INFORMATION CLEARANCE FORM

A. Information Category

- ☐ Abstract
- ☐ Summary
- ☐ Visual Aid
- ☐ Full Paper
- ☐ Other _____
- ☐ Journal Article
- ☐ Internet
- ☐ Software
- ☒ Report

B. Document Number DOE/RL-99-36

C. Title
Phase 1 RCRA Facility Investigation/Corrective Measures Study Work Plan for Single-Shell Tank Waste Management Areas

D. Internet Address

E. Required Information

1. Is document potentially Classified? ◉ No ○ Yes (MANDATORY)
   A. J. Knepp
   Manager's Signature Required
   If Yes _____ ○ No ○ Yes Classified
   ADC Signature Required
2. Internal Review Required? ○ No ◉ Yes
   If Yes, Document Signatures Below
   Counsel _____
   Program _____
3. References in the Information are Applied Technology ◉ No ○ Yes
   Export Controlled Information ◉ No ○ Yes
4. Does Information Contain the Following: (MANDATORY)
   a. New or Novel (Patentable) Subject Matter? ◉ No ○ Yes
      If "Yes", Disclosure No.: _____
   b. Information Received In Confidence, Such as Proprietary and/or Inventions?
      ◉ No ○ Yes If "Yes", Affix Appropriate Legends/Notices.
   c. Copyrights? ◉ No ○ Yes If "Yes", Attach Permission.
   d. Trademarks? ◉ No ○ Yes If "Yes", Identify in Document.
5. Is Information requiring submission to OSTI? ◉ No ○ Yes
   If Yes UC-_____ and B&R-_____
6. Release Level? ◉ Public ○ Limited
7. Charge Code 73500 110163 CA10 HMLM0351

F. Complete for a Journal Article

1. Title of Journal

G. Complete for a Presentation

1. Title for Conference or Meeting _____
2. Group Sponsoring _____
3. Date of Conference _____
4. City/State _____
5. Will Information be Published in Proceedings? ○ No ○ Yes
6. Will Material be Handed Out? ○ No ○ Yes

H. Author/Requestor
M.M. McCarthy
(Print and Sign)

Responsible Manager
A.J. Knepp
(Print and Sign)

I. Reviewers

	Yes	Print	Signature	Public Y/N (If N, complete J)
General Counsel	☒	S.D. Brumley ~~B. D. Williamson~~	2-7-00	(Y) / N
Office of External Affairs	☐			Y / N
DOE-RL	☒	R. M. Yasek		(Y) / N
Other	☐			Y / N
Other	☐			Y / N

J. If Information Includes Sensitive Information and is not to be released to the Public indicate category below.

- ☐ Applied Technology
- ☐ Personal/Private
- ☐ Proprietary
- ☐ Business-Sensitive
- ☐ Predecisional
- ☐ UCNI
- ☐ Protected CRADA
- ☐ Export Controlled
- ☐ Procurement-Sensitive
- ☐ Patentable
- ☐ Other (Specify) _____

Information Clearance Approval

APPROVED FOR RELEASE
OFFICIAL DOCUMENT
2-10-2000

K. If Additional Comments, Please Attach Separate Sheet

A-6001-401 (02/98)

DOE/RL-99-36
Rev. 0

Phase 1 RCRA Facility Investigation/Corrective Measures Study Work Plan for Single-Shell Tank Waste Management Areas

United States
Department of Energy

TRADEMARK DISCLAIMER

Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

This report has been reproduced from the best available copy.
Available in paper copy and microfiche.

Available to the U.S. Department of Energy
and its contractors from
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831
(615) 576-8401

Available to the public from the U.S. Department of Commerce
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
(703) 487-4650

Printed in the United States of America

DISCLM-5.CHP (8-91)

DOE/RL-99-36
Rev. 0

Phase 1 RCRA Facility Investigation/Corrective Measures Study Work Plan for Single-Shell Tank Waste Management Areas

August 1999

United States Department of Energy

P.O. Box 550, Richland, Washington 99352

RELEASE AUTHORIZATION

Document Number:	DOE/RL-99-36, Rev. 0
Document Title:	Phase 1 RCRA Facility Investigation/Corrective Measures Study Work Plan for Single-Shell Tank Waste Management Areas

This document, reviewed in accordance with DOE Order 241.1, "Scientific and Technical Information Management," and DOE G 241.1-1, "Guide to the Management of Scientific and Technical Information," does not contain classified or sensitive unclassified information and is:

APPROVED FOR PUBLIC RELEASE

Chris Willingham — 2/10/2000

C. Willingham — Date

Lockheed Martin Services, Inc.
Document Control / Information Clearance

Reviewed for Applied Technology, Business Sensitive, Classified, Copyrighted, Export Controlled, Patent, Personal/Private, Proprietary, Protected CRADA, Trademark, Unclassified Controlled Nuclear Information.

TRADEMARK DISCLAIMER. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof. This report has been reproduced from the best available copy.

Printed in the United States of America.

Available to the U.S. Department of Energy and its contractors from the U.S. Department of Energy Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831; Telephone: 423/576-8401.

Available to the public from the U.S. Department of Commerce National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161; Telephone: 703/487-4650.

EXECUTIVE SUMMARY

This document is the master work plan for the *Resource Conservation and Recovery Act of 1976* (RCRA) Corrective Action Program (RCAP) for single-shell tank (SST) farms at the U.S. Department of Energy's (DOE's) Hanford Site near Richland, Washington. Evidence indicates that releases at four of the seven SST waste management areas (WMAs) have impacted groundwater. The responsible Federal agency, the DOE, along with the lead regulatory agency, the Washington State Department of Ecology (Ecology), have agreed to evaluate the releases and, as appropriate, to implement corrective measures to protect human health and the environment. Because the SSTs will ultimately be closed under SST RCRA treatment, storage, and disposal (TSD) closure regulations, any near-term measures taken to address past releases will necessarily be *interim* actions, with the TSD closure process providing the avenue for *final* actions. The DOE and Ecology have also agreed to address tank waste retrieval and closure related information needs as part of this process.

As a consequence of the waste releases, Ecology and DOE negotiated RCAP milestones for conducting corrective action activities targeted at the four WMAs. Although future RCAP activities beyond those identified are not currently planned, DOE and Ecology recognized the possibility that future activities could be required and designated the currently planned activities as "Phase 1." This master work plan, an initial RCAP activity, will be supplemented by three addenda, one each for WMAs S-SX and B-BX-BY and one to address WMAs T and TX-TY. The addenda will provide the specific detailed instructions for assessment of each WMA.

As a precursor to writing this master work plan, DOE and Ecology conducted a workshop with the Tribal Nations and other key contributors to develop key work plan direction. The resulting approach streamlines development of WMA-specific documents by leveraging as much as possible on this master work plan. To support this approach, the master work plan does the following:

- Establishes the regulatory and programmatic frameworks for the overall RCAP
- Establishes process and content requirements for development of the WMA addenda and subsequent RCAP documentation
- Provides initial technical inputs for consideration when developing WMA addenda and subsequent RCAP documentation
- Provides, in a single location, materials that are common to all WMA addenda.

The regulatory framework defines the regulatory requirements and process for implementing the SST RCAP. As stipulated by the *Hanford Federal Facility Agreement and Consent Order*, the framework integrates the requirements of RCRA and the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) and identifies other applicable or relevant and appropriate requirements. The key elements of the process include this master work plan followed by the WMA addenda, WMA field investigation reports, a Phase 1 RCRA facility investigation report, and a Phase 1 corrective measures study. The corrective measure implementation plan and interim measure implementation will be conducted as appropriate.

The programmatic framework discusses the project management structure and reporting requirements and specifies integration with the various activities associated with, or occurring near, the WMAs. The integration of these activities is important to optimize the use of resources and provide an understanding of cumulative impacts. Primary integration points include planning, field activities, and evaluation of data.

The master work plan addresses process and content requirements for the RCAP activities. Planning protocols are defined for WMA characterization planning, including a requirement to follow the data quality objectives (DQO) process, and a framework for this process. As part of the DQO process, the WMA project team will evaluate what is known about each WMA to develop WMA-specific decision statements, and to design characterization programs addressing information gaps. The DQO process will include participation from DOE and Ecology. It is

anticipated that Tribal Nations and projects requiring integration may participate in the DQO process as well. This master work plan also provides annotated outlines for subsequent RCAP documentation.

To facilitate the DQO process for each WMA, and to promote consistency, this master work plan provides preliminary inputs to guide the WMA teams at various steps of the process. These include a preliminary, generalized conceptual exposure model, risk evaluation approaches, and a preliminary list of programmatic decisions that must be supported by Phase 1 RCRA facility investigation data collection.

The master work plan also provides common work plan materials (i.e., materials that would otherwise have to be repeated in each WMA addendum). Examples of this material include a discussion of the physical setting at the regional and local levels, quality assurance project plan, health and safety plan, information management plan, and waste management plan. The WMA addenda and subsequent RCAP documentation will build upon the initial technical inputs and reference the common materials as appropriate.

1

TABLE OF CONTENTS

1.0 INTRODUCTION 1-1
1.1 OVERVIEW 1-1
1.1.1 General Background 1-1
1.1.2 Overview of the Single-Shell Tank RCRA Corrective Action Program 1-2
1.1.3 Phase 1 RFI/CMS Planning Workshop and Work Plan 1-4
1.1.4 Project Management and Integration 1-4
1.1.5 Ongoing Interim Measures and Supporting Studies 1-5
1.2 PURPOSE, SCOPE, AND OBJECTIVES OF THE WORK PLAN 1-6
1.2.1 Purpose and Objectives 1-6
1.2.2 Scope 1-8
1.3 WORK PLAN ORGANIZATION 1-9

2.0 REGULATORY FRAMEWORK 2-1
2.1 REGULATORY OVERVIEW 2-1
2.1.1 Hanford Regulatory Setting 2-1
2.1.2 RCRA Overview 2-2
2.1.3 CERCLA Overview 2-8
2.1.4 AEA Overview 2-9
2.1.5 NEPA and SEPA Overview 2-11
2.1.6 Regulatory Status of the Single-Shell Tanks 2-14
2.2 SINGLE-SHELL TANK INTERIM CORRECTIVE ACTION PROCESS 2-17
2.2.1 Master Work Plan and Waste Management Area Addenda 2-17
2.2.2 Phase 1 RCRA Facility Investigation 2-19
2.2.3 Phase 1 Corrective Measures Study 2-20
2.2.4 Corrective Measures Implementation 2-21
2.2.5 Interim Measures 2-22
2.3 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS 2-23

3.0 SUMMARY OF EXISTING INFORMATION 3-1
3.1 OPERATIONAL OVERVIEW AND SOURCE OF CONTAMINATION 3-3
3.1.1 Hanford Site Background 2-2
3.1.2 Nuclear Processing and Operational History 3-3
3.1.3 History of the Single-Shell Tanks Waste Management Areas 3-4
3.1.4 Current Hanford Tank Waste Inventories 3-6
3.1.5 Tank Inventories at the Time of Leaks 3-6
3.1.6 Sources of Tank Waste Currently in the Vadose Zone 3-7
3.1.7 Leaks Associated with Single-Shell Tank Waste Storage and Operations 3-8
3.1.8 Gamma-Ray Logging and Leak Detection 3-9
3.1.9 Major Potential Contaminants 3-10

TABLE OF CONTENTS (cont.)

3.2 PHYSICAL SETTING 3-12
3.2.1 Topography of the 200 Areas 3-12
3.2.2 Meteorology of the 200 Areas 3-14
3.2.3 Hydrogeologic Setting 3-16
3.2.4 Geochemistry Summary 3-25
3.3 ENVIRONMENTAL AND CULTURAL RESOURCES 3-31
3.3.1 Plants 3-31
3.3.2 Wildlife 3-31
3.3.3 Species of Concern 3-32
3.3.4 Significance of Ecological Resources to Contaminant Fate and Transport 3-33
3.3.5 Cultural Resources 3-33
3.4 NATURE AND EXTENT OF CONTAMINATION 3-35
3.4.1 Vadose and Groundwater Contamination at Waste Management Area B-BX-BY 3-35
3.4.2 Vadose and Groundwater Contamination at Waste Management Area S-SX 3-37
3.4.3 Vadose and Groundwater Contamination at Waste Management Areas T and TX-TY 3-39
3.5 CONCEPTUAL MODEL 3-41

4.0 RISK ASSESSMENT AND PRELIMINARY IDENTIFICATION OF POTENTIAL CORRECTIVE MEASURE, RETRIEVAL, AND CLOSURE TECHNOLOGIES 4-1
4.1 RISK ASSESSMENT 4-1
4.1.1 Anticipated Land Use 4-1
4.1.2 Preliminary Conceptual Exposure Model And Risk Scenarios 4-3
4.1.3 Preliminary Corrective Measure Performance Standards 4-4
4.1.4 Preliminary Media Cleanup Standards 4-5
4.1.5 Risk Assessment Application 4-6
4.2 PRELIMINARY IDENTIFICATION OF INTERIM CORRECTIVE MEASURE TECHNOLOGIES 4-8
4.3 PRELIMINARY IDENTIFICATION OF RETRIEVAL AND CLOSURE TECHNOLOGIES 4-10
4.3.1 Waste Retrieval Technologies 4-11
4.3.2 Closure Technologies 4-11

5.0 PRELIMINARY DECISION FRAMEWORK 5-1
5.1 INTRODUCTION 5-1
5.1.1 Process for Defining Phase 1 Objectives 5-1
5.1.2 Initial Decision Framework 5-2
5.1.3 Limitations and Uncertainties 5-3
5.2 PROBLEM STATEMENT FOR PHASE 1 RCRA FACILITY INVESTIGATION AND CORRECTIVE MEASURES STUDY 5-4

TABLE OF CONTENTS (cont.)

5.3 CORRECTIVE ACTION PROGRAM DECISIONS 5-5
5.3.1 Program Overview and Goals 5-5
5.3.2 Decision CA-1: Impacts of Past Leaks 5-5
5.3.3 Decision CA-2: Corrective Measures Alternatives 5-5
5.4 RETRIEVAL DECISIONS, DECISION CRITERIA, AND DATA NEEDS 5-6
5.4.1 Program Overview and Goals 5-6
5.4.2 Decision RE-1: Impact of Retrieval Leaks 5-6
5.4.3 Decision RE-2: Waste Retrieval Technologies 5-7
5.4.4 Decision RE-3: Strategies for Sequencing Waste Retrieval 5-7
5.4.5 Decision RE-4: Leak Detection, Monitoring, and Mitigation 5-7
5.5 CLOSURE DECISIONS, DECISION CRITERIA, AND DATA NEEDS 5-8
5.5.1 Program Overview and Goals 5-9
5.5.2 Decision CL-1: Post-Retrieval Impacts 5-9
5.5.3 Decision CL-2: Closure Alternatives 5-10
5.5.4 Decision CL-3: Establish Retrieval Performance Requirements 5-10
5.6 PRIORITIZATION OF PHASE 1 RCRA FACILITY INVESTIGATION AND CORRECTIVE MEASURES STUDY CHARACTERIZATION OBJECTIVES 5-11

6.0 PROCESS APPLICATION AND TOOLS FOR WASTE MANAGEMENT AREA ASSESSMENT AND IMPLEMENTATION 6-1
6.1 CORRECTIVE ACTION PROCESS APPLICATION 6-1
6.1.1 Waste Management Area Addenda 6-1
6.1.2 Phase 1 RCRA Facility Investigation 6-3
6.1.3 Phase 1 Corrective Measure Study 6-4
6.1.4 Corrective Measures Implementation 6-5
6.1.5 Interim Measures 6-5
6.2 DATA QUALITY OBJECTIVES PROCESS 6-6
6.3 CHARACTERIZATION TECHNIQUES AND INNOVATIVE TECHNOLOGIES 6-8

7.0 PROJECT MANAGEMENT AND PROGRAMMATIC INTEGRATION 7-1
7.1 WORK BREAKDOWN STRUCTURE 7-1
7.2 PROJECT MANAGEMENT 7-2
7.2.1 Project Organization and Responsibilities 7-2
7.2.2 Work Control 7-3
7.2.3 Meetings 7-4
7.2.4 Records Management 7-4
7.2.5 Progress and Final Reports 7-5
7.2.6 Quality Assurance 7-5
7.2.7 Health and Safety 7-6
7.2.8 Community Relations 7-6

TABLE OF CONTENTS (cont.)

7.3 INTEGRATION WITH OTHER PROGRAMS AND AGENCIES 7-6
7.3.1 Groundwater/Vadose Zone Integration Project 7-7
7.3.2 Groundwater Management Project 7-8
7.3.3 200 Areas Remedial Action Assessment 7-9
7.3.4 Other Projects Under the River Protection Project 7-11
7.3.5 Other Related Hanford Site Projects 7-12
7.3.6 Other Organizations 7-13
7.4 SCHEDULE 7-13
7.5 TRIBAL NATION ROLE AND INVOLVEMENT 7-13
7.6 PUBLIC INVOLVEMENT 7-14

8.0 REFERENCES 8-1

APPENDICIES

A QUALITY ASSURANCE PROJECT PLAN ..... A-i
B GENERAL HEALTH AND SAFETY PLAN ..... B-i
C INFORMATION MANAGEMENT OVERVIEW ..... C-i
D WASTE MANAGEMENT FOR THE RCRA CORRECTIVE ACTION PROGRAM ..... D-i
E PRELIMINARY IDENTIFICATION OF CORRECTIVE MEASURE TECHNOLOGIES ..... E-i
F APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS ..... F-i
G DATA QUALITY OBJECTIVE TEMPLATES ..... G-i
H ANNOTATED OUTLINES ..... H-i
I PRELIMINARY IDENTIFICATION OF RETRIEVAL AND CLOSURE TECHNOLOGIES ..... I-i

FIGURES

1-1. Hanford Site and Area Designations. 1-13
1-2. Tank Farms and Waste Management Areas in the 200 East Area. 1-14
1-3. Tank Farms and Waste Management Areas in the 200 West Area. 1-15
1-4. Proposed Tri-Party Agreement Milestones for Corrective Actions 1-16
3-1. Hanford Site Radioactive Material Flow Diagram. 3-45
3-2. Typical Single-Shell Tank. 3-46
3-3. Waste Management Area B-BX-BY. 3-47
3-4. Waste Management Area S-SX. 3-48
3-5. Waste Management Areas T and TX-TY. 3-49
3-6. Topography of the Hanford Site. 3-50
3-7. Wind Roses at the 100-m (30-ft) Level of the Hanford Meteorological Monitoring Network, 1982-1996. 3-51
3-8. Average Daily Barometric Pressure at the Hanford Meteorological Station, 1997. 3-52
3-9. Generalized Stratigraphic Column for the Hanford Site 3-53
3-10. Geologic Cross Section – Hanford Site. 3-54
3-11. Geologic Units Present at the Water Table 3-55
3-12. Estimated Recharge at the Hanford Site from Infiltration of Precipitation and Irrigation. 3-57
3-13. Water Table Map of the Hanford Site and 200 Areas 3-59
3-14. Generalized Conceptual Model. 3-61
4-1. Hanford Future Site Uses Working Group Basemap Central Plateau Cleanup Scenario for Feasible Future: "Exclusive" with Buffer. 4-13
4-2. DOE Preferred Land-Use Alternative 4-15
4-3. Conceptual Exposure Model for the Waste Management Areas. 4-17
4-4. Hypothetical Receptor Locations for Risk Evaluation. 4-18
4-5. Risk Characterization Approach for Human Health Evaluations 4-19
4-6. Risk Characterization Approach for Environmental Evaluations. 4-20
5-1. Preliminary Identification of Decisions and Inputs. 5-13
5-2. Preliminary Identification of RCRA Corrective Action Program Decisions and Inputs. 5-15
5-3. Preliminary Identification of Single-Shell Tank Waste Retrieval Program Decisions and Inputs. 5-17
5-4. Preliminary Identification of Single-Shell Tank RCRA Closure Program Decisions and Inputs. 5-19
6-1. Data Quality Objectives Process. 6-15
7-1. Project Organization for the RCRA Corrective Action Program. 7-15
7-2. RCRA Corrective Action Program Schedule. 7-16

TABLES

2-1. Overview of the Hanford Facility Dangerous Waste Portion of the RCRA Permit for the Treatment, Storage, and Disposal of Dangerous Waste. 2-20
2-2. Single-Shell Tank System Waste Management Areas, Associated Treatment, Storage, and Disposal Units, and Operable Unit Assignment 2-21
3-1. Single-Shell Tanks, Associated Facilities and Adjacent Waste Sites 3-63
3-2. Fuel Reprocessing Waste Intentionally Discharged to the Ground from Single-Shell Tanks 3-65
3-3. Uranium Recovery Tank Waste Intentionally Discharged to the Ground 3-66
3-4. Potential Radionuclides of Concern in the 200 Areas 3-67
3-5. Master List of Organics and Inorganics for the RCRA Corrective Action Program 3-69
3-6. Average Monthly Temperatures by Season 3-71
3-7. Monthly Average Precipitation by Season 3-71
3-8. Statistical Characteristics of the Sitewide Background Data for Nonradioactive Analytes 3-71
3-9. Selected Values for the Sitewide Background Radionuclide Data Set (pCi/g) 3-73
3-10. Root Penetration and Burrowing Depths of Selected 200 Area Wildlife and Plant Species 3-74
4-1. Typical Human Health Risk Assessment Input Parameters 4-21
7-1. Summary of RCAP Integration Points 7-17

ACRONYMS

AAMS	aggregate area management study
AEA	*Atomic Energy Act of 1954*
ACL	alternate concentration limit
ALE	Fitzner-Eberhardt Arid Lands Ecology Reserve
amsl	above mean sea level
ARAR	applicable or relevant and appropriate requirement
AWQC	ambient water quality criteria
BBI	best-basis inventory
BFMS	Baseline Funds Management System
BMP	best management practice
CAP	corrective action program
CEC	cation exchange capacity
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
CMI	corrective measures implementation
CMS	corrective measures study
COPC	contaminant of potential concern
CWC	Central Waste Complex
CX	categorical exclusion
DOE	U.S. Department of Energy
DOE-GJO	U.S. Department of Energy, Grand Junction Project Office
dpm	disintegrations per minute
DQA	data quality assessment
DQO	data quality objective
DST	double-shell tank
EA	environmental assessment
Ecology	Washington State Department of Ecology
EFT	Effluent Treatment Facility
EIS	environmental impact statement
EMI	electromagnetic induction
EPA	U.S. Environmental Protection Agency
ER	environmental restoration
ERC	Environmental Restoration Contractor
ERDF	Environmental Restoration Disposal Facility
FS	feasibility study
FSUWG	Future Site Uses Working Group
FY	fiscal year
GPH	ground-penetrating holography
GPR	ground-penetrating radar
GRA	general response action
GW/VZ	groundwater/vadose zone
HASP	health and safety plan
HEIS	Hanford Environmental Information System

HLAN	Hanford Site local area network
HLW	high-level waste
HMS	Hanford Meteorological Station
HPG	high-purity germanium
HRA-EIS	*Hanford Remedial Action-Environmental Impact Statement*
HSRAM	Hanford Site Assessment Methodology
HSRCM	*Hanford Site Radiological Control Manual*
HSWA	*Hazardous and Solid Waste Amendments of 1984*
HTRW	hazardous, toxic, and radiological work breakdown structure
HWMA	*Hazardous Waste Management Act*
ICM	interim corrective measure
ILAW	immobilized low-activity waste
IM	interim measure
ITRD	Innovative Treatment Remedial Demonstration
K_d	distribution coefficient
LDMM	leak detection, monitoring, and mitigation
LERF	Liquid Effluent Retention Facility
LIBS	laser-induced breakdown spectroscopy
LMHC	Lockheed Martin Hanford Company
MCL	maximum contaminant level
MTCA	*Model Toxics Control Act*
MYWP	multi-year work plan
NCP	*National Oil and Hazardous Substance Contingency Plan*
NEPA	*National Environmental Policy Act of 1969*
NRC	U.S. Nuclear Regulatory Commission
NPL	National Priorities List
NRDWL	Nonradioactive Dangerous Waste Landfill
O&M	operation and maintenance
Oregon Energy	Oregon Office of Energy
ORP	U.S. Department of Energy Hanford Office of River Protection
OU	operable unit
PA	programmatic agreement
PHMC	Project Hanford Management Contractor
PSR	process summary report
PUREX	plutonium/uranium extraction
QA	quality assurance
QAPjP	quality assurance project plan
QC	quality control
RA	remedial action
RAWP	remedial action work plan
RCAP	RCRA Corrective Action Program
RCRA	*Resource Conservation and Recovery Act of 1976*
RCW	*Revised Code of Washington*
RDR	remedial design report
REDOX	reduction oxidation
R_d	contaminant retardation factor

RFA	RCRA facility assessment
RFI	RCRA facility investigation
RI	remedial investigation
RL	U.S. Department of Energy, Richland Operations Office
ROD	Record of Decision
RPP	River Protection Project
S&T	science and technology
SAC	system assessment capability
SAP	sampling and analysis plan
SEPA	*State Environmental Policy Act*
SST	single-shell tank
STCG	Site Technology Coordination Group
SWMU	solid waste management unit
TBC	to be considered
TEDF	Treatment Effluent Disposal Facility
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
Tri-Parties	U.S. Department of Energy, Richland Operations Office; U.S. Environmental Protection Agency; and Washington State Department of Ecology
TRU	transuranic
TSD	treatment, storage, and disposal
TWINS	Tank Waste Information Network System
TWRS	Tank Waste Remediation System
UNH	uranyl nitrate hexahydrate
URP	Uranium Recovery Project
WAC	*Washington Administrative Code*
WBS	work breakdown structure
WIDS	Waste Inventory Data System
WMA	waste management area
WRAP	Waste Retrieval and Processing (Facility)
WSTRS	*Waste Status and Transaction Record Summary*

METRIC CONVERSION CHART

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

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

1.0 INTRODUCTION

This document is the master work plan for the *Resource Conservation and Recovery Act of 1976* (RCRA) Corrective Action Program (RCAP) for single-shell tank (SST) farms at the U.S. Department of Energy's (DOE's) Hanford Site. The DOE Office of River Protection (ORP)[1] initiated the RCAP to address the impacts of past and potential future tank waste releases to the environment. This work plan defines RCAP activities for the four SST waste management areas (WMAs) at which releases have contaminated groundwater. Recognizing the potential need for future RCAP activities beyond those specified in this master work plan, DOE has designated the currently planned activities as "Phase 1." If a second phase of activities is needed for the WMAs addressed in Phase 1, or if releases are detected at other SST WMAs, this master work plan will be updated accordingly.

This introduction contains three subsections. Section 1.1 provides an overview of the Phase 1 RCAP, and the remaining subsections provide detailed information on the purpose, scope, and objectives of the work plan (Section 1.2) and a guide to the organization of the document (Section 1.3).

1.1 OVERVIEW

This section provides an overview of general background information, the SST RCAP, the role of this master work plan, the planned approach to project management and integration, and ongoing corrective actions.

1.1.1 General Background

The Hanford Site is managed by DOE and encompasses approximately 1,450 km^2 (560 mi^2) in the Columbia Basin of south-central Washington State. The Hanford Site is divided into a number of operational areas, including the 200 Areas located near the center of the site (Figure 1-1). The 200 Areas comprise the 200 East, 200 West, and 200 North Areas. The 200 East and West Areas contain waste management facilities and inactive, irradiated fuel-reprocessing facilities. The 200 North Area was formally used for interim storage and staging of irradiated fuel.

Numerous active and inactive waste sites are located in the 200 Areas. Cleanup and closure activities for these sites are conducted within the legal framework of the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1998), developed by DOE, the U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology (Ecology) (collectively referred to as the "Tri-Parties"). The Tri-Party

[1] The DOE created the ORP in 1999 to manage the storage, treatment, and disposal of high-level radioactive and hazardous wastes contained in the Hanford Site's 149 SSTs and 28 double-shell tanks (DSTs). The ORP has created the River Protection Project (RPP) to accomplish this mission. (Both the ORP and RPP were previously known as the Tank Waste Remediation System [TWRS].) The U.S. Department of Energy, Richland Operations Office (RL) is responsible for the balance of the Hanford Site cleanup mission.

Agreement describes how RCRA and the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) are applied at the Hanford Site and designates each waste site as either a RCRA or CERCLA site.

A number of waste management facilities located within the 200 East and West Areas are regulated under RCRA as hazardous waste treatment, storage, and disposal (TSD) units, with Ecology serving as the lead regulatory agency. Significant among these are the 149 Hanford Site SSTs, which are grouped into 12 SST farms. Closure of the SST farms is the largest project at the Hanford Site and involves numerous activities aimed at the design, construction, and operation of waste retrieval, treatment, and disposal facilities. The project also must maintain the tanks in a safe condition pending closure, and respond to past releases (e.g., via the RCAP).

The Tri-Party Agreement requires periodic groundwater monitoring at the SSTs to detect potential releases. To facilitate this groundwater monitoring, the 12 tank farms are grouped into 7 WMAs. Figures 1-2 and 1-3 show the SST and double-shell tank (DST) farms in the 200 East and 200 West Areas, respectively, and show how the SST farms are grouped into WMAs. Groundwater monitoring data for the SSTs indicate that SST wastes have contaminated groundwater at 4 WMAs, including WMA S-SX (containing the S and SX SST farms), WMA B-BX-BY (containing the B, BX, and BY SST farms), WMA T (containing the T SST farm), and WMA TX-TY (containing the TX and TY SST farms).[1]

As a consequence of these findings, Ecology and DOE negotiated draft Change Control Form Number M-45-98-03 (Ecology et al. 1999). When approved, the Change Control Form will establish the SST RCAP and describe schedule milestones for corrective action activities targeted at the four WMAs identified above.[2] Although DOE and Ecology have not planned specific RCAP activities beyond those identified in the draft Change Control Form, they recognize that future activities could be necessary and have designated the currently planned activities as Phase 1.

1.1.2 Overview of the Single-Shell Tank RCRA Corrective Action Program

The RCRA corrective action regulations, discussed in detail in Section 2.0, require DOE to institute corrective actions as necessary to protect human health and the environment from releases of regulated waste constituents from the SSTs. The RCAP provides the framework for implementing these requirements and, per the Tri-Party Agreement, adheres to a prescribed process. This process includes a RCRA facility investigation (RFI) to investigate and assess impacts of past releases; a corrective measures study (CMS) to assess and recommend appropriate corrective measures; and a corrective measures implementation (CMI) phase to establish design requirements, implement the corrective actions, and conduct performance monitoring (as needed).

---

[1] For detailed information regarding the groundwater monitoring and assessment programs at these WMAs, the reader is referred to Section 3.4 and to reports referenced therein.

[2] For the purposes of the RCAP, WMA T and WMA TX-TY are grouped and referred to throughout the remainder of this document as WMA T/TX-TY. These two WMAs are adjacent and, by grouping them, DOE can streamline planning and characterization activities (e.g., by developing a single work plan for both WMAs).

The SSTs will ultimately be "closed" under RCRA TSD unit closure regulations (discussed in Section 2.0). Therefore, any actions taken by DOE to address past releases will necessarily be *interim* actions, with the TSD unit closure process providing the avenue for *final* actions to address past and potential future releases. Interim actions are classified as either interim measures (IMs) or interim corrective measures (ICMs). These are discussed in greater detail in Section 2.0, but as an overview, consider that IMs are relatively straight forward actions of an operational or "good-housekeeping" nature that are warranted to reduce the potential for impacts. The ICMs, on the other hand, are generally more complex actions that may impact ongoing operations and that require public involvement in the decision making process.

The initial (Phase 1) activities and high-level logic for the Hanford Site SST RCAP are specified in the draft Change Control Form and are illustrated in Figure 1-4. A detailed discussion of each activity is presented in Section 2.0; a summary of the required activities, in approximate chronological order, is presented below:

- Prepare this Phase 1 RFI/CMS work plan (referred to herein as the master work plan) to establish the overall framework and requirements for subsequent activities.

- For each of WMAs S-SX, B-BX-BY, and T/TX-TY:

  - Prepare a WMA-specific work plan addendum (WMA addendum).
  - Complete characterization activities specified in the WMA addendum.
  - Prepare a WMA-specific field investigation report to document results and evaluate the need for IMs and/or an accelerated CMS to evaluate ICMs.

- Prepare a Phase 1 RFI report that integrates the results of the WMA-specific characterization activities and field investigation reports, and establishes the basis for a CMS.

- Prepare a Phase 1 CMS report, if necessary, to identify, evaluate, and recommend ICM alternatives to address impacts documented in the Phase 1 RFI report.

- Implement ICMs as recommended in the CMS report and as approved by Ecology.

- Implement IMs as agreed to by DOE and Ecology *at any time* during the RCRA corrective action process (see Section 1.1.5 for additional detail).

- If needed, based on the results of either the Phase 1 RFI/CMS process or RCRA groundwater quality monitoring results at other WMAs, update this master work plan for a final phase of activities (i.e., develop a final RFI/CMS work plan).

Also required by the draft Change Control Form, but not listed above, is an accelerated and focused characterization effort at WMA S-SX. The purpose and scope of this activity are described in the *Preliminary Site-Specific SST Phase 1 RFI/CMS Work Plan Addendum for WMA S-SX* (LMHC 1999a). The primary reason for accelerating this activity was to begin characterization activities during fiscal year 1999. Characterization results, as available, and

lessons learned from the initial S-SX characterization activity will be incorporated into the planning process for the Phase 1 WMA S-SX addendum.

1.1.3 Phase 1 RFI/CMS Planning Workshop and Work Plan

The draft Change Control Form identifies preparation of this master work plan as one of the initial activities under the RCAP. As a precursor to writing the work plan, a planning workshop was conducted with DOE, Ecology, the Tribal Nations, and the other key contributors to develop direction for the document. The workshop was conducted as a series of five half-day meetings held between March 16 and April 1, 1999. Results of the workshop, including specific agreements affecting the scope, content, and organization of the RFI/CMS work plan, are documented in the *Summary Report for the Hanford Single-Shell Tank RFI/CMS Planning Workshop* (LMHC 1999b).

In developing the overall scope of activities for Phase 1, DOE and Ecology created an approach that streamlines development of WMA addenda by leveraging as much as possible on this master work plan. Based on requirements stated in the draft Change Control Form and direction developed in the planning workshop, the master work plan establishes the regulatory and programmatic frameworks for the RCAP, establishes requirements for the development of RCAP documentation, provides initial technical inputs for developing WMA addenda, and provides materials that are common to the WMA addenda. Section 1.2 describes the purpose, objectives, and scope of this master work plan in detail and elaborates on the items listed above.

1.1.4 Project Management and Integration

The DOE has established the River Protection Project (RPP) to accomplish its mission to store, treat, and dispose of the high-level radioactive and hazardous wastes contained in the Hanford Site's 149 SSTs and 28 DSTs. Project management responsibility for the SST RCAP has been assigned to the Vadose Zone Project.[1] Project management protocols for the RCAP are described in detail in Section 7.0. The following two subsections provide a brief overview of how the project will be managed and the importance of integration with other Hanford Site programs to ensure the success of the RCAP.

1.1.4.1 Project Management. The scope of Phase 1 RCAP activities was developed by DOE and Ecology and is described in the draft Change Control Form. The DOE will ask the responsible RPP contractor (Lockheed Martin Hanford Corporation [LMHC]) to develop a work breakdown structure (WBS) that defines the tasks and subtasks needed to accomplish this scope, and to develop corresponding detailed schedules and budgets for each WBS element. Upon approval by DOE, these will be compiled to form the project "baseline." The DOE will generally authorize the RPP contractor to proceed with work defined in the baseline on a fiscal year by fiscal year basis. The baseline will be updated at the start of each fiscal year during the

[1] The Vadose Zone Project is a component of the SST Waste Retrieval Program, which is responsible for retrieval and delivery of SST wastes to treatment facilities, for SST closure under RCRA TSD unit closure regulations, and for management of information and issues related to the vadose zone beneath the tank farms. The Vadose Zone Project was created to address this latter responsibility. An overview of the Vadose Zone Project can be found in the *Tank Waste Remediation System Vadose Zone Program Plan* (DOE-RL 1998e).

RPP's annual planning cycle. Changes directed by DOE during the fiscal year will be managed through a formal baseline change management process.

The RPP Vadose Zone Project Manager will be the single point of accountability for RCAP activities within LMHC. The RPP Vadose Zone Project Manager will assign task managers for Phase 1 RCAP activities at each WMA, which will include development of work plans, oversight of field and laboratory activities, and development of subsequent studies and reports. Task managers will also be assigned for the RFI report, the CMS, and subsequent ICM activities, as well as for ongoing and future IMs. (As appropriate, a single individual may serve as the task lead for multiple activities.) During execution of the work, project accomplishments and cost and schedule performance data will be communicated monthly to DOE and to the Hanford Site Groundwater/Vadose Zone (GW/VZ) Integration Project (described below).

1.1.4.2 Integration. The technical, regulatory, and management issues associated with the RCAP are numerous and complex. For example, the program must consider that many contaminant sources exist in the 200 Areas (other than the SSTs), that these sources are creating intermingling groundwater plumes, and that characterization and environmental restoration (ER) activities for these sites and plumes are often managed by different organizations and under different regulatory frameworks. The DOE has recognized the need to integrate groundwater and vadose zone activities across the Site and has created the Hanford Site GW/VZ Integration Project to facilitate this process. The GW/VZ Integration Project is charged with providing site-wide leadership and an infrastructure to support integration. Within the framework established by the GW/VZ Integration Project, the RPP Vadose Zone Project Manager will be responsible to ensure that RCAP-specific interfaces are managed aggressively to support both SST and site-wide objectives.

The project management plan (Section 7.0) addresses specific program interfaces and the protocols for integration. The key interfaces are grouped as follows:

- GW/VZ Integration Project
- Groundwater management projects (e.g., 200 Area groundwater remediation)
- 200 Area remedial action assessment (i.e., for approximately 700 source sites)
- Other RPP projects (e.g., SST tank farm operations)
- Other Hanford Site projects (e.g., Environmental Restoration Disposal Facility [ERDF])
- Other organizations (e.g., Hanford Advisory Board).

1.1.5 Ongoing Interim Measures and Supporting Studies

The RCAP encourages early actions and DOE has already initiated SST IMs, as well as several studies designed to support future corrective action decisions[1]. As described in Section 1.1.2, IMs are actions to protect human health and the environment that may be implemented without the need for a formal CMS. The DOE and Ecology have agreed that authorization to proceed

[1] These activities were identified by DOE and Ecology during RCAP negotiations and are included in the draft Change Control Form.

with IMs may be given by Ecology at any time during the RCRA corrective action process. The IMs and supporting studies already initiated include the following:

- Caps on approximately 750 monitoring drywells around the SSTs were upgraded to be leak-tight. This activity was initiated in January 1999 and was completed in June 1999.

- An Innovative Treatment Remedial Demonstration (ITRD) workshop to identify and evaluate interim surface barrier concepts was conducted from May 4 through 6, 1999. A summary of the workshop results with conclusions and recommendations for additional evaluation of interim surface barrier concepts was completed in July 1999 (PNNL 1999).

- A summary of results and recommendations based on past and ongoing engineering studies is being prepared to address isolating water lines, sealing abandoned wells, and controlling surface drainage in or near SST WMAs. The summary will include data to support a decision on whether drainage controls are needed to prevent or reduce surface water infiltration. The studies and the resulting summary and recommendations are scheduled for completion in October 1999.

The opportunity to implement future IMs will be evaluated on an ongoing basis. Formal evaluation of the need for additional IMs is provided at the completion of each WMA-specific characterization effort, as well as in the RFI report.

1.2 PURPOSE, SCOPE, AND OBJECTIVES OF THE WORK PLAN

1.2.1 Purpose and Objectives

The overall goal of the RCRA corrective action rule is to protect human health and the environment from contaminant releases at RCRA-permitted facilities. To achieve this goal, Federal guidance for RCRA corrective action (EPA 1994a) requires facility owners to assess contaminant releases and associated human health and environmental impacts and, as needed, to evaluate, select, and implement corrective measures.

The RCAP for the Hanford SSTs presents unique considerations in that activities will be conducted at multiple, highly complex TSD units over a period of five or more fiscal years. Furthermore, beyond addressing past releases, the SST Phase 1 RFI/CMS process is called upon to support programmatic decision making in support of the eventual safe closure of the SSTs, which is a process that will involve retrieval of SST wastes and subsequent (assumed in-place) closure of the tank farms. These and other factors led DOE and Ecology to agree on the need for this master work plan.

The purpose of this master work plan is to define an overall framework for the safe and successful completion of the RCRA corrective action activities specified in the draft Change Control Form. This framework is intended to establish an efficient, defensible, and legally compliant approach to planning, executing, and documenting the work.

The specific objectives of the master work plan, briefly listed in the overview, are described below in more detail, along with the elements of the work plan that address the objectives.

- *Establish the regulatory and programmatic framework for the overall RCAP.* This objective is accomplished through the information provided in Section 1.0, "Introduction"; Section 2.0, "Regulatory Framework"; and Section 7.0, "Project Management and Program Integration."

- *Establish process and content requirements for development of WMA addenda and subsequent RCAP documentation.* This objective is driven by the need to ensure consistency, data quality, and defensibility in a program that will address multiple sites over several fiscal years. The objective is addressed in Section 6.0, "Process Requirements for Assessment of WMAs"; Section 7.0, "Project Management and Program Integration"; and Appendix H, "Annotated Outlines" (i.e., for subsequent RCAP documentation). The regulatory requirements established in Section 2.0 also address this objective.

- *Provide initial "technical inputs" for consideration when developing WMA addenda and subsequent RCAP documentation.* As part of the DQO process, the WMA project teams[1] will evaluate what is known about each WMA, develop WMA-specific decision statements, and design characterization programs to address information gaps. To facilitate the DQO process for each WMA and to promote consistency, the RFI/CMS planning workshop team developed preliminary "inputs" to guide the WMA teams at various steps. This information is included in Section 4.0, "Risk Assessment and Preliminary Identification of Potential Corrective Measure, Retrieval, and Closure Technologies," and Section 5.0, "Preliminary Decision Framework."

- *Provide, in a single location, materials that are common to the WMA addenda.* During negotiations, DOE and Ecology stated their desire to keep WMA addenda as short and focused as possible. To avoid duplicating general information for the Hanford Site and the 200 Areas in each WMA addenda, such information is summarized (or referenced) in Section 3.0 of this master work plan. The WMA addenda, as a result, present only WMA- and tank farm-specific details. This approach also applies to other work plan content that will not differ significantly from WMA to WMA. Most significantly, the preliminary identification of corrective measures and closure technologies (Appendices E and I, respectively), and the list of applicable or relevant and appropriate requirements (ARARs) (Appendix F) are addressed only once. The same approach is taken with "secondary plans," which establish procedural requirements for certain aspects of the work. These include the quality assurance project plan (Appendix A), the general health and safety plan (Appendix B), the information management plan (Appendix C), and the waste management plan (Appendix D).

[1] The "WMA project team" is used as a general term throughout this document and describes, collectively, the individuals involved in planning and performing WMA-specific RFI/CMS activities. The WMA project teams may include DOE, Ecology, Tribal Nation, stakeholder, and contractor staff. The individuals composing the team may vary from WMA to WMA and, for a given WMA, from activity to activity.

The master work plan provides overall direction for planning and performing WMA-specific RCAP activities to ensure data quality and defensibility. It is not intended to provide detailed instructions for the assessment of individual WMAs. The WMA-specific data needs, DQOs, data collection programs, and associated assessment tasks and schedules will be defined as part of the WMA-specific work planning process.

1.2.2 Scope

This master work plan addresses RCRA corrective action activities for Hanford Site SST WMAs S-SX, B-BX-BY, and T/TX-TY as specified in the draft Change Control Form. The master work plan is intended to serve as a guide for completing the Phase 1 RFI/CMS process; any subsequent phase of investigations warranted by Phase 1 results, or by groundwater monitoring results at other WMAs, would necessitate an update to this master work plan.

The Phase 1 RFI is intended to collect environmental data to support decision making not only for RCRA corrective action, but also for the SST waste retrieval and SST closure projects. In addition, Phase 1 will seek to address the information needs of other Hanford Site activities, but only to the extent that these information needs are incidental to those associated with corrective action, retrieval, and closure. Characterization to support the design of tank waste treatment and related support facilities[1] is not within the scope of the RCAP, nor is characterization to support design of the immobilized low activity waste (ILAW) disposal facility.[2] Evaluations under the RCAP will not postulate any releases from these facilities (i.e., in the context of supporting cumulative risk analyses).

The scope of the RCAP includes assessment of contaminant releases to soils and groundwater from the SSTs, ancillary equipment, and associated diversion boxes (collectively referred to as the RCRA SST system). Contaminants from the SST system that have migrated beyond any fence line or local boundary are still within the scope of the program and must be appropriately addressed. Characterization to assess if contaminants at a specific location originate from the TSD units (i.e., versus another waste site) is also within the scope of the RCAP, regardless of location or environmental media to be sampled. Such characterization will require integration with other programs conducting complementary activities.

The focus of Phase 1 is on understanding releases from elements of the TSD units that lie within the WMA boundaries. Notwithstanding this focus, the WMA-specific DQO process must identify all relevant sites associated with and adjacent to the tank farms (e.g., nearby waste sites being addressed under DOE's ER Project). As judged appropriate by the Tri-Parties through the DQO process, the scope of Phase 1 RFI characterization may be expanded to consider releases from TSD elements outside the WMA boundaries and to consider releases from adjacent waste

[1] The DOE is evaluating the option of privatizing the treatment of Hanford Site tank wastes and has selected BNFL, Inc. to complete initial planning and facility design activities. The preferred treatment option involves immobilizing the radioactive and hazardous constituents through a high temperature "vitrification" process.

[2] The ILAW disposal facility will be constructed by the RPP for disposal of treated, low-activity wastes produced by the tank waste privatization contractor.

sites being addressed by the ER Project. Actual characterization of such sites may be performed by other programs, if appropriate, but would be coordinated with the SST RCAP.

As described in Section 1.1.2, the scope of any corrective actions recommended and implemented during the Phase 1 RCAP will be limited to *interim* actions. *Final* actions to address past and potential future environmental impacts of the SSTs will take place as part of the TSD unit closure process. Therefore, the minimum performance period to be considered in developing corrective measures alternatives will be from the present until commencement of closure activities approved in the TSD unit closure plans.[1] The Tri-Parties will focus on IMs and ICMs that can be implemented and can be effective within that period, with consideration to potential environmental impacts associated with the waste retrieval and final closure processes.

The *evaluation* of data under the Phase 1 RCAP will be driven by the need to define risks associated with past releases and to define what measures should be implemented to address those releases. Evaluation of data to support retrieval- and closure-related decisions will be performed by the retrieval and closure projects, respectively, and is not within the scope of the Phase 1 RCAP as defined in the draft Change Control Form. However, because some of the data evaluation activities needed to support retrieval and closure decisions are very similar to those needed to answer corrective action decisions, the RCAP project teams will seek opportunities to leverage their data evaluation activities.

1.3 WORK PLAN ORGANIZATION

Sections 1.0 through 7.0 constitute the main body of this work plan and describe the regulatory framework, site background, conceptual exposure model, planning processes, and project management. Appendices are attached to the report and are referenced from the main text; they may be consulted as desired by the reader.

The contents of each section are briefly described below:

- Section 1.0, "Introduction," provides an overview of the Hanford Site SST RCAP; the purpose, objectives, and scope of this master work plan; and a guide to the organization of the report.

- Section 2.0, "Regulatory Framework," describes the laws and regulations governing corrective action and closure activities for the SSTs and how they will be applied in the RCAP.

- Section 3.0, "Summary of Existing Information," summarizes available information regarding topography, meteorology, vadose zone hydrogeology, and groundwater. It also presents natural background concentrations of chemical and radiological analytes and discussions on environmental and cultural resources of the 200 Areas.

[1] A RCRA TSD unit closure plan(s) for the SSTs will be prepared following selection of a closure alternative by DOE.

- Section 4.0, "Risk Assessment and Preliminary Identification of Potential Corrective Measure, Retrieval and Closure Technologies," introduces the conceptual exposure model for assessment of impacts, including anticipated land use, exposure scenarios, and risk assessment application. Section 4.0 also presents the preliminary identification of potential corrective measure, retrieval, and closure technologies.

- Section 5.0, "Preliminary Decision Framework," describes overall program objectives and associated decisions that must be supported by the Phase 1 RFI/CMS.

- Section 6.0, "Process Application of Tools for Waste Management Area Assessment and Implementation," describes the DQO process, overall characterization requirements and strategies, and requirements for WMA addenda.

- Section 7.0, "Project Management and Program Integration," describes how the work will be organized and managed. It also addresses integration needs and the processes for achieving this integration.

- Section 8.0, "References," lists documents and other sources referenced throughout the main body of the text. The appendices each have their own reference sections.

- Appendix A, "Quality Assurance Project Plan," provides the overall quality assurance (QA) framework that will be used to prepare WMA-specific QA plans for characterization.

- Appendix B, "General Health and Safety Plan," provides the general health and safety requirements for field activities for all WMAs. Activity-specific health and safety plans will be prepared prior to beginning field work.

- Appendix C, "Information Management Overview," describes how data from all assessment activities will be organized. This plan will be applied to all WMAs; WMA-specific plans will not be required.

- Appendix D, "Waste Management for the RCRA Corrective Action Program," describes the general waste management processes and requirements for wastes that may be generated during the course of assessing the WMAs. Activity-specific waste control plans will be prepared as necessary to identify the specific type, volume, and disposal of wastes.

- Appendix E, "Preliminary Identification of Corrective Measure Technologies," describes corrective measure technologies that may be employed during the RCAP, as well as information regarding the feasibility of deploying these at the SST farms.

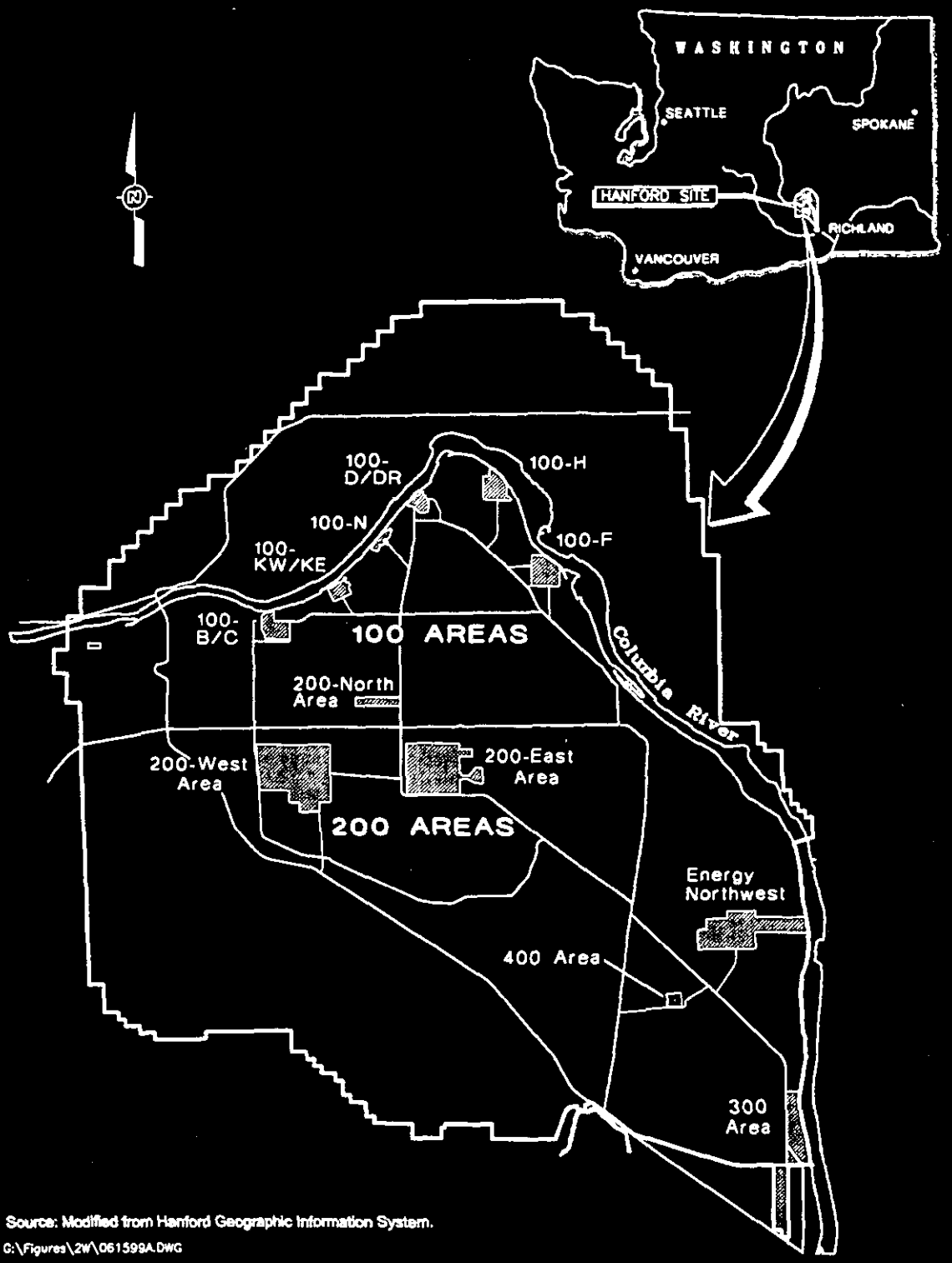
- Appendix F, "Applicable or Relevant and Appropriate Requirements," summarizes action-, location-, and chemical-specific requirements.

- Appendix G, "Data Quality Objective Templates," presents information and tools to support the DQO process for each WMA.

- Appendix H, "Annotated Outlines," includes recommended outlines for WMA addenda and subsequent reports.

- Appendix I, "Preliminary Identification of Retrieval and Closure Technologies," describes technologies being considered to support waste retrieval and closure.

Figure 1-1. Hanford Site and Area Designations.



Source: Modified from Hanford Geographic Information System.
G:\Figures\2W\061599A.DWG

Figure 1-2. Tank Farms and Waste Management Areas in the 200 East Area.

