed to be conservative and their use in risk assessment tends to result in conservative estimates of potential risk. Only chemicals in the ALF were assessed for this HHRA. The ALF represents the master list of potential chemicals of

concern designated by CDPHE, EPA, and DOE in the 1996 Rocky Flats Cleanup Agreement (RFCA) (DOE 1996). However, chemicals not on the list may contribute to risk. These contributions are not assessed quantitatively (see section 2.3.7). In addition, some PCOCs do not have EPA-established toxicity factors. Therefore, they cannot be evaluated in a quantitative risk assessment. This adds a degree of uncertainty to the results of the risk assessment.

6.0 SUMMARY AND CONCLUSIONS

The HHRA estimated health risks for the WRW on-site receptors that could be exposed to COCs at the SEP. Exposure media evaluated were pond liner material, surface soil, subsurface soil, and outdoor air. COCs were identified as metals and radionuclides in liner material and soils that are above PRGS and background. Americium-241, plutonium-239,240, and uranium-235 in surface soil are the largest contributors to risks. Hazard and risk estimates are summarized in Tables 5.1 to 5.4 (also in Appendix C). Results of the risk assessment are summarized below:

- Cumulative HIs for the WRW were well below 1.0 and RME cancer risk estimates for RCRA nonradiological COCs (cadmium and chromium) were below EPA's minimal risk target of 1E-06.
- The highest cancer risks to the WRW were from radionuclides in surface soil, with an RME risk of 2E-06.
- The majority of the risk was from chromium, americium-241, and uranium-235 in surface soil.
- Uncertainties discussed in the previous section indicate that actual risk may be lower.

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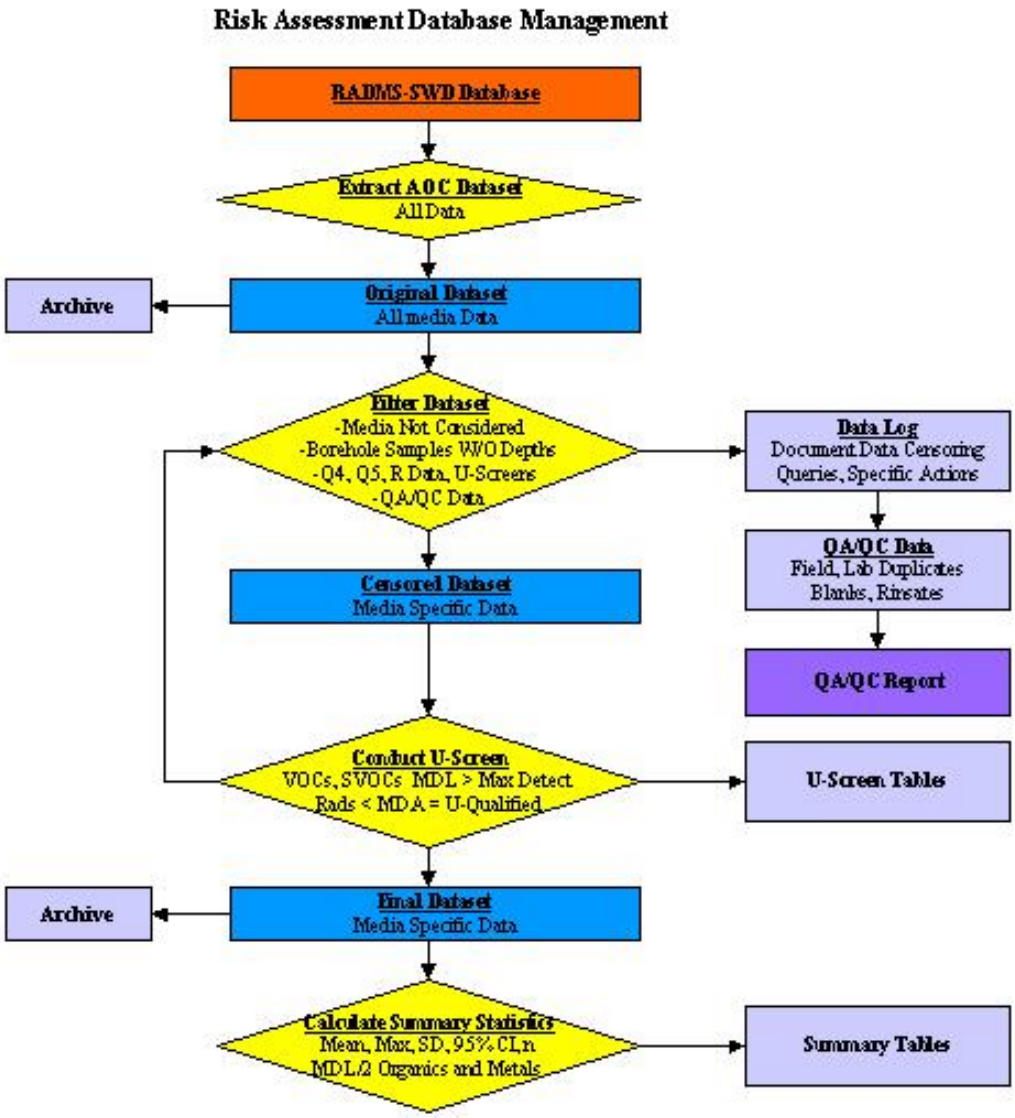
APPENDIX A
Solar Evaporation Pond Data and Background Comparison Tables, and Figures

The solar evaporation pond (SEP) data set was subjected to a screening process to enable statistical calculations and subsequent risk assessment evaluation. This process was used to determine basic statistics, detection frequency, and comparison with worker risk-based preliminary remediation goals (PRGs) at a target risk of 1E-06 and hazard quotient (HQ) of 0.1, and for statistical background comparisons. Primary elements of this screening process are as follows:

- All solid matrix sample records were selected for the area of concern (AOC).
- Records were split into radionuclide, inorganic, and organic constituents.
- Field and laboratory duplicates, laboratory control samples (LCSs), R-validated results, and samples with no depth data were removed from the data set.
- A unit screen was conducted to consolidate all records with the proper units and covert or remove those with improper units.
- The detection frequency was calculated for the final results.
- Summary statistics were calculated.
- Comparisons with PRGs were performed.
- Compounds with less than a 5 percent detection frequency were screened to ensure detection limits were below PRG screening levels.
- Statistical distribution testing was performed
- Statistical comparisons to background were performed.
- The 95 percent upper confidence limit (95UCL) was calculated using parametric or nonparametric methods, depending on the statistical distribution of the analyte.

Database Management Process for Risk Assessment Support

1. The initial data set is queried and extracted from the soil water database (SWD)/Remedial Action Decision Management System (RADMS) databases. The initial data set is archived in its entirety.
2. Preliminary data quality screens and filters are conducted on the original data set to eliminate quality assurance (QA)/quality control (QC) results, duplicates, unit problems, and so forth. The censored (removed) data are saved to a file. The resulting screened data set and the censored data file are archived with the original data set.
3. An independent reviewer performs a QA/QC check on the screened data for each site. Reviewer comments are archived in the location of the archived data.
4. If the reviewer determines that additional queries are necessary, they will be limited to the screened data set, which is managed and approved by the Database Manager.
5. Any changes to the screened data set are documented; any additions or deletions to the data set are saved in separate files and archived with the revised and approved final data set in the same location as the original.
6. The approved final data set is then used to generate summary statistics tables in a pre-specified uniform format for metals, volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and radionuclides in each medium. The tables include information to conduct a screen for U-qualified data with elevated detection limits. The summary tables are archived in the location with the initial data set.
7. The entire final data set and all summary tables are then submitted to Risk Assessment.
8. Risk Assessment conducts qualified data and contaminant of concern (COC) screening followed by intake and risk characterization calculations.
9. Risk Assessment requests additional data information only from the screened data set when required to further evaluate data and risk impacts. If this results in data changes, the Database Manager must approve changes to the final data set.
10. Risk assessment results are submitted in draft form to the Project Manager and submitted for review.
11. The final risk report is generated following review. Figure Aa.1 illustrates the steps for generating the risk assessment data set.



12.

Figure A.1 Database Management Flow Chart For Risk Assessment

APPENDIX A TABLES

(These tables are available on CD from Anna Martinez at (303) 966-5881.)

APPENDIX B
AOC AREA AND EXPOSURE UNIT SIZE

APPENDIX B TABLES
Exposure Unit Calculations

(These tables are available on CD from Anna Martinez at (303) 966-5881.)

APPENDIX C
Risk Calculations

APPENDIX C TABLES

(these tables are available on CD from Anna Martinez at (303) 966-5881)

ATTACHMENT III
Responsiveness Summary

	RFCLOG Comments Dated October 15, 2002	Response
	CHARACTERIZATION	
1	We are concerned the available characterization data for the Solar Evaporation Ponds (SEP) is insufficient. In the Human Health Risk Assessment (Attachment II), Figure 2.1 shows that the liner of SEP 207-B South was not sampled. Figure 2.2 shows that SEP 207-B South had only one surface sample taken, while SEP 207-A, which covers three acres, had only five surface samples, the most of any of the five ponds. Figure 2.3 shows that neither SEP 207-B South nor SEP 207-C had subsurface samples taken in the first six feet below the asphalt liners. Due to what appears to be a small number of samples for a relatively large area, we question whether there are adequate data to support a No Further Action (NFA) decision. While an NFA decision may indeed be appropriate, it is difficult to have confidence at this point that the SEPs will not adversely impact surface water quality in the future based on the limited data provided. We understand that clean fill will be placed on top of the SEPs liners, which will make subsurface soils harder to access and thus may reduce the overall risk to a future user. However, not knowing what is underneath some of the SEPs does not answer the question about the potential for a secondary source to be contributing to the Solar Ponds Plume (SPP).	A Data Adequacy Evaluation for the Solar Evaporation Ponds (SEP) was conducted and is available as Attachment I. This evaluation includes a geospatial analysis and assessment of impacts to risk using various upper confidence limit (UCL) calculations and hot spot removal. It was concluded that adequate data were collected to support risk quantification. In addition, in Section 5.0, first paragraph, the following sentence was added: "Attachment I presents an evaluation of data adequacy used to support and quantify risk calculations submitted in the Human Health Risk Assessment (HHRA) as presented in Attachment II."

2	**Section 2.1.2 Actions Taken at the SEPs** • Bullet 11: "Twelve boreholes were completed and subsurface soil samples collected from within ponds 207A, 207B-Center and 207B-North." Were subsurface samples taken based on biased sampling (under known leaks in the liners), statistical sampling, or other? What is the confidence level that the Site has adequately characterized the subsurface?	Sampling was biased. The overall sampling for the SEP is adequate at the 95% confidence level for surface and subsurface soil. The sum of ratios is well below 1.0 (0.11) and total risk is 1E-06 following hot spot removal. Added to this bullet is the following sentence: "Boreholes were placed at locations where breaches in the liners were observed and at locations where the liner was intact (DOE 1995a)."
3	**Attachment II (Human Health Risk Assessment): Section 2.2 Segregation of Samples by Media** "Most surface soil samples were collected using the RFP method, in which the top 2 inches…of soil are collected…. Other were collected as the first interval of a borehole sampling." Is surface soil for the ponds themselves considered to be the first few inches of soil under the liners, or sediments on top of the liners? Please clarify this distinction in the document.	Surface soil was typically collected as the 0- to 6-inch interval. All data with a starting and ending depth between 0 and 6 inches were considered surface soil. All surface soil was collected below liner material. Sediments were identified separately as SD or SED sample numbers. In Section 2.2, Surface Soil Section, the following sentence was added: "Surface soil for the ponds is considered to be within 0 to 6 inches of soil below the liners."
	DATA AVAILABILITY	