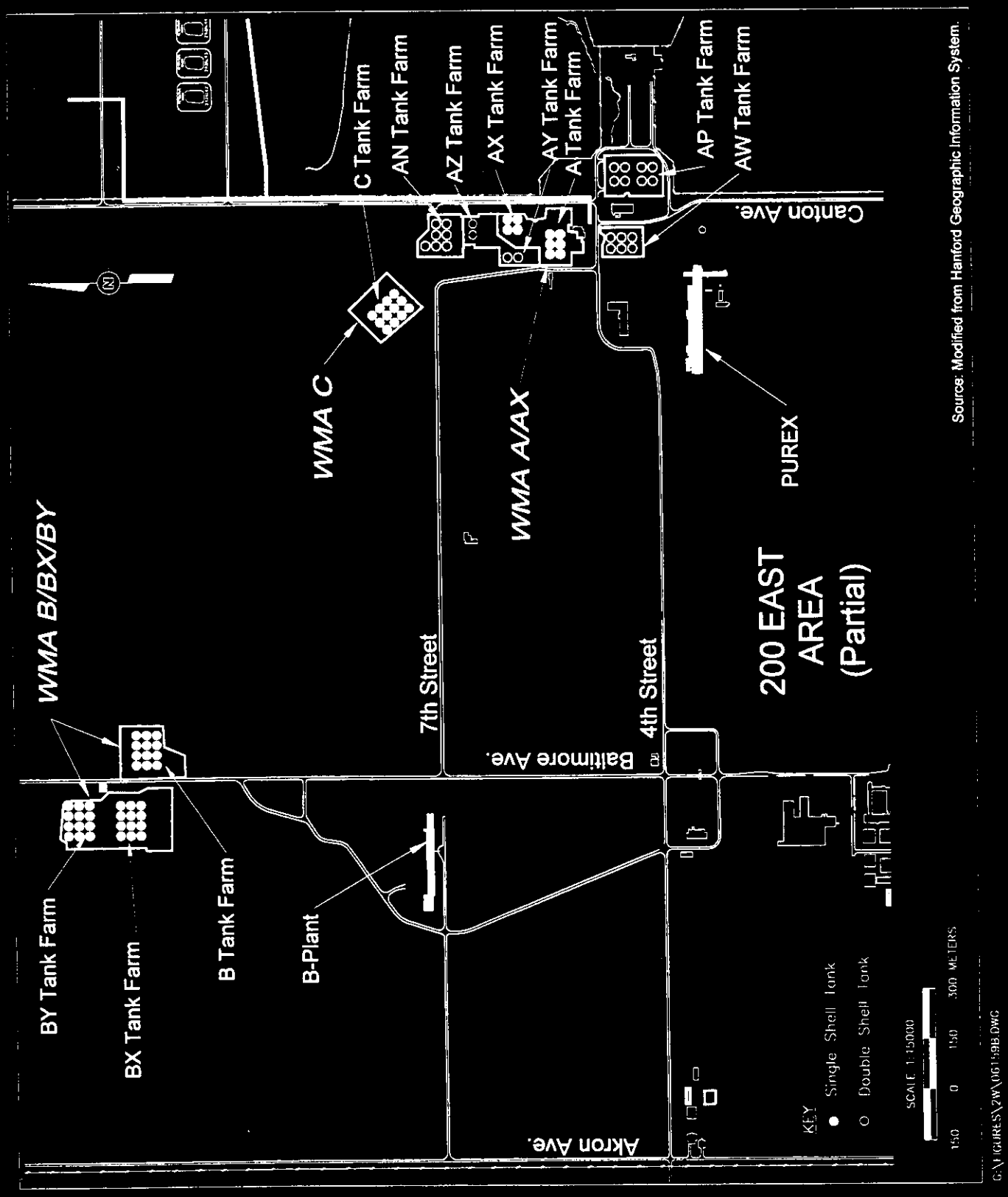


Figure 1-3. Tank Farms and Waste Management Areas in the 200 West Area.

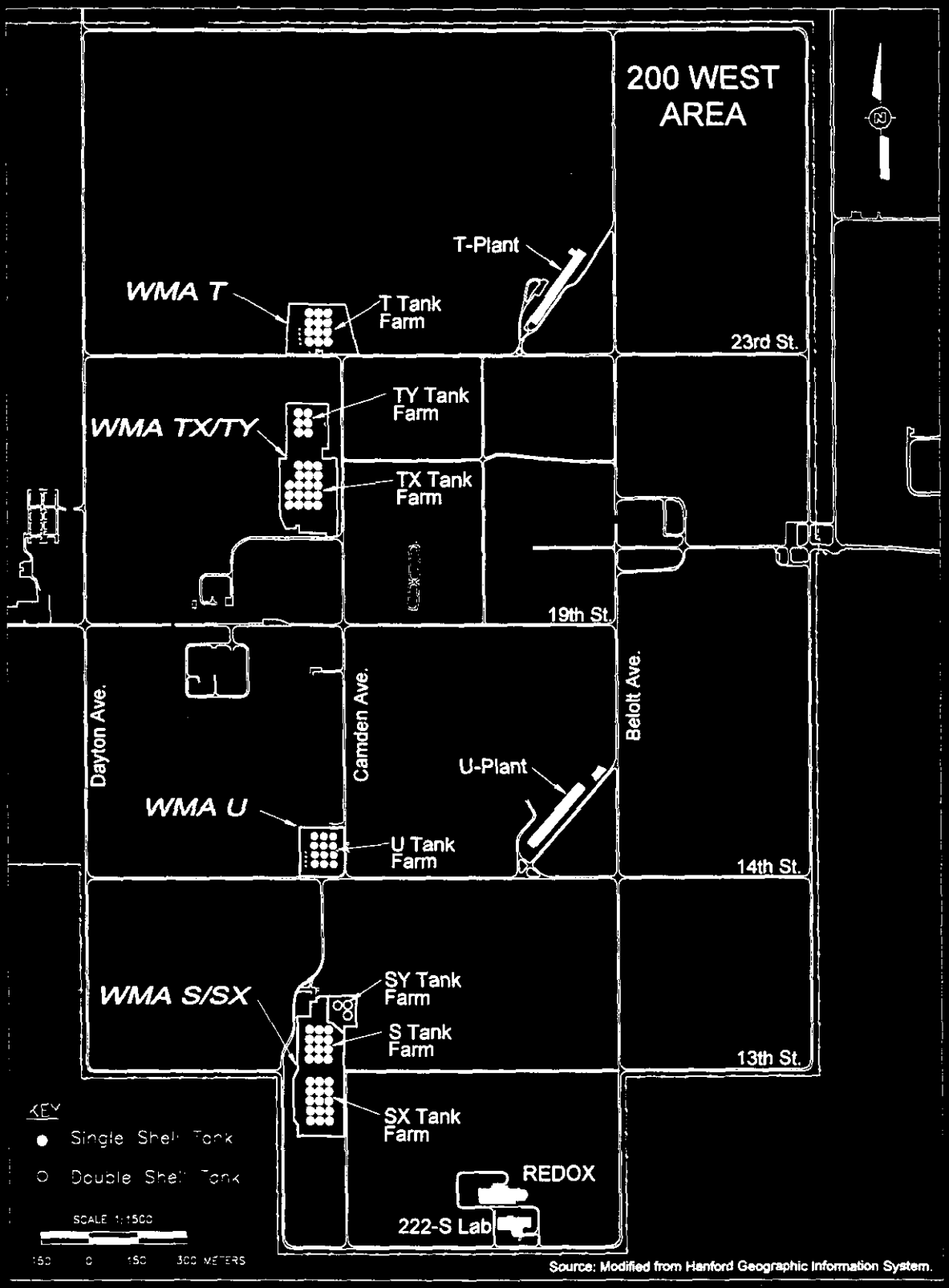
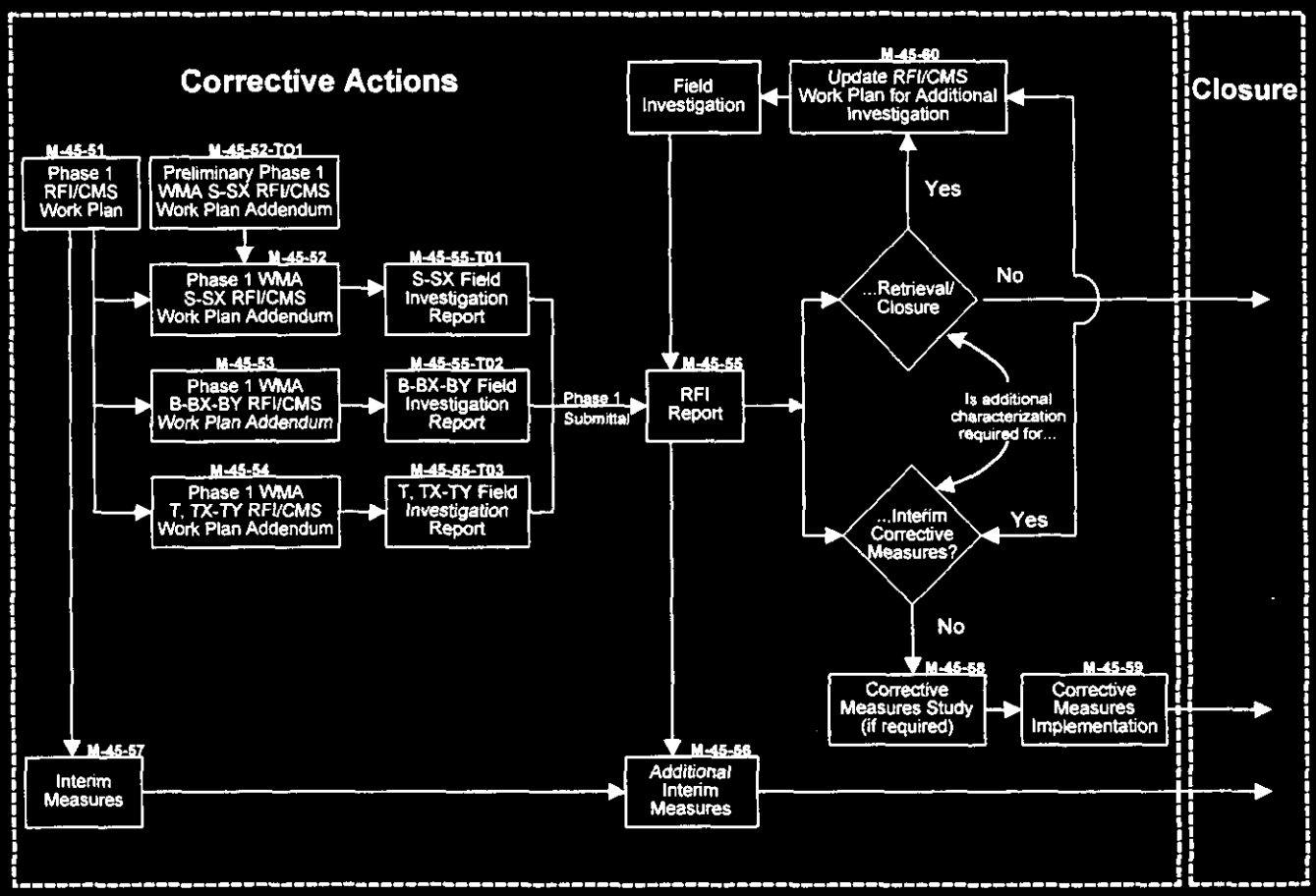


Figure 1-4. Proposed Tri-Party Agreement Milestones for Corrective Actions (modified from Ecology et al. 1999)



2.0 REGULATORY FRAMEWORK

This section describes the regulatory background for the SST RCAP and presents the regulatory framework within which the RCAP will be conducted. The framework is intended to satisfy the corrective action requirements deriving from RCRA, the State of Washington *Hazardous Waste Management Act of 1982* (HWMA) (*Revised Code of Washington* [RCW] 70.105), the Tri-Party Agreement (Ecology et al. 1998), and the Hanford Facility RCRA Permit. As necessary to support the RCAP, the framework also incorporates requirements related to CERCLA, the *Atomic Energy Act of 1954* (AEA), and other environmental laws that may affect RCAP decisions. The framework supports development of future RCAP documents and will be incorporated by reference into the WMA addenda, avoiding the need to provide extensive regulatory discussions in each addendum.

Ecology is the lead regulatory agency for the SSTs. The SSTs manage mixed (radioactive and dangerous) waste and are regulated under RCRA and the HWMA as interim status TSD tank systems,[1] and they will ultimately undergo RCRA closure. Final remediation of environmental media contaminated by releases from the SSTs will be addressed during closure or as part of post-closure care. Therefore, for purposes of the RCAP, the regulatory framework presented here focuses on interim corrective actions that can be taken prior to implementation of the SST closure plan(s). The regulatory framework also provides an overview of the regulatory processes for waste retrieval, closure, and post-closure of the SSTs to support integration of the RCAP with these programs.

Section 2.1 provides a regulatory overview, including the general regulatory requirements of RCRA/HWMA, CERCLA, the AEA, and other environmental laws influencing cleanup decisions. It also summarizes the regulatory status of the SSTs. Section 2.2 describes the regulatory process that will be used to implement the RCAP to address these requirements. Section 2.3 identifies ARARs that may be sources of media cleanup standards, or that may constrain corrective action activities.

2.1 REGULATORY OVERVIEW

2.1.1 Hanford Regulatory Setting

Two major environmental regulatory programs govern cleanup of waste sites at the Hanford Site: RCRA (including the corresponding state law, the HWMA) and CERCLA. In general, RCRA was enacted to prevent and address releases at active facilities that generate, store, treat,

[1] Each SST and its associated ancillary equipment constitutes a type of TSD unit called a tank system. Ancillary equipment is defined as any device such as piping, fittings, flanges, valves, and pumps used to transfer or control the flow of waste from the point of generation to the SSTs or from the SSTs to a point of shipment or disposal. At the Hanford Site, many of the plants that generated the waste are, themselves, TSD units. In addition, waste from the tanks is often transferred to another TSD unit. Preliminary discussions are ongoing between Ecology and DOE as part of the double-shell tank closure plan scoping to determine which sections of the piping between TSD units are part of which TSD unit. As appropriate, the results of these discussions may be applied to the SSTs.

transport, or dispose of hazardous wastes or hazardous constituents; RCRA was amended to also provide for corrective action for past and current releases at RCRA-permitted facilities. CERCLA was enacted to investigate and respond to past releases and potential releases of hazardous substances at inactive sites.

The Tri-Party Agreement was developed by DOE, EPA, and Ecology to establish how the RCRA and CERCLA programs will be applied at the Hanford Site and was initially issued in 1989. The agreement was designed for the following reasons:

- To ensure that environmental impacts associated with activities at the Hanford Site are investigated and that appropriate response actions are taken
- To ensure compliance with RCRA and the HWMA and provide a procedural framework for permitting RCRA TSD units
- To establish a procedural framework for developing, prioritizing, implementing, and monitoring appropriate response actions in accordance with RCRA and CERCLA
- To delineate the roles of the EPA and Ecology and to facilitate coordinated participation of the parties in carrying out actions.

A key feature of the Tri-Party Agreement is that it encourages integrating RCRA and CERCLA requirements to the greatest extent practicable to promote consistency and to minimize duplication of analysis and documentation.

The requirements of RCRA and the HWMA are also implemented via the Hanford Facility RCRA Permit, which is discussed further in Section 2.1.2.

Other key regulatory programs that directly affect corrective action at the SSTs are the AEA, the *National Environmental Policy Act of 1969* (NEPA), and the *State Environmental Policy Act* (SEPA) (RCW 43.21c). The AEA governs management of radioactive wastes. Requirements deriving from the AEA play an important role in the safe management and eventual closure of the SSTs and the retrieval and management of waste contained in the SSTs. The NEPA requires Federal agencies, including DOE, to evaluate any actions they plan to undertake for potential environmental and community impacts and to mitigate impacts as appropriate. Thus, any SST corrective action activities must be evaluated to determine what impacts would result from those activities. Similarly, SEPA requires Washington State agencies to evaluate state agency actions for potential environmental and community impacts and to mitigate impacts.

2.1.2 RCRA Overview

The (RCRA) was enacted in 1976 and provides for cradle-to-grave management of hazardous waste by generators, transporters, and owners of hazardous waste TSD facilities. The 1984 *Hazardous and Solid Waste Amendments* (HSWA) to RCRA provide for corrective action for releases of hazardous waste and hazardous constituents from any solid waste management units

(SWMUs)[1] located at TSD facilities. The Federal RCRA program has jurisdiction over waste with chemical constituents (hazardous waste) and the hazardous component of mixed waste (waste that is both a hazardous waste and a radioactive waste) but does not have jurisdiction over waste containing only radiological contaminants. The regulations implementing RCRA are found in the *Code of Federal Regulations* (CFR), 40 CFR Parts 260 through 280. Federal regulations specific to the HSWA and corrective action have been proposed but have not been finalized.

Authority to implement most of the EPA hazardous waste program has been delegated to the State of Washington. In 1986, the EPA authorized the state to regulate the generation, treatment, storage, and disposal of hazardous waste. In 1987, EPA extended this delegation of authority to include the hazardous component of mixed waste. In 1996, the state received authority to implement key portions of the HSWA for RCRA corrective action. Ecology is authorized to enforce the state dangerous waste program under the HWMA, which is implemented via the dangerous waste regulations (Washington Administrative Code [WAC], Chapter 173-303), facility-specific RCRA[2] permits, and consent orders (such as the Tri-Party Agreement). The state dangerous waste[3] management program is similar to, but in some cases broader and more restrictive than, the Federal RCRA program.

In general, RCRA facilities are required to obtain a final status RCRA permit before beginning operations. In Washington, the RCRA permit is obtained from Ecology following submittal of Part A and Part B of the RCRA permit application. Facilities that were already in operation on the effective date of the RCRA regulations were allowed to continue interim status operations without a final status RCRA permit but were required to submit a Part A permit application and make progress toward obtaining a final status permit.

The Hanford Site has been assigned a single identification number for use in RCRA permitting. Accordingly, the Hanford Site is considered to be a single RCRA facility, although it contains multiple TSD units, including the SSTs. A Part A RCRA permit application was submitted for each of the TSD units to continue operating under interim status. However, it was not possible to permit all of the TSD units at the Hanford Site simultaneously, so the initial Hanford Facility RCRA Permit, which became effective in September 1994, only incorporated five TSD units. The remaining TSD units are being incorporated a few at a time through annual permit modifications. They can either be incorporated as final status units that will continue actively

[1] Under state and Federal authorities, corrective action applies to all SWMUs within a facility that is subject to a RCRA permit, irrespective of the date that wastes were placed in the units. The SWMUs are discernible locations where solid wastes have been placed at any time, irrespective of whether the location was intended for the management of solid or hazardous waste. The SWMUs include any area where solid wastes, including spills, have been routinely and systematically released. Under the state corrective action regulations, the definition of SWMU encompasses TSD units and single spill sites. It can also include sites that are regulated under CERCLA authority.

[2] Throughout the remainder of this section, the term RCRA will be used to encompass both the Federal hazardous waste program and the corresponding state dangerous waste program implementing the HWMA.

[3] The State of Washington uses the term "dangerous waste" to encompass both those wastes that would be designated as hazardous wastes under the Federal RCRA program and other wastes that would not be designated under the Federal RCRA program but that the state has determined require similar management.

operating or as units undergoing or soon to undergo closure. Until TSD units are incorporated, they remain in interim status.

The Hanford Facility RCRA Permit was issued with two portions: a dangerous waste portion issued by Ecology and addressing TSD units, and a HSWA portion, issued by EPA and addressing corrective action at SWMUs (see Table 2-1 for a summary of the permit). The State of Washington was authorized to oversee portions of the HSWA subsequent to issuance of the permit. Ecology is currently developing new conditions that will incorporate HSWA requirements into its portion of the permit and essentially transfer the EPA portion of the permit to Ecology; however, these conditions have not yet been finalized. When these conditions are incorporated into the permit, they will be incorporated as appropriate into this master work plan or the WMA addenda.

2.1.2.1 Closure and Post-Closure. The TSD unit closure and post-closure requirements are contained in state regulations, the Tri-Party Agreement, and the Hanford Facility RCRA Permit. General closure and post-closure requirements for final status TSD units are specified in WAC 173-303-610 and focus on general closure performance standards and the preparation, content, and approval process for a closure plan. The general closure performance standards include the following:

- Minimize the need for further maintenance
- Control, minimize, or eliminate, to the extent necessary to protect human health and the environment, post-closure escape of dangerous waste, dangerous constituents, leachate, contaminated run-off, or dangerous waste decomposition products
- Return the land to the appearance and use of surrounding land areas to the degree possible.

Detailed closure requirements for individual types of waste units are contained in the unit-specific provisions for each type of waste unit. Closure and post-closure provisions for TSD tank systems are provided in WAC 173-303-640(8). The regulations provide two closure options for tank systems: (1) clean closure (closure in which waste is removed and environmental media are remediated to *Model Toxics Control Act* [MTCA] Method B cleanup levels), and (2) landfill closure (closure in which waste or environmental media are left above MTCA Method B cleanup levels). For clean closure, the point of compliance is all soil and groundwater that may have been contaminated by the TSD unit. Clean closure does not require post-closure care, whereas landfill closure requires a post-closure care plan and permit.

The RCRA permitting and general TSD closure requirements for the Hanford Site are addressed in Section 6.0 of the Tri-Party Agreement. The Tri-Party Agreement reiterates the options of clean closure and landfill closure and explicitly states that any demonstration of clean closure must address soil and groundwater at the unit. The Tri-Party Agreement encourages integrating closure requirements with other regulatory programs and states that TSD units containing mixed waste normally will be closed with consideration of all hazardous substances, including radioactive constituents.

The dangerous waste portion of the Hanford Facility RCRA Permit also addresses TSD unit closure. Section II.K of the permit reiterates the performance standards of WAC 173-303-610(2) and expands the number of closure options to four: (1) clean closure (per WAC 173-303-610[2][b]), (2) closure to background levels (considered a clean closure), (3) modified closure, and (4) landfill closure. As defined in the permit, modified closure means dangerous waste constituents present at the TSD unit at the completion of closure are above MTCA Method B levels but below MTCA Method C levels for all affected media, and landfill closure means leaving contaminants in place above MTCA Method C levels. When neither clean closure nor modified closure is chosen, the TSD unit will be closed as a land disposal unit (landfill closure) following the procedures and requirements specified in WAC 173-303-610. For closure as a land disposal unit, a post-closure permit is required that addresses maintenance and inspection activities, groundwater monitoring requirements, and final corrective actions implemented under the closure plan.

2.1.2.2 Corrective Action. Federal regulations implementing RCRA corrective action have been proposed under 40 CFR Subpart S but have not been finalized (55 FR 30798). However, EPA has provided guidance related to planning RCRA corrective action (EPA 1994). The guidance outlines four components for corrective action and their objectives as follows:

- *Interim/stabilization measures (IMs).* Actions to control or abate threats to human health and/or the environment from releases and/or to prevent or minimize the further spread of contamination while long-term remedies are pursued. The IMs typically do not require detailed evaluation of multiple alternatives and may be implemented at any time during the RCAP process.

- *RCRA Facility Investigation (RFI).* Process to evaluate the nature and extent of the releases of hazardous waste and hazardous constituents and to gather data necessary to support the CMS and/or IM decisions. The RFI may be preceded by an initial assessment called a RCRA facility assessment (RFA). The need for an RFA is based on whether there is sufficient knowledge about the unit to determine if an RFI is needed. If sufficient knowledge indicates that an RFI will be required, the RFA process can be bypassed. (This is the case for the SST WMAs.) In addition, a RCRA corrective action work plan may be required by the regulatory agency prior to beginning the RFI. The work plan describes the overall corrective action objectives and approach, assembles available site data, identifies additional data needs and investigation methods, and identifies potential corrective measure technologies. It also includes a characterization sampling and analysis plan (SAP), health and safety and project management plans, and proposed work schedules.

- *Corrective Measures Study (CMS).* Process to develop and evaluate a corrective measure alternative(s) and to recommend a corrective measure(s) for implementation. The selected corrective measure is typically incorporated into the facility RCRA permit.

- *Corrective Measures Implementation (CMI).* Design, construction, operation, maintenance, and performance monitoring of the selected corrective measure(s).

During the CMS, corrective measure alternatives are evaluated against the following nine criteria:

- Protection of human health and the environment
- Attainment of media cleanup standards
- Reduction or elimination, to the extent practicable, of further releases
- Compliance with waste management standards
- Long-term effectiveness and permanence, and potential for success
- Reduction in toxicity, mobility, or volume through treatment
- Short-term risks and the time required to achieve protection
- Ease or difficulty of implementation
- Cost.

The state corrective action requirements for interim status TSD units (such as the SSTs) are found in WAC 173-303-400(3)(a)(i), which references the corrective action requirements of WAC 173-303-646(2). The requirements of WAC 173-303-646(2) state that the owner or operator must institute corrective action as necessary to protect human health and the environment for all releases of dangerous waste and dangerous constituents, both on and off the facility, and that the corrective action must be specified in the facility RCRA permit with a schedule for compliance. The corrective action requirements for interim status TSD units do not contain details on the corrective action process, nor do they specify cleanup standards or points of compliance.

State corrective action requirements for final status regulated units[1] are contained in WAC 173-303-645(11). These requirements are discussed here because, in accordance with Milestone M-24-00 of the Tri-Party Agreement, they also are applied to the SSTs. The requirements specify that corrective action must ensure that regulated units comply with the established groundwater protection standard at the point of compliance[2] for the WMA[3]. The concentration limits may be those listed in WAC 173-303-645(5) or may be alternate concentration limits (ACLs) established on a case-by-case basis by Ecology (WAC 173-303-645[5][b]). The selection of ACLs depends on a number of factors, including potential for migration, current and future groundwater uses, existing groundwater quality (including other sources of contamination), and potential risks to human health and the environment.

[1] Regulated units are defined as surface impoundments, landfills, land treatment areas, and waste piles. Tank systems such as the SSTs are not included in the definition of "regulated unit."

[2] The point of compliance is where the groundwater protection standards apply. It is a vertical surface located at the hydraulically downgradient limit of the WMA. Alternatively, the point of compliance may be any closer points identified by Ecology (WAC 173-303-645[6][a]).

[3] The WMA is the limit projected in the horizontal plane of the area on which waste is placed during operation of the regulated unit. If there is more than one regulated unit, the WMA is an imaginary line circumscribing several regulated units (WAC 173-303-645[6][b]).

The corrective action requirements at the Hanford Site are addressed in Section 7.0 of the Tri-Party Agreement. The process detailed in Sections 7.2 and 7.4 of the Tri-Party Agreement generally follows the Federal proposed regulations and guidance with the following clarifications and additions:

- The Tri-Party Agreement states that the RCRA corrective action and CERCLA remediation processes are functionally equivalent and that information contained in any RCRA documents is required to be functionally equivalent to information that would be gathered under CERCLA.

- The Tri-Party Agreement requires an RFI/CMS work plan for units undergoing corrective action. According to the Tri-Party Agreement, the work plan must assess whether IMs are necessary, assess available data and additional data needs, identify potential ARARs, and identify potential remedial responses. The work plan must be approved by the lead regulatory agency; it does not require public review, although the Tri-Parties can choose to conduct a public review to solicit public input.

- The Tri-Party Agreement states that if data or information acquired at any time indicate that an expedited response (i.e., an IM in the case of RCRA corrective action) is needed or appropriate because of an actual or threatened release, the lead regulatory agency may require DOE to submit a proposal for an expedited response at that unit. In addition, DOE may submit such a proposal at any time, without a request from the lead regulatory agency. Section 2.2.5 contains further discussion on IMs.

The EPA portion of the Hanford Facility RCRA Permit defines a process for implementing RCRA corrective action at the Hanford Site. However, the EPA portion also states that RCRA corrective action that is being performed in accordance with the Tri-Party Agreement is not subject to the process in the permit, and that decisions made via the Tri-Party Agreement process will be incorporated by reference into the permit. It is anticipated that the corrective action process and conditions being finalized by Ecology for inclusion in the permit will be similar to EPA's RCRA corrective action process.

Corrective action has been initiated for several SWMUs at the Hanford Site in accordance with the Tri-Party Agreement. In all cases, either the RCRA corrective action or the CERCLA remedial action document process (discussed in Section 2.1.3) has been or will be used to evaluate and select corrective measures for these SWMUs. The choice of regulatory processes has depended on regulator preference. For SWMUs in the 100-D and 100-H Areas, the CERCLA process was used, with a RCRA permit modification planned to reference the CERCLA decision. For waste sites in the 100-N Area, a combination of the two document processes was used. Common features of these corrective action activities have included the following:

- Both radioactive and nonradioactive constituents are addressed.

- The MTCA, which is specified as a key cleanup requirement in Section 7.5 of the Tri-Party Agreement, is used to establish nonradioactive constituent cleanup levels for soil and groundwater.

- The EPA-recommended 15 mrem/year (EPA 1997) is used to establish radioactive constituent cleanup levels for soil; the drinking water standard and DOE order limit of 4 mrem/year is used to establish groundwater protection levels.

2.1.3 CERCLA Overview

Four areas of the Hanford Site, including the 200 Areas in which the SSTs are located, are included on EPA's National Priorities List (NPL) for remediation under CERCLA. Therefore, in addition to meeting RCRA requirements, cleanup at the SSTs must ultimately meet CERCLA requirements so the 200 Areas can be removed from the NPL. Section 7.0 of the Tri-Party Agreement requires that Hanford Site remediation efforts coordinate the requirements of the RCRA and CERCLA programs to the extent practicable to achieve both goals. Furthermore, documents prepared to support the RCAP are required to be functionally equivalent to the comparable CERCLA documents. Therefore, although the RCAP is based primarily on RCRA requirements, certain CERCLA elements are important.

The CERCLA was enacted in 1980 to address past releases or potential releases of hazardous substances[1], pollutants, and contaminants to the environment. The CERCLA program is implemented via the "National Oil and Hazardous Substance Pollution Contingency Plan" (NCP), 40 CFR Part 300. The EPA is the regulatory agency responsible for oversight of the DOE's implementation of CERCLA (52 FR 2923).

The cleanup process and objectives under the RCRA and CERCLA programs are very similar. The comparable CERCLA process steps include a work plan, a remedial investigation, a feasibility study, a proposed plan, a Record of Decision (ROD), a remedial design report (RDR), and a remedial action work plan (RAWP). The criteria for evaluating alternatives under CERCLA are the same as those for RCRA corrective action with the addition of criteria evaluating state acceptance and community acceptance. At the Hanford Site, the cleanup standards for both RCRA and CERCLA waste sites are essentially the same because Section 7.5 of the Tri-Party Agreement requires the programs to be based on a common set of ARARs.

Key differences between the RCRA and CERCLA programs include the following:

- Radionuclides are regulated under CERCLA but are not regulated under RCRA. However, the Tri-Party Agreement specifies that RCRA activities at the Hanford Site should address radionuclides to the extent practicable.

- The State of Washington has been delegated authority to oversee a major portion of RCRA. There are currently no provisions in CERCLA to delegate authority to the state.

[1] "Hazardous substances" means those substances defined by Section 101 (14) of CERCLA. It includes a wide variety of chemicals and radioactive constituents, but excludes petroleum products.

- The RCRA activities must comply with the administrative and substantive requirements of other legally applicable regulatory programs (including requirements to obtain environmental permits), whereas CERCLA activities must comply with the substantive applicable or relevant and appropriate requirements but not administrative or permitting requirements of other regulatory programs. The Tri-Party Agreement specifies that RCRA corrective action must comply with ARARs, similar to CERCLA.

2.1.4 AEA Overview

The AEA was enacted in 1954 to ensure the proper management of source, special nuclear, and byproduct material. It is amended by several statutes including the *Nuclear Waste Policy Act of 1982*, which established the national program for the disposal of spent nuclear fuel and high-level waste (HLW). The AEA governs closure of facilities that managed radioactive materials and wastes, but cleanup of radioactive waste sites is outside the jurisdiction of the AEA. The AEA and the statutes that amended it delegate the control of nuclear energy primarily to DOE, the U.S. Nuclear Regulatory Commission (NRC), and the EPA. The DOE has the authority to conduct nuclear defense, waste management, environmental restoration and remediation, and research-related activities and to establish programs at its facilities to protect health, safety, and the environment. The NRC is authorized to regulate commercial nuclear power plants and to license facilities that receive, store, and dispose of HLW. The EPA is authorized to set environmental standards for radiation protection programs.

The AEA identifies three primary classes of radioactive waste. High-level waste is the waste that results from the processing of spent nuclear fuel to recover uranium and plutonium. As such, HLW is defined by origin and not by constituents; therefore, this definition is not based on specific concentrations of various constituents. Transuranic (TRU) waste is waste that is contaminated with alpha-emitting TRU radionuclides with half-lives greater than 20 years and concentrations greater than 100 nanocuries/gram.[1] Low-level waste (LLW) is waste that contains radioactivity and is not HLW, TRU waste, or spent nuclear fuel. A fourth waste type is waste incidental to reprocessing. Incidental waste is not a true class of waste; rather, the term originated in the 10 CFR Part 50 definition of HLW, which notes that HLW does not include "incidental" waste resulting from reprocessing plant operations such as ion exchange beds, sludges, contaminated laboratory items, tools, and equipment.

Historically, DOE implemented the AEA through a series of nonpromulgated orders. More recently, DOE has begun codifying those orders. DOE Order 5400.1 acknowledges that environmental management activities of DOE are extensively, but not entirely, regulated by EPA and state and local environmental agencies. This order also states that compliance with specific legislation, including RCRA and CERCLA, is mandatory for DOE operations. DOE Order 435.1[2] and the associated *Radioactive Waste Management Manual*, DOE M 435.1-1 (DOE

[1] The AEA bases the TRU waste definition on 10 nanocuries/gram concentration but allows deferral to other definitions. The NRC defines TRU waste as containing 100 nanocuries/gram TRU; this is the definition adopted by DOE.

[2] DOE Order 435.1 was finalized in July 1999. It applies to new and existing DOE radioactive waste management facilities and must be implemented no later than October 1, 2001. Implementation requires formal incorporation

1999a) address management of radioactive and mixed waste, establishing requirements that are pertinent to any wastes generated as part of the RCAP. General requirements for radioactive waste management identified in the order are as follows:

- Protect the public from exposure to radiation in accordance with DOE Order 5400.5, *Radiation Protection of the Public and the Environment*

- Protect the environment in accordance with DOE Order 5400.1, *General Environmental Protection Program* and DOE Order 5400.5

- Protect workers in accordance with radiation protection standards in 10 CFR 835, *Occupational Radiation Protection*

- Comply with applicable Federal, state, and local laws, Executive Orders, and other DOE directives.

These requirements must be met during implementation of the RCAP. The manual also specifies requirements for closure of radioactive waste management units. Although the SSTs will not be closed as part of the RCAP, one goal of characterization is to collect data useful to future closure decision-making. Closure requirements for HLW facilities (such as the SSTs), contained in Chapter II of the manual, include the following:

- Facilities that can be decontaminated to meet requirements for decommissioning must be placed in a condition that meets DOE decommissioning and dispositioning requirements.

- Facilities that cannot meet decommissioning requirements must be closed such that residual waste satisfies the requirements for waste incidental to reprocessing specified in the manual. Final closure must meet the requirements for a low-level waste (LLW) facility or a transuranic (TRU) waste facility, or must be completed in accordance with a CERCLA process.

Specific performance objectives for LLW facility closure include a maximum 25 mrem/year total effective dose equivalent for representative members of the public (all exposure pathways) and a limit of 10 mrem/year via the air pathway. For LLW sites that received waste after September 26, 1988, a performance assessment and site-specific composite analysis are also required.

There are no specific processes defined in the DOE orders or DOE regulations for how waste site cleanup is to be accomplished. However, the implementation manual for DOE Order 435.1 requires corrective actions at radioactive waste management facilities whenever necessary to ensure that the requirements of the order and manual are met. Since the requirements include protecting public health and the environment, this could mean that releases from the facilities need to be addressed as necessary to achieve protection. In addition, Chapter IV of DOE

---

into DOE contractor agreements. Radioactive waste management facilities were previously governed by DOE Order 5820.2A.

Order 5400.5 specifies end-point criteria for the cleanup of residual radioactive material and the release of real property (including soil and groundwater) that may impose final cleanup standards for a waste site. The chapter also stipulates that property owned by DOE that is being sold to the public is subject to the requirements of Section 120(h) of CERCLA and to any other applicable Federal, state, and local requirements.

The NRC implements the AEA via 10 CFR Parts 0 through 199. The NRC regulations are applicable only at NRC-licensed facilities and thus are not directly applicable to most DOE facilities such as the Hanford Site. An exception is DOE's geologic repository for HLW, which is subject to NRC licensing and the requirements of 10 CFR Part 60. However, DOE Order 5400.5 states that it is the policy of DOE to adopt and implement standards generally consistent with those of the NRC for DOE facilities and activities not subject to licensing authority. In addition, the NRC is the ultimate authority for determining which wastes must be managed as HLW. The NRC has been involved in making such determinations in several cases related to Hanford tank waste. The NRC has concurred with DOE that the waste in the tanks (including SSTs) is HLW subject to NRC licensing authority, although there are provisions to classify a portion of the waste as incidental waste following treatment (Paperiello 1997).

The EPA's responsibilities under the AEA are implemented via 40 CFR Parts 190 through 195. The radiation protection standards established in these regulations apply to both NRC- and DOE-regulated facilities. 40 CFR Part 191, Subpart B establishes environmental standards for disposal and applies to "radioactive materials released into the accessible environment as a result of the disposal of [HLW] or [TRU] waste" and "radioactive contamination of certain sources of groundwater in the vicinity of disposal systems for such...wastes" (40 CFR Part 191.11[a]); however, it does not apply to wastes disposed before November 18, 1985.

2.1.5 NEPA and SEPA Overview

The NEPA was enacted in 1969 and requires Federal agencies to consider the potential environmental impacts associated with proposed Federal agency actions. It also provides an opportunity for public involvement in the decision-making process. The DOE has the authority and responsibility to implement NEPA at DOE facilities. The general regulations implementing NEPA are found in 40 CFR Parts 1500 through 1508. The specific requirements for implementing NEPA at DOE facilities are contained in 10 CFR Part 1021 and DOE Order 451.1A.

The NEPA review process for a proposed action is normally conducted at one of three levels: preparation of an environmental impact statement (EIS), preparation of an environmental assessment (EA), or application of a categorical exclusion. NEPA requires the preparation of an EIS for all proposed actions that potentially have a significant impact on the quality of the human environment. The EIS presents information on the impacts of the proposed action and compares those impacts against alternative actions. This information is provided for public comment in a draft EIS. After consideration of public input, the EIS is finalized and a ROD is issued.

In some cases, it may be unclear whether an EIS is required (i.e., whether a proposed action has the potential for significant impacts). In such cases, an EA is prepared. The EA is a public document intended to provide sufficient evidence and analysis to determine whether to prepare an EIS or a Finding of No Significant Impact. The EA also aids in compliance with NEPA when no EIS is necessary and facilitates preparation of an EIS when one is necessary.

Categorical exclusions (CX) are categories of actions that individually or cumulatively do not have a significant impact on the human environment and that have been identified as such in the DOE NEPA regulations (Appendices A and B of 10 CFR Part 1021, Subpart D). For this category of actions, neither an EA, nor an EIS is required. Instead, a CX summary is prepared to document that the proposed action fits within the CX listed in the regulation, there are no extraordinary circumstances related to the action that may affect the significance of its environmental effects, and the proposed action is not connected to other actions with potentially significant effects. Examples of CX categories that may be pertinent to the RCAP include certain facility operations (e.g., routine maintenance, installation of tanks/small basins to control run-off), safety and health activities, site characterization/monitoring, and certain ER/waste management activities (e.g., small-scale, short-term cleanup actions under RCRA). The CX for cleanup actions applies if the action would cost less than approximately $5 million and be of less than 5 years duration (Berube 1997).

If there are substantial changes to a proposed action that was previously evaluated in an EIS, DOE must prepare a supplemental EIS (10 CFR Part 1021.314). If it is unclear whether an EIS supplement is required, DOE must prepare a supplement analysis. The supplement analysis allows DOE to determine whether an existing EIS should be supplemented, a new EIS should be prepared, or no further NEPA documentation is required.

The DOE addresses the application of NEPA to RCRA corrective actions in *Guidance on NEPA Review for Corrective Actions Under the RCRA* (Berube 1997). The guidance states that if the proposed corrective action would occur at a site listed on the NPL and there is a cleanup agreement that integrates the requirements of RCRA and CERCLA, DOE may be able to rely on the integrated process for environmental review of action, integrating NEPA values to the extent practicable. If the site is not listed on the NPL and is not included in a cleanup agreement that integrates RCRA and CERCLA, a NEPA review is required. In this latter case, the NEPA review approach could consist of preparing a separate NEPA document or integrating the requirements of the RCRA and NEPA processes into one document. Because the SSTs are part of the 200 Areas NPL site and are subject to the Tri-Party Agreement, which integrates RCRA and CERCLA, either approach could comply with the guidance if NEPA values are evaluated in the RCRA corrective action documents.

The State of Washington's *State Environmental Policy Act* was enacted in 1971. It provides the framework for state agencies to consider the environmental consequences of a proposal before taking action and a mechanism for public involvement. Agency actions subject to SEPA include issuing permits and other formal approvals for proposed actions taken by private applicants (which include federal agencies requesting state permits). The SEPA also gives state agencies the ability to condition or deny a proposal due to identified likely significant adverse impacts. The SEPA is implemented through the "SEPA Rules" found in WAC 197-11.

Since SEPA was originally modeled after NEPA, the policies as well as the intent of the two laws are very similar. The SEPA encourages environmental review early in the planning process. It also provides for combining environmental documents with other documents and using existing environmental information through incorporation by reference or adoption (WAC 197-11-600). Like NEPA, SEPA identifies categorical exclusions (exemptions) for actions that do not have a significant effect on the environment and, therefore, do not require environmental review (WAC 197-11-800 to –890).

For proposed actions that are not categorically excluded, the SEPA process is typically initiated through completion of a SEPA checklist, which identifies potential environmental impacts. The information in the checklist is used to make a threshold determination, with two possible outcomes:

- The lead agency determines the proposal is not likely to have a significant impact and issues a determination of nonsignificance (DNS). The DNS may include mitigation conditions. No further documentation is required,

- The lead agency determines the proposal is likely to have a significant impact and issues a determination of significance/scoping notice (DS/Scoping). The environmental impact statement (EIS) process is begun.

The SEPA recognizes that some projects may require approval from both federal agencies and state or local agencies, thus requiring compliance with both NEPA and SEPA. An agency may adopt any analysis prepared under NEPA (WAC 197-11-610), or an EIS may be prepared to satisfy the requirements of both NEPA and SEPA (WAC 197-11-640). An example of the latter is the TWRS EIS, wherein DOE and Ecology served as cooperating agencies for evaluating the environmental impacts of tank waste disposition.

In addition, existing environmental documents that analyze all or part of the environmental impacts of a proposal may be adopted, addended, or incorporated by reference to satisfy SEPA requirements. If there are any remaining environmental concerns, they can be addressed in supplemental analysis, such as a supplemental EIS or by an addendum issued with the new threshold determination.

There have been many NEPA and SEPA documents prepared at the Hanford Site. Three EISs that are of particular relevance to the SSTs include:

- *Disposal of Hanford Defense High-Level, Transuranic, and Tank Waste Environmental Impact Statement* (HDW EIS) (DOE 1987). This EIS examined the final disposal of waste, including SST waste, stored at the Hanford Site since 1943.

- *Safe Interim Storage of Hanford Tank Wastes Environmental Impact Statement* (SIS EIS) (DOE 1995). This EIS addressed near-term safety issues at the Hanford SSTs and DSTs.

Tank Waste Remediation System Environmental Impact Statement (TWRS EIS) (DOE and Ecology 1996). This EIS was issued jointly by DOE and Ecology and specifically addressed the management and disposition of waste contained in the Hanford SSTs and DSTs.

The implications of the HDW EIS and TWRS EIS and the associated RODs with respect to the SSTs are described in Section 2.1.6.

2.1.6 Regulatory Status of the Single-Shell Tanks

The SSTs are regulated under both RCRA and the AEA. They are regulated as RCRA TSD units because they store and treat[1] mixed (dangerous and radioactive) waste. The SSTs were in operation as of the effective date of the RCRA regulations and have continued to operate as RCRA interim status units in accordance with a Part A permit application submitted by the DOE for the SST system (DOE-RL 1997). The Part A permit application defines the SST system as 149 SSTs, their associated ancillary equipment, and 54 inactive isolated diversion boxes designated as RCRA waste piles. With respect to RCRA, the SSTs are operated in accordance with the interim status requirements of WAC 173-303-400 and the requirements of the Tri-Party Agreement. Tri-Party Agreement Milestone M-24-00 requires DOE to install groundwater monitoring wells around the SSTs in accordance with WAC 173-303-645[2]. For purposes of groundwater monitoring, the 12 SST farms are grouped into seven WMAs. Each WMA is provided with upgradient and downgradient monitoring wells intended to detect releases to the groundwater. To date, tank leaks and associated releases of tank wastes have resulted in groundwater contamination documented at four of the SST WMAs. These WMAs are WMA S-SX, WMA B-BX-BY, WMA T, and WMA TX-TY (Ecology et al. 1999). Maps showing the location of these four WMAs are provided in Figures 1-2 and 1-3. In accordance with WAC 173-303-645, detection of contaminants attributed to these WMAs and exceeding groundwater protection standards (defined as the drinking water standards) triggered a RCAP for these SST farms.

Table 2-2 lists the SST WMAs along with the tanks and diversion boxes included in each WMA. The table also indicates the operable unit[3] designations for the tanks and diversion boxes as defined in Appendix B of the Tri-Party Agreement. Each operable unit also includes nearby

---

[1] Per the Part A permit application for the SST system, treatment consists of separation of solids and interstitial liquids and addition of cooling liquids (DOE-RL 1997a).

[2] Under state regulation (WAC 173-303-645), only final status regulated units are subject to specific groundwater monitoring provisions, so interim status tank systems such as the SST system are not normally subject to groundwater monitoring. However, because of known releases from the SSTs, the provisions for groundwater monitoring were applied to the SSTs via the Tri-Party Agreement. WAC 173-303-645 specifies a program for detection monitoring, compliance monitoring (when contaminants are detected at the point of compliance), and corrective action and corrective action performance monitoring (when the groundwater protection standard is exceeded).

[3] The Hanford Site contains over 2,000 waste sites. To organize cleanup of the sites, they are divided into groupings called operable units that share a common geography, waste source, or both.

waste sites that are not TSD units (e.g., septic tanks and unplanned releases) and that are not included in the table. This RCAP focuses on the SST WMAs rather than the operable units.

The SSTs are regulated under the AEA because of the radioactive component of the SST waste and are operated in accordance with applicable DOE orders. The NRC has determined that wastes transferred to the SSTs included HLW, and that because of mixing over the years, it is difficult to differentiate between HLW and LLW in the tanks (Petersen 1995). This has a significant impact on retrieval of SST waste and closure of the SSTs, because the tanks and waste therein are subject to the HLW requirements. However, consistent with the concepts embodied in the definition of incidental waste, secondary waste generated at the SSTs (e.g., sampling equipment and contaminated soil) is not managed as HLW.

There are no plans to add new waste to the SSTs. Currently, liquid that can be retrieved from the SSTs has been or is in the process of being removed via saltwell pumping. In the future, the SSTs will undergo closure in lieu of being permitted under RCRA as final status TSD units. However, Tri-Party Agreement Milestone M-45-00 requires that all TSD units located within the boundaries of the SST farms to be closed under the final status tank standards contained in WAC 173-303-610 and described in Section 2.1.2.1. Thus, closure of the SST system must follow the closure requirements described in Section 2.1.2.1. A final decision has not been made as to whether closure will be a clean closure under RCRA (i.e., removing tank waste and environmental contaminants to MTCA Method B concentrations) or a modified or landfill closure (i.e., leaving tank waste, environmental contaminants, or both in place above MTCA Method B levels). Closure must also meet AEA requirements described in Section 2.1.4, which are expected to require that HLW facilities must satisfy the requirements for waste incidental to reprocessing identified in the manual DOE M 435 (DOE 1999a).

The Tri-Party Agreement (Ecology et al. 1998) contains several important milestones[1] related to SST closure as follows:

- M-45-00 — Complete closure of all SST farms (September 30, 2024)
- M-45-08A — Complete system design and operating strategy for tank leak monitoring and mitigation for systems to be used in conjunction with initial retrieval systems for SSTs (December 31, 2000)
- M-45-08B — Complete demonstration and installation of leak monitoring and mitigation systems for initial SST retrieval (June 30, 2003)

[1] DOE and Ecology are currently discussing potential modifications to these milestones as appropriate to reflect the award of the tank waste treatment contract.

- M-45-03-T01 — Establish full-scale capability for mitigation of waste tank leakage during retrieval sluicing operations (June 30, 2003)
- M-45-03-T01 — Complete SST waste retrieval demonstration (September 30, 2003)
- M-45-04-T01 — Provide initial SST retrieval systems (November 30, 2003)
- M045-06-T01 — Submit tank closure/post-closure plan for selected closure demonstration on one operable unit or tank farm (November 30, 2004)
- M-45-06-T04 — Complete closure actions on one operable unit or tank farm (March 31, 2014)
- M-45-05 — Retrieve waste from all remaining SST (September 30, 2018).

As noted in Section 2.1.5, the HDW EIS and the TWRS EIS both evaluated the disposition of Hanford tank waste. With respect to SST waste, the HDW EIS evaluated retrieving the waste for offsite disposal versus in place stabilization combined with a protective barrier. The ROD for the HDW EIS, issued in 1988, deferred any decisions regarding disposition of the SST waste to allow for additional development and evaluation of retrieval and processing methods (53 FR 12449). The TWRS EIS analyzed the potential environmental consequences related to the ongoing management,[1] retrieval, and future disposal of radioactive, hazardous, and mixed waste from the Hanford Site tank system, including SSTs. The ROD for the TWRS EIS identified the selected alternative as a phased approach to retrieval and treatment of the bulk of the tank waste, including waste from the SSTs (62 FR 8693). The ROD also supports ongoing waste management activities, including maintaining safety and environmental compliance.

Closure planning for the SSTs is underway and evaluations are ongoing with respect to the technical practicability of waste retrieval and final remediation of the tanks. DOE and Ecology have agreed to use the Retrieval Performance Evaluation (RPE) to demonstrate methodologies that would be used to support SST retrieval and closure decisions. There has been an initial demonstration of the methodology as applied to past-practice sluicing at the AX Tank Farm. Additional demonstrations are expected in the future. The type of RCRA closure negotiated with Ecology and the application of AEA closure requirements negotiated with the NRC will determine retrieval requirements. However, because of technical limitations on retrieval, the retrieval and closure decision-making effort is likely to be an iterative process. Tri-Party Agreement Milestone M-45-00 contains a note that closure will follow retrieval of "as much tank waste as technically possible, with tank residues not to exceed 360 cubic feet in each of the 100 series tanks or the limit of waste retrieval technology, whichever is less. If DOE believes that

[1] The TWRS EIS identified specific activities that were considered as part of ongoing management of the tanks. These activities consisted of a number of routine activities (e.g., management oversight, regulatory compliance and reporting activities, operation and maintenance of facilities and equipment, tank monitoring, and leak detection), as well as additional safety-related activities (e.g., waste volume projections, combining compatible waste types, transferring waste between tanks, waste minimization, characterizing tank waste to support safety and remedial action design activities, removing pumpable liquid from SSTs, and operating the 242-A Evaporator).

waste retrieval to these levels is not possible for a tank, then DOE will submit a detailed explanation specifying the quantities of waste that DOE proposes to leave in the tank." The final quantity of waste left in the SST is likely to vary from tank to tank. Likewise, the extent of leakage during retrieval is expected to vary depending upon the retrieval technology and the condition of a given SST.

The DOE intends to prepare another EIS to evaluate closure alternatives and solicit public input. This EIS will be used to prepare a closure plan for all of the tanks, ancillary equipment, and contaminated soil in the SST system[1]. If post-closure care will be required due to residual waste in the SSTs, residual soil contamination, or both, a post-closure plan will be submitted for incorporation into the Hanford Facility RCRA Permit with the closure plan. Final corrective action for contaminated environmental media will be an element of the closure and post-closure plans. Specific final corrective action activities have not yet been identified and will depend on the amount of residual tank waste and environmental media contamination levels. The SST system will be incorporated into the Hanford Facility RCRA Permit when the closure plan/post-closure plan is approved by Ecology.

2.2 SINGLE-SHELL TANK INTERIM CORRECTIVE ACTION PROCESS

As part of the negotiations related to Tri-Party Agreement Milestone M-45, the Tri-Parties have agreed to a process for implementing interim corrective action at the SSTs (Ecology et al. 1999). This process generally follows the EPA's RCRA corrective action guidance, with modifications to address Tri-Party Agreement requirements and the complexity associated with the SSTs. Figure 1-4 graphically illustrates the process that will be used for interim corrective action at the SSTs. The following subsections provide a brief discussion of each major element presented in the figure.

2.2.1 Master Work Plan and Waste Management Area Addenda

The first step in the SST interim corrective action process will be preparation of an RFI/CMS work plan. Because of the number of SST farms involved and the complexity of this effort, a phased approach will be used. The phased approach will involve preparing this master work plan and WMA addenda that together will satisfy the requirements for an RFI/CMS work plan. This master work plan provides general information and approaches applicable to all of the SST WMAs that can be incorporated by reference into the addenda. Elements of the master work plan include the following:

- Overall approach for the RCAP
- Regulatory framework for the RCAP
- Potential ARARs
- General Hanford Site, 200 Areas, and SST system descriptions
- Contaminants of potential concern (COPC) for the SST system

[1] It has not been determined whether the SST system will be addressed in a single closure plan or multiple closure plans.

- Conceptual exposure model for the SSTs
- Corrective measure performance standards
- Preliminary identification of corrective measure technologies
- Identification of RCAP, retrieval, and closure decisions
- DQO process to be used for all WMAs
- Identification of feasible characterization processes and tools.

Each WMA addendum will provide the following:

- Detailed description of the SST farms included in the WMA
- Summary of available data for that WMA
- Refinement of COPCs for the WMA
- Characterization SAP
- Refinement of potential corrective measure technologies for the WMA, as appropriate
- Schedule for conducting work at the WMA.

In accordance with WAC 173-303-646(2), the corrective action requirements apply to dangerous waste and dangerous constituents. Dangerous wastes are identified via WAC 173-303-070; the dangerous wastes associated with the SST system are listed on the Part A permit application. Dangerous constituents are those constituents defined in WAC 173-303-9905 or 40 CFR Part 264 Appendix IX, or that cause a waste to be listed or designated as a dangerous waste under WAC 173-303, or any hazardous substance under MTCA (RCW 70.105D.020[5])[1]. This definition encompasses a large universe of constituents. Although there is no regulatory requirement to sample and analyze for the full universe of dangerous constituents, all of these sources may be considered in identifying constituents that should be characterized. As required by the Tri-Party Agreement, RCRA corrective action at the Hanford Site must also evaluate radioactive constituents to fulfill requirements under CERCLA.

Previous evaluations have been performed to screen the universe of radiological and chemical constituents and identify those constituents potentially associated with the SST system. Section 3.0 of this master work plan summarizes the results of those screenings and provides tables listing the radiological and chemical constituents that are COPCs for the SST system. These tables will serve as the starting point for defining the WMA-specific COPCs during the WMA-specific DQOs. The WMA-specific DQOs will also be used to establish the number, type, and location of samples and specific analytical requirements not otherwise specified in this master work plan. The results of the DQOs will form the basis for the WMA addenda.

Both the master work plan and the WMA addenda must be approved by Ecology as primary documents under the Tri-Party Agreement. There is no specific requirement for public review of

[1] MTCA defines a state list of hazardous substances that includes the Federal definition of hazardous substances, dangerous waste, petroleum or petroleum products, and any other substance, including solid waste decomposition products, that is determined to be a threat to human health and the environment when released into the environment (e.g., MTCA has determined that secondary drinking water contaminants under the Federal *Safe Drinking Water Act of 1974* are contaminants of concern). State RCRA corrective actions encompass all of these MTCA hazardous substances.

RFI/CMS work plans. However, DOE and Ecology may elect to provide both the master work plan and the addenda for public review and comment at their discretion. Any public comments received will be used to help identify improvements in the work planning process.

2.2.2 Phase 1 RCRA Facility Investigation

The general purpose of the Phase 1 RFI will be to characterize the nature, extent, rate and direction of movement, and concentration of releases from SSTs; determine the potential need for IMs and ICMs; and aid in the selection and implementation of those measures. The current Tri-Party Agreement milestones for the RCAP are based on the assumption that field activities will be staged so the WMAs are characterized consecutively, starting with WMA S-SX. Because of the time span involved in the characterization of the WMAs, field investigation reports will be prepared at the completion of characterization of each WMA (a single report will be prepared for the T and TX-TY WMAs). The purpose of the field investigation report will be to summarize data from the WMA investigation and evaluate the data to the extent necessary to determine the need for immediate action at that WMA. At a minimum, the data will be evaluated to determine the potential risk associated with hypothetical exposure to soil and groundwater at the WMA boundary as described in Section 4.0. If the potential near-term risk is excessive, DOE and Ecology may propose one or more IMs to mitigate the risk or may initiate an accelerated CMS to evaluate and compare more complex ICMs.

The consolidated results of the RFI will be presented in an RFI report after the completion of all Phase 1 investigations at the four WMAs. The RFI report will include descriptions of human and ecological receptors; analyses of current concentrations and extrapolations of future movement, degradation, and fate of contaminants; evaluation of risks associated with existing contamination for several hypothetical receptor exposure scenarios; and preliminary treatability studies. Based on the results of the RFI, Ecology may determine that no further investigation or interim corrective action is required for one or all of the WMAs or may determine that a CMS is required.

The evaluation of the risks associated with existing contamination will serve several purposes:

- Establish the need for additional IMs or ICMs
- Provide necessary input to Hanford Site-wide cumulative risk assessments
- Serve as a basis to begin identifying cleanup standards.

Cleanup standards depend on both regulatory requirements and the potential risk to human health and the environment. The potential risk depends in part on the hypothetical exposure scenario, which in turn depends on the assumed land (including surface water and groundwater) use. Exposure scenarios and land use are also important in identifying the appropriate regulatory requirements for cleanup. For example, the determination of cleanup standards under MTCA depends on whether a residential or industrial scenario is applied, and the use of ACLs under WAC 173-303-645(5) depends in part on future groundwater uses. A NEPA-compliant, long-term land-use decision for the Hanford Site has not been made at this time, although a decision on land use for the next 50 years is expected to be made later in 1999 (DOE 1999b). Therefore, potential risk and the regulatory requirements for establishing media cleanup standards for the

RCAP cannot be finalized. Instead, Section 4.0 presents a risk assessment and evaluation approach that considers several potential exposure scenarios.

2.2.3 Phase 1 Corrective Measures Study

If it is concluded in the RFI that ICMs are required, a CMS will be prepared. The CMS will identify and develop corrective measure alternatives, evaluate the alternatives, and provide justification for a recommended alternative. The identification of general response actions and preliminary screening of corrective measure technologies provided in Section 4.0 and Appendix E of this master work plan will form the starting point for identifying and developing alternatives in the CMS. In the CMS, the alternatives will be evaluated against the following criteria:

- Protection of human health and the environment
- Attainment of media cleanup standards
- Reduction or elimination, to the extent practicable, of further releases
- Compliance with ARARs (including waste management standards)
- Long-term effectiveness and permanence, and degree of certainty that the alternative will be successful
- Reduction in toxicity, mobility, or volume through treatment
- Short-term risks to public health, workers, and the environment and the time required to achieve protection
- Ease or difficulty of implementation
- Capital and annual operation and maintenance cost
- State acceptance
- Community acceptance.

These criteria reflect a synthesis of the RCRA corrective action and CERCLA evaluation criteria, satisfying the Tri-Party Agreement requirement that the CMS must be functionally equivalent to the information obtained in a CERCLA feasibility study.

Any proposed ICM must also be evaluated in accordance with NEPA and SEPA requirements and within the context of the TWRS EIS. There are three potential options to satisfy these requirements:

- If it is determined that the proposed ICM was included in the description of ongoing activities in the TWRS EIS and associated ROD, no further NEPA or SEPA analysis is required.

- If it is determined that the proposed ICM was not included in the description of ongoing activities in the TWRS EIS or was not selected in the associated ROD, a Supplement Analysis may be prepared. The Supplemental Analysis would evaluate and compare the potential impacts of the proposed ICM to the TWRS EIS evaluation of the preferred alternative. If the impacts are bounded by the EIS and associated ROD, no further analysis would be needed. If not, additional NEPA and SEPA analysis and a Supplemental EIS and new ROD or revised TWRS EIS ROD would be required.

- Alternatively, if it is determined that the proposed ICM was not addressed by the TWRS EIS or was not selected in the associated ROD, DOE can propose to do additional evaluation of the ICM alternatives as part of the CMS. In accordance with DOE Order 451.1 and DOE's guidance on RCRA corrective action and NEPA (Berube 1997), this would require that the CMS evaluate NEPA values such as cumulative, offsite, ecological, socioeconomic impacts, and environmental justice for each ICM alternative. State SEPA regulations would require that the CMS include sufficient environmental analysis to be comparable to a standard SEPA analysis. Using the CMS in lieu of a supplement analysis or supplemental EIS could eliminate redundancy between the RCRA corrective action, NEPA, and SEPA requirements. This approach would require approval from the DOE NEPA compliance officer and Ecology.

The determination of the appropriate NEPA and SEPA approach will be made when the CMS alternatives and proposed action are defined.

The CMS will conclude by recommending either no action or one or more ICMs for implementation. The CMS report will become the basis for revision of the Hanford Facility RCRA Permit. Modification of the permit is the process whereby the selected ICM(s) will be documented. The CMS report will be provided for Ecology review and approval and then made available for public review and comment as part of the draft permit modification package.

2.2.4 Corrective Measures Implementation

The purpose of the CMI phase of the RCAP will be to design, construct, operate (if applicable), maintain, and monitor the performance of the selected ICM(s). The CMI may be phased to accommodate the award of construction packages for the corrective measures. In accordance with the Tri-Party Agreement, two documents will be prepared during the CMI phase: a corrective measures design report containing the detailed design, and a CMI work plan describing implementation of the design. Key features of both documents will be demonstrating that the design and implementation of the ICM(s) satisfy the corrective measure performance standards and media cleanup standards established for the ICM(s). Both documents will be submitted to Ecology for review and approval. The CMI work plan will include a schedule for ICMs.

2.2.5 Interim Measures

A near-term action called an IM may be implemented at any time during the corrective action process to provide an expedited response to releases from the SSTs. In general, IMs are used when data or information indicate that actual or threatened releases pose an immediate threat to public health or the environment and that early remediation will reduce or eliminate this threat. The IMs typically do not require detailed evaluation of multiple alternatives.

The general IM process for the Hanford Site is defined in Section 7.2.4 of the Tri-Party Agreement. In accordance with the Tri-Party Agreement process, either DOE or Ecology can identify the need for an IM. If the need is identified by Ecology, the agency may require DOE to submit a proposal for an IM. In addition, DOE may submit such a proposal at any time, without a request from Ecology. The proposal must be consistent, to the extent practicable, with longer-term ICMs and must be approved by Ecology prior to initiation of field work.

One IM was identified as part of the Tri-Party Agreement draft Change Control Form for SST corrective action (Ecology et al. 1999). This IM is identified in Tri-Party Agreement Milestone M-45-57 and consists of upgrading leak-tight caps on monitoring drywells around the SSTs. The draft Change Control Form also identifies several mechanisms for identifying additional IMs:

- In accordance with Tri-Party Agreement Milestone M-45-56-T01, by October 1999, DOE will present the results of an engineering study of other potential near-term IMs (e.g., identifying leaking water lines near SSTs, sealing abandoned wells, and controlling surface drainage and ponding). This study will provide information on which to base further IMs.

- Each WMA-specific field investigation report will evaluate the data collected for that WMA and determine whether any IMs are necessary.

- The RFI report will present an overall evaluation of the characterization data for the four WMAs as it relates to interim corrective action and determine, based on the existing and new data, whether IMs are required and make recommendations regarding the types of IMs required.

The draft change control form also added Tri-Party Agreement Milestone M-45-56, which requires DOE and Ecology to meet annually (by July) to discuss potential IMs for the upcoming fiscal year. This meeting will provide a mechanism for either party to propose the need for IMs. It is anticipated that the majority of IMs will be addressed via this annual process because it will allow DOE to incorporate any selected IMs into the plans and budgets for the upcoming fiscal year. Additional IMs will be documented through establishment of additional Tri-Party Agreement milestones.

2.3 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

In accordance with Section 121(d) of CERCLA, remedial actions undertaken at the Hanford Site must comply with ARARs. ARARs are promulgated laws and regulations. Section 7.5 of the Tri-Party Agreement specifies that ARARs, as appropriate, will also apply to RCRA corrective action activities to ensure continuity between the two programs. This subsection identifies and evaluates potential ARARs for IMs and ICMs at the SSTs. It is intended to capture the major ARARs for all reasonably conceivable activities associated with IMs and ICMs. Future WMA addenda will use the ARARs evaluation provided in this master work plan as the starting point for refining ARARs for the specific WMA.

Potential ARARs are classified into one of three categories: chemical-specific, location-specific, and action-specific. These categories are defined as follows:

- Chemical[1]-specific requirements are usually health- or risk-based numerical values or methodologies that, when applied to site-specific conditions, result in the establishment of public and worker safety criteria and site cleanup criteria.

- Location-specific requirements are restrictions placed on the concentration of dangerous substances or the conduct of activities solely because they occur in special geographic areas (e.g., wetlands).

- Action-specific requirements are usually technology- or activity-based requirements or limitations triggered by the type of activity performed at the site.

When requirements in each of these categories are identified, a determination must be made as to whether the requirements are applicable or relevant and appropriate. A requirement is applicable if the specific terms (or jurisdictional prerequisites) of the law or regulations directly address the circumstances at a site. If not applicable, a requirement may nevertheless be relevant and appropriate if (1) circumstances at the site are, based on best professional judgment, sufficiently similar to the problems or situations regulated by the requirement; and (2) the requirement's use is well suited to the site.

To-be-considered (TBC) information includes nonpromulgated advisories, guidance, or proposed standards issued by Federal or state governments that are not legally binding and that do not have the status of potential ARARs. The DOE orders may be considered TBC materials. In any case, the orders are a major source of requirements for DOE. In some circumstances, TBCs will be considered along with ARARs in determining the requirements for protection of human health and the environment. TBCs complement ARARs in determining what is protective at a site or how certain actions should be implemented. For example, because drinking water maximum contaminant levels (MCLs) do not exist for all contaminants, drinking water health advisories, which are TBCs, may be helpful in defining appropriate corrective action goals.

[1] In this context, "chemical" refers to both radioactive and nonradioactive constituents.

Section 7.5 of the Tri-Party Agreement identifies five circumstances in which compliance with an ARAR may be waived at the Hanford Site:

- The action selected is only a part of a total cleanup action (e.g., ICM) and the final remedy will attain the ARAR upon its completion.

- Compliance with the ARAR will result in a greater risk to human health and the environment than an alternative option.

- Compliance with the ARAR is technically impracticable from an engineering perspective.

- An alternative cleanup action will attain an equivalent standard of performance through the use of another method or approach.

- The ARAR is a state requirement that the state has not consistently applied (or demonstrated the intent to apply consistently) in similar circumstances.

Potential Federal and state ARARs for the SST RCAP are presented in Appendix F.

The chemical-specific ARARs and TBCs likely to be most pertinent to the RCAP are the State of Washington MTCA regulations, EPA's memorandum entitled *Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination* (EPA 1997), and DOE Order 5400.5. These ARARs and TBCs are primary sources of soil cleanup standards and surface water and groundwater protection standards for nonradioactive and radioactive contaminants. The *Safe Drinking Water Act of 1974,* national primary/secondary drinking water standards, *Clean Water Act of 1977* water quality standards, and state surface water quality standards are also pertinent in determining whether corrective action is protective of groundwater and the Columbia River. The several Federal and state air emission standards are likely to be important in establishing air emission limits and control requirements for any characterization or cleanup actions that produce air emissions. RCRA land disposal restrictions establish numerical treatment standards for dangerous wastes generated during RCAP activities.

Location-specific ARARs potentially pertinent to the RCAP include the *Endangered Species Act of 1973,* which might require protective measures for sensitive ecological resources during characterization or cleanup activities. The land surface in and around the SST farms was significantly disturbed during construction, so cultural and historical resources are not likely to be encountered. However, in the event that RCAP activities occur in previously undisturbed areas, laws and regulations pertaining to protection of such resources are also included in the ARARs listing.

Action-specific ARARs that could be pertinent to the RCAP are state solid and dangerous waste regulations (for management of characterization and cleanup wastes and performance standards for waste left in place), DOE orders and EPA radiation protection standards (for performance standards for radioactive waste management and disposal), and Federal and state regulations related to air emissions.

1

Table 2-1. Overview of the Hanford Facility[a] Dangerous Waste Portion of the RCRA Permit for the Treatment, Storage, and Disposal of Dangerous Waste.

Ecology issued a permit to DOE to authorize[b] the treatment, storage, and disposal of dangerous waste at the Hanford Site. The Hanford Facility RCRA Permit consists of six major parts and attachments as summarized below:	
Part I – Standard Conditions	Provides the legal conditions of the permit such as severability and duties and requirements of the parties.
Part II – General Facility Conditions	Provides conditions that are applicable to the entire Site. For example, it discusses onsite transportation and waste manifesting requirements, land disposal restrictions, record keeping and reporting, etc.
Part III – Unit-Specific Conditions for Final Status Operations	Contains individual chapters that provide the specific conditions applicable to *active* treatment, storage, and disposal units. Currently, there are six such units that have been incorporated into the permit.
Part IV – Correction Actions for Past Practices	States that the HSWA permit is issued by EPA in conjunction with this permit. Upon delegation of the corrective action requirements of the HSWA by EPA to Ecology, the permit shall be modified via a Class 3 modification to incorporate the specific requirements of the HSWA permit into this permit. Until this modification is complete, compliance with the terms of the referenced provisions shall be deemed as compliance with WAC 173-303-646.
Part V – Unit-Specific Conditions for Units Undergoing Closure	Contains individual chapters that provide the specific conditions applicable to storage, treatment, and disposal units that are *undergoing closure*. Usually, the individual chapters incorporate, by reference, the closure plans of the specific units. Currently, there are 14 such units that have been incorporated into the permit, 10 of which have already been clean closed.
Part VI – Unit-Specific Conditions for Units in Post-Closure	Contains individual chapters that provide the specific conditions applicable to storage, treatment, and disposal units that *have already been closed, but that require a post-closure care period.* Generally, land-based units that were not clean closed are subject to post-closure requirements such as groundwater sampling and monitoring. Currently, there are two such units that have been incorporated into the permit.
Attachments	There are currently 40 attachments to the permit, most of which are the closure or post-closure plans or Part B permit applications for specific TSD units. The attachments also include the Tri-Party Agreement, which is an enforceable portion of the permit. Other pertinent attachments include such things as the Facility Contingency Plan, Purgewater Management Plan, the Hanford Legal Description, and acceptable laboratory methods.

[a] For the purposes of the permit, the Hanford Site is considered to be a single facility consisting of over 60 TSD units. Approximately 25% of the TSD units are or are anticipated to be operating, while approximately 50% are closed or are undergoing closure. The remaining TSD units are being dispositioned through other options under the Tri-Party Agreement.

[b] Authority for the permit is pursuant to RCW 70.105, the *Hazardous Waste Management Act of 1976*, as amended; RCW 70.105D, the *Model Toxics Control Act;* and regulations promulgated thereunder by Ecology, codified in WAC 173-303.

[c] Information presented in this box is based on Revision 4A of the dangerous waste portion of the *Resource Conservation and Recovery Act* permit for the treatment, storage, and disposal of dangerous waste, issued by Ecology on February 25, 1998.

Table 2-2. Single-Shell Tank System Waste Management Areas, Associated Treatment, Storage, and Disposal Units, and Operable Unit Assignment. (2 Pages)

WMA (Operable Unit)[a]	TSD Units[b]
A-AX (200-PO-3)	241-A-101 through 241-A-106 (6 SSTs) 241-AX-101 through 241-AX-104 (4 SSTs) 241-A-152 diversion box 241-A-153 diversion box 241-AX-151 diversion box 241-AX-152 diversion box 241-AX-155 diversion box 241-AY-151 diversion box 241-AY-152 diversion box
B-BX-BY (200-BP-7)	241-B-101 through 241-B-112 (12 SSTs) 241-B-201 through 241-B-204 (4 SSTs) 241-BX-101 through 241-BX-112 (12 SSTs) 241-BY-101 through 241-BY-112 (12 SSTs) 241-B-151 diversion box 241-B-152 diversion box 241-B-153 diversion box 241-B-154 diversion box 241-B-252 diversion box 241-BR-152 diversion box 241-BX-153 diversion box 241-BX-154 diversion box 241-BX-155 diversion box 241-BXR-151 diversion box 241-BXR-152 diversion box 241-BXR-153 diversion box 241-BYR-152 diversion box 241-BYR-153 diversion box 241-BYR-154 diversion box
C (200-PO-3)	241-C-101 through 241-C-112 (12 SSTs) 241-C-201 through 241-C-204 (4 SSTs) 241-C-151 diversion box 241-C-152 diversion box 241-C-153 diversion box 241-C-154 diversion box 241-C-252 diversion box 241-CR-151 diversion box 241-CR-152 diversion box 241-CR-153 diversion box

Table 2-2. Single-Shell Tank System Waste Management Areas, Associated Treatment, Storage, and Disposal Units, and Operable Unit Assignment. (2 Pages)

WMA (Operable Unit)[a]	TSD Units[b]
S-SX (200-RO-4)	241-S-101 through 241-S-112 (12 SSTs) 241-SX-101 through 241-SX-115 (15 SSTs) 240-S-151 diversion box 240-S-152 diversion box 241-S-152 diversion box 241-SX-151 diversion box 241-SX-152 diversion box
T (200-TP-6)	241-T-101 through 241-T-112 (12 SSTs) 241-T-201 through 241-T-204 (4 SSTs) 241-T-151 diversion box 241-T-152 diversion box 241-T-153 diversion box 241-T-252 diversion box 242-T-151 diversion box 241-TR-152 diversion box 241-TR-153 diversion box
TX-TY (200-TP-5)	241-TX-101 through 241-TX-118 (18 SSTs) 241-TY-101 through 241-TY-106 (6 SSTs) 241-TX-153 diversion box 241-TX-155 diversion box 241-TXR-151 diversion box 241-TXR-152 diversion box 241-TXR-153 diversion box 241-TY-153 diversion box
U (200-UP-3)	241-U-101 through 241-U-112 (12 SSTs) 241-U-201 through 241-U-204 (4 SSTs) 241-U-153 diversion box 241-U-252 diversion box 241-UR-151 diversion box 241-UR-152 diversion box 241-UR-153 diversion box 241-UR-154 diversion box

[a] The TSD units listed in the second column have been assigned to the indicated operable unit. The operable units and also contain waste sites that are not TSD units. These other waste sites are listed in Appendix B of the Tri-Party Agreement.
[b] The TSD units as listed in the Part A permit application for the SST system.
SST = single-shell tank
TSD = treatment, storage, and disposal
WMA = waste management area

3.0 SUMMARY OF EXISTING INFORMATION

This section summarizes information presented in existing reports describing the Hanford Site, and its operations, waste generation, physical setting, geochemical conditions, tank releases, and the nature and extent of contamination applicable to the 200 Areas SST system. Background information presented in this section and referenced in supporting reports is common to the Hanford Site and the 200 Areas. These data provide an overview of information and shall be used in the development of WMA addenda. Section 3.1, "Operational Overview and Source of Contamination"; Section 3.2, "Physical Setting"; and Section 3.3, "Environmental Resources" of this plan shall be incorporated into WMA addenda by reference. The WMA-specific information not included or partially addressed in this section shall be developed in WMA addenda. Consolidating generic background information in this master work plan is part of the commitment to provide an efficient and consistent approach for planning, performing, and documenting work. The contents of each section are described below.

- The overview of operations (Section 3.1) provides data on the sources of contaminants in the 200 Areas. Discussion of site processes, operational history, waste management philosophies, and chemicals used since 1943 supports the identification of the types and volumes of wastes transferred to the SSTs and contaminants of potential concern.

- Data on the physical characteristics of the Hanford Site and 200 Areas (Section 3.2) are needed to define potential contaminant transport pathways, potential receptors, and to support engineering and corrective action. Emphasis is placed on describing the physical setting and identifying factors that control the migration of contaminants in the subsurface.

- Information on environmental and cultural resources (Section 3.3) provides data on flora, fauna, species of concern, and cultural assets in the 200 Areas. The significance of ecological resources to contaminant fate and transport is also discussed.

- Section 3.4 presents brief discussions describing the current understanding of the nature and extent of vadose and groundwater contamination in WMAs B-BX-BY, S-SX, and T/TX-TY. The combination of background information and the nature and extent of contamination provide the foundation for developing a generic conceptual site model (Section 3.5) for the SST system. This report's conceptual site model presents a general understanding of the distribution of contamination in the vadose zone and the potential impact on groundwater. The WMA-specific site conceptual models will be developed in WMA addenda.

A large amount of historical data is available to present a general understanding of waste site conditions, geology, hydrology, and geochemistry for the Hanford Site and the 200 Areas. Information in this section describing the site history, physical setting, and nature and extent of contamination is compiled largely from the following reports:

- DOE/RL-89-16, *Draft Single-Shell Tanks Closure/Corrective Action Work Plan* (DOE-RL 1989)

- DOE/RL-91-60, *S Plant Aggregate Area Management Study Report* (DOE-RL 1992a)

- DOE/RL-91-61, *T Plant Aggregate Area Management Study Report* (DOE-RL 1992b)

- DOE/RL-92-05, *B Plant Source Aggregate Area Management Study Report* (DOE-RL 1992c)

- DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan, Environmental Restoration Program* (DOE-RL 1999)

- DOE/RL-98-72, *Retrieval Performance Evaluation Methodology for the AX Tank Farms* (DOE-RL 1999a)

- HNF-2603, *A Summary and Evaluation of Hanford Site Tank Farm Subsurface Contamination* (Jones et al. 1998)

- HNF-EP-0182-133, *Waste Tank Summary Report for Month Ending, April 30, 1999* (Hanlon 1999)

- LA-UR-96-3537, *Analysis of SX Farm Leak Histories -- Historical Leak Model (HLM)* (Agnew and Corbin 1998)

- LA-UR-96-3860, *Hanford Tank Chemical and Radionuclide Inventory* (Agnew 1997)

- PNL-6415, *Hanford Site Environmental Policy Act Characterization* (Neitzel 1998)

- PNNL-11800, *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site* (Kincaid et al.1998)

- PNNL-11809, *Results of Phase I Groundwater Quality Assessment for Single-Shell Tank Waste Management Area T and TX-TY at the Hanford Site* (Hodges 1998)

- PNNL-11810, *Results of Phase I Groundwater Quality Assessment for Single-Shell Tank Waste Management Areas S-SX at the Hanford Site* (Johnson and Chou 1998)

- PNNL-11826, *Results of Phase I Groundwater Quality Assessment for Single-Shell Tank Waste Management Area B-BX-BY at the Hanford Site* (Narbutovskih 1998)

- PNNL-12086, *Hanford Site Groundwater Monitoring for Fiscal Year 1998* (Barnett et al. 1999).

3.1 OPERATIONAL OVERVIEW AND SOURCE OF CONTAMINATION

3.1.1 Hanford Site Background

The Hanford Site (see Figure 1-1) lies within the semi-arid Pasco Basin of the Columbia Plateau in southeastern Washington State. Established in 1943, the Hanford Site was designed, built, and operated to produce plutonium for military nuclear weapons. The Hanford Site is approximately 50 km (31 mi) north to south and 40 km (25 mi) east to west, and encompasses approximately 1,450 km^2 (560 mi^2) north of the confluence of the Yakima and Columbia Rivers. This land, with restricted public access, provides a buffer for the smaller fenced areas currently used for storage of nuclear materials, waste storage, and waste disposal. Only about 6% of the land area has been disturbed and is actively used. The Columbia River flows eastward through the northern part of the Hanford Site and, after turning south, forms part of the Site's eastern boundary. The Yakima River runs near the southern boundary of the Hanford Site and joins the Columbia River at the city of Richland, Washington, which bounds the Hanford Site on the southeast. Rattlesnake Mountain, Yakima Ridge, and Umtanum Ridge form the southwestern and western boundaries. The Saddle Mountains form the northern boundary of the Hanford Site. Adjoining lands to the west, north, and east are principally range and agricultural land. The cities of Kennewick, Pasco, and Richland (also known as the Tri-Cities) constitute the nearest population centers and are located southeast of the Hanford Site (Neitzel 1998).

The Hanford Site is divided into a number of operational areas. The 100, 200, and 300 Areas were used for irradiation, chemical processing, and fabrication efforts associated with production. The 600 Area includes portions of the Hanford Site not included in the 100, 200, or 300 Areas and served primarily as a transportation corridor and buffer zone between the fabrication, irradiation, and chemical processing areas. Other designated areas of the Hanford Site include the 400 Area (Fast Flux Test Facility) and the 700 and 3000 Areas (the U.S. Department of Energy, Richland Operations Office [RL] and contractor offices in Richland). The current mission at the Hanford Site focuses on waste management and environmental restoration.

3.1.2 Nuclear Processing and Operational History

This section describes the generation and disposal of radiological and chemical contaminants in the 200 Areas and WMAs B-BX-BY, S-SX, and T/TX-TY. The major chemical separation processes and waste management activities in the 200 Areas are described in DOE/RL-91-60 (DOE-RL 1992a), DOE/RL-91-61 (DOE-RL 1992b), DOE/RL-92-05 (DOE-RL 1993c), and Kupfer et al. (1999).

Plutonium production began at the Hanford Site with the delivery of cylindrical metal uranium billets to the 300 Area in 1943. The uranium metal was formed into cylindrical rods, cut into slugs, and fabricated into clad type fuel rods suitable for loading into nuclear reactors. The slugs were placed in reactor piles in the 100 Areas, irradiated, and cooled to allow the decay of high-activity radionuclides. The fuel rods were eventually taken to the 200 Areas for processing in one of the separation plants. The various separation processes (e.g., the bismuth phosphate

[$BiPO_4$], uranium recovery, reduction-oxidation [REDOX], and plutonium/uranium extraction [PUREX]) are described by Kupfer et al. (1999).

All separation processes required decladding of the fuel slugs by caustic dissolution of the cladding. The uranium fuel rod was then dissolved in a bath of nitric acid in preparation for the separation process. The purpose of the separation process was plutonium (and later, uranium) recovery. With the start up of separation processes in the 200 Areas, large volumes of uranium- and fission-product-rich liquid wastes were generated. The wastes also contained hazardous chemicals used in the separation processes such as bismuth phosphate ($BiPO_4$), lanthanum fluoride (LaF_3), organic solvents (e.g., carbon tetrachloride, methyl isobutyl ketone, tributyl phosphate, and normal paraffin hydrocarbon), inorganic acids, and inorganic chemicals.

The waste generated from these processes led to the construction of a total of 12 SST farms and six DST farms that were used to manage the waste. Most of the high-volume, low concentration waste (slightly contaminated) comprised over 90% by volume all liquid waste discharges. Most of the high-volume, low concentration wastes generated by these processes were typically discharged to the ground (i.e., ponds, cribs, trenches, and french drains). Conversely, the low-volume, high concentration streams were managed in tank farms. The radioactive material flow diagram for the Hanford Site is shown schematically in Figure 3-1.

The practice of adding waste to the SSTs ended in 1980 and a program began to transfer all pumpable liquids from the SSTs to the newer DSTs (Jones et al. 1998). The waste currently remaining in the SSTs consists primarily of sludge, saltcake, and interstitial liquid (Hanlon 1999). A cross-section of the typical SST is shown in Figure 3-2.

3.1.3 History of the Single-Shell Tanks Waste Management Areas

From 1943 through 1964, 149 SSTs and associated facilities (e.g., diversion boxes, catches, settling and receiving tanks, receiving vaults, transfer lines, cribs, and valve pits) were constructed to manage liquid waste generated from plutonium production and separation operations at the Hanford Site. Many neutralized nitric acid-based waste types were generated from several operations, including the $BiPO_4$ process (T Plant and B Plant), the uranium recovery process, the REDOX process, the PUREX process, and several isotope recovery processes (Anderson 1980; Agnew 1997). A brief description and history of WMAs B-BX-BY, S-SX, and T/TX-TY are presented in this section. The SSTs, associated facilities, and adjacent waste sites are also identified in Table 3-1.

3.1.3.1 Waste Management Area B-BX-BY Description and History. A total of 40 SSTs are found in WMA 241-B-BX-BY. The tanks and associated facilities were constructed from 1943 to 1944, 1946 to 1947, and 1948 to 1949, respectively, in the north section of the 200 East Area (Figure 3-3). A total of 16 tanks are contained within the 241-B tank farms; 12 tanks are contained within the 241-BX tank farm; and 12 tanks are contained within the 241-BY tank farm. In this WMA, 20 SSTs are suspected of having leaked.

Tanks in the 241-B tank farm were constructed based on two different designs. In both designs, the tanks were vertical cylinders with domed tops. Each tank was constructed using a carbon-steel cylinder surrounded by reinforced concrete. The tanks are all underground and covered with 1.8 m (6 ft) of earth above the tank dome. Twelve tanks, numbered 241-B-101 through 241-B-112, with the same design, are 23 m (75 ft) in diameter and have a capacity of 2,006,000 L (530,000 gal). Four smaller tanks with the same design, numbered 241-B-201 through 241-B-204, have a 6.1-m (20-ft) diameter and a capacity of 209,000 L (55,000 gal).

Tanks in the 241-BX and 241-BY tank farms were designed similar to those in the 241-B tank farm, with the exception of larger capacity tanks. These tanks are also underground and covered with at least 2.1 m (7 ft) of earth above the dome. The 12 tanks in the 241-BX tank farm are numbered 241-BX-101 through 241-BX-112; they each have a 23-m (75-ft) diameter and a capacity of 2,006,000 L (530,000 gal). The 12 tanks in the 241-BY tank farm are numbered 241-BY-101 through 241-BY-112; they each have a 23-m (75-ft) diameter and a capacity of 2,880,400 L (758,000 gal).

3.1.3.2 Waste Management Area S-SX Description and History. The SSTs in the 241-S and 241-SX tank farms and ancillary waste units were constructed from 1950 to 1951 and 1953 to 1954, respectively, in the southern part of the 200 West Area. The area around the S-SX tank farm is shown in Figure 3-4. The S and SX tank farms are the third generation of tanks at the Hanford Site and was built with the intention that the tanks would contain hot, self-boiling waste from the REDOX Facility. The 27 tanks were designed very similarly in both tank farms; each tank is a vertical cylinder with a domed top, constructed with a carbon-steel liner surrounded by reinforced concrete. The liners were butt-welded together and, in some cases, welded with round steel complex knuckles. The inability of the steel liners to expand may be a factor that contributed to containment failures (DOE-GJO 1996). The base of the tanks were placed about 17 to 18 m (56 to 59 ft) below ground surface during construction and were covered with 1.8 m (6 ft) of earth over the dome. The 241-S and 241-SX tanks are 23 m (75-ft) diameter, about 13.5 m (44.4-ft) tall, and have a capacity of 2,880,400 L (758,000 gal) and 3,785,000 L (1,000,000 gal), respectively. The 12 tanks in the 241-S tank farms are numbered 241-S-101 through 241-S-112, and the 15 tanks in the 241-SX tank farms are numbered 241-SX-101 through 241-SX-115. Eleven of the SSTs in this WMA are suspected of having leaked.

3.1.3.3 Waste Management Area T Description and History. There are 16 SSTs in the 241-T tank farm. The tanks and ancillary waste units were constructed in the 200 West Area (Figure 3-5) between 1943 and 1944. Tanks in the 241-T tank farm were constructed based on two different designs. In both designs, the tanks are vertical cylinders with a domed top; each is constructed of reinforced concrete with a carbon-steel liner. The tanks are all underground and covered with 1.8 m (6 ft) of earth over the dome. Twelve tanks with the same design, numbered 241-T-101 through 241-T-112, have a 23-m (75 ft) diameter and a capacity of 2,020,000 L (533,000 gal). Four smaller tanks each with the same design, numbered 241-T-201 through 241-T-204, have a 6.1-m (20-ft) diameter and a capacity of 209,000 L (55,000 gal). Seven of the SSTs in this WMA are suspected of having leaked.

3.1.3.4 Waste Management Area TX-TY Description and History. The SSTs in the 241-TX and TY tank farms and ancillary waste units were constructed from 1947 to 1948, and 1951 to

1952, respectively, in the 200 West Area (Figure 3-5). Eighteen of the 24 SSTs in WMA TX-TY are located in the 241-TX tank farm. Six tanks are located in the 241-TY tank farm. Thirteen of the SSTs in WMA TX-TY are suspected of having leaked.

Tanks in the 241-TX and 241-TY tank farms were designed identically as vertical cylinders with domed tops and constructed of reinforced concrete with a carbon steel liner. The tanks are all underground and covered with 1.8 m (6 ft) of earth above the dome. The eighteen tanks in the 241-TX tank farm are numbered 241-TX-101 through 241-TX-118; six tanks in the 241-TY tank farm are numbered 241-TY-101 through 241-TY-106. The tanks have a 23 m (75 ft) diameter and a capacity of 2,880,400 L (758,000 gal).

3.1.4 Current Hanford Tank Waste Inventories

Because of the extensive transfer and commingling of waste types over the more than 50 years of SST operations, the chemical and radioactive waste inventories currently in each SST are uncertain. Over the last decade, two approaches have been used to estimate the Hanford Site tank waste inventories.

The first approach was a SST waste characterization program that began in 1989 (WHC 1989b). A selected number of cores were collected from the tank of interest and transferred to the analytical laboratory for extensive characterization. Tank inventories were estimated based on laboratory analytical results and were documented in tank characterization reports. Currently, the available database from sampling and analysis is somewhat limited. Tank characterization reports and tank waste analysis data are available electronically on the Tank Waste Information Network System (TWINS) database (http:twins-pnl.gov:8001\TCD\main.html).

The second approach involved estimating tank waste inventories based on process records and waste transfer documentation (WHC 1984). Waste transfer data are summarized in the *Waste Status and Transaction Record Summary* (WSTRS) (Agnew et al. 1995); inventory estimates are reported for each tank in the *Hanford Tank Chemical and Radionuclide Inventories: HDW Model* (Agnew 1997).

Results from both the laboratory analyses and the HDW model were evaluated, and a best-basis inventory (BBI) estimate was developed for each SST and DST on the Hanford Site (Kupfer et al. 1997). The BBI is estimated and managed with a change control process that is updated as new information becomes available. This information is published individually for each tank and is available electronically through the TWINS database. The TWINS database is the official site database for BBI estimates.

3.1.5 Tank Inventories at the Time of Leaks

Future modeling efforts to evaluate the long-term impacts of any tank leak will require an inventory estimate of chemicals and radionuclides lost to the vadose zone at the time of the leak. One approach for estimating tank leak inventories is to use the HDW model to predict tank compositions during the time the tank may have leaked. This information is coupled with the estimated leak volume to calculate the tank waste inventory lost during a leak event. To develop

a historical leak model, Agnew and Corbin (1998) reconstructed the tank waste inventories believed to have been present when the tanks were thought to have leaked. The historical leak model (HLM) was run to specific points in time to predict the chemical and radionuclide inventories for four tanks (SX-108, -109, -111, and -112). Use of the HLM has been criticized for various technical reasons. Additional modeling to develop inventory estimates is needed to support an evaluation of long-term impacts from tank leaks.

3.1.6 Sources of Tank Waste Currently in the Vadose Zone

During the operating lifetime of the chemical separation processes at the Hanford Site, high-level radioactive liquid waste entered the vadose zone (both intentionally and inadvertently) through several pathways. This included tank waste intentionally discharged to the vadose zone, waste transfer line leaks, leaks, and spills associated with SST waste storage and operations.

3.1.6.1 Tank Waste Intentionally Discharged to the Vadose Zone. From 1944 to 1966, approximately 458,035 kL (121,000,000 gal) of tank waste liquid were intentionally discharged from SSTs into the soil column (WHC 1991c). This waste was discharged to cribs, injection wells, and specific retention trenches, many of which are located near the tanks of origin. The types of liquid waste discharged included first- and second-cycle waste coming from the $BiPO_4$ processes, 224-B waste from plutonium purification, and, in limited amounts, evaporator bottoms from 242-T and 242-B evaporators and scavenged first-cycle supernatant liquid. The specific dates, origins, volumes, and disposal sites for each of these waste types are reported in WHC (1991c) and are shown in Tables 3-2 and 3-3. However, the total inventory of radionuclides and contaminants discharged into the vadose zone from these sources has not been fully evaluated or compared to the potential inventory from discharges caused by tank leaks. Over the same period, billions of gallons of uncontaminated and slightly contaminated water from various processing facilities were also discharged to ponds, trenches, ditches, and cribs in and around the 200 Areas. The cleanup approach for most of these liquid waste disposal facilities is addressed in DOE/RL-98-28 (DOE-RL 1999).

3.1.6.2 Waste Transfer Line Leaks. Approximately 70 unplanned releases and spills associated with tank waste are identified in the Waste Information Data System (WIDS) database (WHC 1991c; Maxfield 1979). WHC (1991c) estimated that more than 379 kL (100,000 gal) of liquid waste have been released to the ground from the transfer line leaks.

Jones et al. (1998) provide examples of unplanned releases in and around the S-SX tank farm complex. Radioactive materials from the unplanned releases in this area undoubtedly account for some of the near-surface contamination identified in gamma-logging activities. Thus, as with the intentional tank waste discharges discussed earlier, transfer line leaks in or near tank farms may have affected the vadose zone under the tank farms.

3.1.7 Leaks Associated with Single-Shell Tank Waste Storage and Operations

Currently, 67 SSTs are listed in the monthly waste tank summary report[1] (Hanlon 1999) as confirmed or assumed tanks that have leaked. Along with the list of confirmed or assumed tanks that have leaked, this document provides estimated leak volumes, the date that a tank was declared a leaker, and references. However, the leak dates listed by Hanlon (1999) are the dates that the tanks were declared or assumed leaking, not the time the leak was first suspected. In addition, uncertainties exist in the estimated tank leak volumes and even in the selection of tanks included in this list (see Agnew and Corbin 1998). Confirmed and assumed tanks that have leaked in the WMAs are shown in Figures 3-3, 3-4, and 3-5. SSTs identified as confirmed or assumed to have leaked, have been stabilized by removing drainable liquids. These tanks are not known to be leaking at this time.

The two approaches used for detecting leaks from SSTs include in-tank waste level measurements, and gamma-ray logging in monitoring wells around and in two tank farms, under the tanks (WHC 1988). Neither approach provided unequivocal evidence of a tank leak in all cases. In-tank waste level measurements become less certain when solid waste surfaces are encountered. When liquids are removed from tanks with a solid surface, the surface becomes irregular. Under these conditions, estimating waste volumes from spatially limited surface-level measurements becomes uncertain (WHC 1993).

A recent change in the tank leak assessment procedure involves the implementation of a process that identifies the first data anomaly that may be indicative of a leak. The process utilizes multiple lines of evidence such as in-tank and well monitoring, process history and uncertainty to determine the status of tanks. Decisions regarding the status of tanks are made by a group of experts that have extensive knowledge of tank and well monitoring, and tank operation and process. Based on the methodology described in the LMHC 1999 tanks are classified as assumed sound or assumed tanks that have leaked.

As discussed in Section 3.1.8, gamma activity was monitored in wells within the tank farms. The appearance of, or increase, in gamma activity in a monitoring well would suggest the possibility of a leaking tank (Isaacson and Gasper 1981). The uncertainties associated with using gamma-logging methods to detect tank leaks are well documented (Isaacson and Gasper 1981; Isaacson 1982). Even when gamma logging in wells around a specific tank detected radioactivity, an assumption still had to be made as to where the radioactivity originated. Without a focused effort, the exact source of gamma activity located in a monitoring well remained somewhat uncertain.

[1] The monthly waste tank summary report (Hanlon 1999) is the official DOE source for waste volumes stored in underground storage tanks in the 200 Areas of the Hanford Site. The data depicting the status of stored radioactive waste and tank integrity are reported in this document. This document is updated monthly to reflect the most current referenceable data source and the statuses currently listed in the waste tank summary report are updated as new information becomes available. Therefore, the information listed in the monthly waste tank summary report is taken as the starting point for any discussion of Hanford Site tank leaks.

Given the difficulties in simply identifying a leak in an SST, it is not surprising that estimating the volume of material lost during a leak event is also imprecise (Baumhardt 1989). Except in the cases of the leaks in tanks T-106 and SX-115, a large amount of uncertainty exists in the leak volumes listed in the monthly waste tank summary report (Hanlon 1999, and references therein).

The uncertainties associated with the leak detection methods are necessarily imbedded in the list of confirmed or assumed SSTs that have leaked in the monthly waste tank summary report. Reviewing many of the references listed in Hanlon (1999) for the SST leaks indicates that each tank leak event tends to be unique (Jones et al. 1998). The evidence for a leak, volume of waste lost, the waste chemistry, and overall knowledge about the leak and its impacts on the environment are different for each event. As noted by Hanlon (1999), some undocumented leaks from SSTs are likely because of the limitations of the leak detection methods. The estimated volume of waste released to the environment from leaking SSTs in WMAs B-BX-BY, S-SX, and T/TX-TY is 1,810,320 L (467,400 gal) (Hanlon 1999). The historical documents associated with four tank leak events (A-105 [WHC 1991b], SX-108 [WHC 1992a], SX-109 [WHC 1992b], SX-115 [WHC 1992c]) have been compiled and provide examples of the level of effort required and information available from archived records.

3.1.8 Gamma-Ray Logging and Leak Detection

Since the 1960s, gross gamma logging has been conducted in monitoring wells (drywells) around tanks in the SST, farms both regularly and as needed (Isaacson and Gasper 1981; WHC 1988). Logging was also performed in laterals under selected tanks in two farms (Figure 3-2). Gross gamma-logging techniques provide information on radiation levels as a function of depth to detect leakage of tank waste in the subsurface. These data show the history of contaminant migration and, occasionally, the beginning of a leak (Isaacson and Gasper 1981). Many of these analyses have been completed and provide an essential element in assessing contaminant migration (Adams 1998). Data derived from these logging campaigns through the early 1970s were maintained as paper analog records. Data derived since 1974 have been stored digitally and are available from the Hanford Site local area network. However, most of the early leak history appears to fall within the time frame of the non-digitized information.

The gamma logs were collected as part of the secondary leak-detection system using a variety of tools with a range of sensitivity (Isaacson and Gasper 1981; WHC 1988). In general, these tools were run at an uphole logging speed of about 14 m/min (45 ft/min). Logs were often run as frequently as weekly. These logs were examined immediately after being taken and were assessed to ascertain if the leak detection criteria were exceeded. If the logs did not exceed the established criteria, they were archived and not reviewed further. If the logs exceeded the established criteria, other tank data were analyzed to determine if the tank was indeed leaking.

In 1995, a baseline spectral gamma-logging program of all drywells in the SST farms was initiated by Mactec-ERS and its predecessor, Rust Geotech, through the U.S. Department of Energy, Grand Junction Project Office (DOE-GJO). Spectral gamma-logging techniques provide information on concentrations of specific gamma-emitting radionuclides. Gamma spectra were collected at 0.2-m (0.5-ft) intervals over the depth of the tank farm drywells. Counting time at each interval averages 100 seconds. A high-purity germanium (HPGe) detector was used for this

effort. Baseline spectral gamma logging has been completed for all of the SST farms. Results of these efforts are available (DOE-GJO 1997a, 1997b, 1998a, 1998b, and 1998c) and will be summarized in WMA addenda.

The availability of digitized historical data has presented an opportunity to perform analyses beyond those for which the data were originally collected. The data from the gamma logs routinely collected over more than 20 years are the key to discovering how gamma-emitting contaminants have moved through the subsurface. By ascertaining when these contaminants moved, the driver that caused the movement could probably be determined (Jones et al. 1998). Differences in the rate or timing of movement from various farms will provide additional insight into controlling factors such as leak volume, waste chemistry, or geology. Combining gamma-logging data with speciation data from spectral gamma-logging results and waste chemistry at the time of tank leaks may help to successfully identify sources of radioactive waste plumes in tank farms and the time frames that the plumes were produced.

Gamma-logging techniques do have their associated limitation. The gamma-logging techniques provide no direct information about the non-gamma-emitting, long-lived mobile radionuclides such as Tc-99, I-129, and other chemicals. The gamma-logging data are further limited by the availability of boreholes and the fact that gamma rays are completely attenuated by 30 to 46 cm (12 to 18 in.) of soil. Thus, large tank leaks could have been missed because of the location of available monitoring wells. A summary of logging efforts applicable to SSTs shall be included in WMA addenda.

3.1.9 Major Potential Contaminants

Several prior efforts have been undertaken to identify contaminants associated with the SST system. Lists of potential radioactive contaminants were developed during preparation of seven aggregate area management study (AAMS) reports (DOE/RL-91-52 [DOE-RL 1992c], DOE/RL-91-58 [DOE-RL 1992d], DOE/RL-91-60 [DOE-RL 1992a], DOE/RL-91-61 [DOE-RL 1992b], DOE/RL-92-04 [DOE-RL 1993d], DOE/RL-92-05 [DOE-RL 1993c], DOE/RL-92-18 [DOE-RL 1993e]). There are also lists of radioactive contaminants in DOE/EIS-0180 (DOE 1996), Schmittroth and Delorenzo (1995), Kincaid et al. 1998, DOE-RL (1998a), and DOE-RL 1999a. Lists of potential nonradioactive contaminants were developed as part of *Regulatory Data Quality Objectives Supporting Tank Waste Remediation System Privatization Project* (Lerchen et al. 1998). This section summarizes efforts to identify COPCs for the RCAP. These lists will be utilized during the WMA-specific DQOs.

The AAMS reports were designed to evaluate source terms on a wide scale and are specific to the 200 East and 200 West Areas. The list of potential radioactive contaminants in each of the seven AAMS reports was developed based on the known presence of these contaminants in waste, and their usage, disposal in WMAs, historical association, or detection in environmental media. Known contaminants have been proven to exist based upon sampling and inventory data. Suspected contaminants may be present based upon historical practices, chemical associations or in-growth during radiological decay. The lists of radioactive COPC in the DOE/EIS-0180 (DOE 1996), (DOE-RL 1998a), DOE/RL-98-72 (DOE-RL 1999), Schmittroth and Delorenzo (1995), and (Kincaid et al. 1998) are based on tank inventories. A total of 151 radioactive

constituents were identified based on the review of contaminants in all of these reports. (Table 3-4). A master list of radioactive COPC for the RCAP will be identified through the DQO process based on Table 3-4 constituents. Exclusion criteria shall be developed during the session to screen out potential radioactive contaminants posing insignificant risk to human health and the environment. Exclusion criteria implemented for other Hanford Site environmental projects should be considered. For example, exclusion criteria in BHI 1999 to support Environmental Restoration Contractor efforts include:

- Short-lived radionuclides (half-life less than 3 years)
- Radionuclides that constitute less than 1% of the fission product inventory based on activity and where historical sampling indicates nondetection
- Naturally occurring isotopes that were not created as a result of Hanford Site operations
- Constituents with atomic mass number greater than 242 that represent less than 1% of the actinide activity, or both
- Progeny (P) radionuclides that build insignificant activities within 50 years, or for which parent and progeny relationships exist that permit progeny estimation
- No apparent source in the 200 Areas.

A screening to identify nonradioactive COPCs associated with the Hanford Site tank system (both SSTs and DSTs]) was conducted by a team of technical experts and DOE and Ecology representatives as part of the regulatory DQO process in support of tank waste disposal activities. The screening used the following sources as input to identify the initial universe of constituents to be considered, referred to as the consolidated regulatory DQO input list:

- Process knowledge and history, including knowledge of processes used at the Hanford Site, historical data from previous tank sampling, tank chemistry, and tank and evaporator databases
- The following lists of regulated substances:
  - Toxic air pollutant lists (Classes A and B) (WAC 173-460-150 and –160)
  - Underlying hazardous constituents list (40 CFR Part 268.48)
  - Universal treatment standards list (40 CFR Part 268.48)
  - The waste codes listed on the DST Part A permit application (this list includes all of the SST waste codes)
  - DST waste stream profile constituents.

Two other lists of regulated substances (Appendix VIII of 40 CFR Part 260 and the Hanford Site Effluent Treatment Facility delisting petition list of compounds) were considered by the team for inclusion on the input list. By mutual agreement, it was determined that these sources did not provide additional constituents that should be considered (Lerchen et al. 1998).

The consolidated regulatory DQO input list was screened further against several criteria. For screening, organic and non-organic constituents were grouped separately. The organic constituents were further separated into regulated non-detected versus regulated and detected. The following screening steps were performed:

- Regulated nondetected organics were eliminated if they were unlikely to have been used in any Hanford Site processes or if they were unlikely to have been stable in a tank waste environment (e.g., the organics decomposed).

- Detected and nondetected regulated organics were reviewed for potential toxicity and carcinogenicity; those in low toxicity classes were eliminated.

- Regulated non-organic constituents were eliminated if they were not included on the Hanford Site inventory list and are seldom used in industry.

The resulting list of organic and non-organic constituents is being used for tank waste disposal programs and will be considered the nonradioactive COPC list for the SST system. This list is provided in Table 3-5.

3.2 PHYSICAL SETTING

A summary of the significant characteristics of the Hanford Site and 200 Areas physical settings are included in this section to support development of the generic conceptual site model and exposure pathways. This section describes the topography, meteorology, and hydrogeologic framework of the Hanford Site and the 200 Areas. A geochemistry summary is also included to provide an overview of factors that control contaminant fate and transport in the subsurface. Detailed discussion of the Hanford Site and 200 Areas physical setting is presented in the following reports and is used to developed this section: DOE (1988), DOE-RL (1992a), DOE-RL (1992c), DOE-RL (1992d), DOE-RL (1993a), DOE-RL (1993b), DOE-RL(1989), Neitzel (1998), Barnett et al. (1999), Jones et al. (1998), DOE-RL (1998a), Kincaid et al. (1998), and Barnett et al. (1999). The information in this section is also included so it can be referenced rather than repeated in WMA addenda.

3.2.1 Topography of the 200 Areas

The land surface of the Hanford Site is dominated by low-relief plains and basaltic ridges (i.e., Gable Mountain, Umtanum Ridge, Yakima Ridge, and Rattlesnake Hills) in the western portion of the site that rise above these plains (Figure 3-6). This general topography of the Hanford Site has been modified by two natural processes, Pleistocene cataclysmic flooding and Holocene eolian activity, and by Hanford Site construction activity.

Cataclysmic flooding occurred when ice dams in western Montana and northern Idaho were breached, allowing large volumes of water to spill across eastern and central Washington. The last major flood occurred about 13,000 years ago, during the late Pleistocene epoch. Flood channels, giant current ripples, and giant flood bars are among the landforms created by the floods. One of these flood bars (Cold Creek Bar) forms a prominent terrace, roughly defined by the 215-m (700-ft) contour line that is commonly referred to as the "200 Area Plateau" because the surface of the flood bar is a broad, flat area that constitutes a local topographic high (Figure 3-6). This terrace drops off to the north and northwest with elevation changes between 15 and 30 m (50 and 100 ft) (DOE-RL 1993b).

Cold Creek Bar trends generally east-west. The northern boundary of the flood bar is defined by an erosional channel that runs east-southeast before turning south, just east of the 200 East Area. This erosional channel formed during waning stages of flooding as floodwaters drained from the basin (Bjornstad et al. 1987). The northern half of the 200 East Area and the entire 200 North Area lie within this ancient flood channel (Figure 3-6). The southern half of the 200 East Area and most of the 200 West Area are situated on the flood bar. A secondary flood channel running southward off the main channel bisects the 200 West Area (Last et al. 1989). Buried former river and flood channels may influence the pathways for groundwater and contaminant movement.

Since the end of the Pleistocene epoch, winds have locally reworked the flood sediments, depositing primarily sand on the low-relief plains, and loess (windblown silt) around the margins of the Pasco Basin Neitzel (1998). In the 200 West Area and southern part of the 200 East Area, these deposits consist dominantly of laterally discontinuous sheets of wind-blown silt and fine-grained sand (Barnett et al. 1999). Anchoring vegetation has stabilized much of the dune sand; however, stabilized dunes are easily reactivated in areas where vegetation is disturbed by fire or humans. Stabilized sand dunes are present along the southern boundary of the 200 East Area (Last et al. 1989).

Construction and operation of chemical separation processing and waste management facilities also resulted in modifications to the topography. Specifically the construction of roads, processing facilities and support buildings, as well as construction and operation of the tank farms, ponds, cribs, ditches burial grounds and other disposal facilities have altered natural features.

The topography of the 200 West Area is generally flat with elevations ranging from approximately 221 m (725 ft) above mean sea level (amsl) along the northern half of the eastern perimeter, situated on the flood bar, to approximately 197 m (647 ft) amsl in the southwestern corner (DOE-RL 1993b). The topography of the 200 East Area is also generally flat. Its elevation ranges from approximately 225 m (740 ft) amsl in the southwestern part, situated on the flood bar, to approximately 180 m (590 ft) amsl in the northeastern part, situated within the flood channel (DOE-RL 1993a).

3.2.2 Meteorology of the 200 Areas

The Hanford Site lies east of the Cascade Mountains and has a semi-arid climate because of the rainshadow effect of the mountains. Climatological data are monitored at the Hanford Meteorological Station (HMS), which is located between the 200 East and 200 West Areas, and at other locations throughout the Hanford Site. Meteorological data from the HMS are available for 1945 through 1996 (Hoitink and Burk 1997), and for 1997 through 1998 on the HMS internet site (Hoitink and Burk 1998). Historical data tables of temperature and precipitation are also available through the HMS internet site (Hoitink and Burk 1998). Data from the HMS are representative of the general climatic conditions for the region and describe the specific climate of the 200 Area Plateau (Neitzel 1998).

3.2.2.1 Wind. The Cascade Mountains have considerable effect on the wind regime at the Hanford Site by serving as a source of cold air drainage. Because of this gravity drainage, prevailing wind directions on the 200 Area Plateau are from the northwest during all months of the year (Figure 3-7). Secondary maxima occur for winds from the southwest. Winds from the northwest quadrant occur most often during the winter and summer. During the spring and fall, the frequency of winds from the southwest increases with a corresponding decrease in northwest flow. Winds blowing from other directions (e.g., northeast) display minimal variation from month to month (Neitzel 1998).

Monthly average wind speeds are lowest during the winter months, averaging 10 to 11 km/hr (6 to 7 mi/hr), and highest during the summer, averaging 13 to 15 km/hr (8 to 9 mi/hr) (Hoitink and Burk 1997). Wind speeds that are well above average are usually associated with southwesterly winds. However, the summertime drainage, winds are generally northwesterly and frequently reach 50 km/hr (30 mi/hr) (Neitzel 1998).

Winds are a potential agent of contaminant transport for particles at the ground surface. For example, former liquid waste disposal sites at ground surface (e.g., ponds and trenches) that dry out may expose contaminated soils that could be mobilized by wind.

3.2.2.2 Barometric Pressure. The average barometric pressure at the HMS is 98.9 kPa (29.2 in. mercury). In general, the barometric pressure is higher in the winter than in the summer, although both the highest and lowest recorded pressures at the Hanford Site occurred during the winter (DOE 1988). Fluctuations in barometric pressure also tend to be greater in winter than in summer (Figure 3-8). Fluctuations in barometric pressure affect the movement of volatile contaminants within the vadose zone by inducing natural subsurface pressure gradients. This naturally occurring barometric pumping phenomenon can also cause release of volatile contaminants to the atmosphere.

3.2.2.3 Temperature and Humidity. The mean surface air temperature averages approximately 12°C (54°F) at the HMS (DOE 1988). During the 52 years between 1945 and 1997, the average monthly temperature was coldest in January at -1°C (31°F) and the hottest in July at 25°C (76°F) (Hoitink and Burk 1998). The maximum and minimum monthly average temperatures during any single year are listed for each season in Table 3-6. The maximum temperature recorded at

the HMS was 45°C (113°F) in August 1961; the minimum temperature recorded at the HMS was –31°C (-23°F) in February 1950 (Hoitink and Burk 1998).