4	**Section 2.1.2 Actions Taken at the SEPs** • **Bullet 17**: "Surface soil areas exceeding proposed soil action levels (October 2002) for Americium-241 and Plutonium 239/240 were removed under the ER RSOP Notification # 02-08." Where were soils removed? What concentrations were removed? As per the Human Health Risk Assessment (HHRA), the maximum concentration of americium remaining in surface soils is 130 pCi/g, which is somewhat higher than the proposed soil action level of 76 pCi/g. Where is the americium maximum concentration located? If not under the pond liners, this concentration could remain at the surface post-remediation and should be noted.	The attached map shows the locations of hot spots that were removed. Analytical results indicate that all americium concentrations are below 50 pCi/g. Added to this bullet is the following sentence: "Locations and concentrations removed are documented in the Closeout Report for ER RSOP Notification #02-08."
5	**Section 3.2 Soil Contamination** • "In addition, characterization data that was obtained based upon actions conducted under the ER RSOP such as confirmation samples collected after the removal of sumps, has been included in the closeout report and will not be included in this PAM." Since the remediation of the SEP Area of Concern (AOC) is not complete, the closeout report is not complete. Thus, the characterization data referenced are not available to the reader. To have confidence in an NFA decision, it would seem important to know what concentrations of	Data that support the NFA are available in the risk assessment. Analytical results from samples collected under the ER RSOP do not affect the risk assessment. These data will be included in the ER RSOP Closeout Report and the Historical Release Report (HRR). Analytical results indicated that all contaminant concentrations were less than RFCA ALs. In Section 5.0, first paragraph, second sentence was modified to add at the end, "based on historical data." Also added: "Results of this risk assessment do not take into account soil removed in

	contaminants remain at the point the NFA is proposed. Please provide documentation of what contaminant concentrations remain, so that the reader can be assured the remaining contaminants are less than the proposed soil action levels.	accordance with ER RSOP Notification #02-08."
	GROUNDWATER PROTECTION	
6	**Section 2.1.2 Actions Taken at the SEPs** • **Bullet 16**: "Environmental monitoring, including downstream surface water and downgradient groundwater monitoring, is being conducted as part of the Site-wide Integrated Monitoring Program to ensure that contaminant concentrations are not increasing and that water quality standards are being met…." What SEP contaminants are being monitored? Does the suite of contaminants monitored track the contaminants from the SEPs that could get into groundwater?	At the SEP treatment system, groundwater is monitored by ER for uranium and nitrate. SEP groundwater is monitored by Integrated Monitoring Program (IMP) for volatile organic compounds (VOCs), nitrate, uranium, plutonium, americium, neptunium, metals, and tritium. Added to this bullet is the following sentence: "The IMP monitors groundwater for volatile organic compounds (VOCs), metals, nitrate, uranium (U), plutonium (Pu), americium (Am), neptunium, and tritium."
7	**Section 3.1 Groundwater Contamination** • "Performance monitoring wells for the SPP treatment system have also detected selenium, nickel and thallium at concentrations above groundwater action levels. However, an analysis of metals distribution was conducted, and indicates that there is no metals	The text in the second paragraph was corrected to indicate there are no performance monitoring wells for the SPP treatment system. The text is now located in the sixth paragraph and states: "Monitoring wells have also detected lithium, selenium, nickel, and thallium at concentrations above groundwater ALs." And a

	groundwater plume associated with the SEPs." What was the action, if any, that resulted from the exceedances? If the SEPs are not the source of the exceedances, has the source been identified and dealt with appropriately? Section 3.2.1 states that the "occasional incidence of elevated metals in the seep areas north of the SEPs were attributed most likely to the local accumulation of metals transported in groundwater that discharges to ground surfaces." This statement appears to conflict with the above statement that no metals groundwater plume is associated with the SEPs. Please clarify this apparent discrepancy. • Uranium concentrations…at well 1386 and well 1786 exceeded RFCA Tier II groundwater action levels during the Fourth Quarter of 2001…." What is the trend of uranium in the groundwater entering the treatment system? Are concentrations increasing, decreasing, or staying fairly constant? If decreasing or staying constant, what does this fact reveal about a potential secondary source of uranium in the soils under the SEPs? Would removal of a potential secondary source decrease the required operating life of the SPP treatment system?	new sentence was also added to the end of the fifth (now ninth) paragraph, "Gauging Station (GS) 13 is the performance monitoring location for the SPP treatment system." The third (now seventh) paragraph was modified to indicate the four monitoring wells are not performance monitoring wells and the last sentence has been added: "However, U activities in these wells are consistently below RFCA Tier I groundwater ALs." New sentences were added in Section 3.2.1. first paragraph, after the fourth sentence: "Although metal concentrations in seeps are occasionally elevated, there is no distinctive metals plume associated with the SEP (DOE 1999). These fluctuations may be associated with variations in water chemistry such as pH or the concentration of various anions." New sentences were added to the last paragraph (now ninth) of Section 3.1: "Groundwater influent concentrations of U are fairly constant at 20 to 30 pCi/L. U effluent concentrations from the SPP treatment system are 0 to 0.96 pCi/L, averaging 0.15 pCi/L (DOE 2001)." In addition, a sentence was added to section 3.2.2, third (now fourth) paragraph: "U contamination exists as a large dispersed area beneath and to the north of the SEP; no discrete secondary source of U is apparent (Kaiser-Hill 2001)."
	CONTAMINANTS OF CONCERN	

8	**Section 3.2.1 Surface Soil Contamination** • "All concentrations of contaminants are below RFCA Tier I. In addition, contaminant concentrations are below proposed soil action levels (October 2002), with the exception of manganese." What is the proposed strategy to address elevated manganese concentrations? Additionally, it appears that the list of potential contaminants of concern in this PAM is much smaller than that considered in the 1995 IM/IRA (though we understand that document was never approved). We are concerned that not all of the contaminants present in the SEP AOC were examined, which could result in an incomplete remediation (see comments below).	At the end of this paragraph, after the word "manganese", the following statement was added: ", which is discussed further in the risk assessment (Attachment II) for the SEP." Manganese was dropped as a PCOC based on a statistical analysis of SEP Manganese vs. background Manganese at the Alpha = 0.05 level. The result was P = 0.9932 with an alternative hypothesis of SEP>Bkg. All PCOCs present in the SEP dataset were screened. All SEP data are presented in Appendix A of the risk assessment, Tables A1-A12. Summary statistics used to screen all PCOCs are presented Appendix A, Tables A13-A18.
9	**Section 3.2.2 Subsurface Soil Contamination** • "Toluene, acetone, and methylene chloride were the only VOCs detected at significant frequencies…. The pervasive distribution of toluene in the subsurface at low levels indicates that external factors, such as cross-contamination during sampling or analysis, may have been responsible for the identification of toluene in samples. Acetone and methylene chloride were detected in equipment rinsate and laboratory blanks, which also suggests that these VOCs were introduced during sampling and laboratory activities."	An additional paragraph was added to the end of section 3.0: "It is noted that this section may indicate possible explanations for the presence of certain contaminants (for example, acetone as a laboratory contaminant) in defining the nature and extent of contamination. However, for purposes of defining risk (as discussed in Section 5.0 and Attachment II) all SEP data were used as defined in Attachment II."

	What is your confidence that volatile organic compounds (VOC) are not a problem in the subsurface, and instead, are a function of laboratory error or contaminated sampling methodologies? What are the potential repercussions if your assumption is incorrect, and what mechanisms will be in place to address any potential problems resulting from the incorrect assumption? • "With the exception of uranium-233/235, uranium-238, gross beta radiation sources, and tritium, the presence of radionuclide contaminants is generally restricted to areas beneath the SEPs and the drainage tile outfall north of SEP 207-A and SEP 207-B North." What is the source of tritium? At what concentrations is it found? Has it been detected in the SPP? Tritium was not indicated in the risk assessment as a Contaminant of Concern (COC). Was tritium considered as a Potential COC (PCOC)? Could it pose a threat to surface water? • The distribution of nitrate in the subsurface suggests that nitrate has a distribution pattern similar to that of tritium and that concentrations decrease with depth. Cyanide is present beneath SEP 207-A, north of the drainage tile outfall area, and north of SEP 207-C at shallow depths (0 to 6 feet). Cyanide is also found pervasively throughout the vadose zone beneath the northeastern portion of SEP 207-B North, and at depth (greater than 12 feet) northeast of the SEPs in the buffer zone."	All VOCs were eliminated as PCOCs based on maximum concentrations that were well below the corresponding ALs. This observation was true for the entire subsurface data set. VOCs therefore, do not have any contribution to risk above the screening target risk of 1E-06 and the HQ of 0.1. Tritium was not considered a PCOC in soil. A localized source term for H-3 has not been observed at the ponds. The following information has been added to Section 3.1, tenth, eleventh, and twelfth paragraph: "Tritium has been detected in the vicinity of the SEP in both surface soil and groundwater based on historical sampling conducted in 1991. A signature of tritium was observed around the ponds in groundwater with a maximum concentration of 13,850 pCi/L in 1991. This concentration was below the drinking water standard of 20,000 pCi/L and currently this concentration is approximately 6,300 pCi/L due to radiological decay. Vadose transport and dispersion in saturated zones should further reduce this maximum concentration. Tritium sampling has also been conducted near the SPP treatment system and the Site boundary to assess possible surface water impacts. The maximum concentration detected near the SPP treatment system in 1991 was 780 pCi/L. This detection was observed in January 1991 and exceeded the surface water standard of 500 pCi/L. Subsequent samples collected from October 1991 to February 1992 had concentrations below the surface water standard. Samples collected after April 1991 had

	Cyanide and nitrate are not listed as COCs in the HHRA for the subsurface. Were they considered as PCOCs and then rejected as COCs? Cyanide has a published reference dose (RfD) for oral exposure and would be pertinent to the non-carcinogenic health effect calculations in the HHRA. We know that nitrate is adversely affecting water quality. Is the same true for cyanide?	tritium concentrations below detection limits. The overall averaged concentration at this location was 55 pCi/L. Tritium samples collected at the Site boundary from 1991 to 2002 had a maximum reported concentration of 13,400 pCi/L in 1991. Maximum concentrations steadily declined in the following years from 3,310 pCi/L and were below detection limits from 1999 to present day. Detection limits ranged from 150 to 180 pCi/L at the Site boundary location. The activity of tritium in groundwater and surface water near the SEP and for the Site as a whole are well below drinking water and surface water standards." Cyanide and nitrate were rejected as PCOCs in subsurface soils because the maximum concentrations are below ALs. Cyanide maximum = 30.7 ppm and the AL = 2,040 ppm at risk 1E-06 and HQ = 0.1. The Nitrate maximum = 1,600 ppm with an AL = 164,000 ppm.
10	**Attachment II (Human Health Risk Assessment): Section 1.1 Site Description** "… these ponds have historically received wastes such as… lithium metal, [and] lithium chloride…." Was lithium considered as a PCOC? In Section 2.3 (Selection of Contaminants of Concern), it is stated that "All analytes listed in the Action level framework (ALF) are considered PCOCs." Lithium is in the ALF. Nevertheless, lithium does not seem to be included in the HHRA. Is there evidence of lithium in the SPP or in N.	Lithium was considered a PCOC in the risk assessment for surface and subsurface soil. This constituent was eliminated as a PCOC because the maximum concentrations were below ALs. The maximum concentration in surface soil = 46.3 ppm and AL= 2,040 ppm. The subsurface soil maximum concentration = 60 ppm. Based on collected data, there is no evidence of lithium at the SEP or associated drainages.

	Walnut Creek?	
11	**Attachment II (Human Health Risk Assessment): Figure 2.6 IHSS PCOC Screening Process** This diagram indicates that if the detection frequency of a PCOC is less than 5%, an analysis is done to see if the concentration of PCOC is greater than three times the PRG. In Section 2.3.4, it is stated that benzo(a)pyrene [B(a)P] was not "carried on as a PCOC because the ratio of the maximum detect to the PRG is less than 3, and the detection frequency is less than 5 percent." It is true that the ratio of maximum detect to the PRG for B(a)P was less than 3 for subsurface soil, as evidenced in Table 2.5 (PRG Screen for Subsurface Soil Above 6 Feet). However, as shown in Table 2.3 (PRG Screen for Surface Soil), that ratio is 4.87, which is greater than 3. Does that ratio not warrant B(a)P being considered as a COC?	Your observation is correct. However, Section 2.3.6, Application of Professional Judgement assesses benzo(a)pyrene in detail. This PCOC has a very weak data set that is dominated by qualified data. In addition, the observed detections were predominately at detection limits and the calculated 95% UCL was below the AL. Benzo(a)pyrene and other polyaromatic hydrocarbons (PAHs) are widespread in the environment due to breakdown products from asphalt. These PCOCs have no known historical use or specific release associated with Site operations or locations.
	STEWARDSHIP	
12	Stewardship is of great importance to the Coalition and must be integrated with remedy selection decisions to ensure the long-term protection and viability of selected remedies. We recognize that a stewardship evaluation section was incorporated in the PAM (Section 8.0). In addition, groundwater contamination was "discussed	The following text was added to Section 8.0 Long-Term Stewardship: "This stewardship evaluation describes current site conditions, proposed actions and the anticipated effect on current site conditions, and stewardship recommendations.