The annual average relative humidity at the HMS is 54%. Humidity is highest during the winter months, averaging about 75%, and lowest during the summer, averaging about 35% (Neitzel 1998).

Temperature affects the evapotranspiration of precipitation and is one factor determining the amount of recharge to the unconfined aquifer. Precipitation that infiltrates through the vadose zone can mobilize contaminants.

3.2.2.4 Precipitation. Average annual precipitation at the HMS during the 50 years between 1947 and 1997 was 17.3 cm (6.8 in.) (Hoitink and Burk 1998). In the wettest year on record, 1995, 31.2 cm (12.3 in.) of precipitation were measured; in the driest year (1976), only 7.6 cm (3.0 in.) were measured. On average, winter is the wettest season; approximately 38% of the annual precipitation falls during December, January, and February. Only 14% of the annual precipitation falls during June, July, and August. Even though precipitation is less frequent during the summer months, summer rainfall (when it does occur) is on average twice as intense as winter precipitation (DOE 1988). The maximum monthly average precipitation during any single year is listed for each season in Table 3-7.

During the 51 winters between 1946 and 1997, the average monthly snowfall was the highest in December at 13.7 cm (5.0 in.) and the lowest in March at 1.3 cm (0.5 in.) (Hoitink and Burk 1998). The record monthly snowfall of 59.4 cm (23.4 in.) occurred in January 1950; the second highest monthly snowfall of 57.4 cm (22.6 in.) occurred in December 1996. The seasonal record snowfall of 142.5 cm (56.1 in.) occurred during the winter of 1992-1993. Snowfall accounts for about 38% of all precipitation from December through February (Neitzel 1998). On average, the depth of snow on the ground will exceed 150 mm (5.9 in.) in about only one winter out of eight (DOE 1988).

Days with greater than 1.3 cm (0.5 in.) of precipitation occur on average less than one time each year. Rainfall intensities of 1.3 cm/hr (0.5 in./hr) persisting for 1 hour are expected once every 10 years. Rainfall intensities of 2.5 cm/hr (1 in./hr) for 1 hour are expected only once every 500 years (Neitzel 1998).

The average occurrence of thunderstorms is 10 per year. Thunderstorms are most frequent during the summer; however, they have occurred in every month (Neitzel 1998). Lightning strikes in the summer have occasionally ignited grass fires that have burned thousands of acres in the Hanford Site region (DOE 1988).

The frequency and intensity of precipitation at the Hanford Site are of specific interest because of their influence on moisture infiltration to soil and potential recharge to groundwater. The rate and degree of infiltration of snow will also depend on the rate at which it melts. Large amounts of precipitation can enter the ground over relatively small areas as the result of a downpour from a thunderstorm or rapid snow melt. Potential surface run-off and run-on at individual waste sites will depend on the local topography and permeability of ground surface

cover. Building and road run-off of relatively low rates of rainfall can lead to water being focused on small areas and ponding in low areas, both of which could increase the infiltration rate. Another cause of increased infiltration is associated with leaks or spills from utility water lines, such as those in the fire hydrant systems.

3.2.3 Hydrogeologic Setting

This section provides an overview of the hydrogeologic setting of the Hanford Site and the 200 Areas. This section is developed using the following reports: DOE (1988); DOE-RL (1992a), DOE-RL (1992c), DOE-RL (1992d), and DOE-RL (1993a), DOE-RL (1993b), DOE-RL (1989), Hartman and Dresel (1998), DOE-RL (1998b), Kincaid et al. (1998), and Barnett et al. (1999). The hydrogeologic setting in WMA addenda will focus on the WMA setting.

3.2.3.1 Regional Geologic Setting. The Hanford Site lies in the Columbia Plateau, a broad plain situated between the Cascade Range to the west and the Rocky Mountains to the east. The Columbia Plateau was formed by a thick sequence of Miocene-age tholeiitic basalt flows, called the Columbia River Basalt Group, that erupted from fissures in north-central and northeastern Oregon, eastern Washington, and western Idaho (Swanson et al. 1979). The Columbia Plateau is often called the "Columbia Basin" because it forms a broad lowland surrounded by mountains. In the central and western sections of the Columbia Plateau, where the Hanford Site is located, the Columbia River Basalt Group is underlain by continental sedimentary rocks from earlier in the Tertiary Period.

The basalt and sedimentary rocks have been folded and faulted over the past 17 million years, creating broad structural and topographic basins separated by asymmetric anticlinal ridges. Sediments up to 518 m (1,663 ft) in thickness accumulated in some of these basins. Basalt flows are exposed along the anticlinal ridges, where they have been uplifted as much as 1,097 m (3,599 ft) above the surrounding area. Overlying the basalts in the synclinal basins are sediments of the late Miocene, Pliocene, and Pleistocene ages. The Hanford Site lies within one of the larger basins, the Pasco Basin, which is bounded on the north by the Saddle Mountains and on the south by Rattlesnake Mountain and the Rattlesnake Hills. The Yakima and Umtanum Ridges trend into the basin and subdivide it into a series of anticlinal ridges and synclinal basins. The largest syncline, the Cold Creek syncline, lies between Umtanum and Yakima Ridges and is the principal structural basin containing the Hanford Site. The geology of the Columbia Basin and Hanford Site are described in detail in the *Site Characterization Plan* (DOE 1988) and Reidel et al (1994).

Figure 3-9 shows the stratigraphic units underlying the Hanford Site. These include, in ascending order, the Columbia River Basalt Group, Ringold Formation, Plio-Pleistocene unit (including the early Palouse soil), and Hanford formation. A regionally discontinuous veneer of Holocene alluvium, colluvium, and/or eolian sediments overlies the principal geologic units. The various stratigraphic units found within the Hanford Site boundaries are described below.

Columbia River Basalt Group – There are a minimum of 50 basalt flows beneath the Hanford Site with a combined thickness of >3,000 m (>9,843 ft) (DOE 1988). The most recent, laterally

extensive basalt flow underlying the Hanford Site is the Elephant Mountain Member of the Saddle Mountains Basalt. However, the younger Ice Harbor Member is found in the southern part of the site (DOE 1988). Located between various basalt flows are sedimentary interbeds, collectively called the Ellensburg Formation, which include fluvial and lacustrine sediments consisting of mud, sand, and gravel deposited between volcanic eruptions. Along with the porous basalt flow tops and bottoms, these sediments form basalt-confined aquifers that extend across the Pasco Basin. The Rattlesnake Ridge interbed is the uppermost laterally extensive hydrogeologic unit of these sedimentary interbeds.

Ringold Formation – The Pliocene-age Ringold Formation sediments overlie the basalts and are overlain by late Pliocene and Pleistocene-age deposits. Ringold Formation sediments consist of a heterogeneous mix of variably cemented and compacted gravel, sand, silt, and clay deposited by the ancestral Columbia and Snake Rivers (Fecht et al. 1987; Reidel et al. 1994; WHC 1991e). The upper part of the Ringold Formation is composed of interbedded fluvial sand and overbank facies, which are overlain by mud-dominated lacustrine facies (BHI 1995, WHC 1991e). The lower part of the Ringold Formation contains five separate stratigraphic intervals dominated by the fluvial gravel facies. These gravels, designated Units A, B, C, D, and E, are separated by intervals containing deposits typical of the overbank and lacustrine facies. The lowermost of the fine-grained sequence units, overlying Unit A, is designated the lower mud sequence.

Plio-Pleistocene Unit and Early Palouse Soil – The laterally discontinuous Plio-Pleistocene unit unconformably overlies the Ringold Formation and is found only in the western part of the Hanford Site (DOE 1988). This unit consists of sidestream alluvial deposits and buried soil horizons with significant caliche in some areas and is generally above the current water table (Slate 1996).

The Pleistocene-aged early Palouse soil is a buried eolian unit that overlies part of the Plio-Pleistocene unit. Because of the difficulty in distinguishing the early Palouse soil from the Plio-Pleistocene unit, these two are commonly grouped together and called the Plio-Pleistocene unit. The early Palouse soil consists of up to 20 m (66 ft) of massive, brown-yellow, and compact, loess-like silt and minor fine-grained sand (DOE 1988; Fecht et al. 1979). The early Palouse soil is found only in the vicinity of the 200 West Area. The early Palouse soil and the fine-grained and caliche portions of the Plio-Pleistocene unit, both of which are found in the 200 West Area, form a low-permeability layer that significantly affects migration of water through the vadose zone.

Hanford Formation and Pre Missoula Gravels – The informally named Hanford formation consists of deposits from a series of Pleistocene-age cataclysmic floods. The floods occurred when ice dams gave way, releasing water from Lake Missoula, a large glacial lake that formed in the Clark Fork River valley. Three principal types of deposits were left behind by the floods: (1) high-energy deposits, consisting of gravel; (2) low-energy, slackwater deposits, consisting of rhythmically bedded silt and sand of the Touchet Beds; and (3) coarse- to fine-sand deposits, representing an energy transition environment. Fluvial pre-Missoula (flood) gravels underlie the Hanford formation gravel deposits in the central part of the Hanford Site. The pre-Missoula deposits are difficult to distinguish from the Hanford gravels, so the deposits are usually grouped together.

The Hanford formation is divided into a variety of sediment types, facies, or lithologic packages. Reports dealing with the Hanford formation (Lindsey et al. 1991, WHC 1992e and 1991e) recognize three basic facies: gravel, sand, and silt dominated. These facies generally correspond to the coarse gravels, laminated sands, and graded rhythmites, respectively (Baker et al. 1991; DOE 1988; WHC 1991f). These facies are designated as the upper gravel, sand, and lower gravel sequences in this report. The Hanford formation ranges in thickness from <1 to >100 m (<3 to >328 ft).

Holocene Surficial Deposits – Holocene surficial deposits, consisting of silt, sand, and gravel, form a thin (<5-m [16-ft]) veneer across much of the Hanford Site. These deposits consist dominantly of laterally discontinuous sheets of wind-blown silt and fine-grained sand.

Figure 3-10 shows a geologic cross-section of the Hanford Site and the location of the water table between Cold Creek Valley and the Columbia River in 1998.

3.2.3.2 Geologic Setting of the 200 Areas.

Columbia River Basalt Group – The Elephant Mountain Member is the uppermost basalt unit (i.e., bedrock) in the 200 Areas. Except for a small area north of the 200 East Area boundary where it has been eroded away, the Elephant Mountain Member is laterally continuous throughout the 200 Areas. The Elephant Mountain Member is 21- to 30-m (69- to 98-ft) thick and thins to the north. Where the Elephant Mountain Member is absent, the Pomona Member forms the uppermost basalt unit. Areas of basalt project above the water table north of the 200 East Area (Figure 3-11).

Ringold Formation – The Ringold Formation is an interstratified sequence of unconsolidated clay, silt, sand, and gravel-to-cobble gravel deposited by the ancestral Columbia River. The Ringold Formation forms the lower part of the vadose zone throughout the 200 West Area and south of the 200 East Area. The Ringold Formation generally occurs completely in the saturated zone in and north of the 200 East Area, although relatively small isolated pockets of Ringold occur within the 200 East Area vadose zone. In the 200 Areas, these clastic sediments, from oldest to youngest, consist of four major facies: fluvial gravels of Unit A; paleosol and lacustrine muds of the lower mud sequence; fluvial gravels of Unit E; and overbank-dominated deposits of the Upper Ringold. Ringold Units B, C, and D are not present in the 200 Areas with the exception of localized occurrences of fluvial gravel of Unit C in the 200 East Area. Geologic cross-sections through the 200 Areas are presented in DOE-RL (1989) and DOE-RL (1999). Geologic cross-section applicable to the SST system are presented by Jones et al. (1998).

Unit A of the Ringold Formation – In the 200 East Area, the fluvial gravels and sands of Unit A generally thicken and dip to the south (Connelly et al. 1992a). This unit rises above the water table in small isolated pockets near the western and eastern boundaries of the 200 East Area and south of Gable Mountain (Figure 3-11). Unit A is below the unconfined aquifer and, therefore, is not part of the vadose zone in the 200 West Area.

Lower Mud Sequence of the Ringold Formation – The overbank and lacustrine deposits of the lower mud sequence occur beneath the gravels of Unit E. The lower mud sequence generally thickens and dips to the west and to the southeast away from the 200 East Area. The unit appears in the vadose zone as small isolated pockets in the center of the 200 East Area, underneath B Pond and between B Pond and Gable Mountain (Figure 3-11). In the 200 West Area, it forms the aquitard at the base of the unconfined aquifer and is not a part of the vadose zone.

Unit E of the Ringold Formation – Unit E is the uppermost unit of the Ringold Formation in the 200 East and 200 North Areas. It is dominantly composed of fluvial gravel, but strata typical of the fluvial sand and overbank facies may be encountered locally. The unit is recognized by (1) coarse texture, (2) a high proportion of quartzite and granitic clasts, (3) a relatively low calcium carbonate content, (4) partial consolidation, and (5) relatively low natural gamma response. In the 200 West Area, the gravels of Unit E generally thin from north-northwest to east-southeast while the surface dips toward the east-southeast. Gravels of Unit E occur in the southwest corner of the 200 East Area, at a thickness up to 35 m (115 ft) and are thicker to the south-southwest.

Upper Ringold Unit – The Upper Ringold Unit is missing in the 200 East Area and is discontinuous across the 200 West Area because of post-Ringold erosion. The upper unit in the 200 West Area consists of silty overbank deposits and fluvial sands. This unit is recognized by (1) abundance of well-sorted sand, (2) light color, and (3) variable natural-gamma response. It is found only in the west, north, and central portions of the 200 West Area and dips to the south-southwest.

Plio-Pleistocene/Early Palouse Soils – The Plio-Pleistocene/early Palouse soils are missing from the 200 East Area. The early Palouse soil is largely restricted to the vicinity of the 200 West Area. The unit is differentiated from the overlying Hanford slackwater deposits by (1) greater calcium carbonate content, (2) cohesive structure in core samples, (3) uniform fine-grained texture, and (4) high natural-gamma response. It is distinguished from the underlying Plio-Pleistocene unit by the high natural-gamma response and lower calcium carbonate content. The loess-like sediments of the early Palouse are uncemented. The unit pinches out near the southern, eastern, and northern boundaries of the 200 West Area. Boreholes located west of the 200 West Area, however, do encounter the unit. Due to the fine-grained nature of the soil, this unit is also an impediment to downward migration of water and contaminants.

Like the early Palouse soil, the Plio-Pleistocene unit is restricted to the vicinity of the 200 West Area, pinching out to the northern, eastern, and southern boundaries of the area. It represents a highly weathered surface that developed on the surface of the Ringold Formation. In the 200 West Area, the calcrete facies dominates and is locally referred to as the "caliche layer." The differentiating features of this unit are (1) high degree of cementation, (2) presence of roots and animal bores in cores, and (3) white color. This unit is an impediment to vertical migration of water and vapor due to the high degree of cementation. The thickness is very irregular and there may be erosional windows through the unit.

Hanford Formation – The Hanford formation is typically described as uncemented gravels, sands, and silts facies. The formation is divided into three sequences: lower gravel, sand, and upper gravel sequences. Because of the variability of the Hanford formation sediments, the contacts between these sequences are sometimes difficult to distinguish, especially where the sand sequence is missing and the upper gravel directly overlies the lower gravel. The Hanford formation as a whole is continuous throughout the vadose zone in the 200 Areas although none of these individual stratigraphic sequences is continuous across the 200 Areas: All three sequences display marked changes in thickness and continuity and are lithologically heterogeneous. Geologic cross-sections through the 200 Areas are presented in DOE-RL (1989) and DOE-RL (1999). Geologic cross-sections applicable to the SST system are presented by Jones et al. (1998).

Reidel et al. (1998) identified three buried soil horizons within the sand sequence that contain calcium carbonate and poorly to well developed caliche in the 200 East Area. Palesols have not been previously identified in the Hanford formation in the 200 Areas. Evaluation of palesols and the collection of quality samples should be considered in WMA addenda to determine the lateral extent of palesols within the sand sequence.

Lower Gravel Sequence of the Hanford Formation – The lower gravel sequence is dominated by deposits typical of the gravel-dominated facies. Local intercalated sandy beds typical of the sand-dominated facies are also found. In the 200 West Area this sequence is missing. It is found throughout most of the 200 East Area at a thickness ranging from 0 to 44 m (0 to 135 ft). Where this unit is overlain directly by the upper gravel sequence, it is not possible to distinguish between the two. Where it is overlain by the sand sequence, the contact between the sand and lower gravel sequences is interpreted to be at the top of the first thick gravelly interval (6 m [20 ft] or greater in thickness) encountered below the sand-dominated strata of the sand sequence.

Sand Sequence of the Hanford Formation – The sand sequence of the Hanford formation in the 200 Areas is thick but locally discontinuous. The sequence is 0- to 90-m (0- to 295-ft) thick in the central portion of the 200 East Area and 0- to 32-m (0- to 105-ft) thick in the 200 West Area. The sand sequence generally thickens to the south. The sequence is missing in the central part of the 200 West Area as a result of erosional scouring during the cataclysmic flooding events. This erosional scour is elongated in a north-south direction (Connelly et al. 1992b). The sand sequence consists predominantly of silt, silty sand, and sand with interbedded coarser sands.

Recent sampling activities performed to support the immobilized low-activity waste assessment in the 200 East area indicate there are three paleosol horizons of significant thickness associated with this sequence. These three horizons represent significant time intervals when soil development took place and are interpreted to be the tops of three Missoula flood deposits (Reidel et al. 1998). These units consist of slightly cemented to well cemented silts and sands and may be laterally continuous near 299-E17-21. Detailed descriptions of these units are described in Reidel et al. (1998).

Upper Gravel Sequence of the Hanford Formation – The upper gravel sequence consists of interstratified gravel, sand, and lesser silt. Gravel-dominated deposits generally dominate the

sequence. This coarse-grained upper gravel sequence is distinguished by a coarse-grained sand to a boulder gravel that displays massive bedding, plane to low-angle bedding, and large-scale cross-bedding in outcrop. The matrix is commonly lacking in the gravels, giving them an open-framework texture. The thickness of this coarse-grained sequence is 70 m (230 ft) north of the 200 Areas and thins to zero near the southern border of the 200 East Area. Within the 200 West Area, the thickness of the upper coarse unit ranges from 0 to 45 m (0 to 148 ft). The contact between the coarse-grained sequence and underlying strata is generally sharp.

Holocene Deposits – Holocene-aged deposits in the 200 Areas are dominated by eolian sheets of sand that form a thin veneer across the 200 Areas, except in localized areas where they have been removed by human activity. Surficial deposits consist of very fine- to medium-grained sand to occasionally silty sand and are generally less than 3-m (10-ft) thick. Silty deposits (<1-m [3-ft] thick) have also been documented at waste management facilities (e.g., ponds and ditches) where fine-grained windblown material has settled out through standing water over many years.

Backfill material is also present in all SST farms. It ranges from coarse gravel to sand and silt and consists of sediments removed from, and subsequently returned to, tank farm excavations. The SST farm backfill also could contain construction debris. The backfill was compacted at irregular intervals.

Clastic Dikes – Clastic dikes are common structures that occur in many of the geologic units in the Pasco Basin and vicinity. One subset, clastic injection dikes, are fissures filled with sand, silt, clay, and minor coarser debris. Many dikes occur as near-vertical tabular bodies filled with multiple layers of unconsolidated sediments. The margins of most dikes and internal layers within dikes are separated by thin clay and silt linings (Fecht et al. 1998).

Clastic dikes range in continuous vertical extent from less than 30 cm (12 in.) to more than 55 m (180 ft) (Fecht et al. 1998). The deepest known occurrence of a clastic dike below ground surface is greater than 75 m (246 ft) in the 200 West Area; the total vertical extent of this clastic injection dike is not known (Fecht et al. 1998). In cross-section, clastic dikes range in width from less than 1 mm (0.04 in.) to over 2 m (6.5 ft) (Fecht et al. 1998). Attitudes of the dikes range from vertical to horizontal, with near-vertical dikes being more common. Material filling the dikes is locally derived and ranges in size from mud to gravel. Distribution and hydraulic properties of the dikes are not well known. Clastic dikes occur in the Hanford formation in both the 200 West and 200 East Areas and are most common in the finer grained sand sequence and are rare in the open-framework gravel. Clastic dikes do occur in the Ringold Formation sediments elsewhere, but their occurrences are rare. Clastic dikes can be both preferential pathways for water and vapor and a barrier to water and vapor flow. Conclusions in DOE-RL (1998c) challenge the presence of clastic dikes as significant preferential pathways. Based on the layered nature of vadose sediments, the report indicates that preferential flow once established, would likely persist for only relatively short distances, on the order of centimeters to meters.

3.2.3.3 Vadose Zone. The vadose zone is the volume of soils, sediments, or both, extending from the ground surface to the water table, and consists of solid, liquid, and gaseous phases (DOE-RL 1989). The vadose zone beneath the 200 Areas ranges in thickness from

approximately 55 m (180 ft) in the 200 West Area to approximately 104 m (341 ft) in the southern portion of the 200 East Area. In the 200 East Area, the vadose zone consists of Holocene surficial deposits, the Hanford formation, the Ringold fluvial gravel Units A and E, the Ringold Lower Mud Unit, and basalt. In the central to northern part of the 200 East Area, the Hanford formation and Holocene surficial deposits dominate. The vadose zone in the 200 West Area is comprised of Holocene surficial deposits, the Hanford formation, the Plio-Pleistocene/ early Palouse horizons, the Upper Ringold Unit, and the upper parts of the Ringold Unit E. The thickness of the vadose zone is increasing with time due to the regional declining water table in the 200 Areas.

Flow of liquid through the vadose zone is a function of the relationship between recharge rates, moisture content, matric potential, and unsaturated hydraulic conductivity for each hydrostratigraphic unit. Fine-grained strata in both the 200 West and East Areas exert significant influences on the rate and direction of infiltration of liquids. Conversely, coarse-grained units may impede the flux of liquids through the vadose zone under unsaturated flow conditions because of the formation of a capillary pressure barrier between the coarse-grained units and overlying fine-grained units. Waste transport in the vadose zone is a function of the movement of moisture through the vadose zone, as well as physical and chemical characteristics of the media in the vadose zone.

Tank farm surfaces are covered with gravel to prevent vegetation growth and to provide radiation shielding for site workers. Bare gravel surfaces enhance infiltration from all water sources. Sources of water in the tank farms are from unintentional surface spills, rain, snow, liquids from damaged water lines, and ancillary tank-related equipment. These sources may enhance contaminant migration. Another feature of the tank farms that may promote contaminant migration are the domes of the tanks beneath the surface. The dome surface creates an umbrella effect that can concentrate water in the subsurface. This umbrella effect causes water to flow over the dome and down the tank walls into underlying sediments. This may cause the moisture content in sediments adjacent to the tanks to increase, while remaining unsaturated and increasing the hydraulic conductivity in soils. The increase of moisture in the vadose zone from natural and artificial sources of recharge can mobilize contaminants and provide the mechanism for transport to groundwater.

In general, two types of moisture movement can occur in the tank farm vadose zone: piston flow and preferential flow (Jones et al.1998). Piston flow (wetting-front infiltration) refers to uniform moisture movement through the soil matrix, whereby infiltrated water displaces initial water (NRC 1995). Under piston-like flow conditions most, if not all, pre-existing water (i.e., "old" water) is displaced and moved ahead of the "new" infiltration water added from above (NRC 1995). Preferential flow is the process whereby water and contaminants move along preferential pathways. Preferential pathways can be natural (e.g., clastic dikes) or constructed (e.g., migration down the casing of unsealed monitoring wells). In order for the well casings to be a preferential path, it is necessary for the matric potential sediments surrounding the annular space to be overcome (saturation). This region is a true permeability break. Other potential preferential pathways during tank leaks include wetting-front instability or "fingering" flow. Wetting-front instability, reported in petroleum-related literature, is a special case of interface instability during immiscible fluid displacement in porous media. Immiscibility is triggered by

differences between the viscosities and densities of two fluids across their interface, a condition that can potentially exist during tank leaks.

A field study (Sisson and Lu 1984) in the 200 East Area, south of the PUREX Plant, demonstrated the effect of geologic heterogeneities on water contents in a natural arid setting. The higher observed water content values were strongly correlated with fine soil layers, which have a higher water-holding capacity than coarse soils. In addition, the observed profiles were remarkably similar for the 15-year interval between measurements at the field site (Fayer et al. 1995). This suggests that, in the absence of artificial recharge, the "natural" moisture content of the sediments is essentially determined by the nature of geologic heterogeneity, and the vadose zone water content profiles are at quasi-equilibrium with the natural recharge rate. This is also demonstrated by the moisture content profiles in borehole 299-W10-196, near tank 241-T-106 in the 200 West Area; the data collected in 1993 show a much higher moisture content in the fine-grained Plio-Pleistocene and upper Ringold layers than in the Hanford formation (BHI 1994).

Leaks from tanks and tank-related sources are typically low-flow regimes: the layered nature of the sediments would cause some lateral spreading of this liquids. A secondary mode of transport is through preferential flow. Preferential flow can be via clastic dikes, and in the form of fingering, funnel flow, and flow along the unsealed annular spaces around drywells. The fraction of leak migration due to preferential flow versus piston flow is highly uncertain and would vary depending on the leak location. Also, the characteristics of past tank liquids (e.g., high pH, high sodium concentration, and high temperature) could result in chemically enhanced or reduced mobility of some contaminants.

The vadose zone contamination expert panel report DOE-RL (1997c) suggests that the combination of high pH, eH, heat, and the density of fluid existing tanks could enhance contaminant transport along preferential pathways by forcing the fluid down openings, enhancing openings by dissolution of siliceous material and occupying exchange. Fine-grained material commonly associated with Cs-137 fixation in soil may likely be affected by these conditions. In contrast to these high temperature conditions, tank waste released during retrieval is anticipated to be less extensive because there are less thermal and chemical drivers involved. The degree to which this information is important to the project should be evaluated further.

There are currently eight SSTs (SX-107 through SX-14 and S-104) in the S-SX WMA that have high heat loads >26,000 BTU/hr. The low heat load SSTs that have leaked include SX-115, TX-110, TX-114, TX-116, and TX-117. The low heat tanks generated <26,000 BTU/hr as defined in Hanlon (1999). The specific gravity in self-heating tanks ranged between 1.5 and 2.2 based on information in DOE-RL 1997c.

3.2.3.4 Regional Hydrologic Setting. Groundwater is present in both unconfined and confined aquifers at the Hanford Site. The unconfined aquifer is generally located in the unconsolidated to semi-consolidated Ringold and Hanford formations that overlie the basalt bedrock. In some areas, low-permeability mud layers form aquitards that create confined hydraulic conditions in the underlying sediments. Although they are extensive in some locations, these aquitards are not continuous across the Hanford Site and, thus, the entire suprabasalt aquifer is hydraulically

connected on a site-wide scale. Consequently, from a regional perspective, the entire suprabasalt aquifer can be referred to as a unconfined aquifer system. From a local perspective, the unconfined aquifer is referred to as the saturated zone above low-permeability mud units for some areas (e.g., the 200 West Area and most of the 100 Areas).

The saturated thickness of the unconfined aquifer system is >180 m (>590 ft) in areas near the central landfill, west of the 200 West Area, and north of Gable Butte near the 100-B/C and 100-K Areas, but pinches out along the flanks of the basalt ridges. Depth to the water table ranges from <1 m (<3 ft) near the Columbia River to >100 m (>328 ft) near the 200 Areas.

Groundwater in the unconfined aquifer system generally flows from recharge areas in elevated regions near the western boundary of the Hanford Site toward the Columbia River, which is a discharge zone for the unconfined aquifer on both sides of the river. The Yakima River lies southwest of the Hanford Site and is generally regarded as a source of recharge to the unconfined aquifer system between the southern part of the site and the area north of Richland, Washington.

A sequence of basalt-confined aquifers is present within the Columbia River Basalt Group beneath the Hanford Site. These aquifers are composed of sedimentary interbeds and the relatively permeable tops of basalt flows. The dense interior sections of the basalt flows form confining layers. Groundwater in the basalt-confined aquifers also generally flows from elevated regions at the edge of the Pasco Basin toward the Columbia River (Spane, Jr. and Weber 1995). However, the discharge zone locations are also influenced by geologic structures that increase the vertical permeability of the confining basalt layers. Additional information on the upper basalt-confined aquifer system is available in DOE (1988), Spane, Jr. and Vermeul (1994) and Spane, Jr. and Webber (1995).

Unconfined Aquifer System Recharge and Discharge – Natural recharge to the unconfined aquifer system occurs from infiltration of run-off from elevated regions along the western boundary of the Hanford Site, infiltration of springwater and upwelling of groundwater that originates from the basalt-confined aquifer system, and infiltration of precipitation falling across the Hanford Site. Some recharge also takes place along the Yakima River. Recharge from precipitation is highly variable, both spatially and temporally, ranging from near zero to >100 mm/yr (3.9 in./yr), depending on climate, vegetation, and soil texture (Gee et al. 1992; Fayer and Walters 1995). Recharge from precipitation is highest in coarse-textured soils with little or no vegetation, which is the case for most of the industrial areas on the site. A map showing estimated average natural recharge based on distributions of soil and vegetation types is shown in Figure 3-12 (Fayer and Walters 1995). Some artificial recharge as a result of irrigation occurs in the upper Cold Creek Valley in the western part of the Hanford Site and in agricultural areas south of the Site.

Since the start of Hanford Site operations in the mid-1940s, artificial recharge from wastewater disposal facilities has been several times greater than the estimated recharge from natural sources. This caused an increase in the water table elevation over most of the Hanford Site and the formation of groundwater mounds beneath major wastewater disposal facilities. However, beginning in 1988, all production activities on the Hanford Site have ceased, resulting in a decrease in wastewater disposal and subsequent decreases in water table elevation over much of

the Site. In the 1950s through 1980s, the annual volume of effluent discharged to the soil column in the 200 Areas typically ranged from 10 to 25 billion L (2.6×10^9 to 6.6×10^9 gal) (Hartman and Dresel 1998). Zimmerman et al. (1986) report that between 1943 and 1980, 6.33×10^{11} L (1.67×10^{11} gal) of liquid wastes were discharged to the soil column in the 200 Areas. Currently, most sources of artificial recharge have ceased in the 200 Areas and are largely limited to liquid discharges to sanitary sewers, the two state-approved land disposal structures, and over 140 small-volume, uncontaminated, miscellaneous waste streams (DOE-RL 1997b).

3.2.3.5 Groundwater in the 200 Areas. The water table for the unconfined aquifer system in the 200 Areas is located within the sediments of the Ringold and Hanford formations. The 1998 water table map of the Hanford Site and 200 Areas is shown in Figure 3-13. Groundwater flow in the unconfined aquifer in the 200 Areas is generally from west to east with the regional flow. In the vicinity of the 200 East Area there is a local northern component of flow between Gable Mountain and Gable Butte. The location of the divide between the two flow systems is not very discernible because the water table in this area is very flat. Contaminant plume maps of the Gable area support the conclusion on flow direction. Groundwater flow in the 200 Areas near decommissioned B Pond also varies from the regional flow direction. Groundwater flow near B Pond is radial and attributed to groundwater mounding when B Pond was receiving effluent. Effluent discharge at B Pond and other liquid waste disposal sites in the 200 Areas has significantly increased hydraulic gradients because of the rise in the elevation of the water table. In recent years, the elevation of the water table and local groundwater mounds have been declining. In some areas, the water table elevations are dropping at a rate on 2 m/yr (7 ft/yr) based on water level measurements collection in 1997 and 1998. As the elevation of the water table continues to drop, hydraulic gradients will decrease and flow may return to the pre-Hanford Site conditions.

3.2.4 Geochemistry Summary

This section is based on the geochemistry summaries in Jones et al. (1998), DOE-RL (1993a), and Kincaid et al. (1998). This section covers geochemical factors and material properties of vadose and aquifer sediments that control contaminant transport in the vadose zone and groundwater, or that might be useful in determining contaminant sources. Contaminant transport is influenced by both hydraulic properties of vadose zone and aquifer lithologic units, and chemical reactivity of sediment minerals with water and waste solutions.

3.2.4.1 Particle Size and Cation Exchange Capacity. The particle size distribution in lithologic units partially controls the hydrologic properties and, indirectly, the chemical reactivity. Coarse-grained materials dominated by cobbles, pebbles, and coarse sand have a lower chemical reactivity than fine sands, silts, and clay-size materials. The fine materials account for most of the lateral dispersion of fluids, chemical sorption of contaminants, and other chemical reactivity with waste solutions.

Hydraulic properties can be altered by secondary chemical precipitates (e.g., calcium carbonate) that can act as a particle cementing agent. A general measure of chemical reactivity is the sodium cation exchange capacity (CEC). Particle size distributions, calcium carbonate cement,

and sodium CEC have been determined on vadose zone samples from several lithologic units and are discussed in more detail in Jones et al. (1998), Appendix A. In general, the Hanford formation is dominated by medium and coarse sands and gravels; the Plio-Pleistocene layer by fine sands, silts, and clays; and the Ringold Formation is variable. The upper and lower Ringold tend to be fine grained; the middle Ringold is coarser. Calcium carbonate cement is generally less than 3% in the Hanford formation, but is generally up to 7% in the Plio-Pleistocene and can be more than 30% locally. The upper Ringold also can have considerable calcium carbonate cement (more than 20% locally). The CEC values are generally 5 to 6.5 meq of sodium/100 g of sediment and may be up to 7 to 8 meq/100 g in fine-grained materials.

3.2.4.2 Background Mineralogical and Chemical Characteristics. Mineralogical characterization of vadose zone or aquifer sediments has not been conducted as extensively as particle size distribution and sorption properties. The mineral content of particles larger than 2 mm (0.08 in.) (which include coarse sand, gravels, and cobbles) is dominated by quartz, feldspars, and rock fragments. The sand-size-and-smaller fraction (<2 mm plus clays) contains 60% to 80% quartz and feldspars with up to 10% mica and secondary iron-bearing minerals. The clay-size fraction consists mostly of smectite-type clays and mica/illites with smaller amounts of chlorite, vermiculite, and kaolinite along with hydrous oxides. The clay-size fraction generally makes up less than 20 weight percent of the <2-mm (0.08-in.) fraction. Higher clay contents can influence sorption properties of sediments disproportionately to the clay volume. Together, clays and hydrous oxides account for most of the sorption capacity and selectivity for waste contaminants.

Background chemical composition, including major and trace constituents, radiochemical content, and organic content of soils, provides a baseline for determining contaminant levels and evaluating risks associated with retrieval options. Hanford Site-wide soil background chemical and radiochemical composition have been reported (DOE-RL 1995b). Specific tank farm background levels have not been determined but are not expected to differ significantly from the Hanford Site-wide estimates. A summary of the background data for nonradioactive and radioactive analytes is presented in Tables 3-8 and 3-9, respectively. Ecology mandates the use of the 90th percentile of the appropriate distribution for purposes of comparing background to cleanup levels (Ecology 1992). Other statistical approaches may also be used when background is used as a cleanup standard. Ecology has accepted alternate statistical tests for use at the Hanford Site (DOE-RL 1994).

3.2.4.3 Chemical Mechanisms Controlling Contaminant Transport. Dissolved and suspended contaminants in waste fluids infiltrating through sediments or moving through the aquifer are transported by advection, diffusion or dispersion mechanisms. Several sediment-water chemical mechanisms control the dissolved concentration and relative mobility of contaminants. These include solubility-precipitation, ionic diffusion, particulate (including colloids) formation, complexation, ion exchange, and sorption. The dominant mechanisms used to estimate and model transport are solubility, and sorption. (Sorption is a composite of several mechanisms and a measure of total contaminant distribution between the liquid and solid phases.) Over the last 40 years, a number of reviews of the literature have been conducted (DOE-RL, 1993a, DOE-RL 1993b). The reviews have emphasized soil chemistry, focusing on sorption and related processes that influence the contaminant-retention capacity of sediments and

retardation factors. Jones et al. (1998), Appendix C, covers these mechanisms and reviews in more detail.

Solubility and sorption behavior are controlled by a number of parameters. One parameter is the pH of solutions in contact with soil minerals. Related parameters are electrical conductivity (a measure of dissolved solids) and E_h, a measure of oxidation-reduction potential. In general, the natural buffering capacity of mineral water interactions in Hanford Site groundwater systems results in pH ranges of 7.5 to 8.5. Soil pH values, obtained by reacting small amounts of soil and water in 1:1 ratios, yield values of about 7.7 to 8.8. Specific conductance values for uncontaminated groundwater are about 200 to 300 Siemens/centimeter (S/cm) compared to Columbia River water of about 140 S/cm. For comparison, specific conductances of contaminated groundwater in the T and TX-TY tank farms were above 2,000 S/cm. Groundwater E_h values range from about 280 to 380 mv at pH values near 8, which indicate that the groundwater is moderately oxidizing. Vadose zone conditions would be expected to be more oxidizing because pore volumes are partially filled with air. Locally, the presence of minerals such as pyrite (iron sulfide) or concentrations of organic constituents may cause reducing conditions in the vadose zone.

Various inorganic and organic complexants, colloids, and particulates can potentially interact with contaminants of concern and affect their mobility in the vadose zone and aquifer. Some complexants are clearly present in the Hanford Site soil-water environment. Their interactions with contaminants are known and reflected in sorption values used in contaminant migration models. For example, aqueous carbonate species are ubiquitous in Hanford Site vadose zone waters and react with soluble uranium to form mobile aqueous species. Other complexants (e.g., organics) that have been introduced into tank waste may have influenced contaminant mobility in the vadose zone, but these species have not been clearly identified in the vadose zone. Similarly, the formation of colloids and particulates that could carry contaminants in migrating fluids are postulated but are not clearly identified as present or functional in the vadose zone. Experiments were performed to evaluate colloid-facilitated transport of radionuclides (McGraw et al. 1997). This report suggests that colloids are not a significant transport mechanisms in the vadose zone and groundwater. Only the smallest colloids (<60 nm) may be able to move through the unsaturated vadose zone. Colloids reaching the water table would possibly be removed from groundwater by diffusion.

3.2.4.4 Sorption and Related Contaminant Retardation Processes. Sorption is a generic term describing the ratio of the amount of contaminant associated with a gram of solid phase (sediment or mineral) divided by the amount dissolved per milliliter of solution. It consequently has units of milliliters per gram and is usually expressed as the distribution coefficient, K_d. The K_d is not a true thermodynamic ion-exchange constant because multiple mechanisms occur that control the partitioning of contaminants between the liquid and solid phases. The sorption process generally is considered the most important measurable contaminant-retardation process for vadose zone mobility, and has been investigated since the early 1950s as the basis for crib disposal capacity and trench field capacity. The K_d is related to contaminant retardation factors (R_d) (i.e., ratio between pore water/groundwater velocity and the velocity of the contaminant being transported) in porous media by functions such as:

$$R_d = 1 + (\rho_b/\phi_\varepsilon)K_d$$

where ρ_b is the porous media bulk density and ϕ_ε is the aquifer effective porosity or moisture content in the unsaturated media. The K_d values are affected by competing cations, ionic strength of solutions, pH, mineralogy, complexants, and redox (E_h). Consequently, K_d values are somewhat site-specific (see Jones et al. 1998, Appendix C). The overall capacity of soils and sediments to sorb ions is often expressed as the sodium CEC and provides a preliminary measure of the ability of soils to retain leaked contaminants before breakthrough occurs. The CEC does not provide information on cation selectivity or reversibility. Certain minerals and sorption sites selectively sorb specific cations (e.g., cesium on certain mica sites). The sorption-desorption kinetics (reversibility) measures the sediment's ability to resist elution and can lead to variable amounts of hysteresis between forward and reverse reactions (Jones et al. 1998). This may be an important factor when multiple contaminant releases take place at the same site.

Distribution coefficients were selected in the composite analysis for low-level waste disposal in the 200 Areas. The purpose of the analysis was to estimate the projected cumulative impact of all radioactive material in the ground that may interact with projected releases from planned or existing disposal facilities (Kincaid et al.1998). Distribution coefficients were estimated for 26 radionuclides based on waste type and background chemistry, where chelating agents, salts organic compounds, and pH were considered in terms of their mobility in eight subsurface zones. Various conditions were considered because constituents exhibit varying degrees of mobility in the vadose zone and aquifer. The source and distribution categories, as well as the distribution coefficients are described and presented in Kincaid et al. (1998), Appendix E. Estimated values in the report are the most recent distribution coefficients developed to-date for subsurface condition in the 200 Areas. The reader is directed to the report for details on the various scenarios and distribution coefficients. An update to this report is expected in 1999. Other primary information sources used in the past include Serne and Wood (1990), Kaplan and Serne (1995), and Kaplan et al. (1995).

3.2.4.5 Geochemical Behavior of Key Contaminants in Tank Leak Fluids. Only a relatively small number of the many radionuclides and chemicals present in the tank waste are potential long-term environmental contaminants of real concern. This is because they are present in sufficient quantity, are sufficiently long lived (in the case of radionuclides), and are rather mobile (Jones et al.1998). Prominent radionuclides with these characteristics that are identified in subsurface include Tc-99, C-14, Np-237, and uranium. Nitrate is the chemical species identified in notable quantities.

As a general rule, elements that tend to form anionic and neutral aqueous species are the most mobile because little or no interaction with solid phases occurs. Those elements that form cationic species tend to react with solid phases and may be pulled out of solution during migration through the soil column. The behavior of elements also can change noticeably with changes in environmental conditions. The following paragraphs briefly summarize what is and is not known about the following constituents: nitrate, Tc-99, C-14, Np-237, uranium, Co-60, Cs-137, Sr-90, and transuranic elements.

Nitrate. Nitrate is essentially nonreactive in the vadose zone and aquifer, both under undisturbed conditions and when affected by tank fluid. Nitrate is assumed to exist as anionic species under either condition.

Technetium-99. Up until recently, technetium-99 has been assumed to be essentially nonreactive with Hanford vadose zone sediments and aquifer, both under undisturbed and tank fluid affected conditions. However, recently (see Myers et al. 1998 and Independent Review Panel [1998]) data has been presented that suggests that Tc-99 may interact with Hanford vadose zone sediments. The speciation of Tc in Hanford SSTs may include some Tc in forms other than the pertechnetate species, TcO_4^-, that interacts with sediments. Further, Kaplan et al. (1998) shows some adsorption data for solutions with >0.5 M Na and pH values >10 where the Tc K_d value is as large as 4 mL/g. As discussed by the Independent Panel (1998) additional studies of Tc mobility is warranted, especially as it relates to SST tank leak conditions.

Carbon-14. Carbon-14 mobility is complex because of the many reactions in which it can be involved as a gas, a liquid, or a solid. Frequently, to be conservative, C-14 is modeled as completely mobile (K_d = 0 mL/g) because aqueous species are anionic. Martin (1996) suggests C-14 undergoes attenuation in the environment because of isotopic exchange or dilution through recrystallization of minerals. The large C-14 spike in the analyzed soil column near the tank bottom of the tank T-106 leak is interesting because of the apparent significant retardation in C-14 migration demonstrated by the field data. What reactions contributed to this spike or whether some aspect of tank fluid chemistry enhanced the retardation effect is unclear.

Uranium. Uranium solubility is very sensitive to pH changes. Because temporary pH increases will occur locally in the vadose zone following tank leaks, uranium mobility may increase or decrease compared to its mobility in undisturbed soil. However, the effects are temporary and the buffering capacity of the soil-water system will return local pH values to ambient levels (about pH = 8) Jones et al. (1998). Soluble uranium readily forms anionic species in undisturbed conditions and is very mobile. Tank chemistry characteristics probably cannot enhance the mobility of dissolved uranium.

Transuranic Elements. Of the three transuranic elements identified in the vadose zone (i.e., americium, plutonium, and neptunium), empirical sorption tests show that americium and plutonium are highly sorbing, and neptunium is moderately sorbing. These radionuclides are expected to slowly migrate over thousands of years through the vadose zone under undisturbed conditions. Tank fluid characteristics may, at least temporarily, enhance transuranic isotope mobility by introducing organic complexants, or facilitating the formation of colloids or other particulates that could carry these isotopes with migrating fluid. To date, no evidence has been found that demonstrates the existence or effectiveness of such mobilizing phenomena in Hanford Site soils. However, tank T-106 data imply that some mobilization of americium and plutonium isotopes has occurred, at least temporarily. Further evaluation of these radionuclides is recommended to determine the current state of their mobility.

Cesium-137. Cesium-137 normally exhibits very strong adsorption onto Hanford sediments and is unlikely to migrate appreciably in undisturbed soil; however enhanced mobility is indicated in some tank-leak-contaminated zones. A prime contributor to enhanced Cs mobility may be the

competition for adsorption sites between the cesium-137 and the extremely high concentrations of sodium present in leaking tank fluids. Serne et al. (1998) review tank relevant Cs adsorption data. They report that the Cs K_d value drops from ≥2,000 ml/g for groundwaters contacting Hanford sediments to values in the vicinity of 6 to 10 ml/g for bismuth phosphate tank liquors, 2 to 6 ml/g for simulated T-106 tank liquors and ~20 ml/g for simulated REDOX tank liquors. Recently, Zachara et al. (1998) have measured the K_d for Cs onto Hanford sediments as a function of the Cs concentration for 5 M Na solutions at neutral pH. The Hanford SST tank liquors have sodium concentrations between 3 and 8 M but most have higher pH values than 7. In these recent studies the K_d for Cs varies with the equilibrium Cs solution concentration. At low Cs concentrations ($<10^{-8}$ M) the K_d is >100 ml/g but drops to values ~ 1 ml/g at Cs concentrations above 10^{-3} M. Tank liquors inside the REDOX tanks appear to have Cs-137 concentrations at or slightly below 10^{-3} M. Thus sorption might be limited in the very near tank environs but should increase as sediment sorption removes Cs and existing vadose zone sediment's pore waters dilute the Cs in the leaked fluids.

Cesium-137 desorption studies using tank simulants have recently shown that adsorbed Cs is essentially irreversibly held in Hanford sediments (see Myers et al. 1998). Studies by Zachara, Serne et al. (unpublished) show that Cs adsorbed onto Hanford sediments from the 41-09-39 borehole below the SX tank farm is very difficult to desorb. Thus the mobility of Cs shows a strong hysteresis; that is, once Cs adsorbs to Hanford sediments it will remobilize at very low rates. The rate of initial adsorption is sensitive to a large number of variables that all trend towards more favorable adsorption as leaked liquor moves further away from the tank. As discussed in Myers et al. (1998), the inferred deep migration of Cs-137 below some of the SSTs may in fact be caused by small percentages of highly contaminated sediment being pushed down as the monitoring dry wells were constructed or adsorption of Cs onto the corrosion products that form on the walls (both inside and outside) of the casing. Leaked liquid and fine-grained sediments laden with Cs-137 may have been transported down the inside and outside of the casing walls after dry well installation. Spectral gamma logging and actual sediment sampling of sediment removed from the inside and outside of casing at dry well 41-09-39 show that Cs-137 contamination is present. Future vadose zone sampling and the decommissioning of 41-09-39 should yield more valuable data on the Cs-137 migration issue.

Strontium-90 and Cobalt-60. Strontium-90 and Cobalt-60 are moderately sorbing under undisturbed conditions (Jones et al. 1998). Strontium-90 will be enhanced because it competes for sorption sites with increased calcium (Routson et al. 1981) in tank fluids that have leaked. Kincaid et al 1998 indicates that Co-60 mobility may also be enhanced under chelate/high salt and high organic/very acidic conditions. Best estimates of K_d in Kincaid et al. 1998 provide a range of values for the two contaminants. K_d for strontium ranges from 0.4 to 50 ml/g and 0 to 1,200 ml/g for Co-60. The lowest K_d estimated for these contaminants are in chemical condition characterized as high organic/very acidic. Jones et al. 1998 suggests that organic complexing in some tank fluids may enhance Sr-90 and Co-60 mobility. Other experimental data suggest that complexants are chemically destroyed with time and might not be present during leak events.

3.3 ENVIRONMENTAL AND CULTURAL RESOURCES

Environmental resources for the 200 Areas refers to the plants and wildlife found within the vicinity of these areas. Biological and ecological information aid in evaluating impacts to the environment, including potential effects of implementing remedial actions and identifying sensitive environments and species. Cultural resources refer to archaeological sites representing both prehistoric and historical periods. Environmental and cultural resource reviews shall be performed prior to the implementation of field activities in WMAs.

3.3.1 Plants

The vegetation of the 200 Area Plateau is characterized by native shrub-steppe, interspersed with large areas of disturbed ground dominated by annual grasses and forbs. In the native shrub-steppe, the dominant shrub is big sagebrush (*Artemisia tridentata*). The understory is dominated by the native perennial, Sandberg's bluegrass (*Poa sandbergii*), and the introduced annual, cheatgrass (*Bromus tectorum*). Other shrubs typically present include rabbitbrush (*Chrysothamnus* spp.), spiny hopsage (*Grayia spinosa*), and antelope bitterbrush (*Purshia tridentata*). Other native bunchgrasses that are also present include Indian ricegrass (*Oryzopsis hymenoides*) and needle-and-thread grass (*Stipa comata*). Common herbaceous species include turpentine cymopteris (*Cymopteris terebinthinus*), globemallow (*Sphaeralcea munroana*), balsamroot (*Balsamorhiza careyana*), milkvetch (*Astragalus* spp.), yarrow (*Achillea millifolium*), and daisy (*Erigeron* spp.).

Disturbed habitat communities are primarily the result of either range fires or mechanical disturbance (e.g., from road clearing or facility construction). Mechanical disturbance typically entails a loss of soil structure and disruption of nutrient cycling, which have a significant effect on the plant species that will recolonize a site. The principal colonizers of disturbed sites are annual weeds, such as Russian thistle (*Salsola kali*), Jim Hill mustard (*Sisymbrium altissimum*), bur-ragweed (*Ambrosia acanthicarpa*), and cheatgrass. Once disturbed, native stands of vegetation may take decades (or centuries if the soil has been removed) in the mid-Columbia climate to return to a state near to the original condition. Disturbed areas with sandy soils that lack vegetation typically have higher recharge rates than sites with a plant cover (Fayer and Walters 1995).

The vegetation that was present in and around the former waste ponds and ditches on the 200 Area Plateau includes cottonwood (*Populus trichocarpa*), willows (Salix spp.), sedges (*Carex* spp.), and cattails (*Typha latifolia*). However, most of this vegetation has died with the cessation of liquid effluents flowing to the ponds and ditches. Tank farm surfaces are maintained free of vegetation.

3.3.2 Wildlife

The largest mammal frequenting the 200 Areas Plateau is the mule deer (*Odocoileus hemionus*). While mule deer are much more common along the Columbia River, the few that forage throughout the 200 Areas make up a distinct group called the central population (Dirkes and Hanf 1997). A large elk herd (*Cervus canadensis*) currently resides on the Fitzner-Eberhardt

Arid Lands Ecology Reserve (ALE). Occasionally a few animals have been seen just south of the 200 Areas, and their presence may increase as the herd on ALE continues to grow. Other mammals common to the 200 Areas are badgers (*Taxidea taxus*), coyotes (*Canis latrans*), Great Basin pocket mice (*Perognathus parvus*), northern pocket gophers (*Thomomys talpoides*), and deer mice (*Peromyscus maniculatus*). Badgers are known for their digging ability and have been suspected of excavating contaminated soil at 200 Areas radioactive waste sites (O'Farrell et al. 1973). The majority of badger diggings are a result of searches for food, especially other burrowing mammals such as pocket gophers and mice. Pocket gophers and mice (especially Great Basin pocket mice and deer mice) are abundant in the 200 Areas, consume predominantly vegetation, and can excavate large amounts of soil as they construct their burrows (Hakonson et al. 1982). Mammals associated with buildings and facilities include Nuttall's cottontails (*Sylvilagus nuttallii*), house mice (*Mus musculus*), Norway rats (*Rattus norvegicus*), and various bat species.

Common bird species in the 200 Areas include starlings (*Sturnus vulgaris*), horned larks (*Eremophila alpestris*), meadowlarks (*Sturnella neglecta*), western kingbirds (*Tyranus verticalis*), rock doves (*Columba livia*), black-billed magpies (*Pica pica*), and ravens (*Corvus corax*). Burrowing owls (*Athene cunicularia*) commonly nest in the 200 Areas in abandoned badger or coyote holes. Loggerhead shrikes (*Lanius ludovicianus*) and sage sparrows (*Amphispiza belli*) are common nesting species in habitats dominated by sagebrush. Long-billed curlews (*Numenius americanus*) have been observed nesting on inactive 200 Areas waste sites.

Common reptiles at the 200 Areas include gopher snakes (*Pituophis melanoleucus*) and sideblotched lizards (*Uta stansburiana*). Three of the most common groups of insects include darkling beetles, grasshoppers, and ants.

3.3.3 Species of Concern

The Hanford Site is home to a variety of species of concern, but many of these are restricted to the Columbia River and associated shoreline. No plants on the Federal list of threatened and endangered species are known to occur on the Hanford Site. Two animal species that do occur at the Hanford Site, bald eagles (*Haliaeetus leucocephalus*) and peregrine falcons (*Falco peregrinus*), depend on the river corridor and are rarely observed at the 200 Areas. Several state-threatened, endangered, and candidate species are found in and near the 200 Areas, such as ferruginous hawks (*Buteo regalis*), burrowing owls, loggerhead shrike, long-billed curlew, and sage sparrow. Migratory bird species are also protected by the *Migratory Bird Treaty Act*. Plant species of concern (which include those listed as state-endangered, threatened, sensitive, and monitored) that may occur at the 200 Areas include Dwarf evening primrose (*Camissonia pygmaea*) and Piper's daisy (*Erigeron piperianus*) (Washington Natural Heritage Program 1998).

Both plant and animal species of concern, their designations, and places of occurrence can change over time. At this time, none are suspected of having the potential to significantly affect the characterization or remediation of any waste site, but incorporating the needs of these species into project planning will help to mitigate any potential effects. Especially important is avoiding, where possible, undisturbed shrub-steppe habitat, as this is important to many species of concern.

The undisturbed shrub steppe in and near the 200 Areas is Level 3 habitat, which requires mitigation of any disturbance, for example through avoidance and minimization, and possibly rectification and compensation (DOE-RL 1996c). Level 3 habitat includes areas occupied by animals that are on a state or federal listing of candidate, sensitive, or endangered species. More detailed direction on protecting Level 3 habitats and species of concern is provided in the *Draft Hanford Site Biological Resources Management Plan* (DOE-RL 1996b). In addition, site-specific environmental surveys, required before ground disturbance can occur, serve as a final check to ensure that ecological resources are adequately protected.

3.3.4 Significance of Ecological Resources to Contaminant Fate and Transport

Wildlife and plants in the 200 Areas have a history of taking up contaminants from waste sites through burrowing and root penetration (e.g., WHC 1991c, 1994). Plant roots can take up radionuclides to varying extents depending on the radionuclide, plant species, depth of contamination, and soil chemistry. Plants such as Russian thistle that have both deep roots and grow preferentially on disturbed, poor soils are especially known for taking up certain radionuclides and then releasing them to the environment as the plant dies back in the fall or as animals eat the contaminated parts of the plant. Animals that burrow (e.g., harvester ants, mice, pocket gophers, and badgers) have all been found to distribute contaminants from buried waste sites at the Hanford Site. For example, O'Farrell et al. (1973) documented the spread of radionuclides by black-tailed jackrabbits (*Lepus californicus*) licking contaminated salts in the 100-B/C cribs and leaving contaminated fecal pellets and urine over an area of several square miles. Animals digging into waste sites can distribute contaminants or be affected by contaminants by many pathways, including (1) wind dispersal of excavated soil, causing spread of contamination; (2) animal consumption of the soil (e.g., if it contains a salt and is consumed on purpose, or is lodged on the pelt of a prey species consumed by a predator); (3) a dose to burrowing animals from radionuclides in the soil; and (4) excavated contaminated materials exposing other animals to an external dose. The probable maximum depths of burrowing and root penetration for the more significant wildlife and plant species are shown in Table 3-10.