	briefly for the purposes of defining the nature and extent of contamination and to determine if additional soil remediation could reduce the long-term stewardship obligations of the Solar Ponds Plume (SPP) treatment system" (Section 3.1). Nevertheless, we are concerned that the document does not truly consider stewardship needs, but rather defers stewardship considerations to another document that won't be written for some time.	**Current Site Conditions** "Based on previous studies and removal actions at the SEP (Sections 2.0 and 3.0) all contaminant concentrations are less than RFCA ALs in surface and subsurface soil with the exception of manganese which was eliminated as a COC at this site. Radionuclides (americium, plutonium, and uranium) and metals (cadmium and chromium) are found in concentrations greater than background in surface soil. Radionuclides (americium, plutonium, and uranium) and cadmium are found in concentrations greater than background in subsurface soil. Americium and uranium are found in concentrations greater than background in the liner material. Results of the risk assessment (Section 5.0 and Attachment II) indicate the cumulative HI for non-carcinogenic health effects was well below 1.0 at 0.04 for RME conditions. Total cancer risk to the WRW was 3E-07 and 2E-06 for radionuclides before removal of hot spots. Total cancer risk to the WRW following removal of hot spots is 1E-06. Surface soil areas exceeding proposed soil action levels for americium-241 and plutonium 239/240 were removed in accordance with ER RSOP Notification #02-08 (DOE 2002b). These removals also resulted in removing soil with beryllium and cadmium concentrations greater than ecological receptor action levels. Lead was determined to be significantly lower than background and was eliminated as an ecological COC. An evaluation of contaminant concentrations present in surface and subsurface soils associated with the ponds indicated that there is no source term present that could impact surface water by

		leaching and transport mechanisms. A reactive barrier treatment system is in place on the north of the SEPs that collects and directs SEP groundwater flow to two passive treatment cells. The treatment system is designed to treat uranium and nitrate, but is also effective at capturing metals and VOCs. **Proposed Action Memorandum Measures** No further action is required at SEP, however several BMPs will be implemented including the following: • Remove standing water within the ponds; • Sample and analyze the liner material and soil beneath pond 207B-South; • Collect additional samples of the liner material and soil beneath pond 207C; • Push in pond berms; • Add clean fill to create a level area; and • Regrade and revegetate. It is anticipated that after BMPs are completed the risks to receptors will be eliminated because surface soil and liner materials will be covered and contact via inhalation, ingestion, and external exposure to radionuclides and metals will be prevented. **Monitoring** Environmental monitoring, including downstream surface water and downgradient groundwater monitoring is being conducted as

		part of the Site-wide IMP. There are currently 8 monitoring wells and 5 surface water monitoring stations. Additionally, groundwater is monitored to measure the effectiveness of the treatment system. **Stewardship Actions and Recommendations** Near- and long-term stewardship requirements are based on residual contamination at the SEP AOC. Because the risk assessment results indicate that environmental risks are below regulatory requirements and potential groundwater impacts are mitigated by the treatment system near-term stewardship actions for the SEP AOC consist of the following: 1. Control excavations through the Site Soil Disturbance Permit process; 2. Control access to groundwater; and 3. Install fencing and post signs restricting access to the site. **Long Term Stewardship Recommendations** Because the risk assessment results indicate that environmental risks are below regulatory requirements and potential groundwater impacts are mitigated by the treatment system, the long-term stewardship actions and recommendations for the SEP AOC are as follows: 1. Continue Federal ownership and control over the site; 2. Land use restrictions to prevent soil excavation that could access or disturb residual contamination. Specific land use restrictions will be discussed in the Site Long-Term

		Stewardship Plan and evaluated along with other institutional controls for implementation in the final remedy selection process. 3. Maintain the groundwater treatment system; 4. Restrict groundwater use; 5. Review groundwater and surface water monitoring stations near the SEP when long-term monitoring options are evaluated; and 6. Maintain environmental data and other relevant data. These recommendations may change based upon other future Site remedial activities.
13	**Section 3.1 Groundwater Contamination** "Based on historical data, uranium and nitrate concentrations in surface soil and subsurface soil are all below RFCA Tier I and Tier II action levels. In addition, lithium, nickel, and selenium are also below Tier I and Tier II action levels in both surface and subsurface soil. Therefore, no additional soil removal is required for purposes of reducing the long-term stewardship obligation of the SPP treatment system." RFCA soil action levels were not designed to be protective of surface water via groundwater. Thus contaminant concentrations in the SEPs relative to the RFCA soil action levels are not a valid basis determining whether additional source removal would decrease long-	RFCA subsurface organic soil ALs were calculated based on the potential to leach contaminants to groundwater and eventually to surface water. Soil/water partitioning coefficients were used. Refer to Table 4 in the ALF. • Subsurface soil is capable of leaching contaminants to groundwater at concentrations greater than or equal to 100 x maximum contaminant levels (MCLs). If an MCL is lacking, the residential groundwater ingestion based preliminary programmatic remediation goal (PPRG) value applies. • A soil/water partitioning equation and dilution factor were used to determine ALs for organics. • Subsurface soil ALs for metals and radionuclides are the same

	term stewardship obligations. The question is whether there are pockets of contamination in the subsurface that continue to act as a secondary source, and whose removal may substantially decrease the required life cycle (and thus long-term cost) of the SPP treatment system. If a discrete secondary source has not been observed, please state this fact clearly. Comparison to action levels does not answer the relevant question.	as surface soil and are, therefore, human-health risk based. Because the groundwater to surface water transport mechanism is active at RFETS, removal of potential soil sources protects both groundwater and surface water. The following sentence was added to the fourth (now eighth) paragraph of Section 3.1: "A discrete secondary source of contamination has not been observed in the area of the SEPs."
14	**Attachment II (Human Health Risk Assessment): Section 2.2.7 Segregation of Samples by Media** Subsurface Soils: "Laboratory analyses of subsurface soil samples generally included the following analytical groups: VOCs, SVOCs, metals, pesticides, PCBs, and radionuclides." We know that the SPP largely consists of nitrates. As evidenced in the previous comment, Kaiser-Hill and DOE do not believe additional remediation of nitrates (among other constituents) would decrease the expected life cycle of the SPP treatment system. Were nitrates sampled in the subsurface, as they were in the surface samples? If so, they were not included in the quoted list above. If not, how can the Site be sure a hot spot does not exist that could be removed in order to decrease long-term costs associated with the SPP treatment system?	Subsurface soil samples were analyzed for nitrate however, results indicate that concentrations in soil were less than Tier II ALs. We know that the SPP largely consists of nitrates. As evidenced in the previous comment, Kaiser-Hill and DOE do not believe additional remediation of nitrates (among other constituents) would decrease the expected life cycle of the SPP treatment system. Nitrates were sampled in the subsurface however results indicate that concentrations in soil were less than Tier II ALs. Nine subsurface soil samples were collected form the AOC. The maximum concentration was 1,600 ppm compared to screening

		action level at 1E-06 of 163,520 ppm. No hot spots were evident for this mobile contaminant in the subsurface.
15	**Section 8.0 Stewardship** A stewardship evaluation should consider long-term needs for the remedy, but this purpose is not achieved in Section 8.0, or anywhere else in the document. ER RSOP #02-08, which addresses a portion of the remedial action, does not include a stewardship analysis either, and states "the stewardship evaluation for these sites will be conducted as part of the PAM." Yet, as discussed earlier, there is no evaluation in the PAM. Section 8.0 states that stewardship mechanisms will be identified in the CAD/ROD. In previous discussions with the RFCA parties, the closeout report for an individual project is cited as the document where stewardship mechanisms will be captured. We are concerned that stewardship, which is integral to remedy selection, is not being considered during remedial actions and is continually being postponed to later documents. Although we recognize that specific stewardship mechanisms will be identified in later documents, it is still necessary to identify long-term stewardship needs early on in the decision document for a given remedy. We also recognize that groundwater is addressed under a different decision document, which complicates the stewardship analysis since stewardship must be addressed for the area as a whole and not in parts. Nevertheless, we believe the following considerations should be specifically addressed in the stewardship evaluation:	Please see response to Comment 12.

	• Stewardship controls will be required to protect receptors from residual contamination. This is inferred by a reference in Section 8.0 to institutional controls and prevention of domestic use of groundwater. From what specifically are receptors being protected in the SEP AOC and SPP? • Will areas of contamination be known via markers or some other type of physical control? Or will these areas be captured in a post-closure institutional control map? • Will continued monitoring be required post-closure? Performance monitoring is mentioned in Section 3, but not listed in the stewardship section. • How long will monitoring be required? How long does the Site anticipate the groundwater treatment system will be required? • The authors of the Draft PAM should refer to recent stewardship language drafted by DOE for the Site Long-Term Stewardship Strategy document regarding institutional controls and the role of the refuge in institutional and physical controls. The LTS Strategy states the refuge will have "indirect benefits in terms of strengthening remedy-related institutional controls." However, the refuge as a type of land-use is not an institutional control in and of itself. • Given that the stewardship requirements for the SPP treatment system and the SEP AOC are identified to varying degrees in two different decision documents, it will be difficult for future stewards to determine the long-term ramifications of this remediation as whole. Thus stewardship requirements referenced in the SPP	

	decision document (including monitoring and maintenance) should also be referenced in this PAM so that stewardship can be evaluated for the area as a whole and not as a sum of parts.	
	ADDITIONAL COMMENTS	
16	As per the PAM, Kaiser-Hill and DOE intend to leave the SEP liners in place. We understand leaving the liners as is may reduce infiltration of water to the subsurface, thereby potentially reducing migration of subsurface contaminants in the future. Nevertheless, could a potential "perched water" situation be created if the liners are left in place without being breaching in any way, which could increase the chance for increased seepage of water out of the north hillside? If so, how does the Site intend to address this problem?	The following information has been added to Section 9.0: "When pushing in the berms, the bottom liner material will not be breached. Perching of groundwater in this area is not anticipated because a few of the ponds have cracks in the liners, some of the ponds will contain a few additional holes from lysimeters previously located within the ponds, the bottoms of the ponds are sloped to one corner, and a sandy fill material exists beneath the ponds. (The B-series ponds slope toward the northwestern corner. The A and C ponds slope towards the northeastern corner.) In addition, a majority of the sidewalls will be removed once the berms are pushed in, which will allow precipitation to flow out laterally. If after the area is regraded and revegetated, water is observed to be perching in this area, equipment will be brought in (for example, a GeoProbe ™) for purposes of breaching the liner material in additional locations."
17	**Table 3.4 Intake Equations for the WLRW** The equations listed are for risk, not intake. This discrepancy creates confusion when trying to reproduce the calculations. In addition, the "concentration in soil" unit is listed as "mg/kg", which means the units don't	These clarifications were made to the risk assessment. Table 3.4 presents equations for risk and intake. A footnote was added to the table to state that risk is equal to intake of x (slope factor). The units of mg/kg for the concentration in soil (CS) have been changed to include pCi/g for radionuclide intake and risk

	track for the radionuclide risk equations. Lastly, what are the units for the "1000" and "0.001" conversion factors in the radionuclide calculations?	calculations. The units for all conversion terms have also been added to the table for 1,000 g/kg, 0.0001 g/mg, and 0.000001 kg/mg.
18	Table 3.5 Chemical Intakes for the Wildlife Refuge Worker from Surface Soil and Liner Materials at the SEPs and Table 3.6 Chemical Intakes for Wildlife Refuge Worker Exposure to Subsurface Soil and Liner Material at Solar Ponds The unit for external radiation intake from surface soil is listed as "yr/pCi/g" in Tables 3.5 and 3.6. This unit should be "yr-pCi/g". Why is the "Total Intake" for radionuclides listed as "NA" for surface soil and pond liner in Table 3.5, but not for subsurface soil in Table 3.6?	The units were corrected to yr-pCi/g as suggested for external exposure to correctly reflect the relationship of risk or dose to the integral of concentration in pCi/g over time.
19	**Section 5.2 Carcinogenic Risk** Equation 5.2: The units for chemical risk are presented, but not for radionuclide risk. What are the units for cancer risk calculated for radionuclides?	A separate formula has been added for radionuclides using units of (pCi) (Risk/pCi) = Risk
20	**Section 5.3 Solar Evaporation Ponds AOC** It would be very helpful to provide a breakdown by chemical of the risks summarized in Tables 5.1 (Hazard Indices for Wildlife Refuge Worker Receptors) and 5.2 (Summary of Wildlife Refuge Worker Carcinogenic Risks	Agreed. A breakdown of risk by COC and exposure pathway is shown in Appendix C, Tables 6 and 8 for surface and subsurface soil. Table 9 in Appendix C shows a percentage breakdown of risk by COC. A summary table Table 5.3 has been constructed

	for the Solar Ponds AOC). The reader will be better able to discern the relative risk of each residual contaminant present, which may also help in determining long-term stewardship needs for the AOC.	and included in the main body of the risk assessment for quick access and evaluation.