3.3.5 Cultural Resources

In 1996, RL, the Washington State Historic Preservation Office, and the Advisory Council on Historic Preservation signed a programmatic agreement (PA) (DOE-RL 1996c) that modified compliance with Section 106 of the *National Historic Preservation Act of 1966* with respect to the Hanford Site's historic buildings. Through the PA, RL created the Hanford Site Manhattan Project and Cold War Era Historic District as a means to replace individual building-by-building documentation and mitigation with the systematic treatment of a representative sample of buildings. As required by the PA, all 200 Areas buildings were evaluated for their eligibility for listing in the National Register of Historic Places as contributing or noncontributing properties within the Historic District. Of the 139 buildings determined to be contributing properties, 62 were selected to represent the events and activities that took place within the 200 Areas. WMAs T/TX-TY are contributing properties. If alteration or destruction is planned for contributing properties in the 200 Areas as a result of the RCAP, mitigation of the impacts will be undertaken in accordance with the conditions of the *Hanford Site Manhattan Project and Cold War Era Historic District Treatment Plan* (DOE-RL 1998b).

The Hanford Cultural Resources Laboratory conducted a comprehensive archaeological resources review for the fenced portions of the 200 Areas from 1987 through 1988 (Chatters and Cadoret 1990). This review incorporated an examination of the existing literature and an intensive pedestrian survey of all undisturbed portions of the 200 East Area, as well as a stratified random survey [of the undisturbed portions] of the 200 West Area (Chatters and Cadoret 1990). Two historic archaeological sites (i.e., can and glass scatters), four isolated historic artifacts, one isolated cryptocrystalline flake, and an extensive linear feature (i.e., the White Bluffs Road) were the only materials greater than 50 years old discovered during the field survey. Only the White Bluffs Road, in its entirety, was determined eligible for listing in the National Register of Historic Places. This road, which passes diagonally southwest to northeast through the 200 West Area, originated as a Native American trail. The road has been in continuous use since antiquity and continued to play a role in Euroamerican immigration, development, agriculture, and Hanford Site operations. Within the 200 West Area, two intact segments of the road are considered contributing elements: (1) the southwest segment from the perimeter fence to approximately 19th Street at Dayton Avenue, and (2) the extreme northeast segment above T Plant to the perimeter fence. A 100-m (328-ft) easement has been created to protect these segments of the road from uncontrolled disturbance. The remaining portions of the road within the 200 West Area have been disturbed or destroyed by previous construction-related activities and are classified as noncontributing.

In general, archaeological sites have been recorded primarily in areas of high topographic relief and near water sources on the Hanford Site. Because of the lack of nearby water supplies, a terrain of low relief and large open inland flats, the 200 Areas maintain only limited archaeological potential, with the exception of trail-associated isolated finds. Previous construction-related activities for the 200 Areas facilities (e.g., buildings and waste sites) further reduce the likelihood of archeological resources being located in these areas of high disturbance. Historic archaeological sites and isolated finds are similarly limited in their distribution. However, site-specific cultural resource surveys will be required before ground disturbance can occur to ensure that archaeological resources are adequately identified and protected. This is particularly important for corrective actions that may take place outside the fenced portions of the 200 Areas.

With the exception of project-specific information provided for undertakings that have, or might have, impacted the sacred sites of Gable Mountain and Gable Butte, no comprehensive consultations have been conducted with Tribal representatives to identify other locations within the vicinity of the 200 Areas that might be of concern to the Native American community. Archaeological surveys of nearby areas in 1968 and in the late 1980s identified numerous sites believed to represent religious and hunting activities (Rice 1968, 1987). In addition to these sites marked by rock cairns, rock alignments, artifacts, or a combination of both, other sites relating to subsistence and ceremonial activities, which are not marked by physical remains, may be present but unrecognized within the project area. For example, subsistence, medicinal, and ceremonial plants were all gathered on the Hanford Site; however, the existence and significance of such locations often can be ascertained only through interviews with knowledgeable users of the area. Plants and the areas from which they are gathered qualify as traditional cultural properties and could merit inclusion in the National Register of Historic Places because of their association with

the cultural practices and beliefs of a living community (Parker and King 1990). This is also true for sites of spiritual significance to the Tribes. The identification of sacred, ceremonial, and traditional-use areas cannot be accomplished without the assistance of traditional elders and spiritual leaders. Their involvement is needed to identify those areas for which no on-the-ground evidence exists. Therefore, consultations with representatives of the Native American communities with ancestral ties to the Hanford Site will be required before ground disturbance can occur to ensure that traditional cultural resources are adequately identified and protected.

3.4 NATURE AND EXTENT OF CONTAMINATION

This section summarizes the results of vadose investigations and groundwater quality assessment efforts in WMAs B-BX-BY, S-SX and T/TX-TY. The current understanding of the nature and extent of groundwater contamination in these WMAs is largely taken from Hodges (1998), Johnson and Chou (1998), Jones et al. (1998), and Narbutovskih (1998). These assessment and groundwater monitoring reports were written to determine if SST WMAs are impacting groundwater quality. The reader is directed to groundwater quality assessment reports for details. Information in this section will be updated in WMA addenda and include descriptions of borehole/groundwater monitoring networks and contaminant plumes.

3.4.1 Vadose and Groundwater Contamination at Waste Management Area B-BX-BY

The nature and extent of contamination in the vadose zone at WMA B-BX-BY discussed here is base on the drilling of well 299-E-33-41 presented in Narbutovskih 1998. This well was drilled in 1991 to support RCRA groundwater monitoring efforts. It is located between the 241-B and 241-BX tank farms.

Radioactive contamination was found in silt lenses of the sand dominated facies of the Hanford formation during drilling of well 299-E33-41. The location and distribution of radioactivity provides information regarding the nature and extent of contamination in the vadose zone. Radiation, up to 4,000 disintegrations per minute (dpm) was detected at 23 m (73 ft), 23.8 m (78 ft), 41.8 m (137 ft), 50 m (164 ft), and 66.4 to 73.2 m (218 to 240 ft) below ground surface. Soil sample analyses identified K-40, U-235, U-238, Pb-214, gross alpha, and beta-gamma radiation; Tc-99 was not a requested analyte. Gross alpha measurements from the 66.4-73.2 m zone ranged from 13.2 to 5.0 pCi/g, and are attributed to natural decay from the uranium and thorium concentrations found in the Hanford formation sediments. Beta-gamma radiation from the same depth ranged from 384.2 to 164.5 pCi/g, approximately 10 times higher than the mean gross beta (20pCi/g) for the Hanford Site. A July 1991 sample from well 299-E33-41 revealed Tc-99 at 333 pCi/g, and supports the conclusion that the elevated beta-gamma is due to Tc-99.

Perched water was encountered at 69.3 m (224 ft) during the drilling of this well. The perched water has been attributed to several flooding events south of the well location at the 244-BX double-contained receiving tank. Well 299-E33-41 is also close to the site of the 114,000 to 342,000 L (30,000 to 90,000 gal) overflow/spill between 241-BX-103 and 241-BX-102 in 1951, and a vadose zone plume near the 241-BX-102 mapped by Womack and Larkin (1971).

In 1991, a system of RCRA-compliant wells was installed around the B-BX-BY WMA to monitor the quality of the groundwater under a detection-level program. In 1996, specific conductance was found to be elevated above the statistical critical means in a single downgradient well (299-E33-32). Because of the elevated specific conductance, a groundwater quality assessment program was implemented. In 1997, elevated conductivity was observed in additional groundwater above the critical means. Meanwhile, no appreciable changes were observed upgradient (well 299-E33-33). Elevated levels of technetium, uranium, tritium, nitrate, chloride sulfate, and sodium have since been detected in the groundwater at this tank farm.

The results of groundwater quality assessment activities at the tank farms strongly suggest that current and past operation practices at WMA B-BX-BY have resulted in observed groundwater contamination. Observation of the groundwater contamination and raw water and tank releases lead to the following conclusions.

Recent elevated Tc-99, nitrate, chloride, sulfate, and sodium concentrations in well 299-E33-41 appear to be related to remobilized tank waste from the WMA. Trend analysis, combined with the wells' proximity to a known tank leak vadose plume and documented sources of water, indicate that this WMA contributes to observed contamination. Data reported in 1997 indicate that Tc-99 is 13 times the drinking water standard. This conclusion is based on the vadose contamination found in 1991 during the drilling of well 299-E33-41, the existence of perched water and saturated sediments, the rapid drop in water level shortly after completion, and the documented events of nearby water releases at the surface. It is likely that this contamination is remobilized vadose waste from a leak in tank 241-BX-102 (266,000 L [70,000 gal]). The overflow/spill that occurred in 1951 of 114,000 to 342,000 L (30,000 to 90,000 gal) between tanks 241-BX-102 and 241-BX-103 may have also contributed. The observed contamination appears to have recently entered the groundwater. Furthermore, the contamination events are localized and the concentrations are low when compared directly to waste stored in SSTs. Consequently, the overall impact on the groundwater quality may be small, especially when compared to the large regional contaminant plumes that currently exist in this region. The concentration of Tc-99 at well 299-E33-41 is increasing. As of March 1998, the level was 2,720 pCi/L. Uranium has also risen above the drinking water standard of 20 ug/L and above the local background level of 3.0 ug/L, to a maximum of 81 ug/L in well 299-E33-41. The uranium trend displayed the same character seen in the technetium and nitrate data, but the pattern occurred almost a year later.

Smith 1980 indicates there may be gamma contamination deep within the unconfined aquifer beneath the B-BX-BY WMA based on gamma scintillation logging profiles. The profiles indicate the presence of low-level gamma activity just above the basalt in wells around the WMA. The source of the gamma contamination in the groundwater is suspected of being a group of seven cribs call the BY cribs. The cribs are located adjacent to the WMA and received about 3.4 X 10^{-7}L (8,976,000 gal) of high salt waste containing ~13,000 Ci Sr-90 and ~3,800 Cs-137. It is suggested that the high salt waste appears to have migrated through the vadose zone to groundwater. The gamma contamination may be migrating along the surface of the basalt, which dips to the south under the WMA.

3.4.2 Vadose and Groundwater Contamination at Waste Management Area S-SX

The nature and extent of contamination in the vadose zone at MWA S-SX is partly based on data derived from the drilling, sampling and analysis of sediments from borehole 41-09-39. The analysis presented in this section is mainly based upon Johnson and Chou (1998). In 1996, borehole 41-09-39 was initially driven to a depth of 40.0 m (131.5 ft) in response to the determination that Cs-137 might reside in the soil column at depths greater than 30 m (100 ft). The borehole was drilled to ascertain whether the contamination was an artifact of an adjacent unsealed borehole or disseminated in the formation. Geophysical logging of borehole 41-09-39 confirmed that dissemination within the formation was probable and that contamination was still present at a depth of 40 m (131.5 ft).

Concern was raised that if relatively immobile Cs-137 was present at that depth, more mobile, long-lived tank waste constituents such as Tc-99 might be at or near the water table at approximately the 64.3 m (211 ft) depth. In response to a recommendation from an expert panel formed to address these early findings (DOE-RL 1997c), borehole 41-09-39 was extended to groundwater and samples of both sediments and groundwater were collected for laboratory analyses of tank waste components (Myers et al. 1998).

Analysis of the seven composited samples from this borehole show that tank waste constituents are predominantly held by the sediments within or above the Plio-Pleistocene soil horizon. Nonradiological constituents (i.e., sodium, calcium, and nitrate) point to the leading edge of tank waste components being at a depth of about 47 m (135 ft). This leading edge may result from natural processes or from drag-down that took place during the drilling process; this study was unable to determine which is most likely.

Analyses for Cs-137, the radionuclide originally recognized as being deeper than anticipated in the vadose zone, were conducted on all samples via gamma energy analysis. Cesium-137 activity in the soils was highest associated with the Plio-Pleistocene sediments at 40 m (131 ft). Activity dropped off rapidly and was at or below detection levels from 48.8 m (160 ft) to the water table at 64.3 m (211 ft).

Technetium-99, the most mobile of the long-lived radionuclides found in tank waste, was sporadically distributed; most occurrences above the minimum detection level were above the caliche-rich horizon. A single deep occurrence was noted at 56.3 m (184.6 ft), which is the location postulated to be the highest level reached by groundwater during operation of the U Pond. The Tc-99 could have migrated horizontally from disposal facilities outside the tank farm boundaries to the sediment extracted. If the technetium source was the SX tanks, it would likely appear as near continual detection throughout the shallower sediments (Johnson and Chou 1998).

Desorption distribution coefficient (K_d) tests were run on sediment samples for both Cs-137 and Tc-99. These tests showed that Cs-137 is strongly bound to the fine-grained sediments. The tests for Tc-99 showed positive values for the K_d, but significant uncertainty was associated with those values.

In 1990, a system of RCRA-compliant wells was installed around the S-SX WMA to monitor the quality of the groundwater under a detection-level program. This WMA was placed in assessment–level monitoring status in 1996 in response to a directive from Ecology. The directive cited anomalous trends in Tc-99 and elevated specific conductance in the groundwater as the primary reason for the assessment. The results of groundwater quality assessment activities at the tank farms suggest that practices at WMA S-SX tank farm have resulted in groundwater contamination. Observation of the groundwater contamination lead to the following conclusions:

- Distribution patterns for radionuclides and RCRA dangerous waste constituents (i.e., nitrate and chromate) indicate that the WMA S-SX tank farm has contributed to groundwater contamination observed in downgradient monitoring wells.

- Multiple sources (e.g., tank leaks or spills) are needed to explain historical as well as recent groundwater contamination. At least two WMA source areas are needed to explain the presence of Tc-99 concentration in groundwater.

- The drinking water standard for technetium has been exceeded but is limited to wells 299-W22-46, 299-W23-6, and 299-W23-1. Technetium-99, the constituent with the highest concentration relative to the standard, is currently four to five times the EPA interim drinking water standard of 900 pCi/L in well 2-W22-46. The drinking water standard for nitrate has been exceeded and is currently limited to one well, 299-W22-46, with concentration at or slightly above the 45,000 ug/L standard. The Tc-99, nitrate, and chromium concentrations in downgradient well 299-W22-46 (the well with the highest current concentrations) appear to be declining after reaching maximum concentrations in May 1997. Wells 299-W23-6 and 299-W22-46 are located downgradient from the largest known soil contamination near tanks SX-108, SX-109, and SX-115.

- Cesium-137 and strontium-90 were not detected in any of the RCRA-compliant monitoring wells. This supports the expected retention or retardation of these radionuclides in Hanford Sites sediments and/or aquifer sediments.

- Circumstantial evidence suggests that short-term contaminant transients in multiple wells occurring at different times between 1985 and the present may have been caused by leaking water lines, rupture events, ponded snowmelt water, or a combination thereof, adjacent to and within the WMA. Data obtained from this preliminary investigation and subsequent investigation may provide an answer to whether contaminant migration that impacted groundwater was enhanced by water line leaks. Continuing efforts are underway to identify and eliminate potential sources within and around the tanks.

- Confirmed detections of Sr-90 and Cs-137 have been limited primarily to one older well 299-W23-7. Whether this occurrence represents a breakthrough from a vadose zone source to the groundwater or is a result of faulty well construction has not been completely evaluated.

- Preliminary results for groundwater samples collected January 1965 from new borehole (41-09-39) suggest that little if any tank waste reached the water table at this location. Gross alpha and gross beta concentrations are within the range of Hanford Site natural background, and hexavalent chromium was not detected (<10 ug/L).

A subsurface investigation was performed in the SX tank farm in 1965 to evaluate the nature and extent of contamination. Results of the investigation are reported in Raymond and Shdo (1966). Conclusions of the investigation indicate that Cs–137 was the predominant long-lived isotope in the subsurface, and three separate leak events were associated with tanks SX-108 and SX-115. Virtually all the long-lived isotopes were detected within several feet of the bottom of the tank and groundwater was not impacted by the releases.

3.4.3 Vadose and Groundwater Contamination at Waste Management Areas T and TX-TY

The nature and extent of contamination at the T and TX-TY WMA discussed here is based on gamma logging measurements and the drilling of borehole 299-W10-196 as presented in Hodges (1998). The tank T-106 leak has been one of the most studied tank leaks at the Hanford Site (ARHCO 1973; Routson et al. 1979). Most recently, an extensive evaluation was performed on the soil column contaminated by this leak (BHI 1994). The type of radionuclide contamination most often evaluated in this zone has been high-energy gamma emitters, which are amenable to gamma-logging measurements. While this information helps qualitatively map the extent of the leak event, it provides little information about other radionuclides that may have contaminated the soil. In particular, the distribution in the soil of other radionuclides likely to be mobile in the future and capable of contaminating the unconfined aquifer (chiefly Tc-99 and uranium isotopes, and perhaps C-14 and I-129) needs to be determined.

Other than the extensive gamma measurements taken around the tank T-106 leak, the most comprehensive radionuclide contaminant characterization of soils near the leak source has been completed in borehole 299-W10-196 (BHI 1994). The borehole is located just west of tank T-106 and was drilled through the zone of the highest gamma readings identified from previous measurements. Soil samples were collected at selected depths and analyzed for a suite of radionuclides, common elements found in the supernatant liquid, and soil, water, pH, and organics. For this discussion, the characteristics of the radionuclide distribution are considered and sodium, nitrate, and nitrite concentrations were determined.

Cesium-137, Sr-90, and C-14 were present in peak concentrations at or just below the tank bottom (about 10 to 12 m [33 to 39 ft]) in the Hanford formation. Uranium had a peak concentration of 39 µg/g at 22 m (72 ft); Tc-99 displayed a broad peak from 30 to 40 m (98 to 131 ft); Eu-154 peaked at about 22 m (72 ft); and Co-60 showed no real peak. Sodium showed two peaks in the Hanford formation, one at the tank bottom and a slightly larger one at about 20 m (72 ft).

The Pu-239/240, uranium, Sr-90, and sodium displayed a secondary peak in the Plio-Pleistocene unit. Secondary peak concentrations are at much lower concentrations for these radionuclides

(factors at 100 or more). Neptunium-237, Am-241, and Cs-137 were not detected in the Plio-Pleistocene unit and appear not to have reached this layer.

Based on these observations, some qualitative deductions can be made about the relative mobility of the various species. The key indicators are the relative depth of concentration peaks and the depth intervals over which the species are identified. The primary peaks occurring above the Plio-Pleistocene unit indicate that some sort of chemical reaction has occurred to fix a fraction of the radionuclide in place and/or retard its movement downward relative to movement of tank leak fluid toward the water table. Contaminants identified at greater depth obviously show less retardation of transport relative to tank leak fluid flow rates. Mapping of ruthenium distribution from work shortly after the leak (ARHCO 1973) provides a marker for the extent of the leak penetration into the soil column. Ruthenium is known to be highly mobile and should have been transported downward at essentially the same rate as the leaking tank liquid. Earlier data (ARHCO 1973) indicate that the initial leak volume quickly reached the Plio-Pleistocene layer, about 30 m (98 ft) below the surface. The distribution of ruthenium suggests that the relatively lower permeability of the Plio-Pleistocene layer stopped the downward flow of the leak and forced it to move horizontally, at least temporarily. Later measurements showed ruthenium extended below the Plio-Pleistocene unit into the Ringold Formation.

The concentration-versus-depth patterns suggest several broad levels of mobility. The least mobile species are those showing large peaks just below the tank bottom and detection only in the Hanford formation above the Plio-Pleistocene layer. One large peak with relatively little contamination below the peak indicates a relatively rapid and extensive reaction (e.g., sorption, precipitation or both) with the soil column soon after the leak occurred. The radionuclides in this group are Cs-137, Np-237, and C-14.

The next most mobile species are found lower in the soil column and exhibit a broader high concentration band that begins at, and extends further below the tank bottom. Also, these radionuclides are present at lower concentrations down to the Plio-Pleistocene layer where a much smaller secondary peak occurs (approximately 1,000 pCi/g less than the maximum activity). These radionuclides include Sr-90, Pu-239/240, uranium, and sodium.

Finally, the most mobile radionuclides show similar concentrations throughout the Hanford formation, through the Plio-Pleistocene, and into the Ringold Formation. The radionuclides and chemicals in this group are Tc-99, Co-60, nitrite, and nitrate. All radionuclides except Tc-99 and Co-60 have been retarded relative to the downward movement of tank leak fluids, as suggested by the extent of the initial ruthenium plume.

A detection level RCRA groundwater monitoring program for WMAs T/TX-TY was initiated in 1989. Details describing the groundwater monitoring programs are provided by WHC (1989a and 1991a). These WMAs were placed in assessment-level monitoring status in 1993 because of exceedances in specific conductance in downgradient wells. The results of groundwater quality assessment activities at the tank farms suggest that practices at WMAs T and TX-TY have resulted in groundwater contamination. Conclusions regarding groundwater contamination are presented from Hodges (1998). Available evidence indicates, with a high degree of certainty, that WMA T is the source of groundwater contamination in downgradient monitoring well

299-W11-27. Both contaminant chemistry (which indicates a small volume, tank waste source) and lack of lateral spreading in groundwater (dispersion) are indicative of a source within the tank farms. Drinking water standards in this well are exceeded for Tc-99, tritium, nitrate, gross beta, and chromium. The largest exceedance for Tc-99 is 21,700 pCi/L, which is approximately 24 times the drinking water standard of 900 pCi/L.

Available evidence is consistent with a WMA TX-TY source for the groundwater contamination in downgradient monitoring well 299-W14-12. Contaminant chemistry is consistent with a small-volume tank waste source. At this time, however, an upgradient source (216-T-25 trench) cannot be completely ruled out. Given the lack of direct evidence for a source upgradient to the WMA it must be assumed that WMA TX-TY is the source of groundwater contamination in well 299-W14-12. Because of this uncertainty, additional investigation is required. Contaminant levels in well 299-W14-12 have declined to a point where only nitrate and tritium exceed drinking water standards. At peak contaminant levels, Tc-99 and chromium were present at concentrations of 13,300 pCi/L and 600 ppb, respectively. These concentrations are 10 to 15 times the drinking water standard.

Preliminary evidence from wells 299-W11-27 and 299-W14-12 indicates that contaminant concentration may increase downward within the aquifer. Hodges 1998 suggests there are two potential causes of contaminated stratification within the aquifer. The first is brines (high-salt waste) with densities significantly greater than $1 g/cm^3$ which sink within the aquifer. The second potential cause of stratification within the aquifer is recharge with little or incomplete vertical mixing that results in layering at the top of the aquifer. If the aquifer is stratified with respect to contaminant concentration, it has important implication for the source and transport mechanisms within the vadose zone, and about the extent of contamination within the aquifer.

3.5 CONCEPTUAL MODEL

Information in section 3.0 and supporting reports provide the basis for development of a generic conceptual model for WMAs. The most important elements for conceptual model definition include information on waste site history, geology, hydrology, geochemistry and the nature and extent of contamination. Combined, the information in this section describes a generic physical model of WMAs and provides a starting point for definition of site problems. The following summary describes the generic WMA conceptual model.

The SSTs and ancillary structures were constructed on the Hanford Site to manage waste from plutonium production and the waste separation process. The tanks were constructed between 1943 and 1954 in the 200 Areas. Process wastes contain various radionuclides and chemical byproducts from the $BiPO_4$, PUREX, and REDOX processes.

The SSTs were constructed as underground storage units. Tanks were designed as vertical cylinders with domed tops and were constructed with reinforced-concrete with carbon-steel liners on the base and sides. During construction, the base of each tank was placed within the Hanford formation. The depth to the base of the tanks is estimated to be no greater than 21 m (70 ft) below ground surface. Backfill was placed around the tanks during construction to isolate

the structure underground. Once covered, a thin layer of gravel was placed over the surface of the farm. The typical SST has a 23-m (75-ft) diameter and a holding capacity between 2,006,000 and 3,785,000 L (530,000 and 1,000,000 gal). Each tank farm contains between six and 18 SSTs and ancillary structures. A total of 99 SSTs are found in WMAs B-BX-BY, S-SX, T, and TX-TY. The surface of the tank farm areas is maintained free of vegetation.

Process wastes managed in SSTs were released to the subsurface. Some releases were intentional; other releases are characterized as unintentional leaks. The volume of waste intentionally released is approximately 458,035,000 L (121,000,000 gal). The volume of waste that has leaked from the SSTs is not well defined because leak detection methods are not very precise and limited information is available to evaluate conditions under the tanks. Therefore, the radionuclide and chemical inventories in the subsurface are not well defined and should be evaluated further. The estimated volume of waste released to the environment from leaking SSTs in WMAs B-BX-BY, S-SX, and T/TX-TY is 1,810,320 L (467,400 gal).

Contaminants in tank waste consist of long list of radionuclides and chemicals. Major contaminants of concerns are nitrate, sodium, sulfate, chromium, Am-241, C-14, Co-60, Np-237, Pu-239/Pu-240, Pu-241, Cs-137, Sr-90, Tc-99, tritium, and uranium. The distribution and transport rate of contaminants in the vadose zone and aquifer depend on the contaminant source characteristics, hydrogeologic factors, and contaminant transport and loss mechanisms. The contaminant source for the groundwater in the 200 Areas is mainly the vadose zone. Possible contaminant transport mechanisms occurring in the vadose zone and aquifer include advection of dissolved chemicals, transport of suspended particulates (colloids), diffusion, and dispersion mechanisms. Contaminant transport is primarily by the advection of dissolved chemicals in the vadose and aquifer. Contaminant loss mechanisms in the subsurface are contaminant-specific and include adsorption and radioactive decay. In low hydraulic conductivity materials, clays and very fine silts account for most of the lateral dispersion of fluids, chemical sorption of contaminants, and other chemical reactivity.

Liquids released from SSTs and ancillary structures move vertically through the soil column by piston flow. Lateral spreading of tank wastes may occur associated with fine-grained facies such as the Hanford formation and sequence inclusive of paleosols, silt stringers, and the Plio-Peistocene unit. A secondary mode of transport is by preferential flow. Preferential flow can be via clastic dikes and along the annular space of unsealed boreholes. Bare gravel surfaces enhance infiltration from all water sources. Individual tank domes create an umbrella effect that can concentrate infiltrated water. This umbrella effect causes water to flow over the dome and down the tank walls into underlying sediments. Natural and artificial sources of recharge may be significant hydraulic drivers and remobilize contaminant plumes in the vadose zone.

Contamination has been detected in the vadose zone in WMAs. The highest concentrations are detected near the point of release. Concentrations generally decrease with depth; however, elevated levels of contamination are frequently associated with the fine-grained facies such as the Plio-Pleistocene unit, the Hanford formation, and silt stringers. Contaminants with large retardation factors (e.g., Cs-137) are generally detected in very high concentrations near leaks and discharge points. Mobile contaminants such as Tc-99 and nitrate typically move with the moisture flux. Contaminants detected in the vadose zone include Am-241, C-14, Co-60, Cs-137,

Np237, Pu-239/240, Sr-90, Tc-99, and uranium. Contaminants detected at the water table above drinking water standards are chromium, nitrate, Tc-99, tritium, and uranium. The distribution and concentration of contaminants in the subsurface suggests that waste management activities associated with the SST system are impacting the soil column and the unconfined aquifer. However, contaminant impacts may also be attributed to adjacent waste management units.

A generalized conceptual model for the tank farms (modified from Jones et al. 1998) is shown in Figure 3-14. The schematic identifies potential structures, sources of contamination, hydrogeologic units of interest, and contaminant distribution. The WMA-specific site conceptual models will be developed in WMA addenda.

The WMA-specific conceptual model will be presented in WMA addenda and will describe at least the worst-case scenario in the WMA. The WMA model will include a summary of the WMA history (e.g., leak history and inventory of contaminants in the vadose zone), local geology, local hydrology, WMA-specific conditions that control contaminant fate and transport in the vadose zone and unconfined aquifer, and the nature and extent of contamination. The illustration of the physical model representing the summary description shall show the relationship between the tank and ancillary equipment, geologic units, and the distribution of contaminants in the subsurface. The vertical and lateral extent of contamination in the vadose zone shall be shown on the illustration. Groundwater plumes in, or associated with, the WMA shall be presented on plume maps relative to the tank farms.

1

Figure 3-1. Hanford Site Radioactive Material Flow Diagram (from DOE-RL 1999).

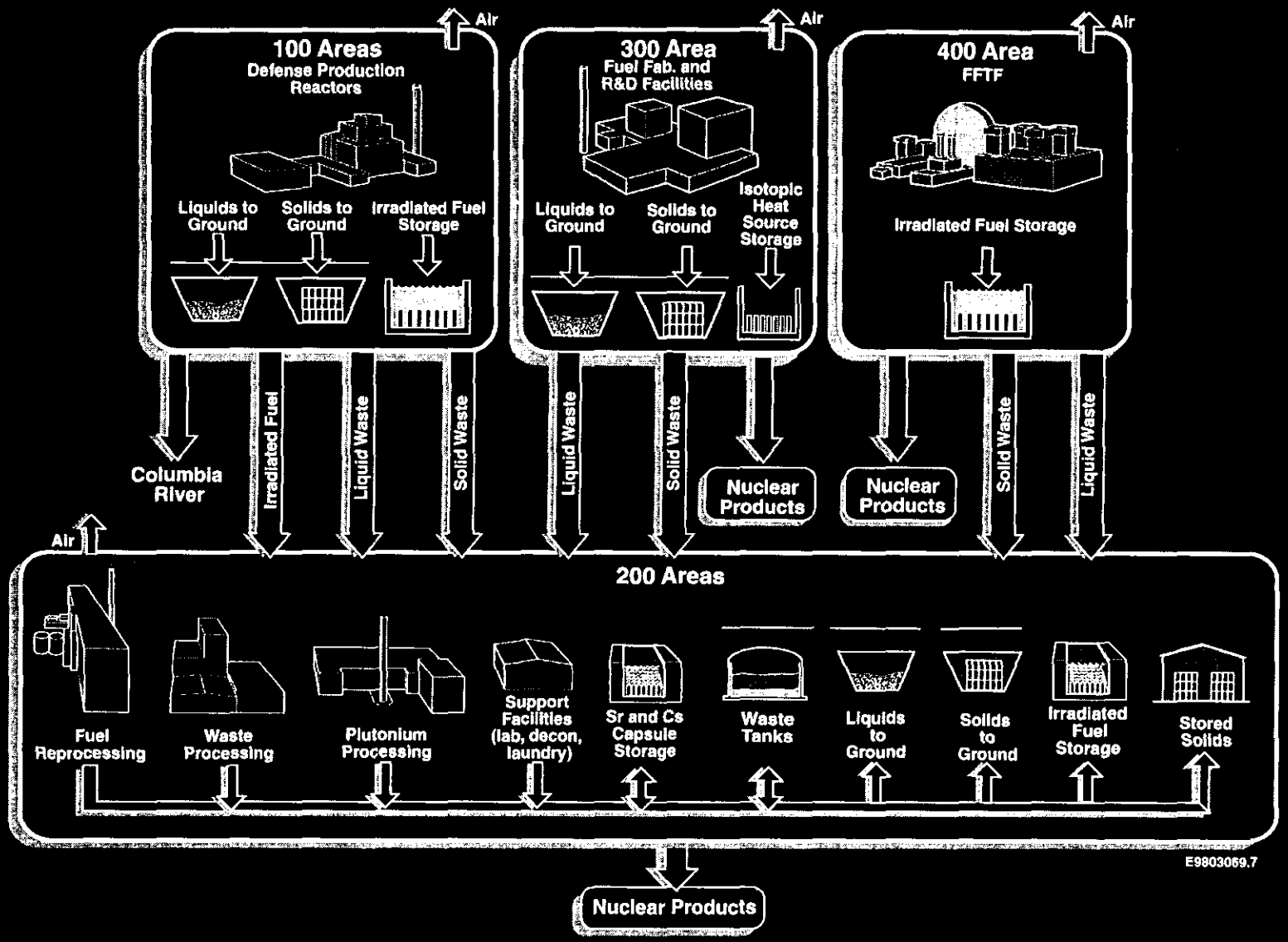


Figure 3-2. Typical Single-Shell Tank.

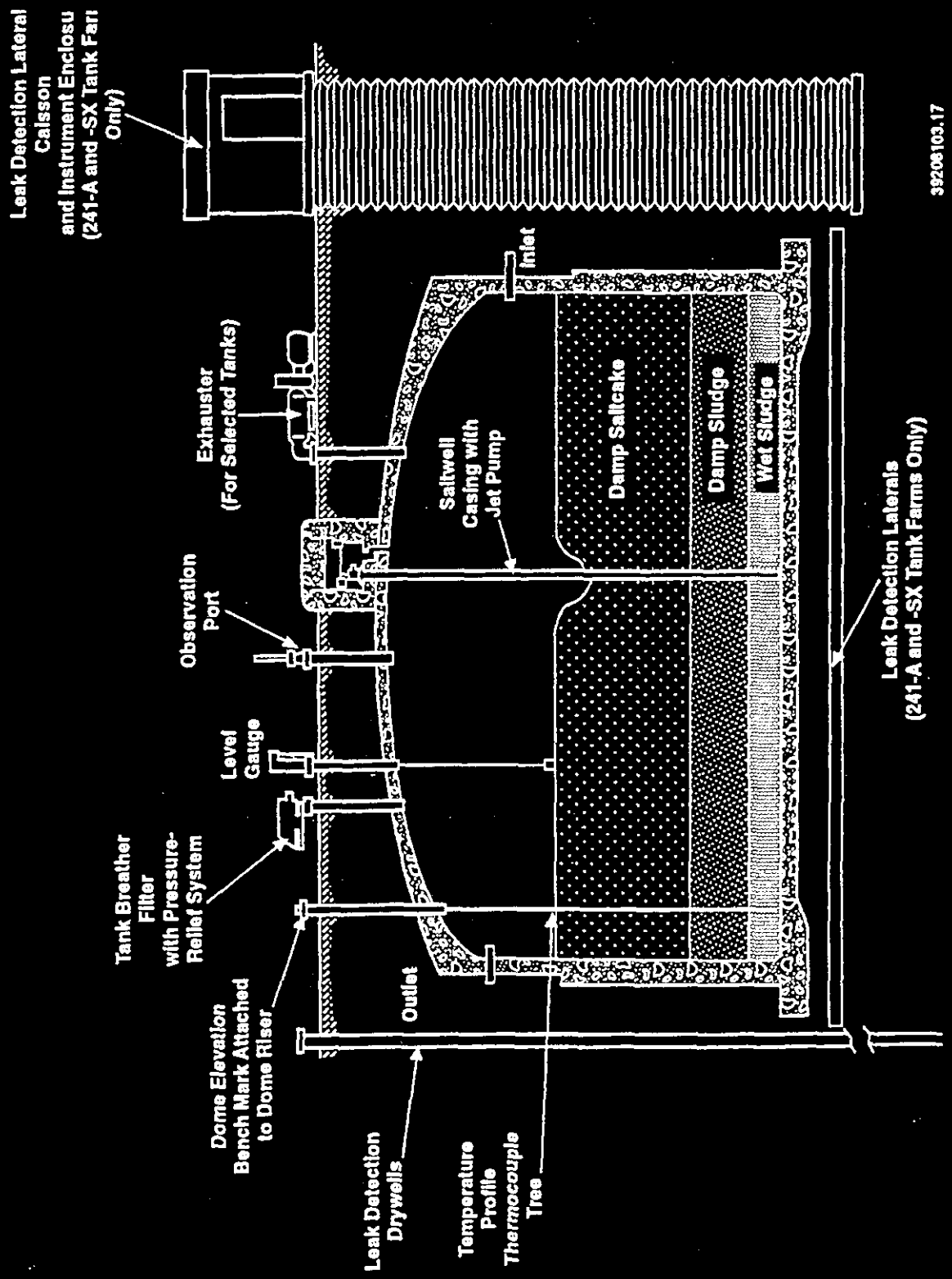


Figure 3-3. Waste Management Area B-BX-BY.

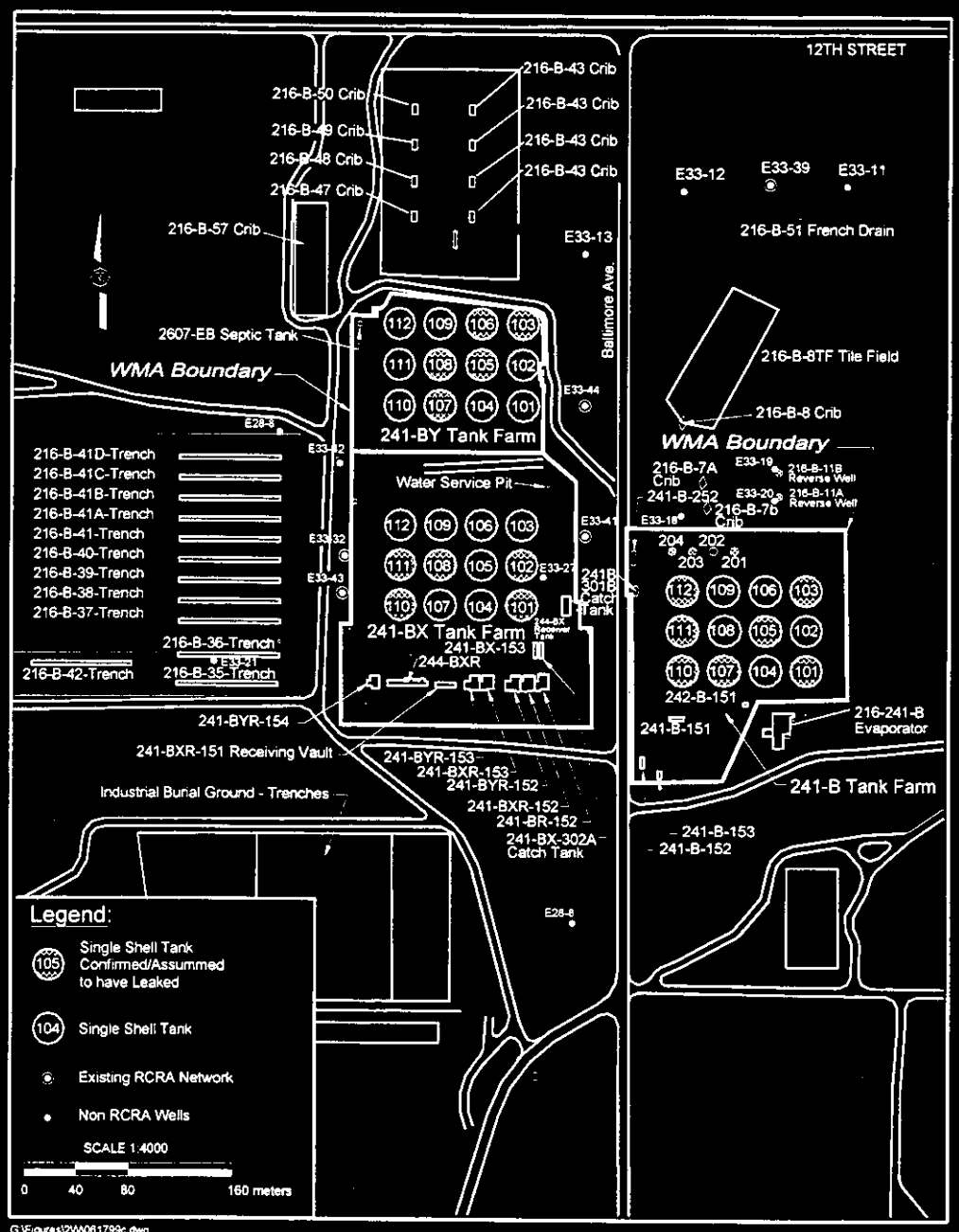


Figure 3-4. Waste Management Area S-SX.

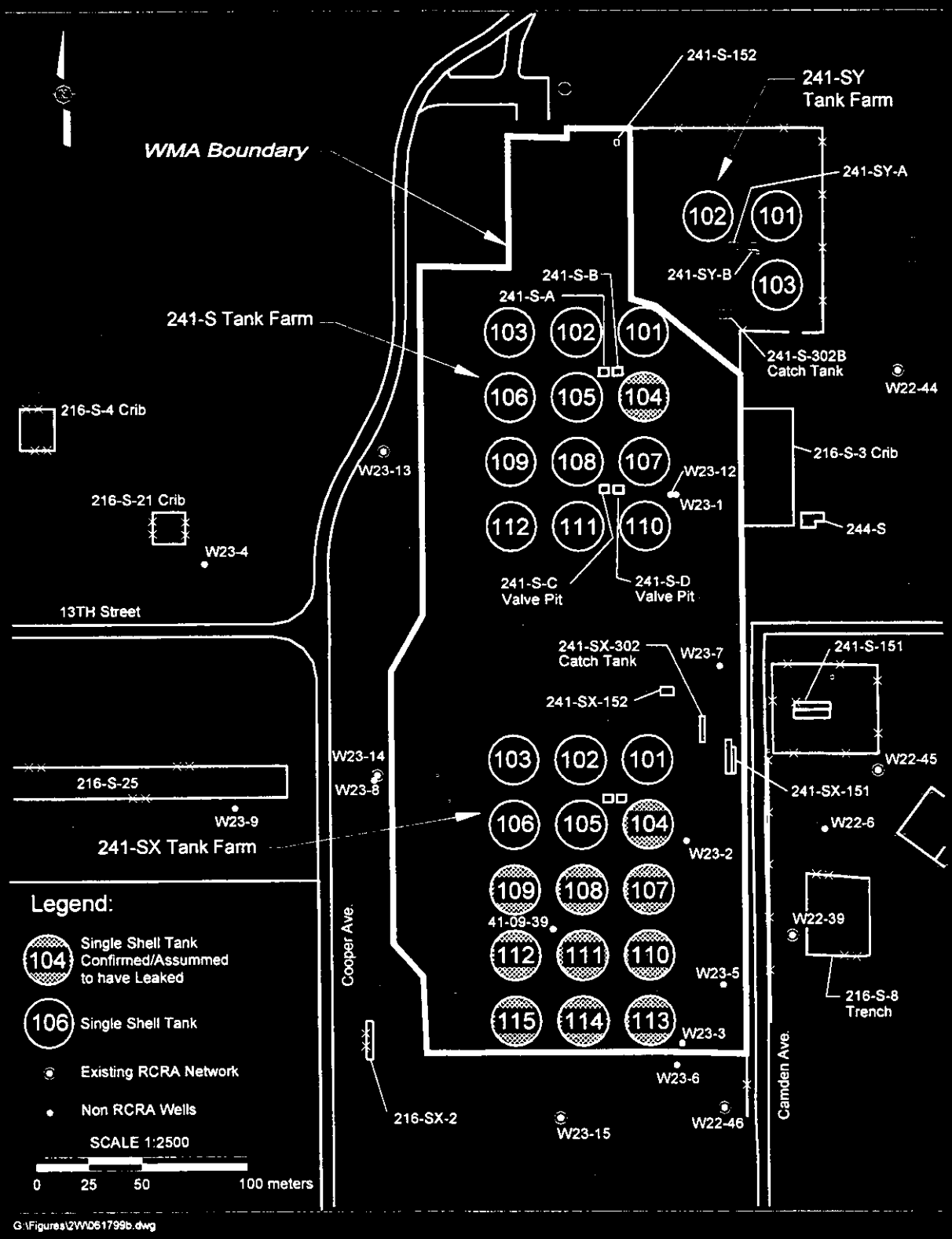
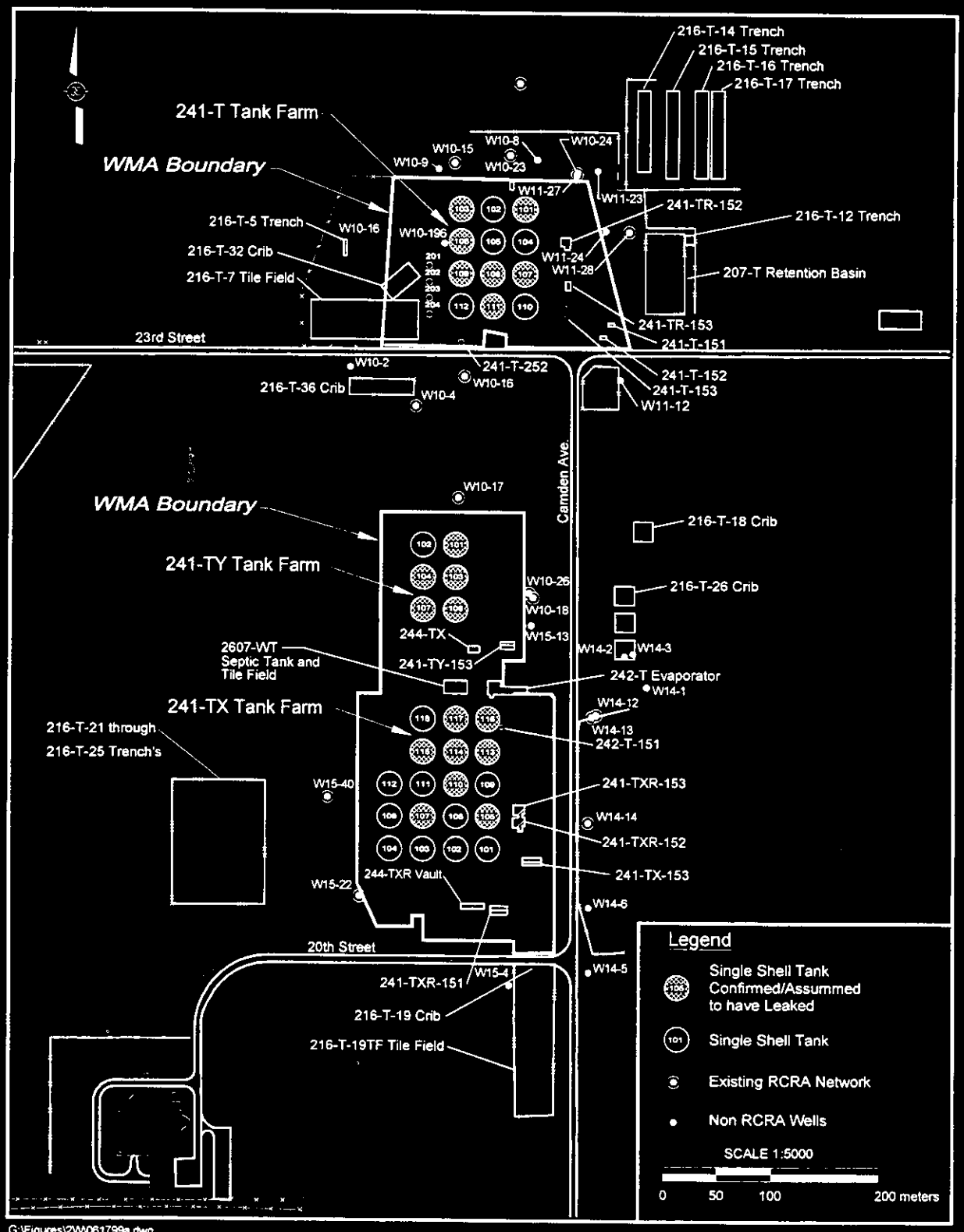


Figure 3-5. Waste Management Areas T and TX-TY.



G:\Figures\2W061799a.dwg

Figure 3-6. Topography of the Hanford Site (from DOE-RL 1999).

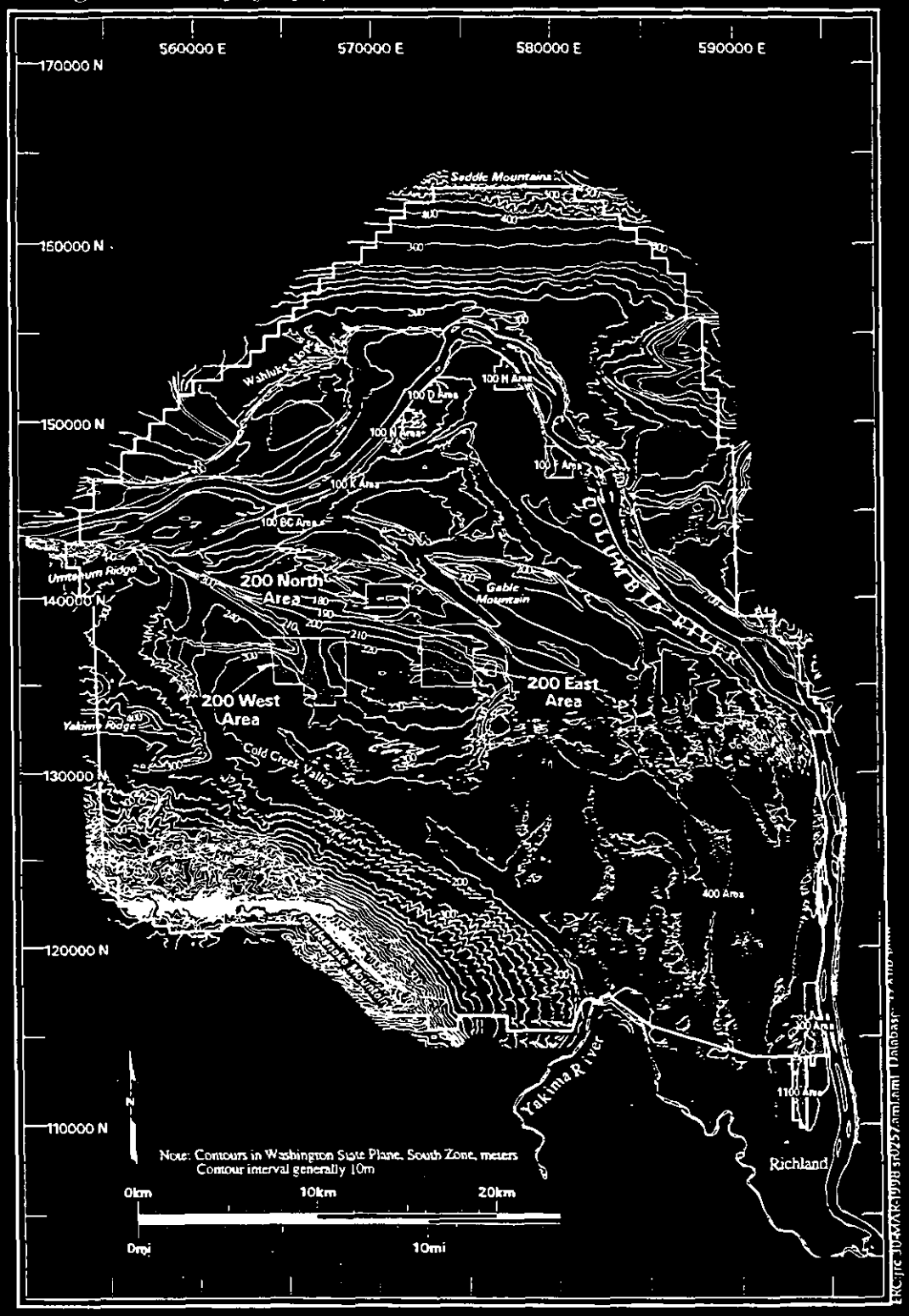


Figure 3-7. Wind Roses at the 100-m (30-ft) Level of the Hanford Meteorological Monitoring Network, 1982-1996 (from Neitzel 1998).

Figure 3-8. Average Daily Barometric Pressure at the Hanford Meteorological Station, 1997 (average from hourly observations provided by HMS).

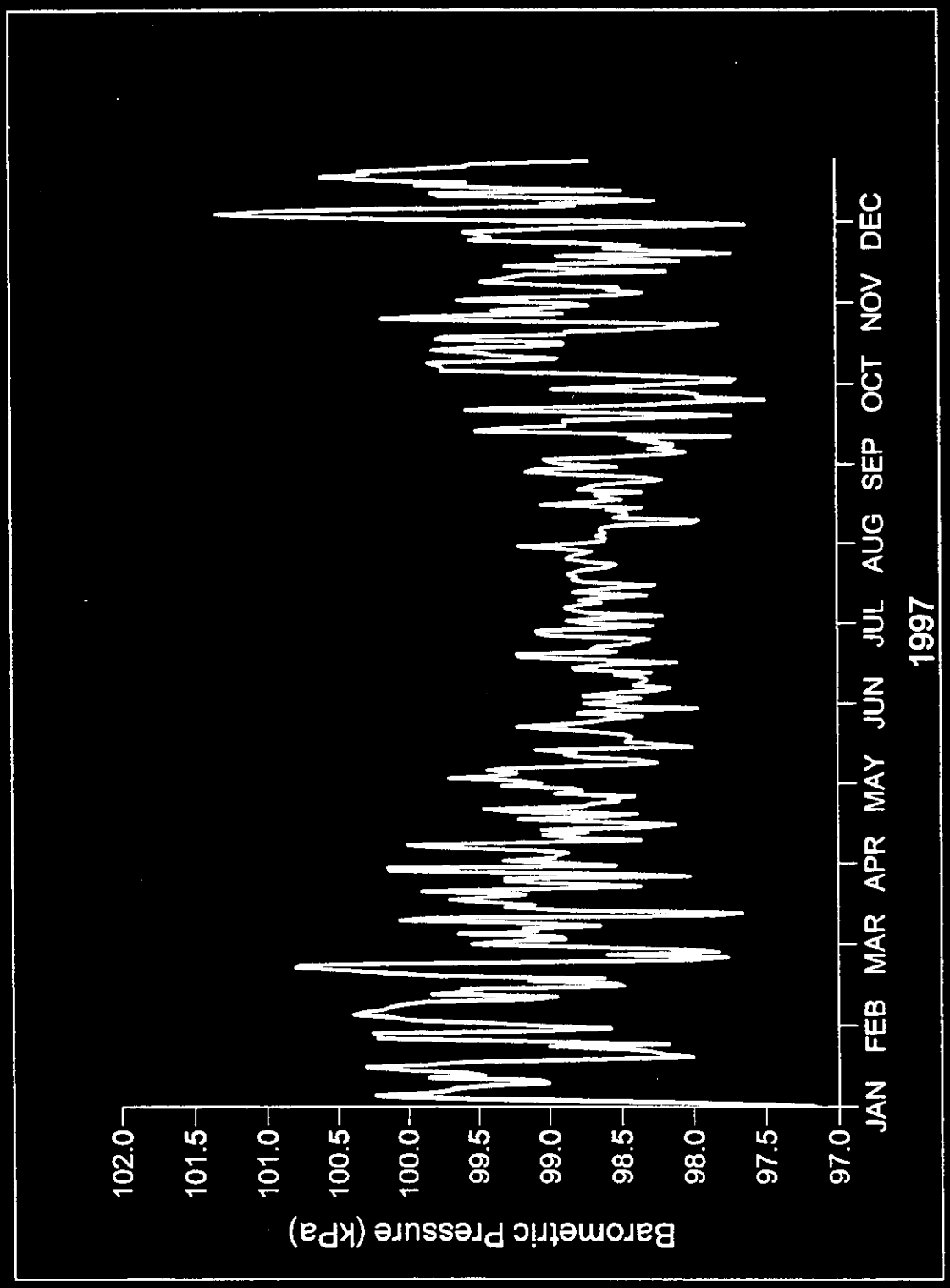
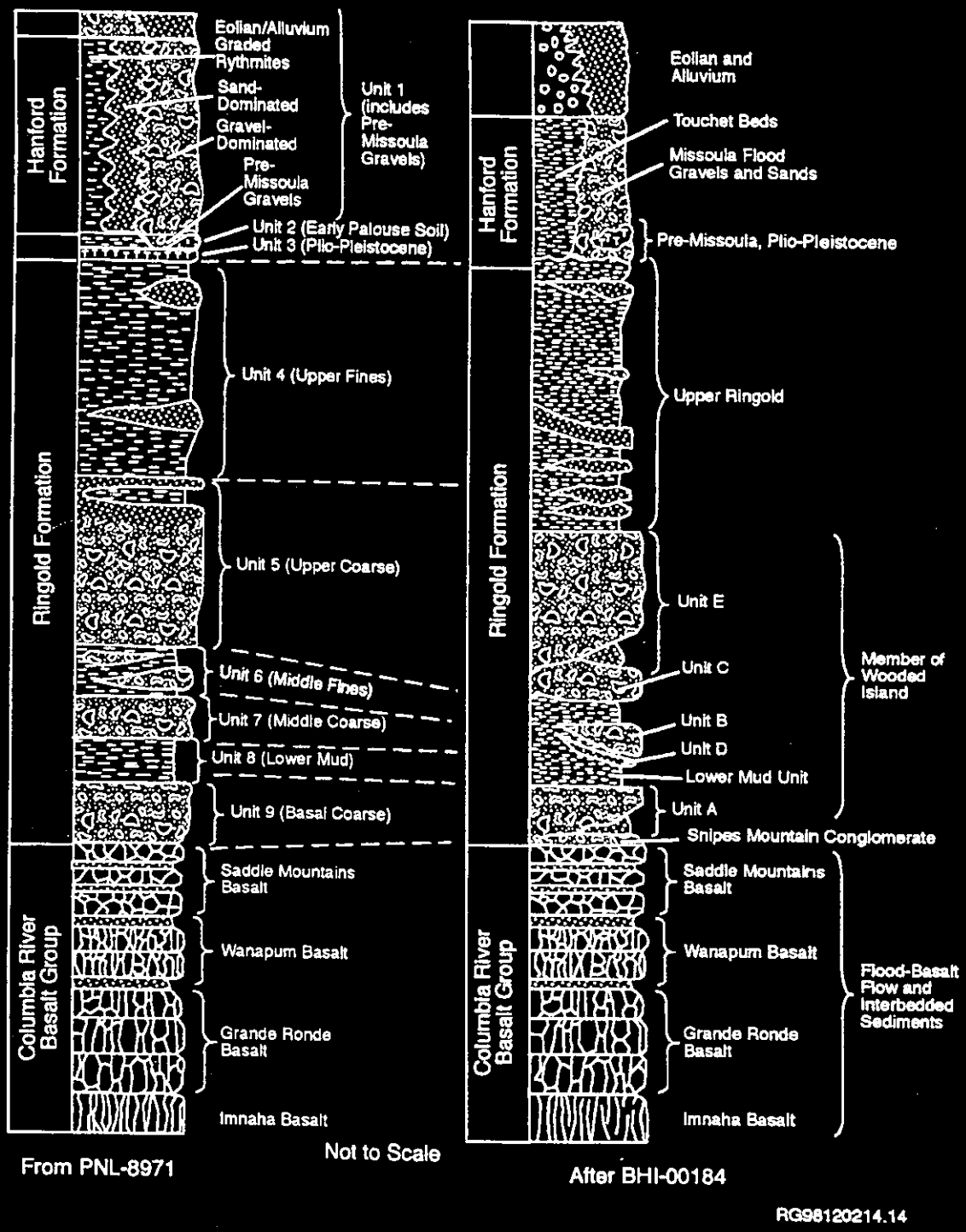


Figure 3-9. Generalized Stratigraphic Column for the Hanford Site



(from Barnett et al. 1999).