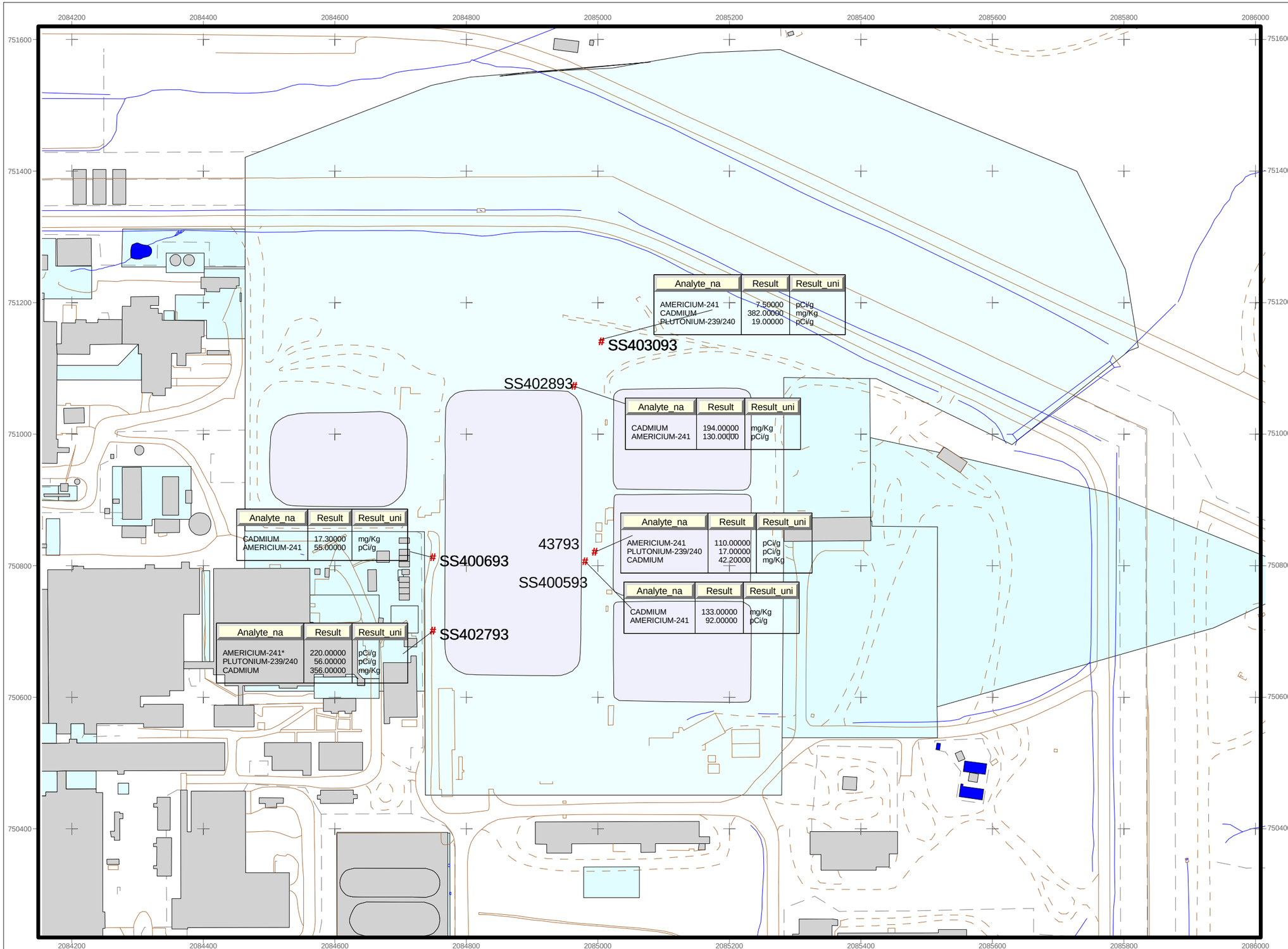


Figure __
Solar Evaporation Ponds Area of Concern Hot Spots

KEY

- SEP
- AOC
- Building
- IHSS
- Streams
- Fence
- Paved Road
- Dirt Road
- # Hot Spot

* Rejected data due to MDA exceeded the RDL and % recovery was outside acceptability range.

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N

50 0 50 100 Feet

Scale = 1:1,750

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

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

Prepared by:

Prepared for:

sep082302.apr

September 2002

	CDPHE Comments, Dated October 9, 2002 Draft SEP PAM	**Response**
	EXECUTIVE SUMMARY	
1	The first sentence in the first paragraph seems too long, is difficult to follow and should be broken up. The second portion of this sentence beginning with "since a release" should be further explained. A second sentence containing the information defining the term "this contamination" should be included.	This comment was accepted and the text was rewritten as follows (before the Proposed Action Memorandum [PAM] was released for public comment): "Closure of the Solar Evaporation Ponds (SEP), Individual Hazardous Substance Site (IHSS) 101, at Rocky Flats Environmental Technology Site (RFETS), is proposed under alternative Resource Conservation and Recovery Act (RCRA) interim status closure requirements found in 6 Code of Colorado Regulations (CCR) 1007-3, 265.110(d). Alternative closure requirements are proposed because a release from the SEP has occurred resulting in radiological and hazardous constituent contamination. Releases from other units in the area of the SEP have also contributed to the SEP area of contamination."
2	In the second paragraph, it would be helpful if 'cumulative hazard index' was defined and a value threshold explained in this section for individuals that are not familiar with this term.	This comment was accepted and the following explanation was provided after the third sentence in the second paragraph (before the PAM was released for public comment): "(Hazard Index >1 indicates adverse non-carcinogenic health effects are expected, and action is warranted for protection of public health.)" However, since the PAM was released, additional clarification has been provided and the sentence added above has been deleted. Instead the following footnote has been added: "The potential for non-carcinogenic effects is evaluated by comparing an exposure level over a specified time period (for

		example, lifetime) with a reference dose (RfD) derived for a similar exposure period. An RfD represents a level that an individual may be exposed to that is not expected to cause any deleterious effect. The ratio of exposure to toxicity is called a hazard quotient (HQ). An HQ<1 indicates that a receptor's dose of a single contaminant is less than the RfD, and that toxic non-carcinogenic effects from the chemical are unlikely. The Hazard Index (HI) is the sum of the HQs for all chemical(s) of concern that affect the same target organ (for example, liver) or that act through the same mechanism of action within a medium or across all media to which a given individual may reasonably be exposed. An HI<1 indicates that toxic non-cancer effects from all contaminants are unlikely. An HI>1 indicates that site-related exposures may present a risk to human health."
3	Add the phrase, "and replacement wells installed", after the word "abandoned" in the last sentence of the fourth paragraph.	This comment was accepted and the changes were made to this sentence before the PAM was released for public comment.
	SECTION 1.0	
4	The description of the regulatory process in the first 2 paragraphs might be clearer if closure of IHSS 101 under RFCA were described in the first paragraph and closure of the interim status unit were described in the second.	This comment was accepted and the following changes were made to the first paragraph, first and second sentence, and to the second paragraph, new first sentence (before the PAM was released for public comment): "This Proposed Action Memorandum (PAM) decision document serves to close the Solar Evaporation Ponds (SEP), Individual Hazardous Substance Site (IHSS) 101. IHSS accelerated actions and Resource Conservation and Recovery Act (RCRA) unit closures are approved by the U.S. Department of Energy (DOE), Colorado Department of Public Health and Environment (CDPHE) and the U.S. Environmental Protection Agency (EPA) under the Rocky Flats Cleanup Agreement (RFCA) (DOE, et al. 1996). RFCA is both a cleanup agreement

		under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and a compliance order on consent under RCRA and the Colorado Hazardous Waste Act (CHWA). Therefore, actions associated with IHSS 101 will be completed under RFCA and closure of the SEP will be completed under RCRA. This PAM also serves as the RCRA/CHWA closure plan for the SEP, which are a RCRA interim status unit. However, …"
5	Changes to first 2 sentences in first paragraph: "This Proposed Action Memorandum (PAM) decision document serves to close the Solar Evaporation Ponds (SEPs), Individual Hazardous Substance Site (IHSS) 101. Accelerated actions and closures of IHSSs are approved by the Department of Energy (DOE), the Colorado Department of Public Health and Environment (CDPHE, and the Environmental Protection Agency (EPA) under the Rocky Flats Cleanup Agreement (RFCA) (DOE/CDPHE/EPA, 1996)."	This comment was accepted and these changes were made to the text (before the PAM was released for public comment). Please see response to Comment 4.
6	New first sentence of the second paragraph: "This PAM also serves as the Resource Conservation and Recovery Act (RCRA)/ Colorado Hazardous Waste Act (CHWA) closure plan."	This comment was accepted and this change was made to the text (before the PAM was released for public comment). Please see response to Comment 4.
7	Changes to the end of the third paragraph: "…which provides for <u>alternative requirements that are protective of human health and the environment.</u> DOE <u>has proposed</u> a modification to Attachment 10…However, because the <u>proposed modifications to the other RFCA Attachments</u> are	This comment was accepted and this change was made to the text (before the PAM was released for public comment).

	still under development…"	
	Section 1.1	
8	The second sentence of the third paragraph states that "Results of the risk assessment were used to determine if any actions **or if additional sampling** was warranted". Determining whether or not to collect additional samples would be partially based on a statistical spatial analysis that was not included in the risk assessment. This analysis must be made to demonstrate that sample coverage is adequate.	This comment was accepted and a Data Adequacy Evaluation has been performed and is now included as Attachment I to the PAM.
	Section 3.1	
9	Lithium is a COC for groundwater from the SEPs.	This comment was accepted and lithium has been added to Section 3.1, specifically Paragraphs 3 (now 6) and 5 (now 8)to indicate lithium has been detected in groundwater monitoring wells. This change was made before the PAM was released for public comment.
10	It would be helpful if you included a short description of the groundwater conditions for informational purposes, such as depth to groundwater and aquifer characteristics. It is not clearly stated that you have sufficient information to conclude that remaining surface and subsurface contamination will not further contribute to groundwater contamination. This should be explained if that is indeed the case.	This comment was accepted and the following information was added to Section 3.1: "The groundwater flow path in the area of the SEP is very complex due to the varying thickness of the unconsolidated deposits and weathered bedrock units and the highly variable primary and secondary permeabilities of the two units. The combination of the varying thickness of the unconsolidated deposits and seasonal water table fluctuations result in large areas of the unconsolidated deposits in the area of the ITS becoming unsaturated. The hydraulic gradient between the

		unconsolidated deposits and weathered bedrock at the SEP is downward, due to infiltration of rainfall at the ponds. General depth to groundwater beneath the SEPs has historically been approximately 10 to 20 feet (DOE 1999). However, based on the dry conditions during 2002, depth to groundwater is approximately 25 to 30 feet. Recharge and subsurface inflow to the SEPs area originates from both natural and anthropogenic sources. Sources of recharge to the SPP include natural groundwater flow entering the SEP area from the west and southwest, infiltration of precipitation on the SEP and ITS hillside, runoff from the former PA directed to the ITS, and water used for dust suppression at the SEP (DOE 1999). At the SEP, the UHSU groundwater contains high total dissolved solids (TDS) concentrations, most notably in the immediate vicinity of the ponds and the portion of North Walnut Creek located north of the SEP. Leakage of process water concentrated by evaporation from the ponds provided a source of chemically distinct water to groundwater in the IHSS area. Concentrated water is easily distinguished from natural recharge water by its high TDS and major-ion contents (EG&G 1995c)."
	Section 3.2.2	
11	We recommend that you include summary information such as depths of samples analyzed and contamination detected at these depths to give a clearer picture of the situation in	This comment was accepted, and the various depth ranges were added to Section 3.2.2. The following text was also added: "Subsurface soil samples were collected from within the 0 to 6

	the subsurface.	foot depth interval, the 6 to 12 foot depth interval and depths greater than 12 feet. (Most samples stopped at the top of bedrock.) Samples outside the SEP were composited over 6-foot intervals, with the exception of samples for VOC analyses, which were collected at discrete 2-foot intervals. The sample intervals for collection of subsurface samples beneath the SEP were specified in TM No. 2 and varied from those subsurface samples collected outside the SEPs: • Samples composited over 2 feet intervals: Radionuclides, Target Analyte List (TAL) metals. • Samples collected 2 feet below ground and every other 2 feet, and one sample from bedrock: VOCs • Samples compositied over 4 foot intervals: Nitrate • Samples composited over 6 foot intervals: SVOCs, pesticides, PCBs, cyanide, sulfide." And this statement was added to the end of this section: "(For specific depths and concentration of contaminants, see the various tables in Appendix A of the risk assessment.)"
	Section 5.0	
12	It is unclear to what two exposure scenarios the second sentence of the fourth paragraph is referring.	This comment has been accepted and the sentence has been edited to delete a reference to two exposure scenarios (before the PAM was released for public comment).
	Section 6.0	
13	In several instances in this section (and at the end of Section 5.0), the statement, "determined not to be contaminated with hazardous waste", is used. Such a statement can only	This comment was accepted and the sentences have been modified to reflect that either the soil or liner material does not contain hazardous waste above a 1E-05 risk to a WRW (before

	be used if a determination has been made that a media does not contain a listed or characteristic waste. A determination that certain media are below a 1E-05 risk to a WRW is not a valid hazardous waste determination. These statements should probably be limited to explaining that these media do not contain hazardous waste above a 1E-05 risk to a WRW.	the PAM was released for public comment).
	Section 8.0	
14	This section should state whether there are elements of the final surface and vegetation cover the SEPs that will require maintenance to be effective.	Because a cover will not be placed over this area, regrading and revegetation will be consistent with the other areas of the Site.
	Section 9.0	
15	Some elements of the proposed best-management practice actions may impact the Solar Ponds Plume. The thickness of the unsaturated zone across the area needs to be provided along with an assessment of the evapotranspiration properties expected from the materials used to cover the site. A realistic assessment of recharge with the finished configuration should be provided, with and without breaching the liners. These assessments could be conducted with the UZ module of MIKE SHE or UNSAT-H.	In response to this comment and Rocky Flats Coalition of Local Governments (RFCLOG) comments the following paragraph has been added to Section 9.0: "When pushing in the berms, the bottom liner material will not be breached. Perching of groundwater in this area is not anticipated because a few of the ponds have cracks in the liners, some of the ponds will contain a few additional holes from lysimeters previously located within the ponds and from recent samples taken through the liners, the bottoms of the ponds are sloped to one corner, and a sandy fill material exists beneath the ponds. (The B-series ponds slope towards the northwestern corner. The A and C ponds slope towards the northeastern corner.) In addition, a majority of the sidewalls will be removed after the berms are pushed in, which will allow precipitation to flow out laterally. If, after the area is regraded and revegetated, water is observed to be perching in this area, equipment will be brought in (for example, GeoProbe ™) for

		purposes of breaching the liner material in additional locations."
	General Comments	
16	Information should be provided in the Closeout Report on type, location, depth and contaminant characterization of any pipeline left in place. Any pipelines encountered during regrading should be removed.	The information requested to be included in the Closeout Report is consistent with the type of information currently included in Closeout Reports. In addition, any pipelines encountered during regrading will be removed, as requested.
17	References to existing Tier I and Tier II action levels and proposed new WRW-based action levels is confusing. Soil below Tier I, but above new action levels need to be identified.	The purpose of including both current Tiered action levels and the new proposed soil action levels is to demonstrate that the SEPs area complies with both action levels. Clarification has been added to section 3.2 and to Table 6-1 to eliminate this confusion and to emphasize compliance with both.

	CDPHE Comments, Dated October 9, 2002 Attachment II-Human Health Risk Assessment, Solar Evaporation Ponds	**Response**
	Introduction and Purpose	
1	Page 1: It is stated that this document supports closure of the SEPs, however, closure is a risk management decision and is not the role of the risk assessment. It should instead be indicated that the risk assessment will be used as a tool by the risk manager in making remediation and/or closure decisions.	This statement was deleted.
2	Page 3-Figure 1.1: Revise title to remove "and Sampling Locations", as the sampling locations are not shown on this figure.	The Figure title was changed as suggested.
	Selection of COCs	
3	Page 6-Bottom Paragraph: Validation frequencies that are greater than 90% are not evident.	The text was change to discuss the range from 53 to 86% validated data.
4	Page 10-Section 2.2.5: The text indicates that the number of records where the RL exceeds the associated WRW PRG values is given below. This information is not evident.	The text in Section 2.1.1, Sensitivity, was changed to include this information.
5	Page 11-Last Line: The correct Section (2.x.x.) should be identified.	The text was corrected.
6	Page 12-Figure 2.2: There is an inconsistency with the title (0 to 6-inch depth) and Page 11-Surface Soil (0-2 inches). Please clarify the depths used to assess surface soil exposures.	The text was corrected. Surface soil data is defined as data from the surface to 0.5 feet or 6 inches. All samples that start within this interval are also included if their end depth is to 0.5 feet or 6 inches.

7	Page 16-Section 2.3.1: Please provide a table showing a comparison between site concentrations and western U.S. background levels of calcium, iron, magnesium, potassium and sodium.	Intakes comparison to RDAs and Western US background ranges is shown in Table 2.3.
8	Page 17-Table 2.2-Calculation of element intakes: For the majority of the elements (see ratio column in table below), a re-calculation produced values, which are 100-fold higher than those presented in the table. Overall, it should have little effect on which chemicals are carried through the risk assessment. However, the calculations should be double checked prior to finalization. For example, using a maximum concentration of 7,650 mg/kg manganese and assuming an intake of 200 mg of soil per day, an intake value of 1.53 mg/day was calculated. 7650 mg/kg * 200 mg/day * 1kg/1E06 mg = 1.53 mg/day (See also attached table, identified as Table I, which was also included with these comments.)	The intakes were reviewed and corrected as necessary.
9	Page 21-Table 2.7: Footnote for "a" is missing. Since the liner is a manmade material, it may not be appropriate it is to compare this material to soil background levels.	Liner results were compared to surface soil PRGs in Table 2.5 and Section 2.3.6 in accordance with agreements made with the regulatory agencies.
10	Page 22-Dibenzo (a,h) anthracene: Please provide a similar discussion for dibenzo (a,h) anthracene as was given for benzo (a) pyrene. (e.g., provide the summary statistics and compare to a PRG)	The additional text was added.
11	Page 22-Arsenic-Bottom of Page: The text states that there	The text was modified to indicate that arsenic was statistically

	was no evidence of arsenic contamination in the surface soil or the liner materials. However, arsenic failed the preliminary PRG screen in surface soils.	below background and was dropped as a COC.
12	Page 23-Section 2.3.7: Please provide a list of those chemicals for which no toxicity values were available.	The risk assessment only considered ALF analytes. All ALF analytes without toxicity values were listed in Table 2.15.
	Exposure Assessment	
13	Page 27-Table 3.1: Although an upcoming comment will ask that you remove this parameter from the table and reformat the equations follow those presented in the RSALs document, this parameter should be 230/365 rather than 250/365.	This was changed in Table 3.1.
14	Page 29-Third bullet-gamma-exposure time factor: This parameter will be handled differently once the equations are reformatted. Rather than having a separate parameter called Te_d, the exposure time of 4 hours per 24-hour day will be used. This results in the same value, but is just presented differently.	Daily gamma time factor is used by EPA and is now shown in the table. The daily gamma time factor is used in the risk assessment because the hours per day of exposure are needed for the occupational worker exposure to penetrating radiation.
15	Page 30-Section 3.3: This section would be better situated prior to presenting the exposure parameters.	This Section was moved to Section 3.2, ahead of Exposure Scenarios.
16	Page 32-Section 3.4: Second paragraph-Remove the word "be" from "This method was be used…" Third paragraph- The EPA reference is missing a number in the date.	The text was corrected as suggested.

17	Page 36-Table 3.4: Please revise the external radionuclide equation to match the one in the RSALs Task 3 report. Although the two equations result in the same calculated values, the nomenclature from the RSALs report should be utilized. In other words, the Te_A and Te_D parameters are no longer needed, since Te_A is essentially the ED/365 and Te_D is ET/24. There is a parameter name EV (events per day) listed in the dermal equation, which is not defined in the exposure factors table (Table 3.1 and 3.2). This parameter was apparently never used, and should therefore be removed from the equations. The table indicates that the AWF was set to 1, when it should indicate that the AUF was set to 1.	The equation was changed as suggested. The EV needs to be shown in Table 3.4 and is needed for correct units. EV was set to 1. This was noted in Table 3.4. AWF was changed to AUF.
18	Page 37-Table 3.5:Attempts to recalculate the chemical intake values presented in this table were unsuccessful. With the assumption that the HQ=intake/RfD, an intake value should be equivalent to the final HQ value (presented in Table C-3) multiplied by the RfD in Table 4.1. For example: Surface Soil Cadmium HQ (Table C-3) = 0.03 RfD (Table 4-1) = 1.00E-03 Therefore: Intake should equal 3E-05 However, the intake in Table 3-5 shows a value for cadmium of 1.1E-04.	All intakes were checked and corrected as necessary.

	A forward-going calculation of intake using all of the parameters and exposure point concentrations provided in the text was also done. The resulting intake was 2.74E-05 (or essentially still 3E-05). Please double check the source of the intake values that are presented in Tables 3.5, 3.6, C.2 and C.4. Several forward-going re-calculations resulted in the same end HQ values resulted, just not the same intakes.	
	Risk Characterization and Uncertainty	
19	Page 44-First Line: "…radionuclides are presented A." Should this say in Appendix C?	The data are presented in Appendix C.
20	Page 44-Section 5.3.1: Please identify for the reader, which chemicals constitute the RCRA chemicals summarized in the risk tables. For example, out of the COCs evaluated, only uranium is not included in the Hazard Index Summary. Perhaps a quick table could be developed that summarizes, which chemicals are incorporated into the final values.	The text was changed to identify RCRA analytes. Table 5.4 identifies risk by media, analyte, and exposure pathway.
21	Page 45-Third Paragraph: Remove the "is" from "The major contributors is to risk…"	The text was corrected.

Table I (reference comment number 6 under Appendix A-HHRA)

Chemical	Surface Soil Conc (mg/kg)		Recalculated Daily Intake (mg/kg)		Draft Final SEP RA (mg/kg)		Ratio of Recalculated to SEP values*	
	Mean	Max	Mean	Max	Mean	Max	Mean	Max
Calcium	23120	248000	4.62	49.60	0.04	0.5	115.6	99.2
Chromium	20.99	120	0.004	0.024	0.00004	0.0002	104.95	120
Copper	19.89	88.6	0.004	0.018	0.00004	0.0002	99.45	88.6
Iron	12706	27900	2.54	5.58	0.02	0.06	127.06	93
Magnesium	2570.7	6500	0.51	1.30	0.005	0.01	102.828	130
Manganese	308.8	7650	0.06	1.53	0.0006	0.02	102.9333	76.5
Molybdenum	2.36	4.95	0.0005	0.0010	0.000005	0.00001	94.4	99
Nickel	15.1	176	0.003	0.035	0.00003	0.0004	100.6667	88
Selenium	0.376	0.75	0.0001	0.0002	0.007	0.02	0.010743	0.0075
Silicon	3432.6	11300	0.69	2.26	0.000002	0.00001	343260	226000
Vanadium	29.8	67.6	0.006	0.014	0.00006	0.0001	99.33333	135.2
Zinc	64.4	460	0.013	0.092	0.0001	0.001	128.8	92

*With the exception of selenium and silicon (shaded), the ratios between the recalculated intakes and those presented in the risk assessment are 100-fold (with variation attributable to rounding)

	EPA Comments, Dated October 9, 2002 **Attachment II-Human Health Risk Assessment, Solar Evaporation Ponds**	**Response**
	Selection of COCs	
1	Page 17, Table 2.2, Comparison of Element Intake: In our previous comments DOE was asked to compare the analytes they were referring to as essential nutrients to toxicity reference values to ensure that unsafe levels were not being eliminated as COCs. The first choice of a toxicity reference value should always be the IRIS or HEAST databases. Other values, such as FDA's Recommended Daily Allowance (RDA), should be used as a last choice when no values are available from IRIS or HEAST. This hierarchy of toxicity information is described in EPA's 1989 *Risk Assessment Guidance for Superfund.* This table should be revised to be consistent with that guidance. Reference Doses and cancer slope factors are available for chromium, copper, manganese, molybdenum, nickel, selenium, vanadium and zinc. If an appropriate risk-based PRG was done elsewhere, then those analytes should be deleted from Table 2.2.	Essential nutrients with toxicity values in IRIS and HEAST were compared to ALs. Essential nutrients without toxicity values in IRIS and HEAST were compared RDAs. Table 2.3 was added to show the RDA and background comparison. In addition, the essential nutrients without toxicity values were compared to the range reported for Western US soils. All analytes were below ALs, toxicity values and RDAs and were within the reported background range.
2	Page 24, Tables 2.8, 2.9 and 2.10, Contaminants of Concern: In our previous comments of 3 September, DOE was asked to evaluate the COC distributions for normality/ lognormality prior to calculating an exposure point concentration (EPC) term. This was not done. Instead a relatively non-conservative technique was selected without demonstrating any understanding of the distribution of the data or the applicability of the bootstrap technique for the given data sets. This is not consistent with EPA policy or	The risk assessment was revised to determine the distribution for each analyte as requested, and described by EPA 1992 guidance. Tables (Table s 2.8 through 2.13) with results of the distributional testing and the process used are documented in the risk assessment. Transformed and non-transformed data were evaluated. A Data Adequacy Evaluation was performed and submitted as Attachment I to the PAM. Use of the Bootstrap non-parametric

	sound environmental statistics. The first step is to evaluate the data for normality or lognormality. This can be done using histograms, probability plots or goodness of fit (GOF) tests. The *simplest* way to do this is to use the W test for data sets with n< or =50, or D'Agosino's test when n is between 50 and 1000. Use an alpha = 0.05. If the distribution is normal (or lognormal using the transformed data), the EPA 1992 guidance should be used to calculate the EPC. If the distribution is neither normal or lognormal, the bootstrap-t method or a distribution specific method can be used to calculate the EPC. This process **must** be documented in the risk assessment. Tables must be provided showing the results of the GOF tests on both the transformed and non-transformed data and the statistical significance. The most serious shortcoming of the bootstrap method is that the simulations are bound by the minimum and maximum detected concentrations. If sample size is small (i.e., less than 30) and there is uncertainty regarding the representativeness of the data collected, the bootstrap results could underestimate the true mean concentration at a site, resulting in erroneous decisions of "no risk". From Tables 2.8-2.10 it appears that the surface and subsurface data sets have an adequate number of samples, however, the liners do not. A bootstrap method should not be applied to an *n* of 15.	re-sampling method to determine UCLs is consistent with recent EPA guidance and discussed by EPA as a viable technique. This technique is not necessarily non-conservative and the Data Adequacy Evaluation demonstrated this for the surface soils that dominate risk at the SEP. All statistical tests are bounded by minimum and maximum detected concentrations, so this is not a constraint unique to Bootstrap. However, we agree that the Bootstrap should not be used with small sample sizes less than n = 30. Recent EPA (1997 and 2002) guidance discusses the limitations of using an assumption of lognormality to quantify UCLs and reaching decisions based on log-transformed data. Non-parametric tests including the Bootstrap and Geostatistics are specifically discussed in recent EPA guidance and are recommended when distributional assumptions are questionable or when there is an evident spatial pattern. Even an apparent lognormal distribution may not be truly lognormal due to the presence of multiple populations in the observed data. Thus, use of lognormal UCLs can greatly overestimate or underestimate the true mean and it's associated variance. This was observed in the Data Adequacy Evaluation, Attachment I of the PAM. Ref: EPA 1997. Technology Support Center. The Lognormal Distribution in Environmental Applications. Ref: EPA 2002. Calculating Exposure Point Concentrations at Hazardous Waste Sites.
3	Page 27, Table 3.1 and Table 3.2: In our previous comments	The equations are consistent with EPA *2000 Soil Screening*