Figure 3-10. Geologic Cross-Section – Hanford Site (from Barnett et al. 1999).

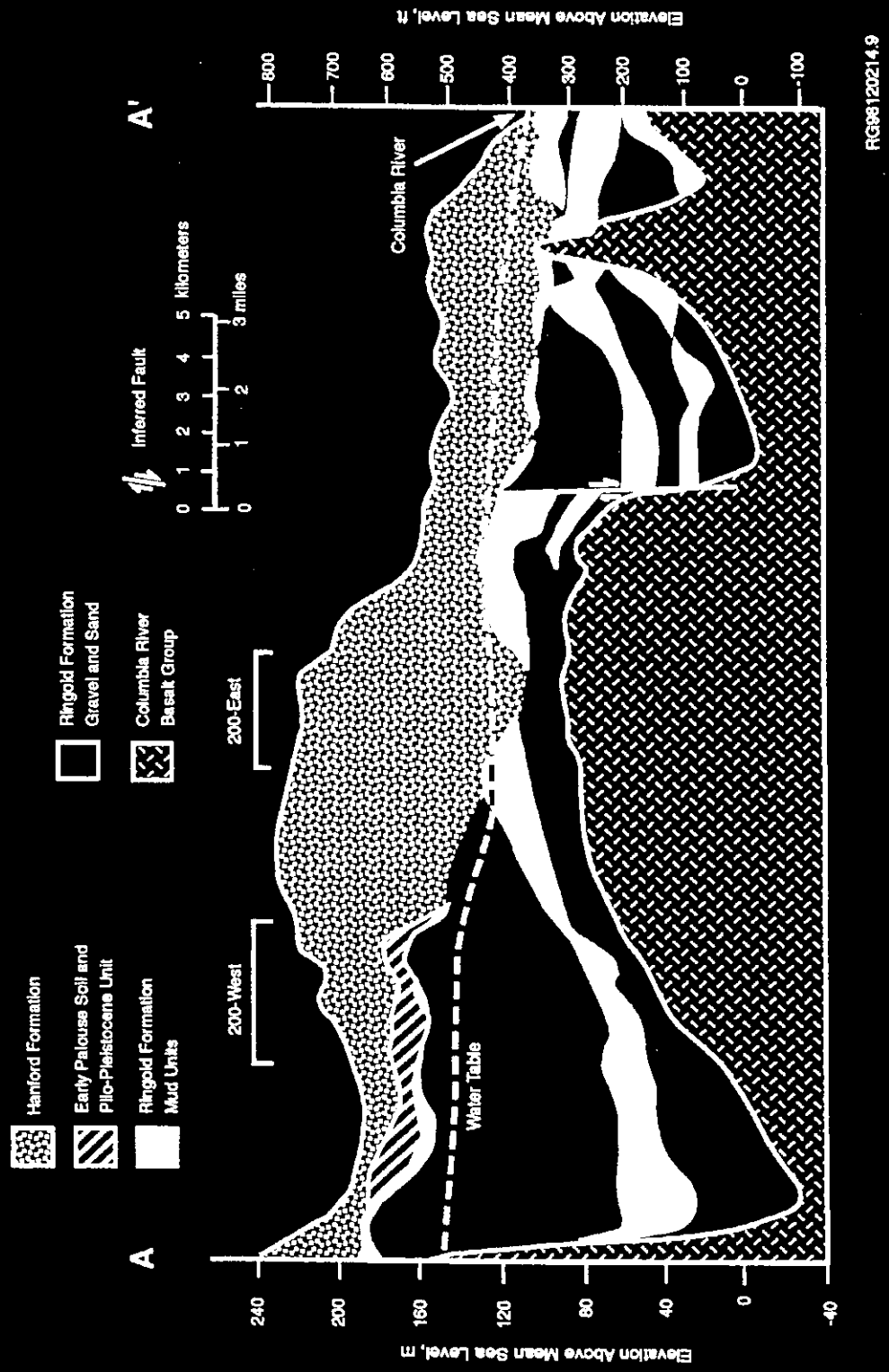


Figure 3-11. Geologic Units Present at the Water Table (from Barnett et al. 1999).

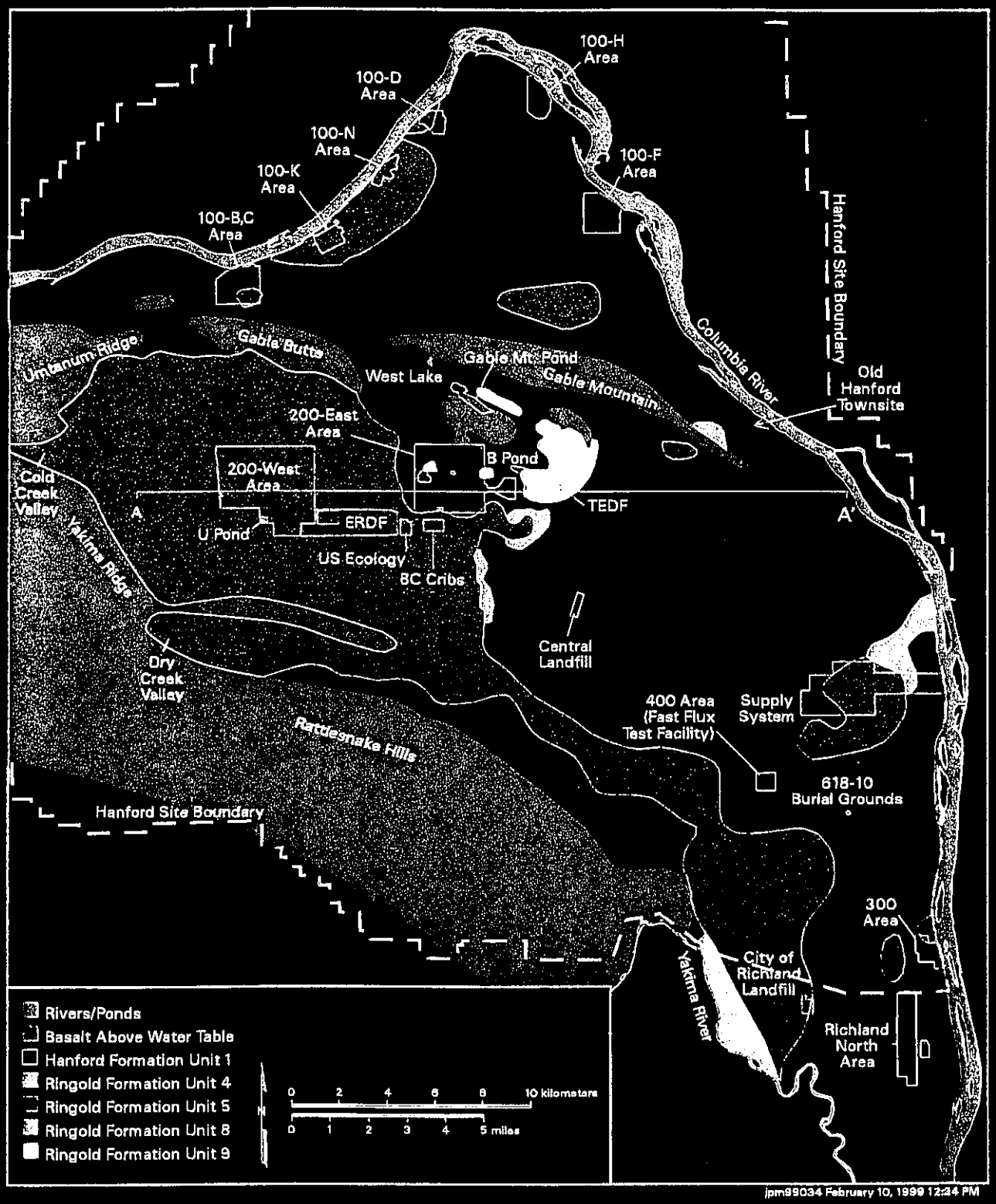


Figure 3-12. Estimated Recharge at the Hanford Site from Infiltration of Precipitation and Irrigation (from Fayer and Walters 1995).

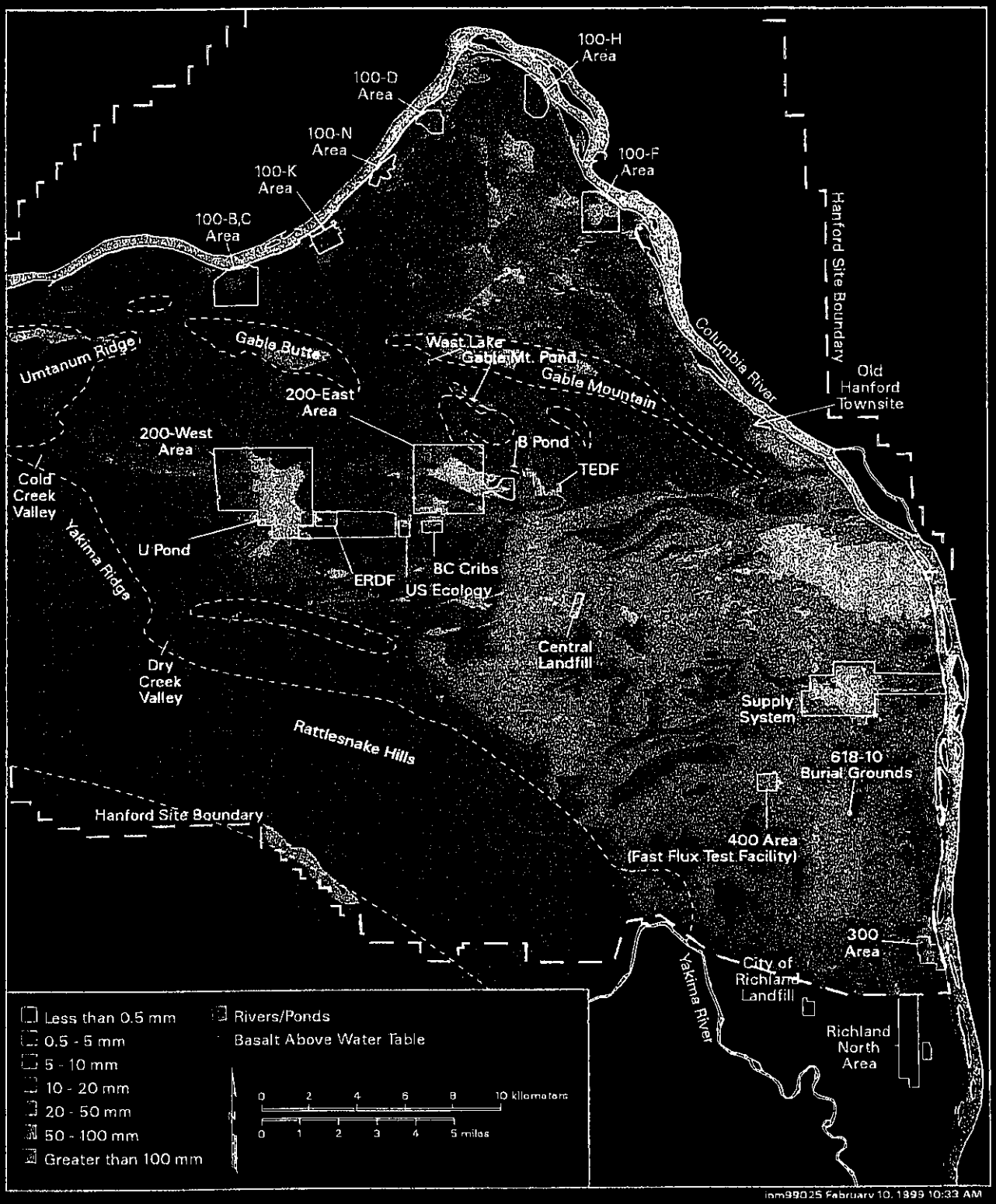
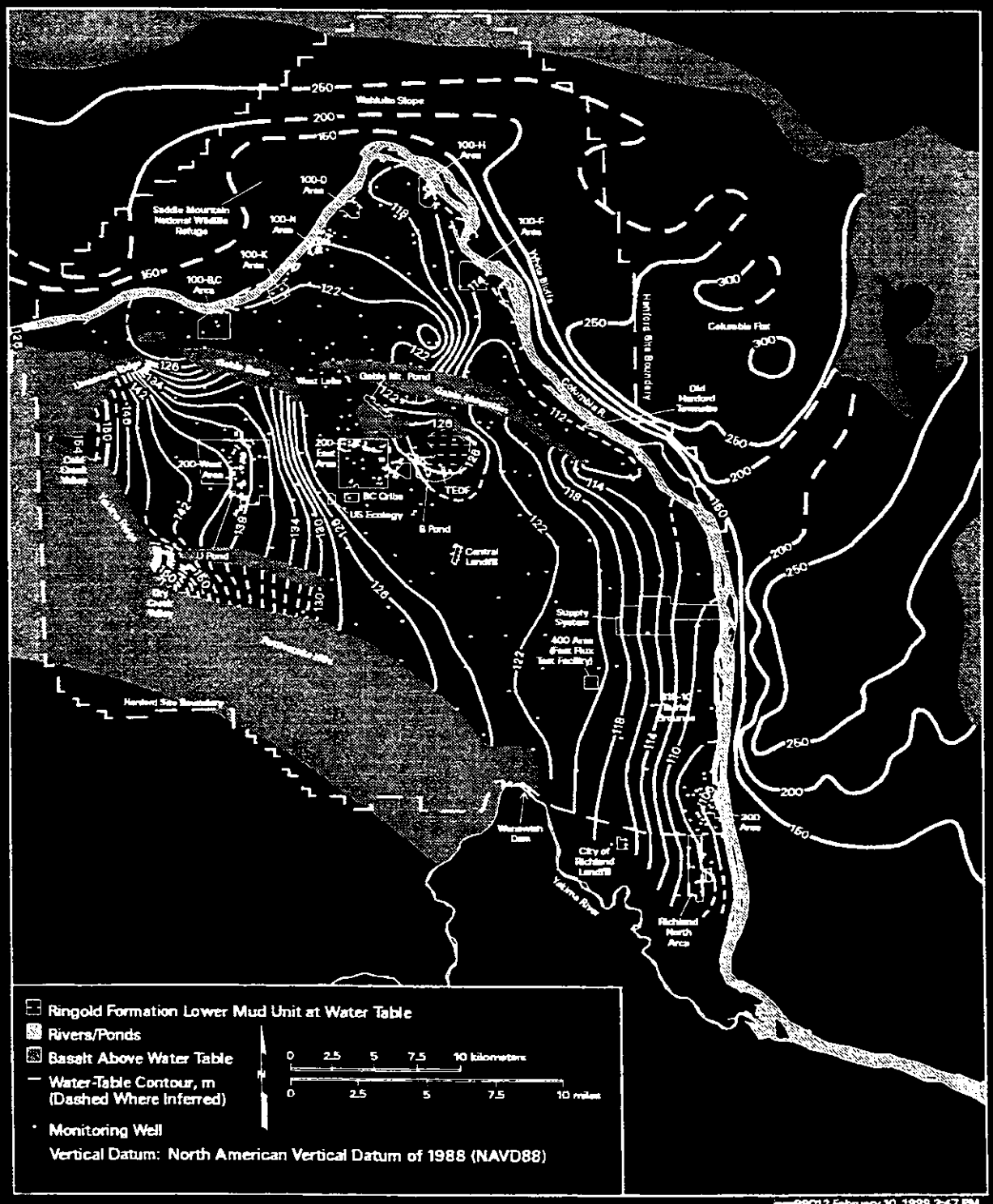
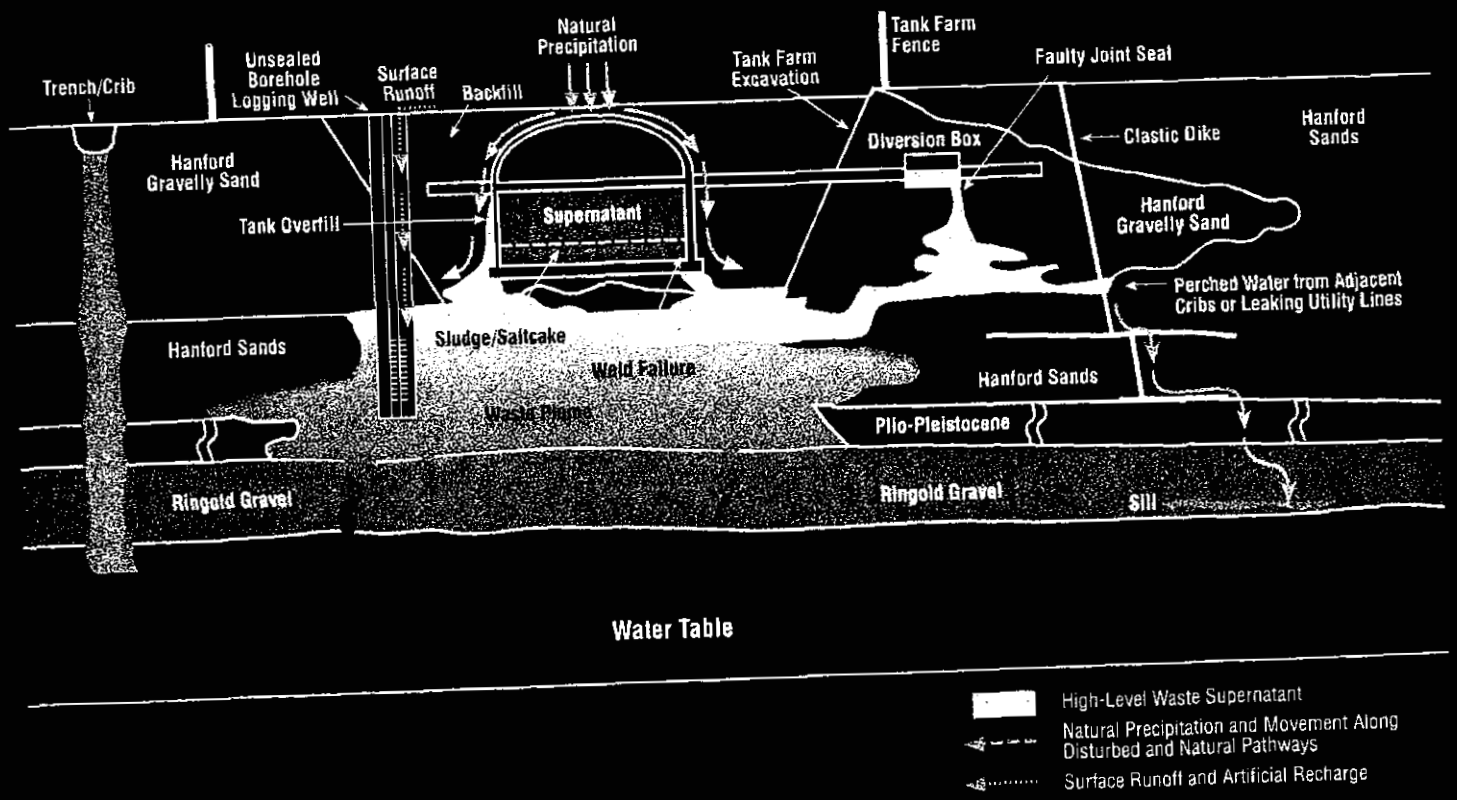


Figure 3-13. Water Table Map of the Hanford Site and 200 Areas (from Barnett et al. 1999).



1

Figure 3-14. Generalized Conceptual Model (modified from Jones et al. 1998).



The tank waste and leakage shown are from early operations in the 1960s. Subsequent hypothetical movement of contaminants through the vadose zone covers a period from early operations to the present. As a result of volume reduction measures, a much smaller volume of free liquid remains in the tank today. Depth to groundwater is 64 m (201 ft). The base of the tank is about 15 m (50 ft) below ground surface. The geologic strata shown are simplified for illustration purposes.

Table 3-1. Single-Shell Tanks, Associated Facilities and Adjacent Waste Sites (from Ecology et al. 1999). (2 pages)

WMA	Within WMA Boundary	Outside WMA Boundary
B-BX-BY	SSTs (40) 241-B-151 diversion box 241-B-152 diversion box 241-B-153 diversion box 241-B-252 diversion box 241-B-301B catch tank 241-BR-152 diversion box 241-BX-153 diversion box 241-BX-302A catch tank 241-BXR-151 diversion box 241-BXR-152 diversion box 241-BXR-153 diversion box 241-BYR-152 diversion box 241-BYR-153 diversion box 241-BYR-154 diversion box 242-B-151 diversion box 244-BXR receiving vault 2607-EB septic tank	242-B evaporator 216-B-7A crib[e] 216-B-7B crib[e] 216-B-8 crib[e] 216-B-8TF tile field[e] 216-B-11A reverse well[e] 216-B-11B reverse well[e] 216-B-35 trench[e] 216-B-36 trench[e] 216-B-37 trench[e] 216-B-38 trench[e] 216-B-39 trench[e] 216-B-40 trench[e] 216-B-41 trench[e] 216-B-41A trench 216-B-41B trench 216-B-41C trench 216-B-41D trench 216-B-42 trench[e] 216-B-43 crib[e] 216-B-44 crib[e] 216-B-45 crib[e] 216-B-46 crib[e] 216-B-47 crib[e] 216-B-48 crib[e] 216-B-49 crib[e] 216-B-50 crib[e] 216-B-51 french drain[e] 216-B-57 crib[be]
T	SSTs (16) T-7 crib[ec] T-32 crib[c] 241-T-151 diversion box 241-T-152 diversion box 241-T-153 diversion box 241-T-252 diversion box 241-T-301 catch tank 241-T-302 catch tank 241-TR-152 diversion box 241-TR-153 diversion box	216-T-5 trench 216-T-7-TF tile field[cde] 216-T-14 trench[e] 216-T-15 trench[e] 216-T-16 trench[e] 216-T-17 trench[e]

Table 3-1. Single-Shell Tanks, Associated Facilities and Adjacent Waste Sites (from Ecology et al. 1999). (2 pages)

WMA	Within WMA Boundary	Outside WMA Boundary
TX-TY	SSTs (24) 242-T-151 diversion box 241-TX-153 diversion box 241-TX-302A catch tank 241-TX-302-XB catch tank 241-TXR vault 241-TXR-152 diversion box 241-TXR-153 diversion box 241-TY-153 diversion box 241-TY-302A catch tank 241-TY-302B catch tank 244-TXR vault 2607-WT septic tank 2607-WTX septic tank	216-T-18 crib[e] 216-T-19 crib[be] 216-T-19 TF tile field[be] 216-T-21 trench[e] 216-T-22 trench[e] 216-T-23 trench[e] 216-T-24 trench[e] 216-T-25 trench[e] 216-T-26 crib[e] 242-T evaporator[b]
S-SX	SSTs (27) 241-S-152 diversion box 241-S-A valve pit 241-S-B valve pit 241-S-C valve pit 241-S-D valve pit 241-SX-151 diversion box 241-SX-152 diversion box 241-SX-302 catch tank[e]	216-S-3 crib[b] 216-S-4 french drain[be] 216-S-21 crib[be] 216-S-25 crib[be] 216-S-8 crib[e] 216-SX-2 crib[e] 241-S-151 diversion box 241-S-302B catch tank

[a] Not including unplanned release sites. For unplanned release sites, see Appendix B of the Tri-Party Agreement (Ecology et al. 1998).
[b] Unit handled condensate from evaporator operations or from self-boiling waste.
[c] Unit is partially inside WMA boundary.
[d] Unit is partially outside WMA boundary
[e] Environmental Restoration
SST = single-shell tank
WMA = waste management area

Table 3-2. Fuel Reprocessing Waste Intentionally Discharged to the Ground from Single-Shell Tanks.[a,b]

Waste	Years Discharged	Disposal Sites	Total Volume Discharged (L [gal])	Total Curies (Decayed to December 1989)
Second-cycle supernatant from B Plant and T Plant[c]	1948-1956	216-B-7A crib 216 B-7B crib 216 B-8 crib 216-T-5 trench 216-T-19 crib 216-T-32 crib	222,280,000 [58,725,000]	5,618
Cell drainage from B Plant and T Plant[c]	1951-1956			
Plutonium concentration and decontamination from 224-T and 224-B facilities[c]	1946-1956			
First-cycle supernatant waste from B Plant and T Plant	1953-1954	BX trenches (35, 36, 38-41) T trenches (14-17) TX trenches (21-24)	17,835, 000 [4,711,000]	11,665
Evaporator bottoms from 242-T and 242-B evaporators	1954	216-B-37 trench 216-T-25 trench	7,320,000 [1,934,000]	10,155
Scavenged first-cycle supernatant liquid from T Plant	1955-1956	216-T-26 crib	12,000,000 [3,170,000]	717
Total			259,435,000 [68,540,000]	28,155[d]

[a] Numbers reflect traceable data in the database. The numbers reflect greater accuracy than warranted by the number of figures shown. Two or three significant figures would better reflect data accuracy.
[b] Information in this table was from *Tank Wastes Discharged Directly to the Soil at the Hanford Site*, WHC-MR-0227 (WHC 1991d).
[c] Volume and radionuclide content have been combined because waste was sent to common disposal sites.
[d] Inventory does not include tritium, Tc-99, or I-129.

Table 3-3. Uranium Recovery Tank Waste Intentionally Discharged to the Ground.[a,b]

Disposal Site	Years Discharged	Total Volume Discharged (L [gal])	Total Curies (Decayed to December 1989)
216-T-18 (test run)	1953	1,000,000 [264,000]	223
BY cribs (7 cribs)	1954-1955	33,840,000 [8,940,000]	14,270
216-B-42 (BX trench)	1955	1,500,000 [396,000]	1,010
100-B/C cribs (6 cribs)	1956-1957	38,960,000 [10,293,000]	3,246
100-B/C trenches (15 trenches)	1956-1958	79,690,000 [21,053,000]	11,587
Total		154,990,000 [40,946,000]	30,336[c]

[a] Numbers reflect traceable data in the database. The numbers reflect greater accuracy than warranted by the number of figures shown. Two or three significant figures would better reflect data accuracy.
[b] Information in this table was from *Tank Wastes Discharged Directly to the Soil at the Hanford Site*, WHC-MR-0227 (WHC 1991d).
[c] Inventory does not include tritium, Tc-99, or I-129.

Table 3-4. Potential Radionuclides of Concern in the 200 Areas. (2 pages)

Actinium-225	Iron-55	Selenium-75
Actinium-227	Iron-59	Selenium-79
Aluminum-28	Krypton-85	Silver-108
Americium-241	Lead-209	Silver-110m
Americium-242	Lead-210	Sodium-22
Americium-242m	Lead-211	Strontium-85
Americium-243	Lead-212	Strontium-90
Antimony-122	Lead-214	Sulfur-35
Antimony-124	Manganese-54	Tantalum-182
Antimony-125	Molybdenum-93	Technetium-99
Antimony-126	Neptunium-237	Tellurium-121
Antimony-126m	Neptunium-239	Tellurium-125m
Astitine-217	Nickel-59	Tellurium-127
Barium-133	Nickel-63	Tellurium-129m
Barium-135m	Niobium-91	Thallium-204
Barium-137m	Niobium-93m	Thallium-207
Beryllium-7	Niobium-95	Thallium-209
Beryllium-10	Niobium-94	Thallium-208
Bismuth-210	Palladium-107	Thorium-227
Bismuth-211	Phosphorus-32	Thorium-228
Bismuth-212	Plutonium-238	Thorium-229
Bismuth-213	Plutonium-239	Thorium-230
Bismuth-214	Plutonium-240	Thorium-231
Cadmium-109	Plutonium-241	Thorium-232
Carbon-14	Plutonium-242	Thorium-233
Cerium-141	Polonium-210	Thorium-234
Cerium-144	Polonium-211	Thulium-170
Cesium-134	Polonium-212	Tin-113
Cesium-135	Polonium-213	Tin-123m
Cesium-137	Polonium-214	Tin-126
Chlorine-36	Polonium-215	Uranium-233
Chromium-51	Polonium-216	Uranium-234
Cobalt-57	Polonium-218	Uranium-235
Cobalt-58	Potassium-40	Uranium-236
Cobalt-60	Praseodymium-144	Uranium-237

Table 3-4. Potential Radionuclides of Concern in the 200 Areas. (2 pages)

Curium-242	Promethium-143	Uranium-238
Curium-243	Promethium-147	Vanadium-49
Curium-244	Protactinium-231	Yttrium-88
Curium-245	Protactinium-233	Yttrium-90
Einsteinium-254	Protactinium-234	Zinc-65
Europium-152	Radium-223	Zirconium-93
Europium-154	Radium-225	Zirconium-95
Europium-155	Radium-226	
Francium-221	Radium-228	
Francium-223	Radon-219	
Gadolinium-152	Radon-220	
Gadolinium-153	Radon-222	
Germanium-68	Rhenium-187	
Gold-195	Rhodium-106	
Iodine-123	Ruthenium-103	
Iodine-125	Ruthenium-106	
Iodine-129	Samarium-147	
Iodine-131	Samarium-151	
	Scandium-46	

Table 3-5. Master List of Organics and Inorganics for the RCRA Corrective Action Program. (2 pages)

CAS #	Constituent	CAS #	Constituent	CAS #	Constituent
ORGANICS					
50-32-8	Benzo(a)pyrene	79-01-6	1,1,2-trichloroethylene	110-82-7	Cyclohexane
53-70-3	Dibenz[a,h]anthracene	79-10-7	2-propenoic acid	110-83-8	Cyclohexene
56-23-5	Carbon tetrachloride	79-34-5	1,1,2,2-tetrachloroethane	110-86-1	Pyridine
57-14-7	1,1-dimethylhydrazine	82-68-8	Pentachloronitrobenzene (PCNB)	111-65-9	n-Octane
58-89-9	gamma-BHC (Lindane)	87-68-3	Hexachlorobutadiene	111-84-2	n-Nonane
60-34-4	Methylhydrazine	87-86-5	Pentachlorophenol	118-74-1	Hexachlorobenzene
60-57-1	Dieldrin	88-85-7	2-sec-butyl-4,6-dinitrophenol (dinoseb)	120-82-1	1,2,4-trichlorobenzene
62-75-9	N-nitroso-N,N-dimethylamine	88-89-1	Picric acid	121-44-8	Triethylamine
64-17-5	Ethyl alcohol	92-52-4	1,1-biphenyl	122-39-4	N,N-diphenylamine
64-18-6	Formic acid	95-47-6	o-Xylene	123-19-3	4-heptanone
64-19-7	Acetic acid	95-50-1	1,2-dichlorobenzene	123-38-6	n-Propionaldehyde
67-56-1	Methyl alcohol (methanol)	96-22-0	3-pentanone	123-86-4	Acetic acid n-butyl-ester
67-63-0	2-propyl alcohol (isopropanol; propan-2-01)	98-86-2	Acetophenone	123-91-1	1,4-dioxane
67-64-1	2-Propanone (Acetone)	98-95-3	Nitrobenzene	126-73-8	Tributyl phosphate
67-66-3	Chloroform	100-00-5	p-Nitrochlorobenzene	126-98-7	2-methyl-2-propenenitrile
71-23-8	n-Propyl alcohol (1-propanol)	100-25-4	1,4-dinitrobenzene	127-18-4	1,1,2,2-tetrachloroethene
71-36-3	n-Butyl alcohol	100-41-4	Ethyl benzene	128-37-0	2,6-bis(tert-butyl)-4-methylphenol
71-43-2	Benzene	100-42-5	Styrene	141-78-6	Acetic acid ethyl ester
71-55-6	1,1,1-trichloroethane	106-35-4	3-heptanone	142-82-5	n-Heptane
72-20-8	Endrin	106-42-3	p-Xylene	144-62-7	Oxalic acid
74-83-9	Bromomethane	106-46-7	1,4-dichlorobenzene	287-92-3	Cyclopentane
74-87-3	Chloromethane	106-93-4	Ethylene dibromide	309-00-2	Aldrin
75-65-0	2-methyl-2-propanol	106-97-8	Butane	319-84-6	Alpha-BHC
75-69-4	Trichlorofluoromethane	106-99-0	1,3-butadiene	319-85-7	Beta-BHC
75-71-8	Dichlorodifluoromethane	107-02-8	Acrolein	465-73-6	Isodrin
75-00-3	Chloroethane	107-05-1	3-chloropropene	541-73-1	1,3-dichlorobenzene
75-01-4	1-chloroethene	107-06-2	1,2-dichloroethane	563-80-4	3-methyl-2-butanone
75-05-8	Acetonitrile	107-12-0	Propionitrile	591-78-6	2-hexanone
75-09-2	Dichloromethane (methylene chloride)	107-13-1	Acrylonitrile	624-83-9	Methyl isocyanate
75-15-0	Carbon disulfide	107-87-9	2-pentanone	627-13-4	Nitric acid, Propyl ester
75-21-8	Oxirane	108-10-1	4-methyl-2-pentanone	684-16-2	Hexafluoroacetone
75-34-3	1,1-dichloroethane	108-38-3	m-Xylene	1321-64-8	Pentachloronaphthalene
75-35-4	1,1-dichloroethene	108-87-2	Methylcyclohexane	1335-87-1	Hexachloronaphthalene
75-43-4	Dichlorofluoromethane	108-88-3	Toluene	1335-88-2	Tetrachloronaphthalene
75-45-6	Chlorodifluoromethane	108-90-7	Chlorobenzene	1336-36-3	Polychlorinated biphenyls (PCBs)
76-13-1	1,2,2-trichloro-1,1,2-trifluoroethane	108-94-1	Cyclohexanone	2234-13-1	Octachloronaphthalene
76-14-2	1,2-dichloro-1,1,2,2-tetrafluoroethane	108-95-2	Phenol	3825-26-1	Ammonium perfluorooctanoate
76-44-8	Heptachlor	109-66-0	n-Pentane	4170-30-3	2-butenaldehyde (2-butenal)

Table 3-5. Master List of Organics and Inorganics for the RCRA Corrective Action Program. (2 pages)

CAS #	Constituent	CAS #	Constituent	CAS #	Constituent
78-87-5	1,2-dichloropropane	109-99-9	Tetrahydrofuran	8001-35-2	Toxaphene
78-92-2	1-methylpropyl alcohol (2-butanol)	110-12-3	5-methyl-2-hexanone	10061-01-5	cis-1,3-dichloropropene
78-93-3	2-butanone	110-43-0	2-heptanone	10061-02-6	Trans-1,3-dichloropropene
79-00-5	1,1,2-trichloroethane	110-54-3	n-Hexane		
INORGANICS					
57-12-5	Cyanide	7440-31-5	Tin	7440-69-9	Bismuth
1333-86-4	Carbon	7440-32-6	Titanium	7440-70-2	Calcium
7429-90-5	Aluminum	7440-33-7	Tungsten	7440-74-6	Indium
7439-89-6	Iron	7440-36-0	Antimony	7553-56-2	Iodine
7439-92-1	Lead	7440-38-2	Arsenic	7664-41-7	Ammonia/ammonium
7439-93-2	Lithium	7440-39-3	Barium	7723-14-0	Phosphorus
7439-95-4	Magnesium	7440-41-7	Beryllium	7727-37-9	Nitrogen
7439-96-5	Manganese	7440-42-8	Boron	7782-49-2	Selenium
7439-97-6	Mercury	7440-43-9	Cadmium	13494-80-9	Tellurium
7439-98-7	Molybdenum	7440-46-2	Cesium	14265-44-2	Phosphate
7440-02-0	Nickel	7440-47-3 & 18540-29-9	Chromium (total and VI)	14265-45-3	Sulfite
7440-04-2	Osmium	7440-48-4	Cobalt	14280-30-9	Hydroxide
7440-06-4	Platinum	7440-50-8	Copper	14797-55-8	Nitrate
7440-09-7	Potassium	7440-56-4	Germanium	14797-65-0	Nitrite
7440-16-6	Rhodium	7440-58-6	Hafnium	14808-79-8	Sulfate
7440-21-3	Silicon	7440-61-1	Uranium	16887-00-6	Chloride
7440-22-4	Silver	7440-62-2	Vanadium	16984-48-8	Fluoride
7440-23-5	Sodium	7440-65-5	Yttrium	18496-25-8	Sulfides
7440-25-7	Tantalum	7440-66-6	Zinc	24959-67-9	Bromide
7440-28-0	Thallium	7440-67-7	Zirconium	3812-32-6	Carbonate(axb)

Table 3-6. Average Monthly Temperatures by Season (compiled from Hoitink and Burk 1998).

	Winter		Spring		Summer		Autumn	
Months	Dec. – Feb.		Mar. – May		June – Aug.		Sept. – Nov.	
Maximum	45°F	Feb. 1958	69°F	May 1947	82°F	July 1985	72°F	Sep. 1990
	7°C		20°C		28°C		22°C	
Minimum	12°F	Jan. 1950	39°F	Mar. 1955	63°F	June 1953	25°F	Nov. 1985
	-11°C		4°C		17°C		-2°C	

Table 3-7. Monthly Average Precipitation by Season (compiled from Hoitink and Burk 1998).

Season	**Winter**		**Spring**		**Summer**		**Autumn**	
	Dec. – Feb.		Mar. – May		Jun. – Aug.		Sep. – Nov.	
Maximum	3.7 in.	Dec. 1996	2.0 in.	May 1972	2.9 in.	Jun. 1950	2.7 in.	Oct. 1957
	9.4 cm		5.2 cm		7.4 cm		6.9 cm	

Table 3-8. Statistical Characteristics of the Sitewide Background Data for Nonradioactive Analytes (from DOE-RL 1995b). (2 pages)

Analyte	**Systematic Random Samples, Concentration (mg/kg)**		**Overall Maximum Concentration of All Samples (mg/kg)**	**90th Percentile of the Lognormal Distribution**
	Minimum	**Maximum**		
Aluminum	3,940	18,100	28,800	11,800
Antimony	15.7	15.7	31	--
Arsenic	3	11.4	27.7	6.47
Barium	45.2	221	480	132
Beryllium	0.6	2.1	10	1.51
Cadmium	0.66	0.66	11	--
Calcium	3,820	86,600	105,000	17,200
Chromium	2.9	30.6	320	18.5
Cobalt	5.7	16.9	110	15.7
Copper	8.1	36.1	61	22
Iron	13,200	35,100	68,100	32,600
Lead	1.1	26.6	74.1	10.2
Lithium	34	38.2	38.2	33.5
Magnesium	2,900	10,100	32,300	7,060
Manganese	196	704	1,110	512
Mercury	0.16	3.8	3.8	0.33

Table 3-8. Statistical Characteristics of the Sitewide Background Data for Nonradioactive Analytes (from DOE-RL 1995b). (2 pages)

Analyte	Systematic Random Samples, Concentration (mg/kg)		Overall Maximum Concentration of All Samples (mg/kg)	90th Percentile of the Lognormal Distribution
	Minimum	Maximum		
Molybdenum	2	2	6	--
Nickel	7.2	28.2	200	19.1
Potassium	851	3,280	7,900	2,150
Selenium	5	6	6	--
Silicon	5.2	583	1,203	44
Silver	1.4	14.6	14.6	0.73
Sodium	101	5620	6,060	690
Thallium	3.7	3.7	3.7	--
Titanium	524	2940	3,180	2,570
Vanadium	24.3	97.9	140	85.1
Zinc	30.9	119	366	67.8
Zirconium	11	84.8	84.8	39.8
Alkalinity	31	37,600	150,000	7,710
Ammonia	0.6	26.4	26.4	9.23
Chloride	1	1,480	1,480	100
Fluoride	1	73.3	73.3	2.81
Nitrate	0.6	538	906	52
Nitrite	21	21	36.5	--
O-Phosphate	2	225	225	0.785
Sulfate	1	4,340	12,600	237

Table 3-9. Selected Values for the Sitewide Background Radionuclide Data Set (pCi/g) (from DOE-RL 1996a).

Analyte	Minimum	Maximum	Arithmetic Mean	Standard Deviation	90th Percentile[c]
K-40	9.29	19.7	13.1	2.71	16.6
Co-60[a]	-0.0111	0.0387	0.00132	0.00591	0.00842
Sr-90	0.00661	0.366	0.0806	0.0688	0.178
Cs-137	-0.00156	1.64	0.417	0.338	1.05
Eu-154[a]	-0.0732	0.0790	0.000826	0.0250	0.0334
Eu-155[a]	-0.0187	0.0984	0.0234	0.0184	0.0539
Ra-226	0.298	1.16	0.561	0.202	0.815
Th-232	0.468	1.58	0.945	0.260	1.32
U-234	0.399	1.51	0.793	0.233	1.10
U-235[b]	0.00462	0.386	0.0515	0.0373	0.109
U-238	0.354	1.21	0.763	0.216	1.06
Pu-238[a]	-0.000489	0.0193	0.00158	0.00332	0.00378
Pu-239/240	-0.0050	0.0331	0.00935	0.00782	0.0248
Gross beta	13.6	25	19.78	2.40	22.96

[a] Majority of the data are below detection; included here for completeness.

[b] U-235 statistics were computed using 47 samples: 17 above and 30 below detection limits. Two data were suspended owing to negative values.

[c] Percentiles are based on the lognormal distribution.

Negative radionuclide results = Radioactive results are measured as decay counts (e.g., counts per/minutes). An average background count subtraction is applied, which may be more than the specific sample count, therefore a negative result is possible.

Table 3-10. Root Penetration and Burrowing Depths of Selected 200 Area Wildlife and Plant Species (from DOE-RL 1995a).

Species	Root Penetration or Burrowing Depth		
	Average Maximum Depth (meters)	Maximum Depth (meters)	Reference
PLANTS			
Cheatgrass	0.7	1.2	Foxx et al. 1984
Gray rabbitbrush	1.83	2.5	Klepper et al. 1985
Green rabbitbrush	1.53	1.6	Klepper et al. 1985
Tumblemustard (Jim Hill mustard)	1.0	2.0	Estimated (DOE-RL 1995a)
Big sagebrush	2.0	2.5	Klepper et al. 1985 (at Hanford)
Antelope bitterbrush	2.96	3.0	Klepper et al. 1985
Russian thistle	1.72	3.0	Klepper et al. 1985
Sandberg's bluegrass	--	0.35	Link et al. 1990
Needle and thread grass	1.39	1.6 1.83	Klepper et al. 1985; Schaffer et al. 1979
ANIMALS			
Deer mice	0.4	--	Estimated (DOE-RL 1995a)
Great Basin pocket mouse	0.9	2.0	O'Farrell et al. 1975; McKenzie et al. 1982
Northern pocket gopher	0.3	2	OSU 1998; UC 1998
Badger	2.5	--	McKenzie et al. 1982
Harvester ant colony	2.3	2.7	Rogers et al. 1988

4.0 RISK ASSESSMENT AND PRELIMINARY IDENTIFICATION OF POTENTIAL CORRECTIVE MEASURE, RETRIEVAL, AND CLOSURE TECHNOLOGIES

The essential components of the RCAP include identifying actual and potential risks to human health and the environment from WMA contaminants and identifying appropriate IMs and ICMs to mitigate these risks. Together, these provide the basis for WMA characterization activities. As input to the WMA DQO processes, this section presents preliminary information for risk assessments (Section 4.1) and the early identification of potential ICM technologies (Section 4.2). This section also briefly discusses potential technologies for the retrieval and SST closure (Section 4.3) activities.

4.1 RISK ASSESSMENT

Risk assessments include several key components that help focus the evaluation (e.g., land use, exposure models, and risk scenarios), establish the basis for IMs and ICMs to minimize or mitigate risk (corrective measure performance standards), and establish numerical target cleanup goals (media cleanup standards). These components, plus a discussion of how risk assessment would be applied at the WMAs, are presented in the following sections.

4.1.1 Anticipated Land Use

An examination of anticipated land uses is valuable for developing conceptual exposure models and associated exposure scenarios. Exposure models and scenarios help identify characterization needs and support IM and ICM decisions. Although various exposure scenarios can be postulated, NEPA-compliant long-term land uses (including groundwater use) for the 200 Areas have not been determined at this time. However, efforts to develop future land-use plans have identified potential land uses and boundaries.

In the early 1990s, the DOE commissioned the Hanford Future Site Uses Working Group (FSUWG) to evaluate future land-use options and to scope the HRA-EIS effort. For the foreseeable future, the group identified a single cleanup scenario for the Central Plateau, the central portion of the Hanford Site that includes the 200 East and 200 West Areas (FSUWG 1992). The scenario assumes that future uses of the surface, subsurface, and groundwater in and immediately surrounding the 200 East and 200 West Areas would be exclusively for DOE waste management uses (i.e., only waste management activities). The scenario also assumes that surrounding this "exclusive zone" would be a temporary exclusive "buffer zone" composed of the rest of the Central Plateau. Uses in the buffer zone would be limited to ER activities. The boundaries of the exclusive zone and buffer zone are illustrated in Figure 4-1. Under the FSUWG scenario, waste and contaminants within the 200 Areas would be treated and managed to prevent migration from the 200 Areas to other areas. The FSUWG also expressed the desire that the overall cleanup criteria for the Central Plateau should enable general usage of the land and groundwater for other than waste management activities in the horizon of 100 years after the decommissioning of waste management facilities and closure of waste disposal areas.

More recently, future Hanford Site land-use alternatives were developed through a cooperative effort between the DOE and the Natural Resource Damage Assessment stakeholders (i.e., the Confederated Tribes of the Umatilla Indian Reservation; the Nez Perce Tribe Department of Environmental Restoration and Waste Management; the U.S. Department of Interior; the Washington Department of Fish and Wildlife; the City of Richland; and Benton, Franklin, and Grant Counties). The alternatives are discussed in the Revised Draft HRA-EIS (DOE 1999b). All of the HRA-EIS land-use alternatives generally propose that land use for the next 50 years within the 200 Areas boundary would be restricted to industrial (exclusive) use and that land use surrounding the 200 Areas boundary would be designated for conservation and preservation uses (Figure 4-2). An industrial (exclusive) land use is defined in the Revised Draft HRA-EIS as an area suitable and desirable for treatment, storage, and disposal of wastes. Preservation is defined as an area managed for the preservation of archeological, cultural, ecological, and natural resources, with no consumptive uses. Conservation is defined as an area reserved for the management and protection of archeological, cultural, ecological, and natural resources; limited and managed mining and grazing could occur as a conditional use (e.g., a permit would be required) within appropriate areas (DOE 1999b). No groundwater consumption would occur in the 200 Areas or surrounding areas under the industrial (exclusive) use, or under the preservation or conservation uses. The land use decisions for the Hanford Site are expected to be made in the fall of 1999 in the Record of Decision for the HRA-EIS.

All the SST WMAs are located within the exclusive zone as defined by the FSUWG and the industrial (exclusive) land-use boundary proposed in the Revised Draft HRA-EIS. However, some SST-related contaminant plumes may extend outside the industrial (exclusive) land-use boundary.

As described in Section 2.0, final RCRA corrective actions must comply with Federal and State of Washington ARARs. Of particular importance are MTCA and the AEA. The MTCA is the Washington State cleanup law for hazardous waste constituents, which requires that cleanup levels be based on reasonable maximum exposures under both current and potential site use conditions (WAC 173-340-708[3][a]). Regulations implementing MTCA (WAC 173-340) define exposure scenarios and input parameters for two types of site uses: industrial (MTCA Method C) and unrestricted (MTCA Method B). The latter essentially assumes residential use. Scenarios such as "waste management," "industrial (exclusive)," and "conservation and preservation" are not defined, although there are provisions to develop alternate exposure scenarios (WAC 173-340-708[3][c]). Both the Method B and Method C exposure scenarios include potential consumption of groundwater[1] and both methods require protection of nearby surface water. The exposure scenario under MTCA Method B has been used in the 100 Areas of the Hanford Site to represent an unrestricted land use. The exposure scenario under MTCA Method C, developed for industrial use, is similar to a waste management or industrial (exclusive) scenario, with the notable exception that it includes groundwater consumption.

[1] The MTCA groundwater cleanup levels are based on the highest beneficial use under both current and potential future site use conditions. It is assumed that ingestion represents the highest beneficial use unless (1) the groundwater is not a current source of drinking water and (2) it is not a potential future source of drinking water because of insufficient yield, naturally-occurring contaminants that make consumption impracticable, or a groundwater depth or location that makes recovery technically impossible.

The AEA is the primary ARAR for radioactive constituents. DOE orders implementing the AEA require that HLW facilities such as the SSTs be closed such that any residual radioactive waste can be determined to be incidental waste. The facility must then be closed as a LLW facility. The DOE orders do not define exposure scenarios, but do establish public dose limits.

4.1.2 Preliminary Conceptual Exposure Model And Risk Scenarios

A conceptual exposure model based on risk assessment guidance (EPA 1989) provides a graphical summary of the physical characteristics and mechanisms that could potentially affect the generation of contamination, its transport, and its impact on various media (e.g., soil, air, and water) and receptors (i.e., humans and biota). It identifies potential exposure pathways including the sources of contamination, mechanisms of contaminant release (if applicable), transport media (if applicable), potentially affected media, exposure routes, and potential receptors. A conceptual exposure model summarizes information from physical contaminant distribution models, which generally provide additional details regarding specific contaminants and contaminant fate and transport mechanisms (see Section 3.4). Initially, a conceptual exposure model represents the *a priori* understanding of a site and serves as a basis for determining characterization needs. The potential exposures identified in a conceptual exposure model serve as inputs for a quantitative or qualitative site risk assessment. Characterization data are used to refine or verify the conceptual exposure model before RFI risk assessments are conducted or cleanup decisions are made. Figure 4-3 illustrates the current conceptual exposure model for the SST WMAs.

It is important to note that this master work plan does not attempt to quantify potential human health or environmental risks associated with current or potential future exposure to SST WMA contaminants. Current and future risks would be evaluated, as necessary, using concepts presented in this report after WMA-specific characterization data have been collected and reported.

In the absence of NEPA-compliant long-term land-use decisions and for purposes of the RCAP, risks associated with releases from the SSTs would be evaluated using established MTCA exposure parameters (e.g., multiple exposure scenarios for a 1,000-year time period), the land-use boundaries suggested by the FSUWG and the preferred alternative from the Revised Draft HRA-EIS. For groundwater protection, two exposure scenarios (MTCA Methods B and C) and four hypothetical receptor locations (see Figure 4-4) were identified for evaluation in a DOE/Ecology RFI/CMS planning workshop (see Section 5.1.1) as follows:

- Receptor 1: Downgradient boundary of WMA; MTCA Method B and MTCA Method C scenarios

- Receptor 2: Downgradient boundary of 200 Areas exclusive zone as defined by FSUWG; MTCA Method B and Method C scenarios

- Receptor 3: Downgradient boundary of 200 Areas buffer zone as defined by the FSUWG; MTCA Method B and Method C scenarios

- Receptor 4: Downgradient at Columbia River shoreline; MTCA Method B scenario.

For direct exposure to soil contamination associated with the SSTs, only the MTCA Method C (industrial) scenario would be evaluated. For protection of surface water (the Columbia River), the MTCA Method B scenario would be evaluated.

4.1.3 Preliminary Corrective Measure Performance Standards

Corrective measure performance standards are general descriptions of what a corrective measure is expected to accomplish (i.e., media-specific or site-specific goals for protecting human health and the environment). They provide a basis to evaluate the ability of a specific corrective measure alternative to achieve compliance with ARARs, or an acceptable level-of-risk protection for human health and/or the environment. Corrective measure performance standards are generally defined as specifically as possible and usually include the following components:

- Medium of concern
- Types of contaminants
- Potential exposure pathways
- Potential receptors
- Concentrations of residual contamination that may remain following remediation (e.g., concentrations below media cleanup standards).

The corrective measure performance standards identified in this master work plan are preliminary and are applicable for all the WMAs. These standards are intended as a guide for developing WMA-specific corrective measure performance standards in future WMA addenda. The preliminary corrective measure performance standards for the cleanup of the SST WMAs are as follows:

- Minimize or mitigate risks to human and ecological receptors associated with ingestion of, dermal contact with, inhalation of, and external exposure to contaminants at levels that exceed risk-based ARARs (e.g., MTCA, MCLs, and ambient water quality criteria [AWQC])

- Prevent or mitigate contaminant migration to groundwater such that no further groundwater degradation occurs

- Prevent or mitigate contaminant migration to the Columbia River at levels that exceed risk-based ARARs (e.g., MTCA and AWQC)

- Prevent or mitigate risks to workers performing corrective measures

- Provide conditions suitable for proposed closure activities and future land uses
- Prevent the destruction of significant cultural resources and sensitive wildlife habitat

- Minimize the disruption of cultural resources and wildlife habitat, and prevent adverse impacts to cultural resources and threatened or endangered species.