	of September 3rd, we asked DOE to use the same equations for calculating radionuclide risk which were used in the Task 3 report and which are specified in EPA's *2000 Soil Screening Guidance for Radionuclides*. This still has not been done. The gamma exposure factors listed in Tables 3.1 and Table 3.2 are variables in the older, outdated equations, not the newer ones. A footnote should be added for the dermal adherence factor explaining what it is based on since it is not a recommended default value in the EPA guidance (e.g., 95th percentile for grounds keepers). A footnote should be added for the surface area factor explaining what it is based on (e.g., 50th percentile for men and women for hands, forearms, and faces).	*Guidance for Radionuclides*. The exact equations in the EPA *2000 Soil Screening Guidance for Radionuclides* or the Task 3 report cannot be used because these equations are for continuous exposure and the WRW has a limited occupational exposure of 8/24 hours per day. Subsequent discussions resulted in corrections to the RSAL equations to limit worker gamma exposure from the continuous exposure used in the RSAL report. Based on EPA 2001 guidance, a weighted soil dermal adherence factor (AF_d) of 0.1 was used. This was based on the upper 95% value for a groundskeeper and a geometric mean for a commercial gardener. This text was added. The surface area factor, 4,260 cm^2, was used based on EPA 1997 guidance. The upper 95% value for head, forearms, and hands was used. Text was added to clarify this concept.
4	Page 29, 3rd bullet: See comment #4 above.	The text was changed as discussed in Response 2 above.
5	Table 3.4, Intake Equations: The inhalation risk equations for radionuclides, carcinogens and non-carcinogens have one too man Exposure Time (ET) variables. One of them has to go. The dermal equation for non-carcinogens is missing an exposure frequency (EF) and exposure duration (ED) variable. The external equation for radionuclides is outdated and	ETo was removed from the equation because it was set to 1.0. The text was corrected. The external equation for radionuclides is current and consistent with EPA and other federal guidance. The equation in the Task

	inconsistent with the Task 3 report.	3 report could not be used as presented for the worker, because this equation is for continuous residential exposure.
6	Page 40, Dermal Exposure to Chemicals: The last sentence in this section states that because no adjustments were made to the toxicity values when assessing dermal exposure, this adds conservatism to the assessment. This is incorrect. The reverse is true. By using a default value of complete (i.e., 100%) oral absorption you are actually <u>underestimating</u> risk (Risk Assessment Guidance for Superfund, Part A (Appendix A.1) and Part E (page 4.4)). This should be noted and the section on page 40 revised accordingly. If desired, the oral toxicity factors can be adjusted based on GI absorption for assessing dermal exposure. It would make the assessment more technically accurate.	The text was corrected in Section 4.0.

	RFCAB Comments, Dated November 7, 2002	Response
	CHARACTERIZATION: Attachment 1, the Data Adequacy Evaluation, concludes: "Statistical and spatial analyses both indicate that the sampling at the SEPs is adequate, especially in view of the low estimated risk observed."	
1	Although some new soil samples were taken near valve vaults, sumps, potential OPWL leaks, and RCRA Units 21 and 48, the site is depending on historical data in order to characterize the liners and the soil beneath the ponds and around the pond berms. Per maps provided in the risk assessment, one of five ponds (Pond B-South) had no subsurface characterization at all, and another (Pond C) had characterization only in the depth profile perhaps due to leakage. Pond C is in the vicinity of an original unlined pond, whose soils were regraded and possibly incorporated into the berms of Pond C at the time of its construction in 1970. In terms of historical sampling, how were sample density and location determined, and why were the areas noted above excluded?	Sampling strategies and methodologies for OU 4/IHSS 101, SEP are documented in the Final Phase I RFI/RI Workplan, dated January 1992, Revision 1 dated May 1992 (Administrative Record Number OU04-A-000172 (approved by CDH and EPA on May 8, 1992, OU04-A-000147). In addition, based on significant comments from both CDH and EPA, two Technical Memorandums (TMs) were written to clarify how sampling would be conducted. (TM No. 1-Vadose Zone Investigation, December 1992 [OU04-A-000241] and TM No. 2-Modification to Field Activities, May 1993 [OU04-A-000648]. Based on these documents and comment responses, the types of samples collected and locations/sample density that were agreed upon between CDH, EPA, and DOE are as follows: <u>Surface Soil</u> Based on a review of the 1989 soil sampling data, contamination around the ponds indicated aerosol dispersion existed from the ponds. This observation prompted an OU 4-wide surficial radiological survey for alpha and beta/gamma radiation. Based on these results, surface sampling was divided into two sampling sets: 10 surface soil samples were to be collected in areas exhibiting the highest radiological levels found during the survey, in areas where data gaps existed and where seeps were encountered; and 25 surface soil samples were to be collected in randomly chosen locations throughout the OU 4 area.

		<u>Subsurface Soil and Liner Material</u> - A geophysical investigation was conducted to locate buried lines and structures and distinguish between unconsolidated/consolidated material. - Vadose zone monitoring was conducted to determine infiltration characteristics, identify perched water horizons and characterize vadose water quality. - Borings were placed to characterize lithologies, soil, and chemistry, as well as to identify the old clay liner, depth to groundwater and bedrock; migration pathways; and patterns of leakage. - Unconsolidated soil sampling was conducted under the ponds, in areas surrounding the ponds and in the vicinity of the Interceptor Trench System (ITS). - Agencies agreed to place 48 boreholes as follows: 4 within the original pond area, 26 within the existing pond area, and 18 within the ITS area and the remainder of the OU. - It was agreed that three borings would be placed within each pond, except for the A pond, which would have six. Liner material and subsurface soil samples were to be collected. At this time Ponds 207-C and 207-B-South still contained liquids and it was agreed to postpone placement of these borings. - In April 1995, the C pond still contained some liquids; however, three borings were placed into this pond (locations 48195, 48295, and 48395). Samples were collected of liner material and subsurface soil at depths of 0-0.5, 0.5-2.5, 2.5-4.5, and 4.5-6.0 feet (IA-A-000335). These data were

		included in the risk assessment. Although Attachment I of the draft PAM indicates the data were not validated, the data were used in the risk assessment because the data were not rejected. - Based on a January 4, 1995, letter from CDPHE, Ponds 207-A and all of the B-series ponds were considered "empty" (I101-A-000288). - Based on the sampling results of the Phase I RFI/RI, a draft IM/IRA was written in February 1995. Based on comments to this IM/IRA from CDPHE dated April 11, 1995, CDPHE requested the IM/IRA to clarify that drilling beneath Pond 207-B South was no longer planned. The liner of this pond demonstrated integrity that precluded the need for additional RFI/RI investigation (I101-A-000289).
2	RFCAB recommends that the site not rely solely on historical data for the pond liners, berms and soil beneath the ponds. New samples should be taken in order to better characterize these areas. Similar to the 903 Pad remediation project, the samples should be independently verified. While the Data Adequacy Evaluation concluded that sampling was adequate to show with 95% confidence that residual contamination does not pose unacceptable risk to a hypothetical refuge worker, it does not speak to the question of whether more sampling is needed to analyze contaminant migration potential and impacts to surface water. RFCAB feels additional sampling would be of value for long-term stewardship purposes.	Based on the discussions and comments on the Phase I RFI/RI Work Plan and on TMs No. 1 and 2 as referenced in the response to comment 1, extensive sampling has been performed to characterize contaminant migration pursuant to the RFI/RI. In addition, once all comments and changes were made to these documents to ensure adequate characterization was performed, including the identification of migration pathways, all of these documents were approved by both regulatory agencies. In addition, no such sources in the soil were identified that could potentially leach contaminants and impact surface water via vadose zone transport. Groundwater data confirm that the uranium and past tritium plumes are disperse, dilute, and generalized. Thus, the existing plumes are not indicative of discrete soil source terms at the SEP. In addition, key COCs that drive risk (Am-241, U-235, and U-238) are radionuclides with

		fairly high partition coefficients and are relatively immobile. Finally, an existing treatment system is in place to intercept and capture any contaminants from the ponds prior to impacting surface water.
3	It does not appear that the area was surveyed for radionuclides with field instruments. Given the relatively small size of the area, RFCAB recommends that DOE look into the feasibility of doing field surveys to provide additional assurance that all surface soil hotspots have been detected and remediated.	Please see response to Comment No. 1. An OU 4-wide surficial radiological survey for alpha and beta/gamma radiation was conducted to determine the lacement of several surface soil samples historically. However, use of more portable detection equipment would not be possible given the instrument sensitivity and weak gamma emissions from Am-241 of 60 kev at 36% occurrence. Am-241 also has a low Gamma Ray Dose Constant of 8.479E-05 (mSv/h)/MBq. An adequate number of surface soil samples have already been collected across the SEP area, including the ponds themselves. Additional samples have subsequently been collected as part of the RSOP effort and removal of hot spots. No additional hot spots were observed during RSOP sampling.
4	Although regrading of the area is considered a best management practice, and therefore, outside the scope of the decision document, there exists the potential to expose contaminants in the process. RFCAB recommends that any potentially contaminated subsurface soil to be exposed by regrading be characterized to show that the resultant surface contamination is below action levels. An example of this is soil currently beneath the liners that will be exposed when the liners on the slopes of the berms are peeled back. Likewise, if there are areas where Old Process Waste Lines (OPWL) or other subsurface features are brought near the surface by regrading, these should be analyzed for possible removal consistent with the proposed	Historical sampling beneath the liners has shown concentrations to be below current ALs. In addition, the berms will be pushed in and the entire area will be regraded with fill material. There will be no subsurface soil exposed at the surface. Also, during field activities involving peeling back the liners, radiological control technicians (RCT's) have randomly surveyed field equipment periodically each day to ensure elevated levels of contamination have not been encountered. The liners have very little risk and will be completely covered with berm soil. A very low risk was also associated with subsurface soil with a maximum Am-241 concentration of 6.1 pCi/g. Confirmation samples will be collected on the final

	end state strategy.	graded surface following remediation to verify that no hot spots remain. The attached Table I summarizes risk associated with various pond media. OPWL, line P-26 (IHSS 149.1), was encountered while pushing in the north berm of Pond 207-A. This line was removed back to the western side of Pond 207-A, the end was grouted and coordinates were taken. This information will be included in the closeout report for ER RSOP activities. The pipe debris will be shipped offsite as low-level mixed waste. No other lines or subsurface features have been encountered.
5	How was characterization performed on OPWLs removed under the ER RSOP actions and for what constituents? These results should be made available to the public, especially in view of their relevance to the end state discussions.	Soil surrounding the OPWL in the SEP AOC was sampled in accordance with IASAP Addendum #IA-02-07. Soil was sampled at approximately 3 feet below the surface and analyzed for radionuclides, metals and nitrates. Typically OPWL waste lines < 3 feet below grade were removed and a characterization sample was collected. All of these results will be available in the closeout report.
	LONG-TERM STEWARDSHIP	
6	Section 8.0 on Stewardship runs counter to DOE draft policy, which states, "long-term" stewardship is considered in each decision that impacts DOE cleanup. This responsibility extends from the identification or remedial alternatives, remedial design, construction, and operation and through all relevant decisions made over the lifetime of the hazards." (Version 2.0 of Draft Long-Term Stewardship Strategic Plan)	The Stewardship section (Section 8.0) was revised and has been reviewed by the regulatory agencies. The groundwater treatment system will be addressed in the Industrial Area Plume IM/IRA.

	RFCAB urges DOE to analyze potential impacts of residual soil contamination on the groundwater treatment system. Are there secondary source removal actions that could be taken to enhance the effectiveness of the groundwater treatment system, or to reduce the life cycle costs of maintaining it? A more robust analysis is needed in accordance with DOE's commitment to consider long-term stewardship when making remedial decions.	
7	Section 8.0 purports to address prospective long-term stewardship needs, but does so inadequately. Only the need for institutional controls is specified, and even then, there is no mention of digging restrictions. Other factors that should be considered include physical controls, physical inspections, monitoring/maintenance, information management, periodic assessment and controlling authority, much as was done in the "Present Landfill Interim Measure/Interim Remedial Action." RFCAB urges DOE to be as specific as possible regarding stewardship requirements. RFCAB would like to examine life cycle cost estimates for these requirements as they are being developed.	The following text was added to the stewardship section : "Because the risk assessment results indicate environmental risks are below regulatory requirements and potential groundwater impacts are mitigated by the treatment system, the long-term stewardship actions and recommendations for the SEP AOC are as follows: 1. Continue Federal ownership and control over the site; 2. Implement land use restrictions to prevent soil excavation that could access or disturb residual contamination. Specific land use restrictions will be discussed in the Site Long-Term Stewardship Plan and evaluated along with other institutional controls for implementation in the final remedy selection process; 3. Maintain the groundwater treatment system; 4. Restrict groundwater use; 5. Review groundwater and surface water monitoring stations near the SEP when long-term monitoring options are

		evaluated; and 6. Maintain environmental data and other relevant data. These recommendations may change based upon other future Site remedial activities." Life cycle cost estimates for long-term stewardship requirements will be determined as part of the Long-Term Stewardship Plan."
8	RFCAB understands that a closeout report will be prepared for the Solar Ponds PAM. It should integrate stewardship information for the area as a whole, including not only soil but groundwater and surface water as well, into a single document. It should also include information on the asphalt liners that have been left in place, so that future stewards will be aware that these may require additional breaching should drainage problems arise.	The closeout report is specific to the actions taken in accordance with ER RSOP Notification #02-08. The closeout report does not include information on liners; this information is in the PAM. The stewardship section of the closeout report is specific to the actions taken in accordance with ER RSOP Notification #02-08.
9	The closeout report should also include maps showing residual contamination on the surface, as well as maps correlating contamination with depth. Sampling results from OPWL leaks should be noted, as well as the depths of OPWLs left in place. We recognize this list of criteria for the closeout report to be incomplete and request the opportunity to provide comment on the report prior to regulatory approval.	The closeout report will include maps of residual contamination at the areas where actions were taken in accordance with ER RSOP Notification #02-08. Sampling results from potential OPWL leaks will be included in the closeout report.
	SEGREGATION OF ENVIRONMENTAL MEDIA	
10	The Solar Evaporation Ponds area provides another example of how dividing a remedy into separate media discourages evaluating the system as a whole. For	A general review of groundwater contaminants in relation to subsurface soil concentrations of these contaminants was performed prior to the writing of this PAM. The specific

	instance, a groundwater remedy for the Solar Ponds area was selected as part of a separate decision process three years ago with no analysis of whether soil removal might enhance groundwater quality over the long term. The Solar Ponds PAM examines soil removal in the context of protecting a future refuge worker, but does not analyze soil removal for the purpose of protecting groundwater and surface water. As stated in comments made recently on other remedial decisions, namely the 903 Pad Soil Removal and the Present Landfill Cover, RFCAB continues to believe DOE would derive benefit from examining all aspects of a remedy at once.	purpose of this review was to determine whether additional soil removal was necessary to protect groundwater beyond that of the current SPP collection and treatment system. A portion of this information was provided in Section 3.1 of the PAM. As additional consideration, the Actinide Migration Evaluation Advisory Group addressed the issue of potential uranium source term associated with the old and new Solar Evaporation Ponds, as documented in the January 8-9, 2001 Meeting Minutes (available on Environmental Data Dynamic Information Exchange [EDDIE] under document archive). "…In general, the U concentrations found in and around the sites ponds were very low, and in the pCi/g (soil) or pCi/L (water) range…Most important is the fact that the soil cores were sampled all the way down to the bedrock layer, and in no case was a large deposit of Uranium observed…. It appears that there is in fact, only a small quantity of U present. This is consistent with the geochemical modeling results of Ball (2000) that suggested that groundwater samples near the Sites ponds were all under-saturated with respect to common U solids. Therefore, the observed retardation of U relative to nitrate is more consistent with sorption/desorption processes. This is also consistent with our expectations for U geochemical behavior, namely that it will be relatively soluble and mobile under the soil and groundwater conditions at RFETS. The fact that only a small amount of U present beneath the Sites ponds suggests that the reactive barrier presently installed downslope of the Sites ponds should continue to capture and remediate U as an ancillary role to the treatment of nitrate."

		The following sentence has been added to section 3.2.2, 4th paragraph: "Uranium contamination exists as a large dispersed area of very low concentrations beneath and to the north of the SEPs, and no discrete secondary source of uranium is apparent (Kaiser-Hill, 2001)."
	CONSISTENCY WITH END STATE PROPOSAL	
11	The end state proposal involves applying a risk screen to subsurface contamination in order to evaluate the potential of erosion/landslide activity and burrowing animals to bring contaminants to the surface. Likewise, the potential impact of residual contamination on surface water quality must be analyzed. Please describe how the Solar Ponds remedial decision considered the factors noted above. This is not to be viewed as RFCAB endorsement of the risk screen methodology, as Board deliberations on the proposal are still pending.	It is noted that the SEP AOC remedial decision is not based on the proposed risk screen, but rather on the risk assessment. The risk screen will not be implemented until formally incorporated into RFCA. However, for purposes of the SEP AOC, the following is provided: The risk screen identified in this comment relates to Screen 2 as referenced in Figure 3 of the Revised RFCA Attachment 5 (DOE, et al. 2002). Screen 1 asks "Are COC concentrations below Table 3 Soil Action Levels for the WRW?" The answer is "Yes" for the SEP COCs. Therefore, Screens 2, 3 and 4 are skipped leading directly to Screen 5. Screen 5 asks, "Are COC concentrations below Table 3 Soil Action Levels for ecological receptors?". The answer is "Yes" for COCs. Lead (a non-COC) is the only constituent in which the surface soil concentration (121 mg/kg) exceeds the ecological receptor AL (97.7 mg/kg). However, after consultation, it was determined not to be an impact to target species. The last screen, Screen 6 asks "Is there a potential to exceed Surface Water Standards at a POC?" The answer is "No", because a treatment system has been installed, and points of evaluation SW093 and GS10 monitor this area. In addition, Pond A-4 is the detention pond within Segment 5 for North

		Walnut Creek and Pond B-5 is the detention pond on South Walnut Creek. Any runoff from this area is sampled and analyzed in these ponds to determine water quality and ensure downstream standards are met. Based on the COCs for the SEPs, these constituents have not been a concern for these monitoring areas. Therefore, based on the soil risk screen process, no further accelerated action is required. This process is summarized in Table 6-1 of the PAM.
	CONSTITUENTS OF CONCERN	
12	The list of potential constituents of concern in this PAM is much smaller than that considered in the 1995 IM/IRA (a document that was never approved). RFCAB understands that this discrepancy stems from the fact that the RFCA parties have developed a new process for determining constituents of concern. Where is the new process documented? Was it the result of new regulatory guidance? Was it subject to public review?	The COC selection process is documented in the Risk Assessment (RA) on pages 14-22. A flow chart is shown on page 15. This selection process has been extensively discussed with the regulatory agencies. The current COC selection process has evolved since 1995 and now utilizes more current statistical methods discussed by EPA guidance: EPA, 2001, Risk Assessment Guidance for Superfund (RAGS) Volume 3 Part A, Characterizing Variability and Uncertainty in the Concentration Term, December. EPA, 2002, Calculating Exposure Point Concentrations at Hazardous Waste Sites, OSWER 9285.6-10, July. EPA, 1997, The Lognormal Distribution in Environmental Applications, Technical Support Center, December. In addition, the Data Adequacy (Attachment I) discusses these

		issues as they relate to the SEP.
	HOTSPOT REMOVAL	
13	Although RFCAB has not yet taken a position on the proposed action levels, we commend DOE for the common-sense approach used for hotspot removal at the Solar Ponds area. That is, RFCAB understands that surface soil hotspots in excess of proposed action levels were simply removed, regardless of size. RFCAB prefers simple removal to the complex, area-weighted approach spelled out in the Industrial Area Sampling and Analysis Plan, whereby small hot spots may not qualify for removal. RFCAB appreciates the maps provided separately showing hot spots removed under the ER RSOP. These should be added to the Solar Ponds PAM because of their relevance to a no further action decision. In addition, RFCAB recommends that DOE provide maps showing residual contaminant levels for each contaminant of concern, and include them in the closeout report.	The closeout report will include maps of residual contamination at areas where actions were taken in accordance with ER RSOP Notification #02-08.
	BUDGET	
14	The Closure Project Baseline estimates over six million dollars will be spent on the Solar Ponds source removal activities. With the proposed "No Further Action," DOE may stand to save a great deal of money on this project. If this proves to be the case, RFCAB recommends that these funds be put towards remediation at other areas of the site.	The completion of the SEP closure at a lower cost than originally estimated only means that the unused estimated resources may be available to accomplish and perhaps accelerate the overall Rocky Flats closure project. However, there is no direct tie from SEP savings to other Environmental Restoration projects. There are a number of Environmental Restoration projects currently unfunded in Fiscal Year 2003. Actual budgeted resources that become available because they were not expended on Solar Ponds closure (and other work that is accomplished under budget) may allow currently unfunded

		Environmental Restoration projects or other higher priority unfunded work to proceed. Such savings may also be needed to accomplish scheduled and funded work that costs more than originally estimated.
	DETAILED COMMENTS ON THE DECISION DOCUMENT	
15	PAM, Page 19, ¶ #8: "During 1992, a brief investigation was performed to determine if the 207B-Series Ponds were leaking into the uppermost aquifer. This was accomplished by sampling wells in the vicinity of the SEPs for a dye that was placed in the SEPs. Based on the study, it was determined that no leakage was occurring from the 207 B-Series Ponds." It should be pointed out that this study represents a snapshot in time and does not prove that the B-series Ponds have never leaked. In fact, according to the 1995 Proposed IM/IRA, "the subsurface PCOCs generally appear to be higher in the subgrade samples beneath the northern side of SEP 207-B than the other two SEPs sampled (Ponds A and B-Center)…" (Page II.3-20)	The IM/IRA is accurate in stating that the subsurface PCOCs are higher on the northern side of pond 207-B North than the other two (Pond 207-A and Pond 207-B Center). Indicating contamination was flowing to the north from these ponds. Based on the sampling results of the Phase I RFI/RI, a draft IM/IRA was written in February 1995. Based on comments to this IM/IRA from CDPHE dated April 11, 1995, CDPHE requested the IM/IRA clarify that drilling beneath Pond 207-B South was no longer planned. "The liner of this pond demonstrated integrity that precluded the need for additional RFI/RI investigation" (Administrative Record Number I101-A-000289). However, for purposes of long term stewardship, soil samples beneath Pond 207-B South will be collected.
16	PAM, Page 31, Second ¶: "Based on historical data, uranium and nitrate concentrations in surface soil and subsurface soil are all below RFCA Tier I and Tier II action levels. In addition, lithium, nickel and selenium are also below Tier I and Tier II action levels in both surface and subsurface soil. Therefore, no additional soil removal is required for	Please see Response to Comment 10.

	purposes of reducing the long-term stewardship obligations of the SPP treatment systems." RFCA soil action levels have been calculated based on acceptable exposure to a future user of the site (i.e., a refuge worker) and are not necessarily protective of groundwater or surface water. Because RFCA soil action levels were not designed to be protective of surface water via groundwater, they are not a valid basis for this determination. Indeed, uranium in the subsurface soil has contributed to a groundwater plume despite being largely below the RFCA soil action levels. Although the primary source, pond sludge, was completely removed by 1995, there is still the issue of what constitutes a potential secondary source of groundwater contamination. That is, are there elevated concentrations of uranium in subsurface soil whose removal would be expected to reduce the necessary operating life of the groundwater treatment system? A subsurface leachability model would likely be needed to answer this question.	
17	PAM, Page 44 Section 7.0, Environmental Impacts "Implementing Best Management Practices means that about 35,000 cubic yards of soil will be brought into this area." Has DOE analyzed the effect the added weight of this material might have, if any, on the stability of the hillside? The "OU 4 Proposed IM/IRA Decision Document" dated February 10, 1995 states that a 1970 study concluded the steep slope north of the Solar Ponds to be "at high risk of	The final contour for this area has taken into consideration the long-term stability of the north hillside. In phase II, the toe of the berms for each pond on the north slope (Ponds 207-A, 207-B North, and 207-C) was pushed back to the south approximately 60 feet to the natural existing slope. The new crest or high point is established at that point to relieve overburden stresses along the hillside slope. With the crest or high point moved to the south, it will provide greater stability for the slope and minimize

	failure." (Page II.1-6). To what extent does the stability of the area depend on the interceptor trench system, which removes groundwater from the hillside?	erosion.
18	PAM, Page 44, Section 9.0, Best Management Practices: This section should weigh the possible impacts, both beneficial and adverse, of not further disrupting the liners.	The following paragraph has been added to Section 9.0: "When pushing in the berms, the bottom liner material will not be breached. Perching of groundwater in this area is not anticipated because a few of the ponds have cracks in the liners, some of the ponds will contain a few additional holes from lysimeters previously located within the ponds, the bottoms of the ponds are sloped to one corner, and a sandy fill material exists beneath the ponds. (The B-series ponds slope towards the northwestern corner. A and C ponds slope towards the northeastern corner.) In addition, a majority of the sidewalls will be removed after the berms are pushed in, which will allow precipitation to flow out laterally. If after the area is regraded and revegetated, water is observed to be perching in this area, equipment will be brought in (for example, a GeoProbe ™) for purposes of breaching the liner material in additional locations."
19	Attachment II, Page 12: Based on a review of the maps provided, very few surface soil samples appear to have been taken from the south end of the Solar Ponds area. Does runoff from this area drain through surface water monitoring station, GS10, where there have been recurring exceedances for plutonium and americium? If so, this area deserves increased scrutiny as a possible source of the surface water exceedances.	In August 2001, RFETS published the Final Source Evaluation Report for Point of Evaluation GS-10, Water Years 2000-2001 (RF/EMM/WP-01-003.UN; Revision 0) (available on EDDIE). This report investigates possible pathways that may be contributing to Pu/Am detected at GS-10. This includes the area surrounding the SEP, which indicate a majority of soil and sediment samples from the areas surrounding the SEP show Pu/Am ratios of less than 1.0. (Refer to Section 4.4 of this report.) "Considering the topography of this area (low gradient) and the relative pervious surfaces (unpaved dirt areas) it is unlikely that this area contributes runoff for most precipitation events. Although this area is likely not the current source of the

		actinides associated with the *lower Am set*, it may have been a past source of Am to S. Walnut Cr." In addition, on March 28, 2001, a gauging station GS50 was installed to monitor runoff from the southern edge of the SEP area. All the runoff measured at GS50 is tributary to GS10; consequently, GS50 also serves as a source location monitoring station for GS10. To date, very little runoff has been collected at this station. Based on flows, the SEP area is not a significant contributor to GS-10. Loads to GS-10 from this area are less than 1% for both Am and Pu. Based on the results of surface soil samples, concentrations of americium and plutonium exceeding proposed RFCA ALs were removed as hot spots in accordance with RSOP Notification # 02-08.