4.1.4 Preliminary Media Cleanup Standards

Preliminary media cleanup standards are numeric representations of the corrective measure performance standards. Using anticipated future land-use scenarios, the conceptual exposure model, and the corrective measure performance standards as a basis, preliminary media cleanup standards are identified for applicable contaminants and exposure pathways. Preliminary media cleanup standards are used to define unacceptable risks posed by specific contaminants (WMA-specific or cumulative risks from multiple WMAs), to identify the contaminants that are the most likely risk drivers (i.e., contaminants of concern), and to provide target goals for use during implementation of ICMs. They are based on acceptable levels of human health and ecological risk, ARARs, TBC guidance, points of compliance, and remediation timeframes. Contaminant-specific, numeric media cleanup standards are not presented in this document. Instead, potentially applicable standards are outlined. These potentially applicable standards (and an examination of how evaluation against these standards would be established) should be defined for individual contaminants in the WMA addenda.

The corrective measure performance standard guidelines designed to protect human and ecological receptors from direct exposure to soil containing SST contaminants could be achieved by meeting the following risk-based ARAR and TBC:

- A radionuclide soil cleanup standard of ≤15 mrem/yr above background (EPA 1997)

- The State of Washington MTCA standards for nonradioactive contaminants.

The corrective measure performance standards designed to ensure no further degradation of groundwater and protection of the Columbia River could be achieved by meeting the following ARARs:

- The MCLs promulgated under the *Safe Drinking Water Act of 1974,* the State of Washington's drinking water standards, or ACLs established where groundwater restoration is shown to be impracticable

- The State of Washington MTCA standards for nonradioactive contaminants

- The AWQC developed under the *Clean Water Act of 1977* or the State of Washington surface water quality standards.

The above guidelines are based on current ARARs and TBCs (see Appendix F). In subsequent WMA addenda, the guidelines would be reviewed to ensure that they reflect ARARs that are current when the addenda are written.

The numerical media cleanup standards for corrective action will depend on the points of compliance and exposure scenarios under which each of these ARARs and TBCs are applied. In the absence of land use determinations, neither points of compliance, nor exposure scenarios have been established for the 200 Areas. However, eight sets of hypothetical media cleanup standards can be calculated based on the hypothetical receptor locations and exposure scenarios identified in Section 4.1.2. The most conservative combination of receptor location and exposure scenario (e.g., the combination that would result in the lowest cleanup levels) would likely be a residential user at the WMA boundary. Therefore, hypothetical media cleanup standards based on a residential user at the WMA boundary should be used for identifying data quality needs during the WMA-specific DQOs.

Ultimately, points of compliance and exposure scenarios will need to be specified before the CMS can be completed. Future characterization data may be used to help define appropriate points of compliance and exposure scenarios. For example, the ≤15 mrem/yr above background guideline, which has been applied in other areas of the Hanford Site, may not be practicable or achievable within the confines of the 200 Areas land-use boundary (the DOE's industrial [exclusive] preferred land-use option). A point of compliance at or outside the 200 Area boundary may need to be specified. As WMA-specific data become available, the points of compliance and exposure scenarios would be reevaluated and would ultimately be approved by Ecology via a permit modification (for ICM implementation).

4.1.5 Risk Assessment Application

Risk evaluations should be used to establish baseline human health and environmental concerns related to WMA-specific contaminants and conditions. Risk evaluations could also be used to support corrective measure decisions and future SST waste retrieval and closure decisions. Integrating WMA risk evaluations with other Hanford Site programs, especially the 200 Areas ER Project, is an important RCAP requirement. Section 7.3 discusses integration with related Hanford Site projects to ensure that technical resources are optimally used, and that a clearer understanding of cumulative human health and environmental risks and other impacts is achieved.

4.1.5.1 Risk Assessment Approach. Qualitative WMA risk evaluations have been performed using historical process and characterization data (DOE-RL 1995c and 1996d). These qualitative risk evaluations have been used to initially evaluate the applicability and relative effectiveness of IMs (e.g., eliminate leaking water lines and replace well caps). Qualitative risk evaluations could also be used to support preliminary corrective measure decisions and could be useful in determining the need for additional WMA-specific characterization data.

Quantitative risk assessments typically require sufficient data for detailed computer models (e.g., the Hanford Sitewide Groundwater Model that is expected to be available in 2000 and will address conceptual and numeric groundwater contaminant fate and transport, plus other appropriate vadose zone/groundwater interaction models as they become available). As an example of the types of data that could be required, the input parameters required for typical human health risk evaluations are summarized in Table 4-1. Quantitative risk results verifying significant human health risks and/or environmental risks are typically required to justify ICMs.

They are also typically required to establish that ICMs have met their intended objectives. Approaches for quantitative human health and environmental risk evaluations are presented in Figures 4-5 and 4-6.

Under MTCA, risk assessment requirements for cleanup and verification for nonradioactive contaminants stipulate that carcinogenic risks shall be less than 10^{-6} for Method B and 10^{-5} for Method C. Also, concentrations of individual noncarcinogenic contaminants that pose acute or chronic toxic effects to human health shall not exceed a hazard quotient of 1.0. The MTCA risk criteria applies only to nonradioactive contaminants. The EPA guidance indicates that a corrective measure is generally warranted when the cumulative carcinogenic risk is greater than 10^{-4} or the cumulative noncarcinogenic hazard index exceeds 1.0 based on assumptions of reasonable maximum human exposure. When the cumulative human cancer risk for contaminated media (e.g., soil, water, and air) is between 10^{-6} and 10^{-4}, the conceptual exposure model must be further evaluated and regulatory agency consultations are necessary to determine if a corrective measure is necessary. Carcinogenic risks below 10^{-6} or hazard indices less than 1.0 are regarded as "points of departure" below which no action is required.

4.1.5.2 RCAP Risk Assessment Implementation. Risk assessment during a WMA characterization and corrective measure would utilize the MTCA Method B and Method C exposure scenarios and would follow the *Hanford Site Risk Assessment Methodology* (HSRAM) guidance (DOE-RL 1995a). Risk assessments would be conducted at three points in the RFI/CMS process:

- Field investigation reports would include preliminary assessments of contamination impacts on human health but would not include evaluations of impacts to ecological receptors.

- The RFI report would contain a quantitative risk assessment evaluating potential human health impacts. The risk evaluation exposure range would include the four hypothetical receptor locations and exposure scenarios presented in Section 4.1.2 (other potential scenarios would be considered for consistency with the TWRS EIS [DOE 1996]). The evaluation would include specific evaluation scenarios agreed to by the Tri-Parties, but would at least include MTCA residential and industrial scenarios at the WMA boundary for 1,000 years. The RFI report should also include a sensitivity analysis of key risk drivers and other pertinent parameters (e.g., temporal risk variations and contaminant fate and transport analyses).

  The RFI report would also contain an evaluation of potential ecological risks for the four hypothetical receptor locations presented in Section 4.1.2. The ecological risk evaluation would focus on potential plant and animal exposures to the WMA contaminants of potential concern and assess the potential toxic effects associated with the exposures. This evaluation would consider the potential population or community effects presented by the WMA contaminants but would also address potential impacts on protected species (e.g., threatened or endangered species) that could utilize the local area.

- The CMS reports would present a summary of the human health and environmental risk assessment results developed in the RFI report. The CMS would also include evaluations to predict the performance of specific alternatives in protecting human health and the environment.

The field investigation reports preliminary risk assessment results would be used to establish the need for additional characterization data or to support the decision to conduct an accelerated WMA-specific CMS process to expedite the implementation of selected ICMs. Examples of preliminary risk results that may indicate an accelerated CMS process include compromised WMA worker safety, significant groundwater contaminant migration, and human health or environmental risks that exceed MTCA criteria or ARARs by orders of magnitude.

4.2 PRELIMINARY IDENTIFICATION OF INTERIM CORRECTIVE MEASURE TECHNOLOGIES

Corrective measure studies identify and evaluate corrective measure alternatives for mitigating waste releases that threaten human health and the environment. This master work plan identifies potentially viable ICM technologies; the information presented is not intended to constrain future corrective action decisions. The process followed in this document is outlined in the Tri-Party Agreement (Ecology et al. 1998). Corrective measure alternatives are developed by assembling combinations of viable technologies or associated process options and applying them to specific media of concern (e.g., soil, groundwater, surface water, and air). The initial process of identifying corrective measure alternatives consists of the following steps:

1. Define corrective measure performance standards (preliminary standards are presented in Section 4.1.3).

2. Identify general response actions (GRAs) to satisfy the corrective measure performance standards (presented in Section 4.2.1).

3. Identify potential technologies and process options associated with each GRA (preliminary technologies presented in Appendix E).

4. Screen process options to select a representative process option for each type of technology based on effectiveness, implementability, worker safety, and cost.

5. Assemble viable technologies or process options retained in Step 4 into alternatives representing a range of removal, treatment, and containment options (plus no action).

The primary media of concern are radioactively and chemically contaminated soils, solid waste, and groundwater. The preliminary WMA GRAs identified to achieve the corrective measure performance standards represent broad classes of corrective measures. GRAs for retrieval and closure are not specifically addressed in this master work plan but must be considered when making corrective measure decisions. The following is a preliminary list of RCAP GRAs:

- No action
- Institutional controls
- Containment
- Removal and disposal
- Ex situ treatment
- In situ treatment.

A brief description of each GRA is presented below:

- **No action** is included to provide a baseline for comparison with other response actions. The no action alternative may be appropriate for some contaminants if risks are acceptable and no exceedances of contaminant-specific ARARs occur.

- **Institutional controls** involve the use of physical barriers (e.g., fences) and access restrictions (e.g., deed restrictions) to reduce or eliminate contaminant exposure. Institutional controls also include groundwater, vadose, surface soil, biotic, and air monitoring. Many access and land-use restrictions are currently in place at the Hanford Site and would remain in place during the implementation of corrective measures. Institutional controls may be an important aspect of ICM, retrieval, and closure alternatives.

- **Containment** includes using physical measures to restrict access to in-place waste and reduce or eliminate contaminant migration from in-place wastes. Containment technologies include engineered surface barriers (covers and caps), subsurface barriers, and vertical barriers. These containment options serve as physical and hydraulic controls for the downward or lateral migration of contaminants and biotic intrusion (including humans). Containment also prevents direct radiological exposure and may be useful in controlling gases. Barriers provide stability with relatively low maintenance requirements.

- **Removal and disposal** involves the excavation of contaminated material for disposal, generally in a landfill. Depending on the nature of the waste removed (e.g., radioactivity levels and hazardous waste classification), ex situ treatment of the waste may be performed prior to disposal. Ex situ treatment of contaminated material typically involves the use of biological, thermal, physical, or chemical technologies that incorporate one or more of the following primary treatment strategies:

  - Destruction or alteration of contaminants
  - Extraction or separation of contaminants
  - Immobilization of contaminants

  Contaminant destruction technologies are generally applicable only to organic contaminants. Active treatment of metals and radionuclides is typically limited to separation or immobilization technologies.

- **Ex situ treatment** involves the treatment of soil or other materials after it has been removed from the ground or some other storage location. Typical treatment options include biological land farming, thermal processing, soil washing, and solidification or stabilization.

- **In situ treatment** technologies are distinguishable from ex situ treatment in their ability to attain corrective measure performance standards without removing the wastes. The final waste form generally remains in place. This feature is advantageous when exposure or worker safety during excavation would be significant, or when excavation is technically impractical. Examples of in situ waste treatment process options include in situ vitrification, in situ stabilization, soil vapor extraction, in situ biotreatment, and immobilization processes (e.g., reactive barriers, sequestering agents, and grouting techniques).

- **Monitored natural attenuation** is addressed as an in situ treatment process for the purpose of this document. Monitored natural attenuation encompasses natural subsurface processes or contaminant characteristics that can effectively reduce contaminant toxicity, mobility or volume. The processes include radioactive decay, biodegradation, biological stabilization, volatilization, dispersion, dilution, chemical stabilization, transformation or destruction, sorption, and applicable monitoring.

After a range of suitable alternatives is developed, a detailed analysis of the alternatives is performed in the CMS process. The detailed analysis involves refining and analyzing each alternative on a WMA-specific basis. The results of the CMS are used to select preferred corrective measures.

A preliminary set of technologies and the applicability or limitations of these technologies with respect to the WMAs is presented in Appendix E. This preliminary list is intended to provide an initial basis for WMA characterization planning and to provide a basis for more detailed analysis of technologies and alternatives during the CMS. Consequently, the preliminary corrective measure technologies are general and cover a range of potential actions in response to a broad range of potential contaminant conditions. The technologies presented would be refined based on WMA characterization data collected during the RFI. These refinements would be made in the CMS.

4.3 PRELIMINARY IDENTIFICATION OF RETRIEVAL AND CLOSURE TECHNOLOGIES

Technology selection decisions are required for retrieval and closure. This section briefly describes several technologies that should be considered. Although waste retrieval and SST closure is outside the scope of the Phase 1 RFI/CMS, it has been agreed that during the DQO process and during preparation of WMA addenda, every effort should be made to identify the environmental data needs to support retrieval and closure decisions. The technologies eventually selected would likely be tank or tank farm specific and no single technology could address all conditions (a suite of technologies would likely be required). An initial list of decisions related

to retrieval and closure is provided in Sections 5-4 and 5-5. The following sections briefly discuss retrieval and closure options that are under consideration. More detailed discussions of retrieval and closure technologies are presented in Appendix I and in DOE/RL-98-72, *Retrieval Performance Evaluation Methodology for the AX Tank Farm* (DOE-RL 1998c).

4.3.1 Waste Retrieval Technologies

Waste could be retrieved from each of the tanks using a combination of sluicing for bulk waste retrieval, confined sluicing, saltcake dissolution, hard-heel retrieval methodologies, and high-pressure water spray and submersible pump technologies. Retrieved waste would be transferred to a receiver tank for eventual separations and immobilization in the RPP waste treatment facilities. Past-practice sluicing has been identified as the baseline SST retrieval technology (DOE-RL 1998c). The vehicle-based retrieval system under development consists of a self-propelled vehicle that is lowered into the tank through a riser and retrieves waste using a confined sluicing attachment.

4.3.2 Closure Technologies

As presently envisioned, closure of SSTs could follow one of three paths; clean closure, modified closure, or closure as a landfill. It is likely that "clean closure" would require either the removal or decontamination of all dangerous waste, waste residues and equipment, bases, liners, soil and subsoils, or other material contaminated with dangerous waste. The removal and decontamination standards are likely to be MTCA Method B. The requirements for "modified closure" should achieve the industrial clean up standards defined in MTCA Method C. Closure as a landfill could follow the closure requirements as specified for all RCRA landfills.

4.3.2.1 Tank Stabilization. Following waste retrieval, the tanks could be stabilized to prevent subsidence and provide a structurally sound base for the surface barrier. Grout would be mixed in a portable batch plant set up near the various tank farms. Grout pipes could be installed in each tank through riser penetrations to distribute the grout within the tank. Grout could be pumped into the tanks through the tank risers in a series of lifts; the thickness of the lifts would depend on the final grout formula. Tank stabilization with grout is a technology that has been used at the DOE's Savannah River Site for tank closure (WHC 1996).

4.3.2.2 Ancillary Equipment Stabilization. Stabilization of the ancillary equipment could include demolishing and removing surface buildings and equipment that would interfere with constructing a surface barrier and stabilizing subsurface equipment to prevent long-term subsidence. Conventional construction equipment would likely be used to demolish noncontaminated facilities. Hydraulic excavators with shielded cabs could be used to demolish contaminated facilities to ensure worker safety. Grouting the subsurface equipment could be accomplished by gaining access to the equipment and injecting the grout mixture.

4.3.2.3 Remediation of Contaminated Soil. Engineering studies (HNF 1999; DOE-RL 1998c) were performed to evaluate technologies that could be used to remediate contaminated soils in the AX tank farm. Soil excavation (and disposal) and in situ stabilization (grout injection) were the primary technologies investigated. Several techniques were evaluated to support the

excavation process (e.g., sheet piles for shallow excavations and caisson construction for deep excavations). The stabilization technology evaluated injected grout through an array of pipes drilled into the soil.

4.3.2.4 Tank Removal. The technologies and costs associated with removing the four tanks in the AX tank farm have been documented in DOE-RL (1998c) and SESC (1997). The unrestricted land use closure strategy includes removing the tanks. Tank removal would involve constructing a confinement facility that would cover the entire tank farm and the soils requiring removal, removing the soil surrounding the tanks, rubblizing the tank structures, and disposing the demolition debris. These actions must be performed in a very carefully controlled environment due to worker safety and potential contamination release considerations.

Figure 4-1. Hanford Future Site Uses Working Group Basemap Central Plateau Cleanup Scenario for Feasible Future: "Exclusive" with Buffer (adapted from FSUWG 1992).

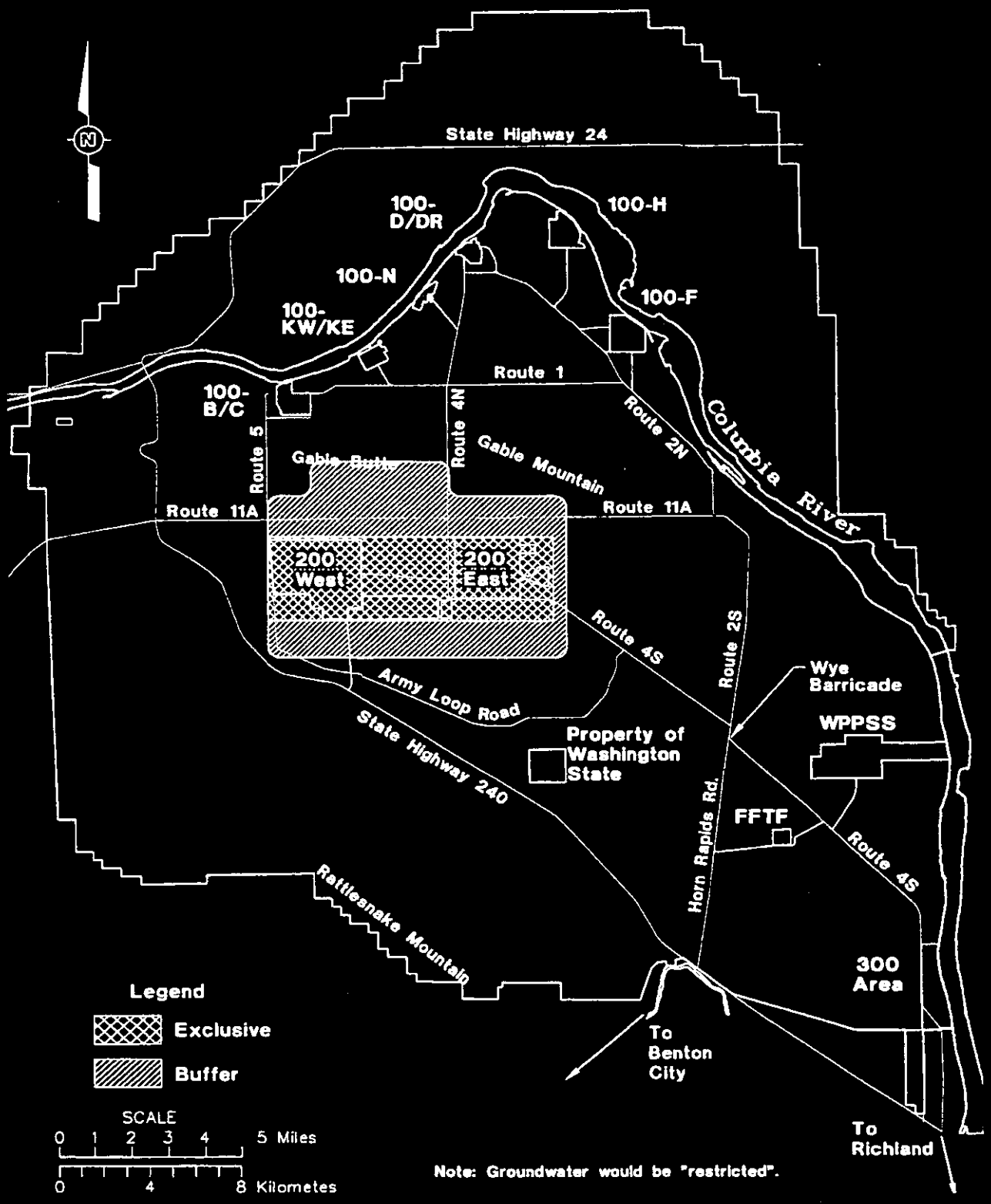
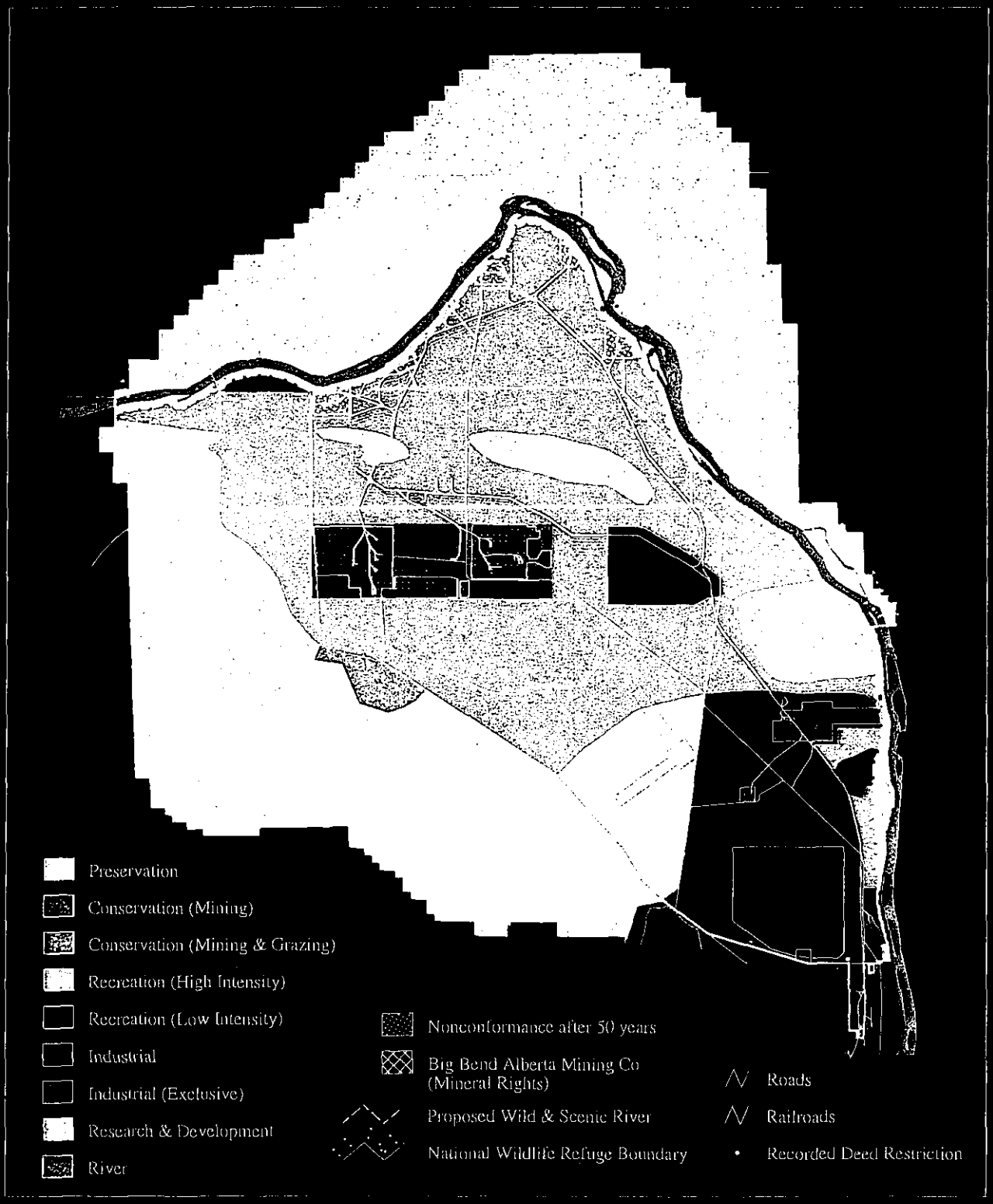


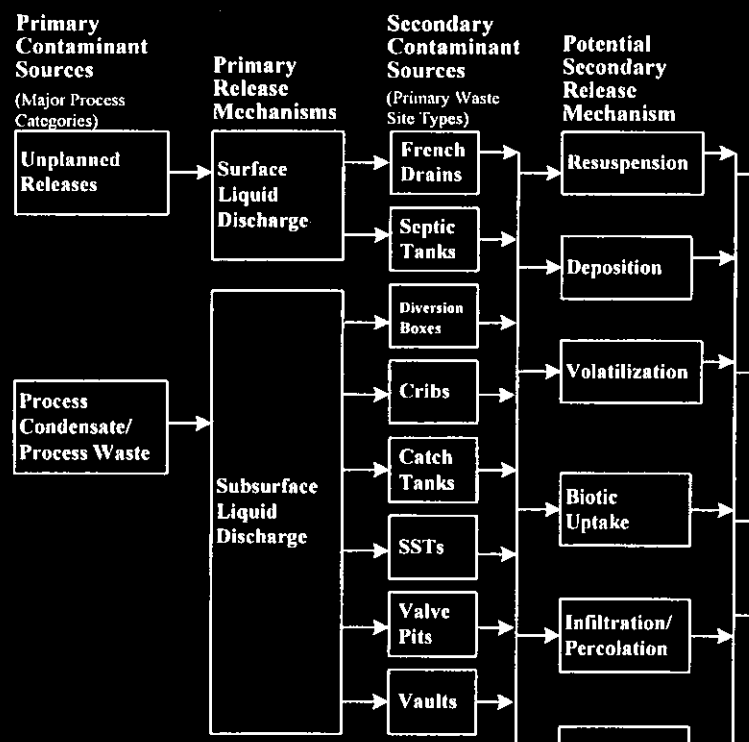
Figure 4-2. DOE Preferred Land-Use Alternative.[a]



BHLpp 04/23/98 clup/prefalt.aml Database: 26-MAR-1999

[a] Presented in the Revised Draft HRA-EIS (DOE 1999b).

Figure 4-3. Conceptual Exposure Model for the Waste Management Areas.



Potential Exposure Routes	POTENTIAL RECEPTORS: Humans: Current Worker	Humans: Future Worker	Humans: Occasional User	Biota: Terrestrial	Biota: Aquatic
Surface Soils					
Ingestion	*C	*C	*B	*	--
Dermal Contact	*C	*C	*B	*	--
External Radiation	*	*	*	*	--
Subsurface Soils					
Ingestion	*C	*C	--	--	--
Dermal Contact	*C	*C	--	--	--
External Radiation	*	*	--	--	--
Air/Soil Gas					
Inhalation	*C	*C	*B	*	--
Biota					
Ingestion	--	--	--	*	--
Groundwater					
Ingestion	* C	* C	* B	--	--
Inhalation	-- C	-- C	--	--	--
Dermal Contact	*C	*C	-- B	--	--
External Radiation	*	*	--	--	--
Surface Water					
Ingestion	-- C	-- C	--B	--	--
Inhalation	-- C	-- C	--B	--	--
Dermal Contact	-- C	-- C	--B	--	--
External Radiation	--	--	--	--	--

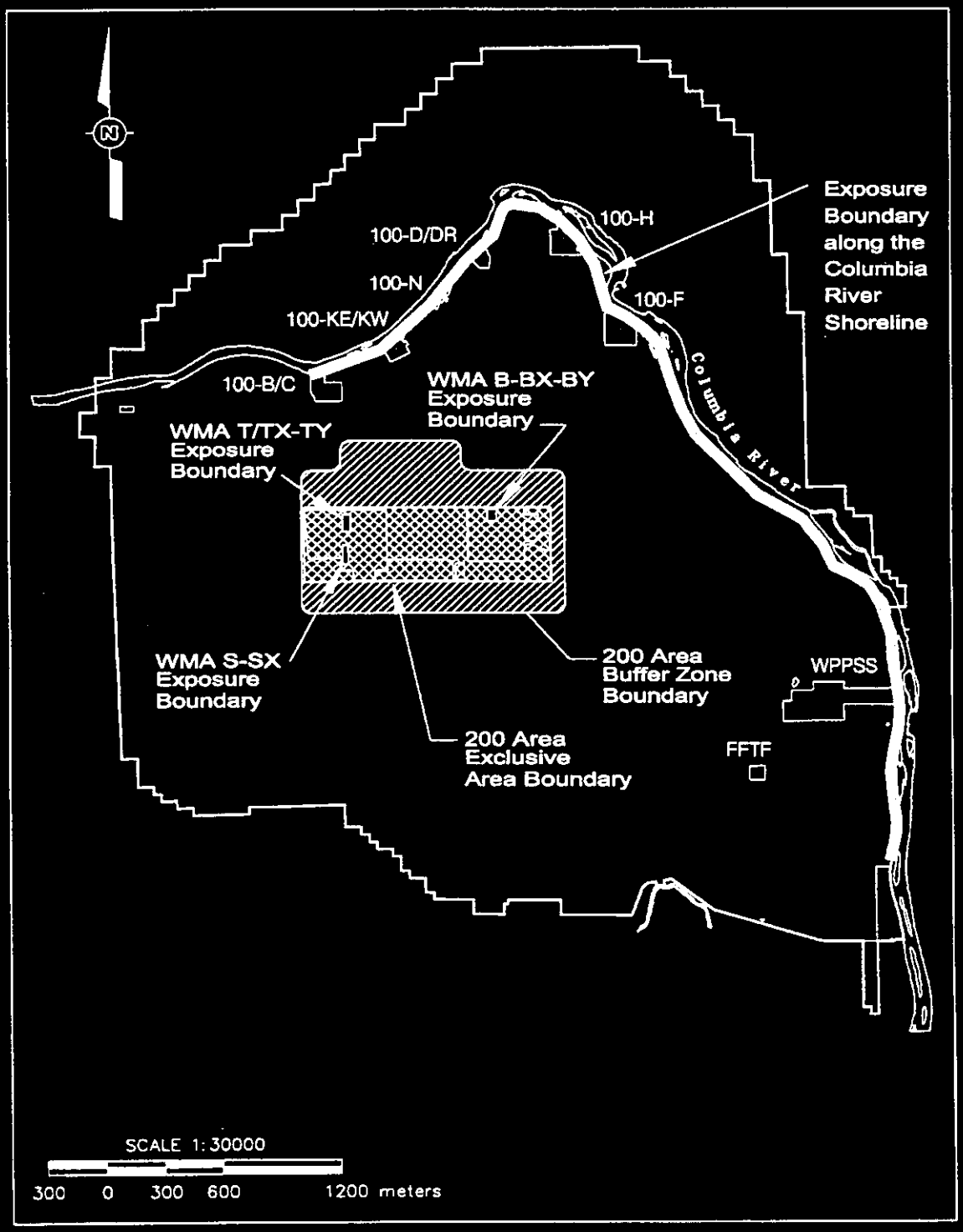
LEGEND

Project Recommendations
- * Probable exposure pathway
- -- Improbable exposure pathway

Regulatory Requirements
- B MTCA B exposure pathway
- C MTCA C exposure pathway

Source: Adapted from DOE/RL-98-28

Figure 4-4. Hypothetical Receptor Locations for Risk Evaluation.



G:\Figures\2W\061799D.dwg

Figure 4-5. Risk Characterization Approach for Human Health Evaluations (from DOE/RL-91-45, Rev. 3).

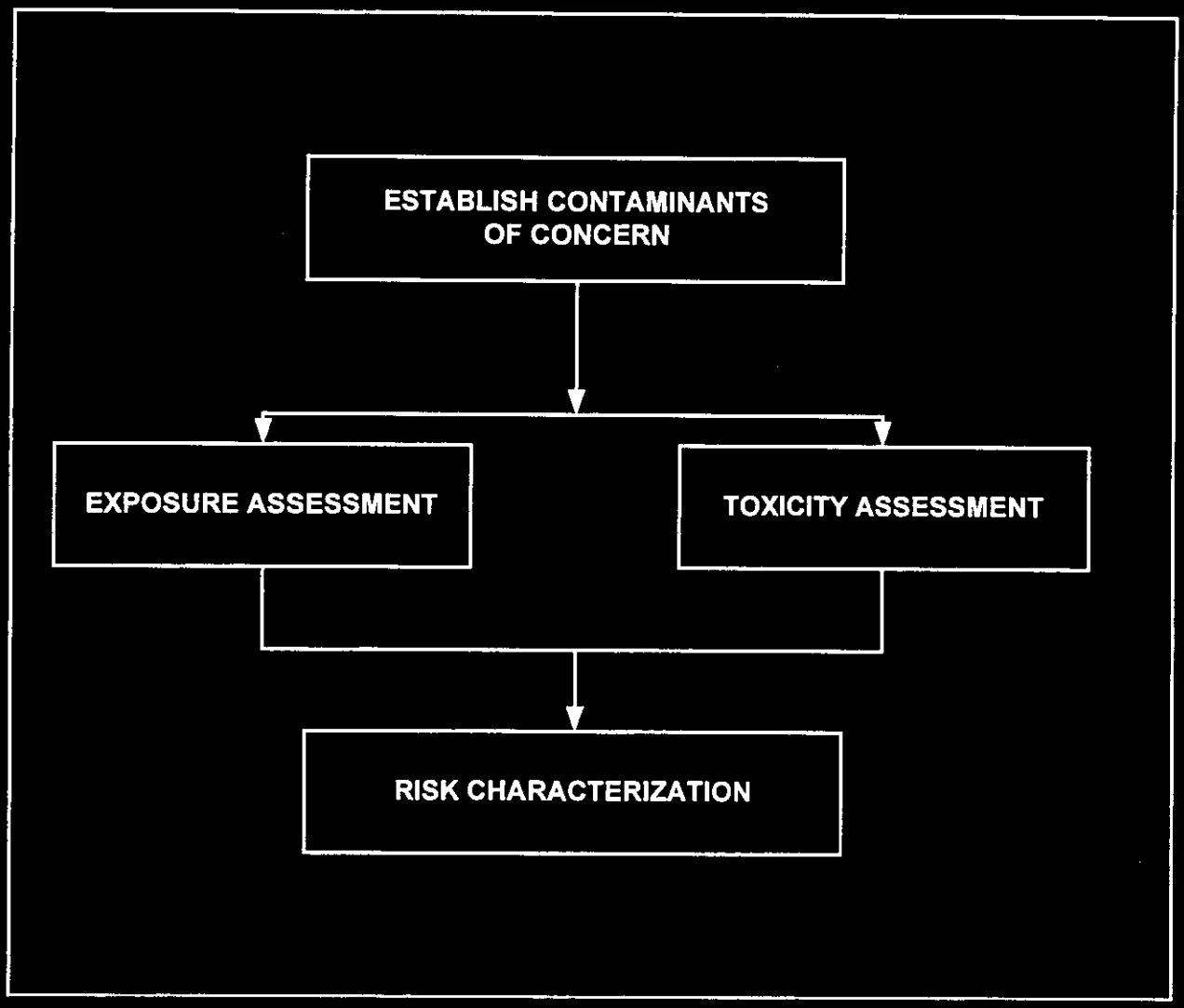


Figure 4-6. Risk Characterization Approach for Environmental Evaluations (from EPA 1992).

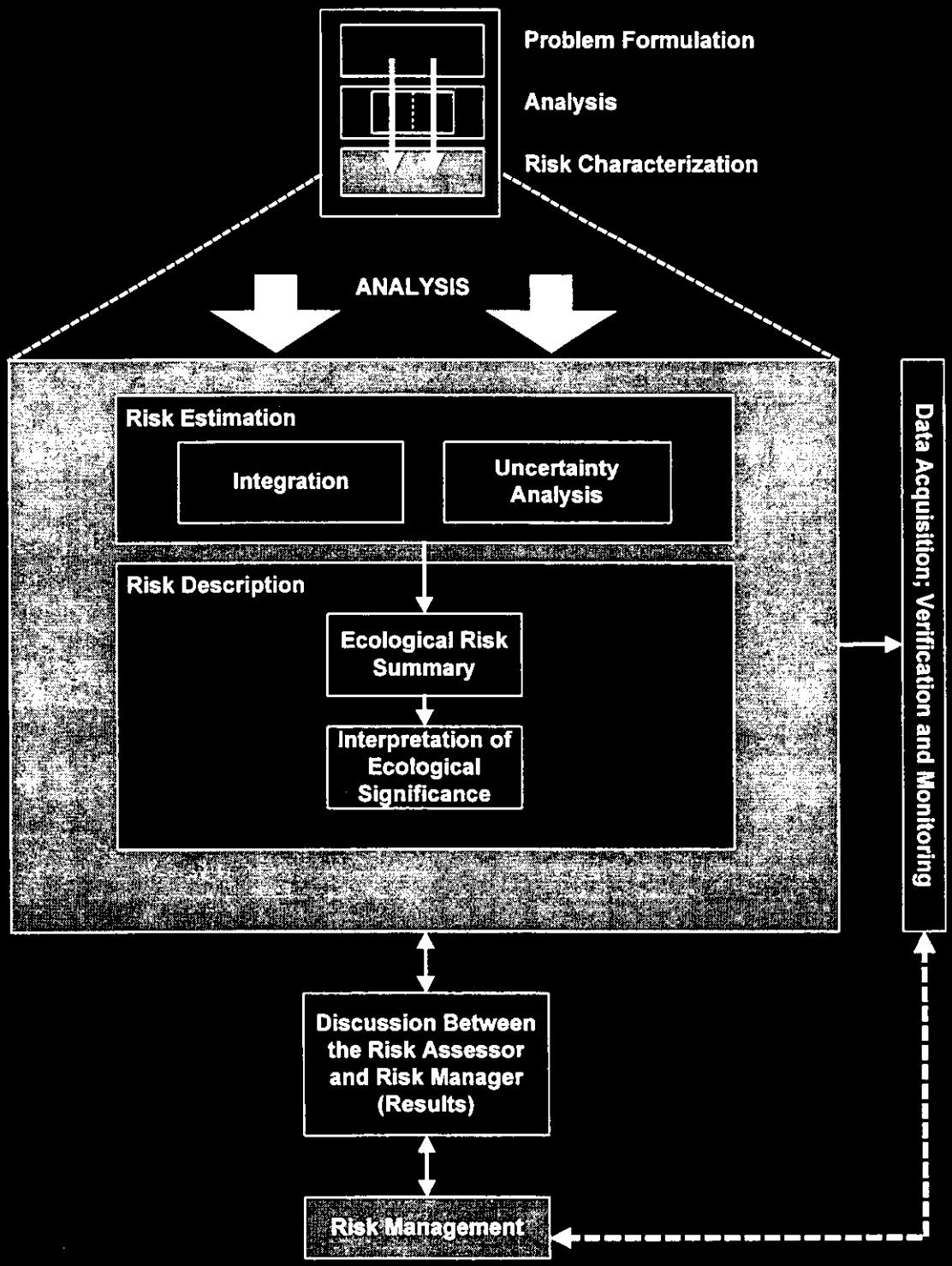


Table 4-1. Typical Human Health Risk Assessment Input Parameters. (4 pages)

Category	Parameter	Units
Exposure Pathways	Pathway: External Gamma: Inhalation: Plant Ingestion: Meat Ingestion: Milk Ingestion: Aquatic Foods: Drinking Water: Soil Ingestion: Radon:	
Contaminated Zone (CZ)	Area of CZ	m^2
	Thickness of CZ	m
	Length Parallel to Aquifer Flow	m
	Radiation Dose Limit	mrem/yr
	Elapsed Time Since Waste Placement	yr
Cover and CZ Hydrological Data	Cover Depth	m
	Cover Material Density	g/cm^3
	Cover Erosion Rate	m/yr
	Density of CZ	g/cm^3
	CZ Erosion Rate	m/yr
	CZ Total Porosity	
	CZ Effective Porosity	
	CZ Hydraulic Conductivity	m/yr
	CZ b Parameter	
	Humidity in Air	g/cm^3
	Evapotranspiration Rate	
	Precipitation	m/yr
	Irrigation Rate	m/yr
	Irrigation Mode	
	Runoff Coefficient	
	Watershed Area for Nearby Stream or Pond	m^2
	Accuracy for Water/Soil Computations	

Table 4-1. Typical Human Health Risk Assessment Input Parameters. (4 pages)

Category	Parameter	Units
Saturated Zone (SZ) Hydrological Data	Density of SZ	g/cm^3
	SZ Total Porosity	
	SZ Effective Porosity	
	SZ Hydraulic Conductivity	m/yr
	SZ Hydraulic Gradient	
	SZ b Parameter	
	Water Table Drop Rate	m/yr
	Well Pump Intake Depth Below Water Table	m
	Nondispersion or Mass-Balance	
	Well Pumping Rate	m^3/yr
Uncontaminated and Unsaturated Strata Hydrological Data	Number of Unsaturated Strata	
	Thickness	m
	Soil Density	g/cm^3
	Total Porosity	
	Effective Porosity	
	Soil-specific b Parameter	
	Hydraulic Conductivity	m/yr
Distribution Coefficients and Leach Rates for Individual Radionuclides	Distribution Coefficients (K_d) for Contaminated Zone, Uncontaminated Zone and Saturated Zone	
	Saturated Leach Rate	
	Saturated Solubility	
Inhalation and External Gamma	Inhalation Rate	m^3/yr
	Mass Loading for Inhalation	g/m^3
	Dilution Length for Airborne Dust	m
	Exposure Duration	yr
	Inhalation Shielding Factor	
	External Gamma Shielding Factor	
	Indoor Time Factor	
	Outdoor Time Factor	
	Shape Factor	

Table 4-1. Typical Human Health Risk Assessment Input Parameters. (4 pages)

Category	Parameter	Units
Ingestion Pathway Data, Dietary Parameters	Fruits, Vegetables, and Grain Consumption	kg/yr
	Leafy Vegetable Consumption	kg/yr
	Milk Consumption	L/yr
	Meat and Poultry Consumption	kg/yr
	Fish Consumption	kg/yr
	Other Seafood Consumption	kg/yr
	Soil Ingestion	g/yr
	Drinking Water Intake	L/yr
	Drinking Water Contamination Fraction	
	Household Water Contamination Fraction	
	Livestock Water Contamination Fraction	
	Irrigation Water Contamination Fraction	
	Aquatic Food Contamination Fraction	
	Plant Food Contamination Fraction	
	Meat Contamination Fraction	
	Milk Contamination Fraction	
Ingestion Pathway Data, Nondietary	Livestock Fodder Intake for Meat	kg/d
	Livestock Fodder Intake for Milk	kg/d
	Livestock Water Intake for Meat	L/d
	Livestock Water Intake for Milk	L/d
	Livestock Intake of Soil	kg/d
	Mass Loading for Foliar Deposition	g/m^3
	Depth of Soil Mixing Layer	m
	Depth of Roots	m
	Groundwater Fractional Usage - Drinking Water	
	Groundwater Fractional Usage - Household Usage	
	Groundwater Fractional Usage - Livestock Water	
	Groundwater Usage – Irrigation	

Table 4-1. Typical Human Health Risk Assessment Input Parameters. (4 pages)

Category	Parameter	Units
Radon	Cover Material Thickness	m
	Cover Material Density	g/m^3
	Cover Material Porosity	
	Cover Material Water Content	
	Cover Material Radon Diffusion Coefficient	m/sec
	Building Foundation Thickness	
	Building Foundation Density	g/m^3
	Building Foundation Total Porosity	
	Building Foundation Water Content	
	Building Foundation Diffusion Coefficient	m/sec
	CZ Radon Diffusion Coefficient	m/sec
	Radon Vertical Dimension of Mixing	m
	Average Annual Wind Speed	m/sec
	Building Air Exchange Rate	1/hr
	Building Room Height	m
	Building Indoor Area Factor	
	Foundation Depth Below Ground Surface	m
	Radon Emanation Coefficient - Rn-222	
	Radon Emanation Coefficient - Rn-220	

5.0 PRELIMINARY DECISION FRAMEWORK

Assessment activities under the RCAP are driven by the need to support decision making. This section presents a preliminary "decision framework" for project teams to start with when developing WMA-specific characterization programs. This framework identifies decisions associated with the RCRA corrective action, waste retrieval, and closure projects as derived from the programmatic and regulatory information presented in Sections 1.0 and 2.0. The framework also identifies example inputs to the decisions based on the site information found in Section 3.0 and the conceptual exposure model and technology information found in Section 4.0. Decisions and decision inputs also reflect information found in the *Tank Waste Remediation System Vadose Zone Program Plan* (DOE-RL 1998d).

The following sections provide an introduction (Section 5.1), a preliminary "problem statement" for the Phase 1 RFI/CMS (Section 5.2), and a discussion of the decisions and decision inputs associated with the SST RCRA corrective action, waste retrieval, and closure programs (Sections 5.3, 5.4 and 5.5, respectively). Section 5.6 discusses prioritization.

5.1 INTRODUCTION

5.1.1 Process for Defining Phase 1 Objectives

The Hanford Site mission and the public interest require DOE to close waste sites in a manner that accelerates schedules, reduces costs, and minimizes risks to workers, while still protecting public health and the environment. The urgency associated with SST waste issues demands extraordinary effort by the SST RCAP to maximize the value of field characterization activities. Data collection must be clearly driven by, and be essential to, achieving the ultimate goal of protecting human health and the environment and maintaining compliance with state and Federal regulations. The work planning process for the WMA RFIs must clearly document how planned data collection activities are tied to a consistent set of program goals.

In the RFI/CMS planning workshop, DOE and Ecology agreed to a general framework and process to define WMA-specific information needs. The following list describes a simple logic that WMA project teams will follow to ensure that WMA-specific characterization programs are essential to achieving overall program goals. The process starts with defining those overall goals and then working through a series of steps that result in a set of essential information needs. The general steps are as follows:

Define program objectives. Define the ultimate objectives of the RCRA corrective action, retrieval, and closure projects based on regulatory and programmatic drivers. With these objectives in mind, define any secondary (or contributing) objectives that are essential to achieving the primary objective. The goals should be comprehensive, well-defined, and nonredundant.

Define the decisions. Identify the major decisions implicit in the program's strategies for achieving the objectives. For example, with respect to the RCAP, a major decision is to determine if past releases pose a threat to human health and the environment that warrant corrective actions prior to tank closure.

Define the decision criteria. Identify the criteria that will or may be used in making the decisions described in the previous step. In the example used above, one decision criterion might be whether or not contaminant concentrations in groundwater at a particular location exceed an acceptable risk level.

Determine the information needed to evaluate against the criteria. This process involves understanding what method(s) will be used in the evaluation, with a corresponding understanding of what inputs are demanded by the methodology, what the sensitivity of the final result is to the inputs, and what data are needed to develop the inputs.

Determine what information is currently available and what information must be developed during the RFI. The WMA-specific planning processes will include compilation and review of all existing relevant information prior to designing any new characterization programs. The RFI field characterization activities will focus only on obtaining essential data that are not currently available.

The process described in general terms above is implicit in the EPA DQO process, which is discussed in detail in Section 6.0.

5.1.2 Initial Decision Framework

As general guidance to WMA project teams during the DQO process, the RFI/CMS workshop (Section 1.1.3) developed an initial decision framework by following the first several steps listed in Section 5.1.1. This initial framework identifies, on a preliminary basis, the overall program objectives, associated decisions and criteria, and examples of decision inputs (e.g., methodologies and types of information needed to complete the evaluations). The framework derives in a significant way from work accomplished by the TWRS Vadose Zone Interagency Team[1], as documented by DOE-RL (1998d), as well as from the decisions identified in the *Retrieval Performance Evaluation Methodology for the AX Tank Farm* (DOE-RL 1998c).

Project teams will use the initial decision framework as a *starting point* for each WMA-specific DQO process. During each DQO process, the team will update the decision framework based on the best regulatory and programmatic information available at that time. Such revisions will ensure that data collection activities are focused on information essential to the RCAP. To facilitate the DQO process, the teams may choose to consolidate some of the decisions listed separately below into a single decision (e.g., for decisions with similar decisions inputs). They may also choose to break other decisions listed below into lower-level decisions.

[1] The TWRS Vadose Zone Interagency Team included representatives from DOE, Ecology, the Tribal Nations, and Oregon Department of Energy.

The initial decision framework is described in Sections 5.3 through 5.5 and is summarized graphically in Figures 5-1 through 5-4. Figure 5-1 illustrates the overall structure and Figures 5-2, 5-3, and 5-4 address the decisions associated the RCAP, the retrieval program, and the closure program, respectively. Note that retrieval- and closure-related decisions will be made by the retrieval and closure programs; the RCAP will merely provide data, as appropriate, to support these decisions.

5.1.3 Limitations and Uncertainties

Notwithstanding the development of a decision framework within which to identify data needs, there are some fundamental uncertainties and constraints that must be recognized, understood, and addressed during the DQO process and in subsequent RFI/CMS evaluations. Several of these are described below.

Future land use. The lack of a final land-use decision for the 200 Areas (Section 4.1.1) precludes a single set of receptor scenarios and environmental standards from which to develop numerical cleanup goals. To the extent that such goals are inputs to decisions on ICMs, retrieval leak loss limits, and acceptable tank residues at closure, uncertainty in the goals will introduce a corresponding uncertainty into these decisions. Section 4.1.2 describes a flexible approach to this issue that allows the Tri-Parties to move forward with the RCAP. Using this approach, the WMA project teams will define the information needed to evaluate *several* sets of scenarios that "encompass" the eventual future land-use outcome.

Physical complexity. Each tank farm contains numerous, closely spaced tanks and extensive subsurface piping and other ancillary equipment, creating myriad possible leak locations. It will, therefore, be difficult to fully characterize all the past releases to the vadose zone and groundwater. The WMA project teams should pursue a pragmatic approach that focuses attention on those releases that are likely to be of greatest significance (i.e., the most likely to impact human health and the environment). Step 7 of the DQO process (Optimize Data Collection Design) is a formal step in the WMA-specific planning process to address this issue.

Safety considerations. The SSTs contain large volumes of high-level radioactive and dangerous wastes. This fact and concerns regarding the structural integrity of the tanks demand that the RPP maintain strict management controls on working within the SST farms, especially for intrusive activities such as drilling. These necessary controls constrain the locations available for intrusive characterization so that, as a practical matter, the team may not be able to locate a borehole or well in a location that would be ideal from the standpoint of characterizing impacts. The result of this is to effectively limit the level of understanding achievable by the team, regardless of available time or budget. The WMA project teams must, therefore, develop the optimum characterization strategy within the constraints imposed by working within the WMA.

Cost and schedule considerations. The strict management controls and the high levels of radioactivity present in the tank farms introduce significantly higher costs and lead times for characterization than is typical for soil and groundwater characterization elsewhere on the Hanford Site. The likely consequence is that, barring a large increase in available budgets, there will be a continuing challenge to balance the degree of characterization desired against the

available funding. To respond to this challenge, each project (e.g., retrieval and closure) will periodically update its objectives and associated decisions to ensure that characterization campaigns can be focused on data of maximum value.

Predictive models. Important decisions will be supported by predictive modeling of contaminant transport through varying media, across long distances, and over hundreds or thousands of years. Although powerful computer models exist to support such modeling, the complexities of the subsurface environment are difficult to represent faithfully, and modeling results will generally have significant inherent uncertainty. To respond to this challenge, DOE is working through the system assessment capability (SAC) and the Science and Technology (S&T) functions of the Hanford Site GW/VZ Integration Project to improve the models and methods to be used for such work.[1] Methods of evaluating uncertainties to appropriately inform decision-making processes will be considered. The RPP Vadose Zone Project is associated with these efforts and is supporting improvement of models applicable to the tank farms.

The purpose in describing the above uncertainties and constraints is to emphasize the importance of defining desired end states and of using decision methodologies that incorporate uncertainty.

5.2 PROBLEM STATEMENT FOR PHASE 1 RCRA FACILITY INVESTIGATION AND CORRECTIVE MEASURES STUDY

The first step in the DQO process for each WMA will be to develop a "problem statement." The RFI/CMS workshop team developed a general problem statement for the Phase 1 RFI/CMS that reflects essential issues described in the draft Change Control Form (Ecology et al. 1999) and in the *Tank Waste Remediation System Vadose Zone Program Plan* (DOE-RL 1998d). This statement is included below as a reference for the WMA project teams when initiating the DQO process. It is expected that each WMA project team will develop a problem statement that reflects the general statement below, but which is specific to the WMA under consideration.

Preliminary Problem Statement:

Summary of current situation: Past releases from SST farm areas have caused surface, underlying vadose zone, and groundwater contamination. Future activities required to complete the RPP mission may cause additional releases to the vadose zone and to the groundwater. Contaminants in the groundwater could potentially impact the Columbia River. To date, only partial progress has been made in characterizing and analyzing these past and potential future impacts. *Impact:* The Tri-Parties' current understanding of the nature, extent, fate, and transport of contamination in the environment is insufficient to support RPP decision making for corrective actions to address past releases and to close SSTs in a manner that protects human health and the environment. *Action needed:* The RPP must assess what level of understanding is required to support decision making,

[1] If computer models being developed through the SAC and S&T functions are not available in the timeframe needed, or are not appropriate for RCAP applications, the RCAP will modify existing models to meet its requirements. This would be done in consultation with the Hanford Site GW/VZ Integration Project.

pursue investigations and studies to achieve this understanding, and implement actions as necessary to address past and potential future releases.

5.3 CORRECTIVE ACTION PROGRAM DECISIONS

5.3.1 Program Overview and Goals

The drivers and primary goals of the RCAP are described in Sections 1.0 and 2.0 and relate to the need to assess and respond to past releases from the TSD facility to protect human health and the environment. Decisions implicit in the path forward to achieving these goals are described in the following paragraphs and are shown in Figure 5-2.

5.3.2 Decision CA-1: Impacts of Past Leaks

Does existing vadose zone and groundwater contamination resulting from past releases of SST wastes present an unacceptable risk to human health or the environment and warrant a CMS to evaluate ICMs?

As discussed in Section 4.1, DOE has not made a final future land-use decision for the 200 Areas. Consequently, there is no corresponding single set of health-based criteria on which to base the above decision. To allow the RCAP to move forward, the decision makers have agreed to evaluate risks using several exposure scenarios that are likely to bound the eventual outcome. As described in Section 4.1 and shown in Figure 5-2, risks will be evaluated for MTCA industrial and residential scenarios at four different boundaries.

Evaluations to support Decision CA-1 will involve estimates of current risks and how risks are projected to vary in the future. These estimates will rely on vadose zone and groundwater contaminant fate and transport modeling. Information needs to support modeling will include the nature, extent, and magnitude of contamination, as well as information describing likely contaminant transport mechanisms and pathways through the vadose zone and groundwater.

5.3.3 Decision CA-2: Corrective Measures Alternatives

Are there ICMs that can be implemented to reduce risk and be protective of human health or the environment prior to retrieval and closure and, if so, which ICMs should be implemented?

Criteria and inputs for this decision are shown in Figure 5-2. Criteria are derived from recommendations for evaluation of alternatives in RCRA, CERCLA, and NEPA guidance, as well as from the need to integrate with and support SST waste retrieval or closure processes. Evaluations to support Decision CA-2 include standard engineering, construction, and cost evaluations, as well as risk evaluations of the nature described for Decision CA-1. (These risk evaluations support performance predications for corrective measures alternatives.) Information needs to support the decision, therefore, include "conceptual design" level information for technology alternatives, as well as the types of data described above for Decision CA-1 evaluations.

5.4 RETRIEVAL DECISIONS, DECISION CRITERIA, AND DATA NEEDS

Retrieval-related decisions are identified and discussed in this section with the objective of determining if vadose zone and groundwater data are needed to support the associated decision making processes. As described in the Section 5.1.2, retrieval-related decision making, including evaluation of data to support such decisions, will be performed by the Retrieval Project.