20	Attachment II, Page 22: There is a reference to data having significantly high values and irregular units. In "OU 4 Solar Evaporation Ponds Interim Measure/Interim Remedial Action Environmental Assessment Decision Document, February 1995, Part II, Appendix O" a result of 329,000 pCi/L for tritium in surface soil (Sample #SS00004AE) was noted and would seem to fall into this category, since surface soil results are usually represented in units of pCi/g. This data point does not appear in Table A-21 of the risk assessment. It also carries a "Y" code and may have been omitted for that reason.	Tritium was not considered a possible COC in soil. We do have H-3 results reported in pCi/L for soil and these are the correct units. These results were obtained by extracting the soil moisture. These results are much higher than water due to the residual tritium associated with the soil matrix when these samples were collected. However, we cannot use these results in a meaningful way because we would have to convert them to pCi/g and evaporation of tritium would effectively remove any source term in surface soils. However, an evaluation of H-3 data in groundwater and surface water has been completed and has been added to Section 3.1 of the PAM. It was concluded that H-3 is not a concern. "Tritium has been detected in the vicinity of the SEP in both surface soil and groundwater based on historical sampling conducted in 1991. A signature of tritium was observed around the ponds in groundwater with a maximum concentration of 13,850 pCi/L in 1991. This concentration was below the drinking water standard of 20,000 pCi/L and currently this concentration is approximately 6,300 pCi/L due to radiological decay. Vadose transport and dispersion in saturated zones should further reduce this maximum concentration. Tritium sampling has also been conducted near the SPP treatment system and the Site boundary to assess possible surface water impacts. The maximum concentration detected near the SPP treatment system in 1991 was 780 pCi/L. This detection was observed in January 1991 and exceeded the surface water standard of 500 pCi/L. Subsequent samples collected from October 1991 to February 1992 had concentrations below the surface water standard. Samples

		collected after April 1991 had tritium concentrations below detection limits. The overall averaged concentration at this location was 55 pCi/L. Tritium samples collected at the Site boundary from 1991 to 2002 had a maximum reported concentration of 13,400 pCi/L in 1991. Maximum concentrations steadily declined in the following years from 3,310 pCi/L and were below detection limits from 1999 to present day. Detection limits ranged from 150 to 180 pCi/L at the Site boundary location. The concentration of tritium in groundwater and surface water near the SEPs and for the Site as a whole are well below drinking water and surface water standards."
21	Attachment II, Page 29: "A central tendency mass loading (ML) value was used to estimate risk via inhalation over the 18.7-year exposure period. The RSALs Task 3 calculations used an upper 95th percentile value. This is appropriate for conservative action levels or PRGs." For the refuge worker and rural resident scenarios, the RSALs calculations used a probability distribution for the mass loading parameter. The distribution accounts for the increase in dust inhalation that would be observed in the aftermath of a prairie fire, based on empirical data from the wind tunnel studies. The above implies a high-end point value was used as the basis for the RSAL calculations. The statement is correct for the open space user and office worker scenarios, neither of which was deemed appropriate for setting soil action levels or PRGs.	We are aware of the RSAL probabilistic mass loading distribution. We selected the 50% value from this distribution for the RA pending evaluation and use of actual site monitoring data. The upper 95th percentile mass loading of 67 $\upsilon g/m^3$ is also a point estimate from this distribution and was used to calculate PRGs. The comment implies that the following statement made in the SEP risk assessment is false: " A central tendency mass loading (ML) value was used to estimate risk via inhalation over the 18.7-year exposure period. The RSALS Task 3 calculations used a upper 95th percentile value. This is appropriate for conservative action levels or PRGs." The September 30, 2002, Task 3 Report includes a workbook for the calculation of the refuge worker RSALs. The calculations are performed using both a probabilistic approach and point

		estimates for the parameters. The ML value chosen for the point estimate calculation is the 95th percentile of the probability distribution calculated for the Task 3 Report. As stated in the SEP risk assessment, the use of this high-end value is appropriate for ALs or PRGs, but not for a long-term, forward-looking risk assessment.
22	Attachment II, Page 37, Section 4.0 Toxicity Assessment: Acute Toxicity does not appear to have been considered in the risk assessment. Perhaps that is due to the fact that most observed contaminant concentrations are low. Even so, if there are any contaminants of concern that have acute toxicity values, these levels should be noted so that the reader can be assured that acute toxicity has been given due consideration.	Acute toxicity was considered, but no analytes with ASDR acute oral toxicity values were present at concentrations approaching the acute values. Values are provided below: **Acute Oral Toxicity Table** **Analyte: Acute Toxicity** **mg/kg/day** **mg/kg-soil** Acenaphthene Acetone Aldrin 0.002 1,400 Ammonium 0.5 350,000 Benzene Bromodichloromethane 0.04 28,000 Bromoform (Tribromomethane) 0.6 420,000 Bromomethane (Methyl bromide) alpha-Chlordane 0.001 700 bis(2-Chloroisopropyl)ether 0.3 210,000 Chloromethane (Methyl chloride) 1,4-Dichlorobenzene Dieldrin 0.000007 4.9 Diethylphthalate 7 4,900,000 Endosulfan I 0.005 3,500

		Endrin (technical) 0.002 1400 Hexachlorobenzene 0.008 5600
23	Attachment II, Page 37: "Oral and inhalation SFs (cancer slope factors) are used to characterize the potency of carcinogens. A SF is a dose-response factor used to relate carcinogenic response to chemical dose. SFs are used to estimate the upper bound probability of an individual developing cancer as a result of exposure to a potential carcinogen." Cancer slope factors published in EPA Federal Guidance Report No. 13, "Cancer Risk Coefficients for Environmental Exposure to Radionuclides," apply to an average member of the public, and are therefore central tendency estimates, not upper bound estimates as indicated above.	It is true that the radiological slope factors are central estimates in a linear model of the age-averaged, lifetime attributable radiation cancer incidence (fatal and nonfatal cancer) risk per unit of activity. The statement quoted referred to "chemical dose" and was specifically discussing slope factors for nonradionuclide carcinogens. RAGS Part A (EPA 1989) defines carcinogenic slope factors for nonradionuclides as follows: "A plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. The slope factor is used to estimate an upper-bound probability of an individual developing cancer as a result of a lifetime of exposure to a particular level of a potential carcinogen." Slope factors are conservative because they (1) assume maximum gut uptake, (2) use soluble classes for analytes to assess inhalation, and (3) assume continuous exposure over the entire duration and a 50-year committed dose following each annual intake.
24	Attachment II, Page 45: "A 50th percentile estimate developed by the RSALs Working Group was used in the risk assessment. This figure is about double the documented site average (11.8 ug/cubic meter), but 30 percent of the 95th percentile figure used by the working group for the RSALs action levels (67 ug/cubic meter). The 95th percentile value is appropriate for action levels to be used for screening, but is too conservative for a forward-looking, long-term risk	Please see response to Comment 21 discussing the mass loading coefficient. The statement was not meant to imply that the probabilistic calculations use a point estimate for the ML parameter. Point estimates were recommended in the Task 3 Report and accompanying workbooks. It is this recommended point estimate to which this statement referred. In risk assessment terminology, comparison of the environmental concentrations to a risk-based concentration for the purpose of making remedial decisions is referred to as a screen. Any assessment that does not calculate long-term risk using site-

	assessment. The effect of using multiple high-end factors in a risk assessment quickly leads to unrealistically high estimates of risk. EPA guidance recommends using a balance of high end and central tendency estimates to avoid this problem." Again, this implies incorrectly that the probabilistic RSAL calculations were based on a point estimate for the mass loading parameter. It also incorrectly refers to RSALs as screening level calculations, when, in fact, RSALs are used to make remedial decision per the RFCA.	specific data is generally referred to as a screen. We understand the probabilistic nature of the mass loading distribution and RSAL Report-derived point estimates. We acknowledge that RSAL ALs, as recently corrected for gamma exposure to the worker, will be used to guide remediation as specified in RFCA. However, the Comprehensive Risk Assessment will be used to quantify actual long-term risk estimates for all receptors following remediation based on RSAL screening levels.
25	Attachment II, Page 45 (focusing on the last part of the above paragraph): "The effect of using multiple high-end factors in a risk assessment quickly leads to unrealistically high estimates of risk. EPA guidance recommends using a balance of high end and central tendency estimates to avoid this problem." In the context of the mass loading distribution developed for the RSALs, this statement implies that the RSAL working group failed to use a balance of high end and central tendency values and thereby ran afoul of EPA guidance. Without getting into merits of the RSALs mass loading distribution (which DOE had a hand in developing), discussion of a single parameter says nothing about the overall balance of parameters selected in the RSAL calculations. Moreover, the EPA Office of Radiation and Indoor Air,	The statement concerning RSAL calculations implies nothing more than it says. Multiple high-end factors lead to over estimates of risk in a long-term forward-looking risk assessment. It was not referring to the validity of RSAL methods or results. In fact screening levels should be based on conservative assumptions. We consider the RSAL estimate of mass loading at the 95 percentile of 67 $\upsilon g/m^3$ to be conservative with respect to a long-term forward looking risk assessment. This upper-bound estimate is considered conservative because the assumption of a prairie fire was used without regard to the frequency of occurrence for such an event. In other words, a fire is assumed to occur every year that a receptor is onsite, and this is an unlikely possibility that has not been factored into the mass loading. For purposes of actually quantifying long-term risk to receptors, we therefore intend to use more realistic estimates from measured air monitoring data for the site.

	Radiation Protection Division, reviewed the RSALs Task 3 Report on behalf of EPA Headquarters. A letter to EPA Region VIII dated May 6, 2002 regarding the RSAL report stated: "The document was well thought out and the approach was based on the appropriate science." Since EPA has reviewed the RSAL report and found it to be in accordance with EPA technical guidance on risk assessment, this statement should be stricken from the PAM	Clarification will be added to the text to clearly state that we want to use realistic parameter values for the risk assessment and are using the RSAL action limits to select COCs in a conservative and justifiable manner based on a comprehensive analysis presented in the RSAL Report.
26	Attachment II, Page 45, Section 5.4.2, Uncertainties in Exposure Point Concentrations and Exposure Factors: This discussion should acknowledge that one of the largest sources of uncertainty in any risk assessment is associated with cancer slope factors, which are central tendency estimates of the potency of ga given radionuclide to cause cancer in the general population. EPA has yet to develop probability distributions that would allow risk assessors to simulate the variability of this parameter. As a result, risk assessments do not account for the fact that certain subpopulations may be more susceptible to these carcinogenic effects than is indicated by the risk factors in Federal Guidance Report 13. Quoting from the May 6, 2002 EPA letter noted above, whose comment was directed toward the RSALs Report, but applies equally to the Solar Ponds risk assessment: "It would be clearer if the report stated in a more prominent way that central estimates of slope factors were used for this analysis."	Slope factors are conservative as discussed in Comment 23. This inherent conservatism is protective of the population in general. However, a statement will be added to the risk assessment to discuss this source of uncertainty and the uncertainty associated with the inherent heterogeneity of collected soil data and their spatial distribution. As discussed in the risk assessment, conservatism was applied to every step in the risk assessment and slope factors contribute a small percentage of the total. Also as indicated, there is currently no way to estimate this uncertainty.
27	Attachment II, Page 49:	

	"Americium-241, **plutonium**, and uranium-235 in surface soils are the largest contributors to risk." "The majority of the risk was from **chromium**, americium-214, and uranium-235 in surface soil." These two statements from the Summary and Conclusions section of the risk assessment seem to contradict each other. It may be helpful to include a breakdown of risk by contaminant to clarify the apparent discrepancy.	The text will be corrected to indicate that carcinogenic risk was dominated by Am-241, Pu-239, and U-235 in surface soil with a total risk of 2E-06. Chromium dominated nonradiological carcinogenic risk with a probability of 2.7E-07. Nonradiological carcinogenic risk was approximately an order of magnitude below radiological carcinogenic risk.

Table I Percent of Total Risk by Environmental Media (Risk Estimate)

Percent of Total Risk			
Environmental Media	**NonCarcinogenic**	**Carcinogenic Risk**	
		Radiological	**Nonradiological**
Liner	0.05 (0.00002)	4.7 (1.0E-07)	No COCs
Subsurface Soil	4.8 (0.002)	1.8 (3.9E-08)	1.1 (2.9E-09)
Surface Soil	95.2 (0.04)	93.5 (2.0E-07)	98.9 (2.7E-07)
Total	100.0	100.0	100.0