5.4.1 Program Overview and Goals

The inventory of contaminants still in the SSTs is far greater than the inventory in the environment resulting from past releases. Therefore, removing remaining waste from the tanks for treatment and disposal is essential to long-term risk reduction. The responsibility for waste retrieval lies with the RPP's tank farm waste retrieval program, and the responsibility for treatment has been assigned by the DOE to a private contractor.

The tank farm waste retrieval program's approach is driven by the need to provide waste feed for treatment in accordance with established quality, composition, and schedule requirements, and to do so in a manner that protects human health and the environment. Current and planned retrieval technologies are briefly described in Appendix I. (More detailed information on potential retrieval technologies may be found in DOE-RL [1998c].) The baseline retrieval technology involves adding liquids to the SSTs for dissolution, dislodging, and mobilization of waste. Addition of liquids to potential leaking SSTs creates added risk of leakage of contaminants to the subsurface.

Decisions implicit in the path forward to full-scale retrieval are described in the following paragraphs and are shown in Figure 5-3.

5.4.2 Decision RE-1: Impact of Retrieval Leaks

Do existing vadose zone and groundwater conditions constrain baseline retrieval of tank waste and demand alternative waste retrieval technologies; tank sequencing strategies; leak detection, monitoring, and mitigation (LDMM) technologies and strategies; and/or other measures to protect human health and the environment?

An alternate wording of this decision is to ask whether predicted leaks under a "baseline" scenario would result in unacceptable impacts to human health and the environment. The criteria for making this decision would be similar or identical to those for Decision CA-1, as would the evaluation methodologies. Generally speaking, the types of information needed would also be similar (but not identical); however, the scale or level of detail at which this information would be needed may differ. For example, if the Tri-Parties agreed to specify retrieval design constraints (e.g., leak loss limits) on a tank-by-tank basis, then there could be a corresponding need for vadose zone data from beneath each tank. By contrast, information needs to support Decision CA-1 might not involve this level of detail.

5.4.3 Decision RE-2: Waste Retrieval Technologies

Are there alternatives to the retrieval technology assumed in the baseline plan that can be implemented to further reduce risk and be protective of human health and the environment prior to closure and, if so, which technology(ies) should be deployed?

As noted, current baseline SST retrieval technologies involve adding liquids, thereby creating a potential for future leaks. The SST Program is responsible for developing technologies and procedures to limit the risk of potential retrieval leaks. Many of the criteria for selecting a retrieval technology to deploy are not related to conditions in the vadose zone and groundwater (e.g., removal effectiveness, equipment durability, and safety). However, the technology performance criteria represented by a leak loss limit that protects human health and the environment *is* based on vadose zone and groundwater conditions.

Leak loss limits will be heavily influenced by the effectiveness of final closure technologies in addressing historical and retrieval-related tank releases. The less effective a technology is, the lower the allowable leak loss limit is likely to be. Decision inputs for establishing leak loss limits are discussed in Section 5.5, which addresses closure-related decisions.

5.4.4 Decision RE-3: Strategies for Sequencing Waste Retrieval

Can the tank sequence for waste retrieval contribute to protection of human health and the environment and, if so, what sequence(s) are protective?

The risk of retrieval leakage can be partially mitigated by initially retrieving waste from assumed sound tanks until operating experience and improved technologies can be applied to more problematic tanks. The RPP is developing a waste retrieval strategy that incorporates risk reduction objectives in sequencing SST retrieval operations. Tri-Party Agreement Milestone M-45-02 requires annual updating of the SST waste retrieval sequence.

If the assumption that an SST that has been sound in the past will continue to be sound during retrieval is valid, then a prediction regarding tank soundness during retrieval could be supported by environmental data (i.e., to detect past releases). It is emphasized that, due to the complexity of contaminant transport and constraints on drilling in the tank farms, environmental sampling would likely never prove conclusively that a tank has not leaked in the past. However, when combined with other supporting information, the data may provide increased confidence that this is the case, or that leaks have been relatively minor.

The impacts of past and potential future leaks could be evaluated using the methods and information previously discussed in connection with Decision RE-1.

5.4.5 Decision RE-4: Leak Detection, Monitoring, and Mitigation

The separate aspects of a general decision on LDMM technologies are considered individually below (i.e., as separate questions).

Decision RE-4a: Are there internal and external leak detection technologies available that contribute to protection of human health and the environment and, if so, which technologies should be demonstrated?

A key criterion for evaluating the adequacy of individual leak detection technologies will be the necessary detection sensitivity, a measure that is derived in part from leak loss limits protective of the environment.

Methodologies for establishing waste retrieval leak loss limits would be similar to those described for Decision CA-1, as would the types of information needed. However, the scale or level of detail at which this information is needed may differ. If the Tri-Parties agree to develop tank-specific leak loss limits, then there could be a corresponding need for vadose zone and groundwater data from beneath each tank.

Decision RE-4b: Are there external leak monitoring technologies available that may contribute to protection of human health and the environment and, if so, which technologies should be demonstrated?

If a leak were to occur during waste retrieval, it might be useful to monitor leak migration in the vadose zone so as to have increased understanding regarding potential impacts to human health and the environment and, potentially, to indicate if emergency measures should be implemented.

Specific technologies and criteria for this type of monitoring system have not been published. However, methods to support the evaluation and deployment of candidate technologies would likely involve assessing how postulated leaks might move through the environment, and then evaluating how monitoring technologies could be deployed to monitor that migration. Consequently, initial evaluations would likely involve modeling efforts and information needs similar to those described for Decision CA-1.

Decision RE-4c: Are leak mitigation technologies available that contribute to protection of human health and the environment and, if so, which technology(ies) should be demonstrated?

For leak detection or monitoring tools to be truly effective, retrieval operations should be capable of responding to any detected leaks with appropriate mitigation measures. The currently available strategies for response include operational, procedural, and administrative methods, and retrieval equipment design and availability. Deployment of engineered barriers beneath the tanks has been evaluated and is not viable at this time (see Appendix E). The retrieval project will likely evaluate the viability of other "out-of-tank" mitigation measures in the future, and it is likely that such evaluations would be supported by vadose zone and groundwater data. However, specific information needs are not identified at this time.

5.5 CLOSURE DECISIONS, DECISION CRITERIA, AND DATA NEEDS

Closure-related decisions are identified and discussed in this section with the objective of determining if vadose zone and groundwater data are needed to support the associated decision

making processes. As described in the Section 5.1.2, closure-related decision making, including evaluation of data to support such decisions, will be performed by the closure project.

5.5.1 Program Overview and Goals

As described in Section 2.0, the SST farms are RCRA TSD units and must be closed in accordance with the HWMA and other applicable state and Federal regulations (e.g., the AEA). Regulatory options for SST closure under the HWMA and AEA are described in Section 2.1. The general performance standards for closure include controlling, minimizing, or eliminating post-closure escape of wastes to the environment to the extent necessary to protect human health and the environment, as well as minimizing long-term maintenance. The DOE will use a NEPA EIS process to evaluate and recommend SST closure alternatives, and Ecology will approve these through the SST closure plan and permit modification process. Closure alternatives must address residual waste in the tanks, the tank structure, ancillary equipment, and residual contamination in the vadose zone and groundwater. Potential closure technologies are briefly described in Appendix E. More detailed information on closure technologies may be found in DOE-RL (1998c).

Decisions implicit in the process of achieving a final closure are described in the following paragraphs and are shown in Figure 5-4. Note that, although waste retrieval is a major step towards the ultimate closure of the SSTs, the decisions below relate to post-retrieval closure actions. Retrieval related decisions are identified in Section 5.4.

5.5.2 Decision CL-1: Post-Retrieval Impacts

If no post-retrieval closure actions are taken, do existing groundwater and vadose zone contamination, potential leaks during retrieval, residual waste in ancillary equipment, residual waste left in tanks, and remaining structures pose unacceptable, cumulative risks to human health and the environment and demand additional (post-retrieval) closure actions?

Although the response to the above decision will likely be "yes," and the HWMA *requires* closure of TSD units, there is a need to establish the long-term baseline risks to human health and the environment (assuming no closure action). This baseline provides a foundation for evaluating different closure alternatives.

Final SST closures will not commence for many years when, it is assumed, final decisions on post-closure land uses will be available. Final land-use decisions will support definitive criteria for decision-making in the form of contaminant-specific, risk-based standards based on closure options described in the Hanford Facility RCRA Permit. At this time, however, there is no future land-use decision, and the selection of a specific closure option under the HWMA has not been made. Consequently, for the purposes of this work plan, it is recommended that the WMA project teams consider the same scenarios proposed for Decision CA-1 to provide supporting information for closure planning. These include the MTCA industrial and residential scenarios at the WMA boundary, the 200 Areas boundary, and at the 200 Areas buffer zone boundary.

As for Decision CA-1, evaluations will rely on risk calculations supported by an understanding of the nature, extent, and magnitude of contamination, and how these vary over time. The evaluations or risk over time will likely be supported both by vadose zone and groundwater contaminant fate and transport models. Information needs to support these evaluations include the nature, extent, and magnitude of contamination, and relevant data to define values for input parameters to the models.

5.5.3 Decision CL-2: Closure Alternatives

Determine what closure alternatives should be implemented for (1) contaminated soils, (2) groundwater, (3) ancillary equipment, (4) tank residues, and (5) tank structures to reduce risk and be protective of human health and the environment.

As noted, Ecology will approve final SST closure technologies through the RCRA closure plan and permit modification process. The DOE will use the NEPA EIS process to recommend closure alternatives and to support Ecology's SEPA process. Because of the radiological constituents in SST wastes and because the 200 Areas are listed on the NPL, DOE will also consider AEA and CERCLA requirements in this process. Consequently, this master work plan assumes that the criteria to be used in evaluating closure alternatives will reflect RCRA, CERCLA, AEA, and NEPA guidance. A preliminary list of these is provided in Figure 5-4.

Evaluations to support the decision will include standard engineering, construction and cost evaluations, and human health and environmental impact evaluations of the nature described for Decision CL-1. (The impact evaluations will have the purpose of predicting the long-term performance of the alternatives in protecting human health and the environment.)

Information to support these evaluations will include an understanding of the nature and extent of contamination remaining in the tank farms at closure and the capability to model contaminant transport through the environment. Uncertainties associated with the magnitude, character, location, and interaction of the waste with soils are key to decisions regarding tank farm closure.

5.5.4 Decision CL-3: Establish Retrieval Performance Requirements

Decision CL-3: Determine retrieval system performance requirements (allowable residual waste volume and retrieval leak loss limits).

The final closure decision for SSTs must ensure that the long-term, post-closure impacts of tank residual wastes are protective of human health and the environment. Evaluations to support this decision must define what volumes of waste can safely be left behind, a result that will likely vary with the different closure technologies alternatives applicable to the residuals. The final closure decision will, therefore, include specification of allowable tank waste residuals.

The case is similar for retrieval leakage losses. The final closure alternative must protect human health and the environment from *all* leaks, which will involve an understanding of the impacts of past leaks, specifying a limit for potential future (retrieval inspired) leaks, and specifying appropriate closure technologies.

Since an understanding of vadose zone and groundwater conditions (e.g., nature and extent of contamination; transport processes) is needed to evaluate closure alternatives, establishing performance requirements for retrieval is also dependent, in part, on vadose zone and groundwater characterization. Performance requirements for full-scale retrieval will also depend to a large degree on the results of the demonstration phase of retrieval system capability. Decision criteria and evaluation methodologies are assumed to be similar to those discussed for Decision CL-1.

5.6 PRIORITIZATION OF PHASE 1 RCRA FACILITY INVESTIGATION AND CORRECTIVE MEASURES STUDY CHARACTERIZATION OBJECTIVES

The DOE and Ecology recognize that they have established a broad scope for the Phase 1 RFI/CMS (i.e., to support decisions related to interim corrective actions, SST waste retrieval, and final closure). This breadth of the scope could result in project teams identifying a large number of data needs for each WMA. To the extent that characterization cost estimates (e.g., for field sampling and laboratory analysis) could exceed available budgets, there may be a corresponding need to reduce the characterization scope through prioritization of data needs. Prioritization was not performed during the RFI/CMS workshop because the decision makers anticipate significant overlap in the vadose zone and groundwater information needed to support the three projects. The need for prioritization will be assessed following identification of data needs to support all the decisions described above.

If prioritization *is* needed, DOE and Ecology may conduct the prioritization through a process discussed during the Phase 1 RFI/CMS workshop. This process involves prioritizing RPP objectives and the associated decisions described in Sections 5.3, 5.4, and 5.5. (Prioritizing decisions prioritizes the associated data needs.) The prioritization process would likely consider many factors, but in general terms, DOE and Ecology prefer to focus first on high-priority risk reduction and near-term, mission-critical activities.

As a hypothetical example, the decision makers could elect to prioritize corrective action-related decisions ahead of waste retrieval- and closure-related decisions. The likely consequence would be to focus the RFI on those areas of the tank farms with the greatest potential for significant ongoing and near-term (i.e., pre-retrieval) impacts to groundwater. Such a focus might drive Phase 1 RFI characterization towards developing an understanding of the nature and extent of contamination in the vadose zone immediately above the water table.

Alternatively, the decision makers could elect to prioritize on decisions related to expediting the TSD closure process, including SST tank waste retrieval. An important decision with respect to retrieval and closure relates to establishing allowable leak loss limits. If this decision were given priority, then data collection would likely focus on tank farms and tanks targeted for early retrieval, with an eye to developing data that would allow prediction of cumulative long-term impacts resulting from past leaks, retrieval-inspired leaks, and post-closure releases.

The nature and degree of prioritization needed will drive selection of a specific prioritization methodology (i.e., to rank programmatic decisions and associated data needs). For example, if a prioritization based on schedule milestones allowed for deferral of certain data collection activities without impacting overall programmatic goals, then prioritization could be schedule-driven. If this approach did not meet the needs, then a prioritization process that in effect ranked the relative importance of programmatic goals could be employed. As appropriate, this process might involve establishing a "value model," assigning weights, and then ranking the goals.

If DOE and Ecology decide to prioritize data collection activities, the process and results will be documented in the DQO summary report as part of the WMA RFI planning process (described in Section 6.0).

Figure 5-1. Preliminary Identification of Decisions and Inputs.

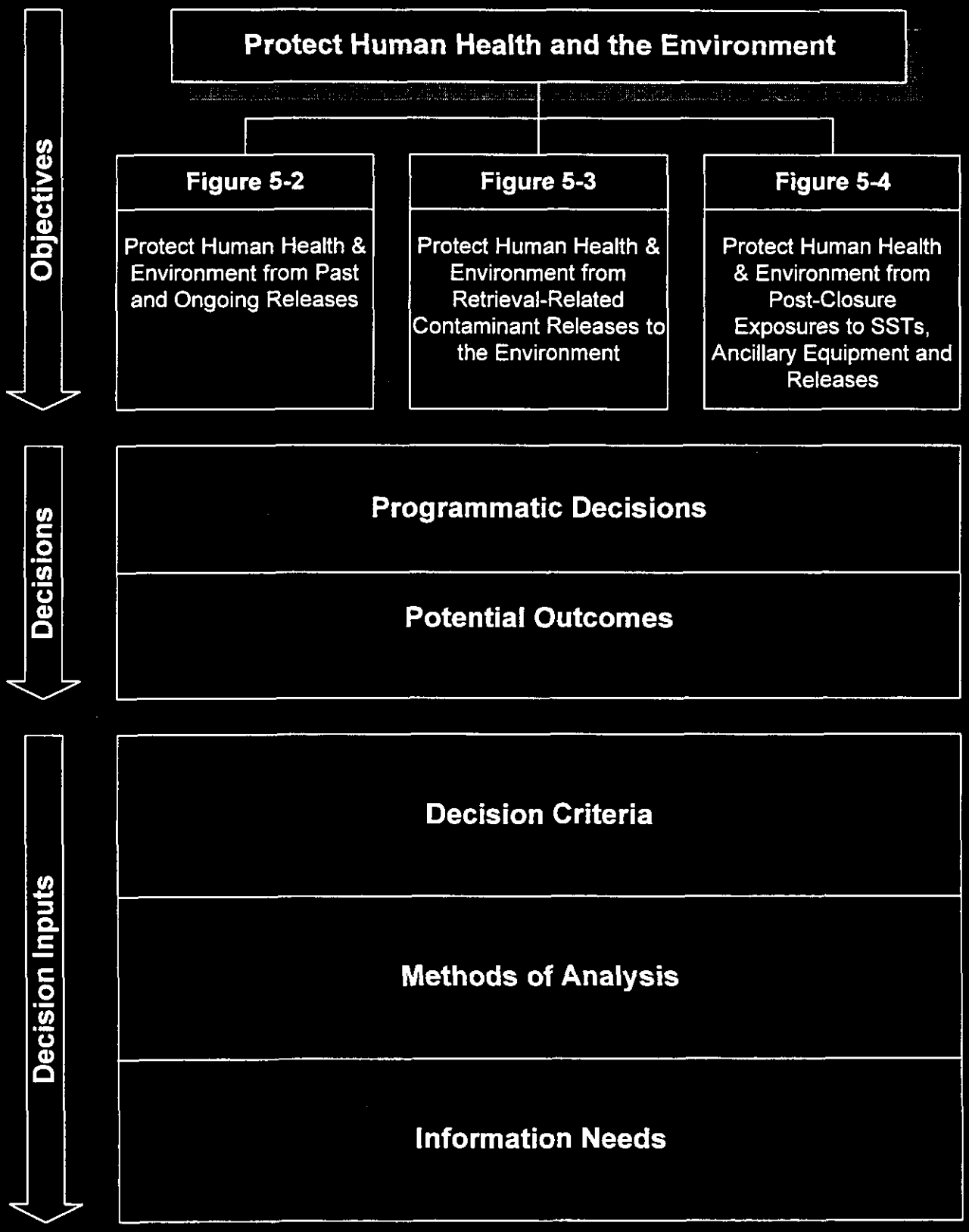


Figure 5-2. Preliminary Identification of RCRA Corrective Action Program Decisions and Inputs.

Objectives

Protect Human Health and the Environment

Protect Human Health & Environment from Past and Ongoing Releases

Decisions

Decision CA-1: Does existing vadose zone and groundwater contamination resulting from past releases of SST wastes present an unacceptable risk to human health or the environment and warrant a CMS to evaluate ICMs?

Potential Outcomes
- Threshold criteria not exceeded; no evaluation of ICMs required
- Threshold criteria exceeded; conduct CMS to evaluate appropriate ICMs

Decision CA-2: Are there ICMs that can be implemented to reduce risk and be protective of human health or the environment prior to closure and, if so, which ICMs should be implemented?

Potential Outcomes:
- General response actions include: no action, containment, removal, treatment (*in situ* or *ex situ*) and disposal
- See Section 4.2 and Appendix E for preliminary identification of ICM technologies

Decision Inputs

Criteria:
Per Section 3.0, no final post-closure land use decisions and clean-up criteria yet established; decision-makers (DOE and Ecology) have identified preliminary risk evaluation scenarios for development of threshold criteria:
- MTCA industrial and residential scenarios at WMA boundary
- MTCA industrial and residential scenarios at 200 Areas boundary
- MTCA industrial and residential scenarios at 200 Areas "buffer zone" boundary
- MTCA residential criteria at Columbia River shoreline
- Ambient water quality criteria at Columbia River

Methods:
- Contaminant fate and transport modeling through vadose zone and groundwater to predict concentrations at receptor locations
- Assessment of impacts to human health by comparing current and predicted future concentrations and/or doses to threshold criteria
- Assessment of impacts to the environment by comparing actual and predicted concentrations and/or doses to threshold criteria

Information Needs:
- Nature and extent of contamination resulting from past releases
- Assumptions regarding any future (pre-retrieval) leaks
- Contaminant transport mechanisms
- Input values for parameters required by models; e.g., hydrostratigraphic parameters (e.g., porosity, unsaturated K vs. moisture content, saturated K, bulk density, moisture retention, matrix potential); moisture content and soil temperature; cation exchange capacity; soil quality (contaminant chemistry and pH); lithologic unit thickness, area extent and features; contaminant mobility (i.e., solubility and Kd); and mineralogy and particle size distribution

Criteria:
- Protection of human health and the environment
- Attainment of media clean-up standards
- Reduction or elimination, to the extent practicable, of further releases
- Compliance with ARARs, including waste management standards
- Long-term effectiveness and permanence, and potential for success
- Reduction of toxicity, mobility or volume through treatment
- Short-term risks and the time required to achieve protection
- Ease or difficulty of implementation
- Capital and annual operations and maintenance costs
- State acceptance
- Community acceptance
- Cumulative, off-site, and socioeconomic impacts
- Environmental justice impacts

Methods:
- Regulatory compliance analyses
- Engineering evaluation of technology performance
- Contaminant fate and transport analyses to assess protectiveness or human health and the environment
- Public review process
- Constructability evaluations
- Cost estimating

Information Needs:
- Impacts evaluation-related information needs as identified for Decision CA-1
- ARARs
- Technology performance and cost data for alternatives
- Conceptual design level information for alternatives
- Stakeholder and Tribal Nation values

Figure 5-3. Preliminary Identification of Single-Shell Tank Waste Retrieval Program Decisions and Inputs.

Objectives

Protect Human Health and the Environment

Protect Human Health & Environment from Retrieval-Related Contaminant Releases to the Environment

Decisions

Decision RE-1: Do existing vadose zone and groundwater conditions constrain baseline retrieval of tank waste and demand alternative waste retrieval technologies, tank sequencing strategies, LDMM technologies and strategies, and/or other measures to protect human health and the environment?

Potential Outcomes:
- Retrieval is impacted; waste retrieval technologies, tank sequencing strategies, LDMM technologies and strategies, and/or other measures warranted
- Retrieval is not impacted; no special measures warranted

Decision RE-2: Are there alternatives to the retrieval technology assumed in the baseline plan that can be implemented to further reduce risk and be protective of human health and the environment prior to closure and, if so, which technology(ies) should be deployed?

Potential Outcomes:
- Sluicing (baseline technology)
- Vehicle-based retrieval system (under development)
- Other

Decision RE-3: Can the tank sequence for waste retrieval contribute to protection of human health and the environment and, if so, what sequence(s) are protective?

Potential Outcomes:
- Alternate tank sequencing strategies (refer to RPP baseline planning documents for strategies under consideration)

Decision RE-4: Leak Detection, Monitoring & Mitigation
Decision RE-4a: Are there internal and external leak detection technologies available that contribute to protection of human health and the environment and, if so, which technologies should be demonstrated?
Decision RE-4b: Are there external leak monitoring technologies available that may contribute to protection of human health and the environment and, if so, which technologies should be demonstrated?
Decision RE-4c: Are leak mitigation technologies available that contribute to protection of human health and the environment and, if so, which technology(ies) should be demonstrated?

Potential Outcomes:
- Alternate LDMM technologies (refer to Hanford Tanks Initiative for technologies under consideration)

Decision Inputs

Criteria (vadose zone-related):
- See criteria for Decision CA-1 (Figure 5-2)
- Ability to achieve retrieval leakage loss limits
- Ability to achieve residual waste volume goals

Methods (vadose zone-related):
- See methods for Decision CA-1 (Figure 5-2)

Information Needs (vadose zone-related):
- See information needs for Decision CA-1(Figure 5-2)
- Assumptions re retrieval losses under baseline plan
- Assumptions re residual waste volumes under baseline plan

Criteria (vadose zone-related):
- Ability to achieve retrieval leakage loss limits
- Ability to achieve residual waste volume goals

Methods (vadose zone-related):
- Establish leakage loss limits per Decision CL-3 (Figure 5-4)
- Establish residual waste volume goals per Decision CL-3 (Figure 5-4)
- Technology development (e.g., design; computer simulation; and testing [bench-scale, pilot-scale, and full-scale])

Information Needs (vadose zone-related):
- See information needs to support Decision CL-3 (Figure 5-4)

Criteria (vadose zone-related):
- Ability to support achievement of retrieval leakage loss limits
- Allows for technology testing and operations optimization on tanks with low likelihood for releases

Methods (vadose zone-related):
- Establish leakage loss limits per Decision CL-3 (Figure 5-4)
- Decision and project risk analysis methods

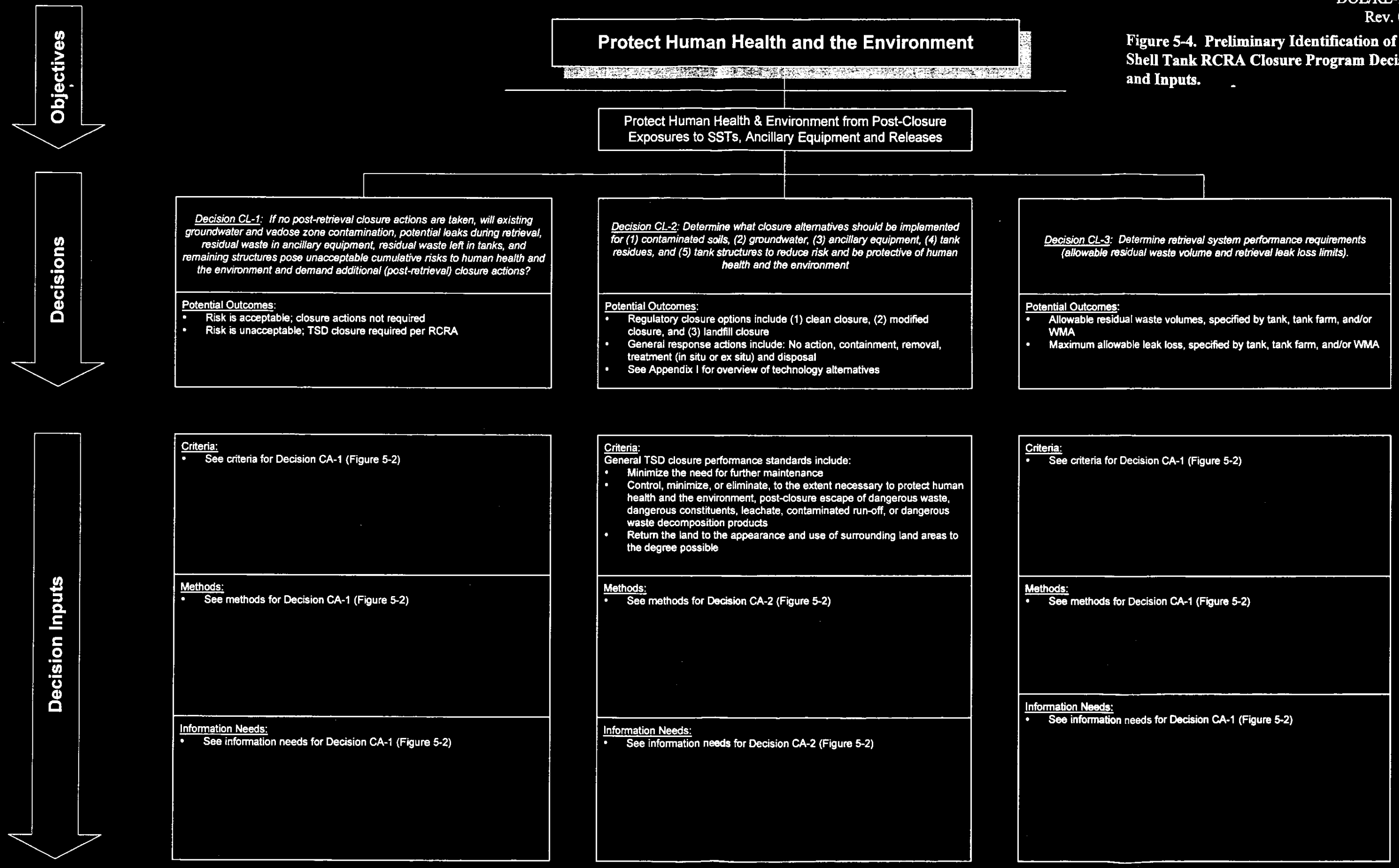
Information Needs (vadose zone-related):
- See information needs to support Decision CL-3 (Figure 5-4)
- Understanding of history of past releases as predictor of likelihood of retrieval induced releases

Criteria (vadose zone-related):
- Ability to support achievement of retrieval leakage loss limits
- Deployability and performance in subsurface

Methods (vadose zone-related):
- Establish leakage loss limits per Decision CL-3 (Figure 5-4)
- Engineering evaluation of performance
- Constructability evaluation
- Contaminant fate and transport modeling

Information Needs (vadose zone-related):
- See information needs to support Decision CL-3 (Figure 5-4)
- Technology performance data

Figure 5-4. Preliminary Identification of Single-Shell Tank RCRA Closure Program Decisions and Inputs.



6.0 PROCESS APPLICATION AND TOOLS FOR WASTE MANAGEMENT AREA ASSESSMENT AND IMPLEMENTATION

The purpose of this section is to provide a comprehensive guide for WMA project teams to utilize during the implementation of the RCAP. Included is a discussion on the application of the corrective action process (Section 6.1), a description of the DQO process as it has been defined for the RCAP (Section 6.2), and a summary of available characterization technologies for consideration during the WMA-specific addenda (Section 6.3).

6.1 CORRECTIVE ACTION PROCESS APPLICATION

The purpose of this section is to describe the major elements of the RCAP, as defined in Section 2.2. The discussion will build upon the regulatory requirements (as referenced in the following sections) and identify additional process requirements defined through the preparation of this master work plan. The major elements are discussed in the following sections.

6.1.1 Waste Management Area Addenda

This master work plan and the preparation of the WMA addenda together satisfy the requirements of a RFI/CMS work plan. The purpose of the WMA addenda is to present only WMA- and tank farm-specific details, utilizing the general information and approaches by reference to this master work plan. Required elements of the addenda are listed in Section 2.2.1 and are incorporated in the annotated outline presented in Section H2.0 of Appendix H. A summary of additional considerations or requirements identified through the preparation of this master work plan is defined as follows with a comprehensive list provided in Appendix H:

- The DQO process, as described in Section 6.2, will form the basis for the WMA addenda (Section 2.2.1).

- The focus for Phase 1 is on understanding releases from elements of the TSD units that lie within the WMA boundary. The scope of the RCAP includes assessment of contaminant releases to soils and groundwater from the RCRA SST system. Contaminants from the SST system that are beyond any fence line or local boundary are still within the scope of the program and must be appropriately addressed. Characterization to assess if contaminants at a specific location originate from the TSD units is also within the scope of the RCAP, regardless of location or environmental media to be sampled (Section 1.2.2).

- Phase 1 is intended to collect environmental data to support decision making not only for RCRA corrective action, but also for the SST waste retrieval and closure projects. In addition, Phase 1 will seek to address the information needs of other Hanford Site activities, but only to the extent that these information needs are incidental to those associated with corrective action, retrieval, and closure (Section 1.2.2).

- The characterization results and lessons-learned from the initial S-SX characterization activity will be incorporated into the planning process for the following WMA addenda (Section 1.1.2).

- Within the framework established by the GW/VZ Integration Project, the RPP Vadose Zone Project Manager will be responsible to ensure RCAP-specific interfaces are managed aggressively to support both SST and site-wide objectives (Section 1.1.4.2).

- Active scheduling will be conducted with other programs during the WMA DQO process to ensure the planned activities will be appropriately integrated and coordinated.

- As part of the DQO process, the WMA project teams will evaluate what is known about each WMA to develop WMA-specific decision statements and to design characterization programs to address the information gaps (Section 1.2.1).

- The WMA-specific DQO process must identify all relevant sites associated with, and adjacent to, the tank farms (e.g., the nearby waste site being addressed under DOE's ER Project) (Section 1.2.2).

- The tables presented in Section 3 will serve as the starting point for defining the WMA-specific COPCs during the WMA-specific DQOs (Section 2.2.1).

- The WMA-specific DQOs will establish the number, type, and location of samples and specific analytical requirements (Section 2.2.1).

- The preliminary corrective measure performance standards are intended as a guide for developing WMA-specific performance standards (Section 4.1.3), and hypothetical media cleanup standards (Section 4.1.4).

- During the DQO process, every effort should be made to identify the environmental data needs to support retrieval and closure decisions (Section 4.3).

- The WMA project teams will use the initial decision framework as a starting point for each WMA-specific DQO process (Section 5.1.2).

- The need for prioritizing decisions will be assessed following identification of data needs to support all the decisions described. If DOE and Ecology decide to prioritize data collection activities, the process and results will be documented as part of the DQO activities (Section 5.6).

- In order to ensure that data utilized in the development of WMA-specific addenda is both sound and adequate, a data evaluation and preliminary subsurface conditions description will be undertaken. Existing data will be evaluated to support the development of conceptual models, to support DQO efforts, and to identify uncertainties and data gaps.

Data of limited value will be discarded or used accordingly. This work will support the development of WMA addenda (Ecology et. al 1998).

- The WMA addenda must be approved by Ecology as primary documents under the Tri-Party Agreement. In addition, DOE and Ecology may elect to provide the addenda for public review and comment at their discretion (Section 2.2.1).

6.1.2 Phase 1 RCRA Facility Investigation

The purpose of summarizing the facility investigation is to evaluate actual and potential risks to human health and the environment from WMA contaminants such that the appropriate corrective measure can be identified and implemented. The magnitude and complexity of the SST system warrants a phased approach in summarizing and evaluating this information. Thus, a field investigation report will be prepared for each WMA followed by a cumulative Phase 1 RFI report. Required elements of both reports are listed in Section 2.2.2 and are incorporated in the annotated outlines presented in Section H3.0 and H4.0 of Appendix H, respectively.

The focus of the WMA field investigation report is to summarize data from the WMA investigation and evaluate the data to the extent necessary to determine the need for immediate action at the WMA (e.g., determine the need for IMs, identify the need for an accelerated CMS to evaluate ICMs). The evaluation would include a qualitative and limited assessment of contamination impacts on human health, but would not include evaluations of impacts to ecological receptors. Recommendations on the need for IMs or accelerating a CMS will be included in this report.

The Phase 1 RFI will build upon the results of the WMA-specific field investigation reports. Typical facility investigation topics such as the investigative approach and WMA-specific results and conclusions will be referenced to the field investigation reports. The focus of this report will be to address cumulative risks (i.e., WMAs and other potential sources to the anticipated receptor) and a more quantitative risk evaluation, as necessary, based on the initial evaluation in the WMA-specific field investigation reports. Recommendations on the need for IMs and the determination of conducting a CMS will be included in this report.

A summary of additional considerations or requirements identified through the preparation of this master work plan, pertinent to either the WMA-specific field investigation reports or the Phase 1 RFI, is defined as follows with a comprehensive list provided in Appendix H:

- Integrating risk evaluations with other Hanford Site programs (e.g., the SAC) is an important requirement to ensure consistency (Section 4.1.5).

- The general purpose is to characterize the nature, extent, rate, and direction of movement, and concentration of releases from SSTs; determine the potential need for IMs and ICMs; and aid in the selection and implementation of those measures (Section 2.2.2).

- The consolidated results will be presented in the Phase 1 RFI Report after completion of all Phase 1 investigations. The report will include descriptions of human and ecological

receptors; analyses of current concentrations and extrapolations of future movement, degradation, and fate of contaminants; evaluation of risks associated with existing contamination for several hypothetical receptor exposure scenarios; and identification of preliminary treatability studies, as appropriate (Section 2.2.2).

- In the absence of NEPA-compliant long-term land-use decisions, and for purposes of the RCAP, risks associated with releases from the SSTs would be evaluated using established MTCA exposure parameters (e.g., multiple exposure scenarios for a 1,000-year time period) and the land-use boundaries suggested by the FSUWG and Revised Draft HRA-EIS. For groundwater protection, two exposure scenarios (MTCA Methods B and C) and four hypothetical receptor locations (see Figure 4-4) may be evaluated. The evaluation would include specific evaluation scenarios agreed to by the Tri-Parties, but would at least include MTCA residential and industrial scenarios at the WMA boundary for 1,000 years (Section 4.1.2 and 4.1.5.2).

- The Phase 1 RFI will include a sensitivity analysis of key risk drivers and other pertinent parameters (e.g., temporal risk variations and contaminant fate and transport analyses) (Section 4.1.5.2).

- For direct exposure to soil contamination associated with the SSTs, only the MTCA Method C (industrial) scenario would be evaluated. For protection of surface water (the Columbia River), the MTCA Method B scenario would be evaluated (Section 4.1.2).

- As WMA-specific data become available, the preliminary corrective measure performance standards and media cleanup standard guidelines will be reevaluated and ultimately approved by Ecology via approval of an IM proposal or a permit modification for ICM implementation (Section 4.1.4).

- When the cumulative human cancer risk for contaminated media (e.g., soil, water, and air) is between 10^{-6} and 10^{-4}, the conceptual exposure model must be further evaluated and regulatory agency consultations are necessary to determine if an evaluation of corrective measures is necessary. Carcinogenic risks below 10^{-6} or hazard indices less than 1.0 are regarded as "points of departure" below which no action is required (Section 4.1.5).

6.1.3 Phase 1 Corrective Measure Study

The Phase 1 CMS will be prepared only as prescribed by the Phase 1 RFI. If possible, it is suggested that the study be coordinated with the Phase 1 RFI such that they can be issued as one document. The focus of this study is to identify and develop corrective measure alternatives; evaluate the alternatives against RCRA, CERCLA, SEPA, and NEPA criteria; and provide justification for the recommended alternative. The study will provide the basis for revision of the Hanford Facility RCRA Permit. The study will build on the information presented in Appendix E. The annotated outline is provided in Section H5.0 of Appendix H.

6.1.4 Corrective Measures Implementation

The purpose of the CMI is to design, construct, operate as appropriate, maintain, and monitor the performance of the selected ICM(s). The CMI is initiated upon selection of the first ICM(s) and may encompass one or several ICM(s), as stated in Section 2.2.4. The primary document(s) required by the Tri-Party Agreement include the corrective measures design report and the CMI work plan. If determined appropriate by DOE and Ecology, the design report and work plan may be combined into one comprehensive document. Other elements of the CMI include the following (EPA 1994):

- Conceptual design, including any necessary supporting activities such as permits, waste management determinations, engineering field investigations (e.g., surface geophysics to locate piping), engineering trade-off evaluations, treatability studies, technology demonstrations, and design evaluations.

- Final design, including design reviews and preparation for procurement process (e.g., solicitations, technical evaluations).

- Construction, including construction quality assurance, quality control, waste management, field sampling activities, construction safety, field change management, and contingency procedures.

- Construction completion and performance monitoring, including a summary of significant construction activities, certification that the construction was in accordance with the final design and contingency procedures, and definition of performance monitoring, as appropriate.

6.1.5 Interim Measures

Interim measures provide an opportunity to accelerate response to releases from the SSTs. The IMs may be implemented at any time during the corrective action process and may be defined by either DOE or Ecology. The general process for IMs is defined in Section 7.2.4 of the Tri-Party Agreement and is summarized in Section 2.2.5 of this master work plan. In accordance with the draft change control form, mechanisms for identifying IMs include but are not limited to the following:

- Engineering studies may be used to evaluate potential IMs for areas of concern (e.g., identifying leaking water lines, sealing abandoned wells, controlling surface drainage and ponding).

- Throughout the RCAP process, additional data evaluations may indicate opportunities to implement IMs. As agreed to by DOE and Ecology in the draft change control form, these opportunities will be discussed annually (by July) at a minimum.

6.2 DATA QUALITY OBJECTIVES PROCESS

The DQO process (EPA 1993a) is a planning approach, based on the scientific method[1], for defining the decisions that any data collected should satisfy. The EPA seven-step DQO process and several associated activities and workshops (see Figure 6-1) will be implemented to support the preparation of each WMA addendum. The various tasks identified in Figure 6-1 were developed through a lessons learned workshop including participants from the RPP, Ecology, DOE, and other key Hanford Site programs. As appropriate, the DQO process will include WMA-specific project managers from Ecology, EPA, and DOE, with technical support by the RPP staff, and input from other key Hanford Site programs and agencies.

The DQO process provides assurance that the type, quantity, and quality of environmental data used to support remediation decisions are suitable for the intended application. The process establishes a consistent, cooperative, and streamlined approach that encourages the optimum use of available data, information, and technical resources. The tasks defined for the DQO process are summarized in the following paragraphs:

Task 1: WMA Planning – Prior to initiating the formal DQO process, initial WMA DQO planning activities are completed. The first activity includes revising the DQO planning tools (e.g., scoping checklist and report templates, see Appendix G) to satisfy project specific requirements and lessons learned. A second activity includes defining and communicating with the required DQO participants. The final activity is the preparation of the preliminary draft DQO scoping checklist. The purpose of the checklist is to (1) present topics to assist the core team during project scoping, (2) address key scoping concepts such that the technical staff are quickly identified and assigned, and (3) form the basis for references materials.

Task 2: WMA Scoping – The technical team will complete the scoping checklist and assemble all pertinent data and information for the WMA. The subsurface conditions description report will provide a summary of evaluation of the pertinent data and information for each WMA. The technical team will identify project scoping issues and develop preliminary resolutions. The DOE project manager and other senior reviewers will participate in a workshop to discuss the scoping checklist and verify the preliminary issue resolutions.

Task 3: Decision-Maker Interview Workshop – The completed scoping checklist, including project issues and tentative resolutions, will be distributed to the decision-makers (i.e., DOE, Ecology) for review. The purpose of the workshop is to provide a brief overview of the project and reach agreement on the issue resolutions. A global issues (e.g., policy issues that cannot be resolved at the current participant level) resolution meeting will be scheduled, as appropriate, to achieve and document the resolution of global issues identified during this workshop.

[1] The scientific method involves the principles and processes regarded as characteristic of or needed for scientific investigation, including rules for concept formation, conduct of observations and experiments, and validation of hypotheses by observations or experiments.

Task 4: Tribal Nation and Integration Project Interview Workshop – The finalized scoping checklist, incorporating comments received during the previous tasks, will be distributed to the appropriate points of contact during the ongoing RPP weekly open meetings. A brief project overview and workshop summaries will be provided, as appropriate.

Task 5: Global Issues Meeting – A meeting will be scheduled to assemble the DOE and regulatory representatives to discuss project policy issues identified during Task 3. The purpose of this meeting is to provide final guidance (i.e., resolution of global issues) to the DQO team.

Task 6: Project Team Briefing – The technical team is briefed on the technical and policy issue resolutions based on the previous two tasks thus enabling the team to initiate the DQO report.

Task 7: Tribal Nation and Integration Project Briefing – As appropriate, the Tribal Nations and the Groundwater/Vadose Zone Integration Project points of contact are briefed on the final technical and policy issues resolutions.

Task 8: Prepare Strawman DQO Report (Steps 1 through 7) – The strawman DQO report is completed utilizing existing information and data (e.g., subsurface conditions) and guidance provided during the scoping checklist preparation. The report is provided as a template (see Appendix G) in a workbook format. The template consists of a series of tables, figures, and text blocks that guide the user through EPA's seven-step DQO process. Although the process is typically depicted as linear, in practice it is iterative; the outputs from one step may influence prior or subsequent steps. This iterative process leads to efficient data collection designs. The seven steps that comprise this process are the following:

- Step 1 – State the Problem
- Step 2 – Identify the Decision
- Step 3 – Identify Inputs to the Decision
- Step 4 – Define the Boundaries of the Study
- Step 5 – Develop Decision Rules
- Step 6 – Specify Limits on Decision Errors
- Step 7 – Optimize the Sampling Design.

During the first six steps, the DQO participants identify the data quality necessary to support environmental decisions. The final step of the process involves optimizing the study design based on the data quality needs. The DQO process is enhanced and simplified by using an electronic "workbook" (see Appendix G) that provides a framework for the seven DQO steps and assists technical staff in identifying and addressing relevant characterization issues and problems, preparing for technical workshops, recording the information and decisions developed, and documenting the overall decision-making process.

The outcomes of the DQO process are environmental measurements (i.e., data types, quantities, and qualities) needed to support decisions. The final version of the DQO workbook is issued as the DQO process summary report (PSR). The PSR is incorporated into the WMA addenda and will be used in the data quality assessment (DQA) process. The DQA process is not required but

may be used as an evaluation of the analytical results, performed at the conclusion of a characterization event, to verify the data are adequate to support corrective action, retrieval, and closure decisions.

Task 9: Author Review and Revise Cycle – The strawman DQO report is provided to the technical team for review. It is anticipated that a technical team workshop will be utilized to identify and resolve all comments.

Task 10: Senior Review and Revise Cycle – The revised DQO report is provided to the senior review team (e.g, DOE and LMHC) for review. It is anticipated that a workshop will be utilized to identify and resolve all comments.

Task 11: Decision-Maker, Tribal Nation, and Integration Project Review and Revise Cycle – The revised DQO report is provided for review. It is anticipated that a workshop will be utilized to identify and resolve all comments.

Task 12: Tribal Nation and Integration Project Briefing – The finalized DQO report, incorporating comments received during the previous task, will be distributed to the appropriate points of contact during the ongoing RPP weekly open meetings. A brief project overview and workshop summaries will be provided, as appropriate.

Task 13: Issue Final DQO Report – DQO report is finalized and issued.

6.3 CHARACTERIZATION TECHNIQUES AND INNOVATIVE TECHNOLOGIES

Characterization methods at the Hanford Facility combine intrusive and non-intrusive techniques. Characterization must consider proven methods and potentially applicable innovative technologies. The following sections discuss characterization methods successfully used in previous Hanford Site investigations, and promising new technologies.

Facility operations within the WMA must be conducted in accordance with the authorization basis documentation (e.g., Basis for Interim Operation (LMHC 1999c), and its associated Technical Safety Requirements document (FDH 1997b and LMHC 1999d). Operations not explicitly addressed by the authorization basis documentation must be reviewed by the Unresolved Safety Question (USQ) process prior to implementation. The USQ process examines the hazards associated with the proposed work activity, and if necessary, modifies the authorization basis documents to include activity-specific hazard controls. A USQ screening process is first used to determine if modifications to the authorization basis documents are necessary (LMHC 1999e and FDH 1997c).

The USQ process typically evaluates two broad aspects of activities such as intrusive characterization. The first includes potential hazards associated only with operation of the equipment. The second evaluates the hazards associated with the location within which the equipment is operated. The first type of evaluation need only be performed once, unless significant modifications are made to the equipment. The second type of evaluation must be

conducted for each separate location or campaign, since each location may have varying types and levels of hazards (e.g., underground utilities and process lines).

Currently, the only intrusive characterization methods that have been through the USQ process include cone pentrometer and air rotary (reverse-circulation) drilling. These processes have been evaluated for a limited number of locations. Different intrusive characterization methods and/or locations will required evaluation by the USQ process. The USQ process, and if necessary, authorization basis documentation modification and subsequent DOE approval, can take up to eight weeks or more to complete. As a consequence, adequate lead time must be factored into project schedules to ensure that milestones are not adversely impacted.

Borehole Drilling - Borehole drilling is primarily used to access the deep (>9.2 m [30 ft]) vadose zone to collect soil samples for direct analysis. Selecting a method (e.g., cable tool, air rotary, sonic) for a specific WMA depends on sampling objectives, contaminants of interest, soil properties, contamination control issues, and cost. Soil sampling with borehole drilling methods provides adequate soil volumes for laboratory analysis and provides a relatively high degree of control regarding sample depth, quality (e.g., little physical and chemical alteration due to sampling activity), and cross-contamination (e.g., contaminant drag-down).

Auger Drilling - Auger drilling is a relatively efficient (e.g., several holes per day) accepted method for collecting soil samples for direct analysis in the shallow vadose zone (0 to 12 m [0 to 40 ft]). A hollow-stem auger capable of accepting a 10-cm (4-in.) split-spoon samples can collect adequate soil volumes for analysis. Auger soil samples have considerably less volume than test pit samples but provide more control regarding sample depth and cross-contamination (e.g., contaminant drag-down). Auger sampling is a less controlled sample collection technique than when using borehole drilling methods.

Test Pit Construction and Trenching - Test pits are shallow, concave-shaped excavations that can extend to 10-m (33-ft) deep depending on the equipment used (e.g., hand excavation, backhoe, track-hoe) and the type of soil encountered. Samples are collected directly from the shovel or bucket and can be representative of as little as 152-mm (6-in.) layers of contaminated soil. Trenching is a laterally extended test pit. Trenching is useful in locating contamination, determining contaminated area geometry, and assessing the lateral extent of contamination. Test pits and trenches provide direct visual confirmation of local shallow soil stratigraphy, allow excellent access for soil sample collection, and are cost effective (less expensive than auger or borehole drilling). Application of this technique may be limited within the tank farms due to operational and safety constraints.

Cone Penetrometer or Geoprobe - The cone penetrometer system consists of special drill rods that are hydraulically pushed into the subsurface. The geoprobe system drives the same type of drill rods with a hydraulic vibratory hammer. As cone penetrometer or geoprobe rods are driven into the ground, the soil is forced aside to provide subsurface access. Both systems are very versatile and can be used to collect a wide range of data and samples, depending on the type of drill rod used. The cone penetrometer or geoprobe capabilities include the following:

- Collection of soil gas samples
- Measurement of geophysical properties
- Collection of soil samples (limited volume)
- Collection of soil moisture measurements
- Measurement of gross gamma radiation
- Collection of perched groundwater samples.

Either method can be a cost-effective tool for quickly defining the lateral and vertical extent of soil contamination at a WMA. Each method has a limited depth of penetration. The small-diameter cores that are collected are not representative of the grain size and are of insufficient volume for extensive laboratory analysis. The equipment specific mobilization cost is low and the systems can accomplish multiple rod replacements within a single day.

At the Hanford Site, the maximum depth of penetration is about 36.6 m (120 ft) under ideal conditions (e.g., sand with some gravel). The maximum depth of penetration in a gravel unit is less than 12.2 m (40 ft). Based on field experience, it is estimated that over 50% the cone pushes do not reach their target depths due to obstructions (e.g., rocks or compacted zones). The geoprobe has been used successfully at the Nonradioactive Dangerous Waste Landfill (NRDWL) site in the 600 Area to collect soil gas samples to assess the presence of volatile organic contaminants at depths of up to 30 m (98 ft) in sand and gravel soils. In the 100 Areas, the geoprobe was used to place near-river groundwater sampling wells in gravel and cobble dominated soils at depths of up to 6 m (20 ft). In a recent (April 1999) cone penetrometer demonstration, the maximum depths achieved were 19.8 m (65 ft) in the 200 West Area and 40.8 m (133.9 ft) in the 200 East Area. Difficulties in penetration, gamma logging, and core sampling at depth occurred in this cone penetrometer demonstration.

Borehole Geophysics - Borehole geophysics is commonly used at the Hanford Site to assess the distribution of gamma-emitting radioactive contaminants and to determine the moisture content in soils. A limitation of the tool is the relative short range for detection (e.g, 0.3 m [1 ft]). A high resolution spectral gamma system has been used to determine the extent of radiological contamination in the soil column identifying both man-made (e.g., Cs-137 and Co-60) and natural (e.g., K-40) gamma-emitting radionuclides, and determining lithology based on a known distribution of naturally occurring radionuclides in specific formations. Moisture content is determined using a neutron logging probe. These tools are used in conjunction with existing characterization boreholes or wells and provide a continuous reading of soil characteristics. They are easily mobilized but only one well per day can be logged due to long count periods.

When used in conjunction with newly drilled wells, the spectral gamma systems have reasonably good correlation with laboratory analytical results from samples that were collected. However, use in existing wells requires complex algorithms due to changing attenuation through multiple casings. The resulting data are not as reliable, particularly for lower gamma energies. Also, because these systems only detect gamma-emitting isotopes, key contaminants of concern such as Sr-90, Tc-99, or I-129 must be determined independently (their ratios to the gamma-emitting radionuclides are not always known).

Surface Geophysical Methods - Surface geophysical methods can be used to locate shallow 0-6.1 m (0-20 ft) subsurface features or determine surface levels of radioactive contaminants. The methods commonly used at the Hanford Site to determine subsurface features include ground-penetrating radar (GPR), electromagnetic induction (EMI), and magnetics (e.g., magnetometer). These methods are commonly used to locate suspected disposal pits, buried materials, utilities, and pipelines. Ground-penetrating radar is reliable in most situations and provides the most information of these three methods. The use of GPR requires experienced personnel and can be time consuming for large sites. Both EMI and magnetometers are good reconnaissance tools that are easier to use than GPR.

Beta-gamma detectors are used to measure surface radioactive contaminants. Current Hanford Site applications include tractor-mounted beta-gamma detectors and portable systems that can be carried by a worker. The tractor-mounted system can be driven over large areas and provides scale maps with radiation-level contours. The portable systems provide similar capabilities but are used for smaller areas or where access is restricted. Either method provides a cost-effective alternative to soil sample collection and laboratory analysis.

Vadose Zone Monitoring - Techniques are available or under final development that may be applicable to monitoring contaminant concentrations or moisture movement (e.g., tank leak detection, liquid lost during retrieval, or contaminant migration during post-closure) at WMAs. These techniques are considered appropriate for use after implementing a chosen remedy under an operation and maintenance (O&M) plan, during tank waste retrieval activities, or as part of a post-closure monitoring plan. Vadose zone monitoring techniques could be configured to show the adequacy of an item to contain contamination in place (i.e., contaminant migration detection) or to track potential liquid waste lost during retrieval. These techniques require a previously constructed installation, typically a single or multiple borehole network, to examine fluid movement potential factors, moisture content, soil gases, or to sample pore liquids. Stephens (1996) provides a good overview of vadose zone monitoring techniques and the data needs they can support.

Geophysical logging techniques can be used to interrogate the soils around a borehole. Gamma detection tools (e.g., radionuclide logging, neutron probes, acoustic velocity logs, and neutron density logging) can be used to track soil moisture or radionuclides in the soil column. Repeated measurements may detect changes in moisture content or radionuclide movement over time.

Cross-hole techniques such as gamma-ray attenuation, and tomography tools such as electrical resistance, nuclear magnetic resonance, and X-ray computed devices, offer the potential to detect minor changes in soil moisture in three dimensions with an appropriate borehole array. At the Hanford Site, electrical resistance tomography has been examined and field-tested (Narbutovskih et al. 1997). The system operates by passing an electrical current through the soil column that is monitored for changes in resistivity resulting from changes in conductivity induced by soil moisture fluctuations. Other tomography techniques are in the developmental stage but have not been widely tested.

Ground-based geophysical techniques are capable of measuring soil moisture using a combination of pre-installed subsurface sensors and surface-based interrogation or data collection systems. Electrical methods use electrodes to apply and receive a current through the soil and commonly measure resistivity changes. The method is best applied to delineate lateral extent over a target area or for depth profiling at a given point. Electromagnetic induction applies an electromagnetic pulse to the soil column and measures the response observed in soil depths from 3 to 60 m (10 to 197 ft), depending upon the spacing of the transmitting and receiving coils. It can be used to measure apparent resistivity changes in the field at a site with uniform undisturbed features. Ground-penetrating radar uses electromagnetic pulses in the radio frequency spectrum (10 to 1,000 MHz) to detect reflecting soil units and conditions. Most surface-based systems are best used as reconnaissance tools to detect relative moisture conditions and are affected by soil column layering and soil material types.

Lysimetry and tensiometry techniques are also available to measure the movement of liquids/moisture through the soil column. Each technique requires isolation of a representative disturbed or undisturbed soil mass from its surroundings. Lysimeters are designed either to collect liquids moving through the soil or monitor weight changes in the mass due to moisture additions and evaporation transpiration reductions. This technique has been used to determine the net amount of water transported across porous media and directly measure migration of contaminants. Tensiometers are designed to measure soil-water negative pressure with the aid of a bourdon gauge or manometer. By knowing the soil-water pressure in the field via tensiometer data, a soil-water characteristic curve can be constructed to determine the corresponding water content value.

Innovative Characterization Technologies - The ongoing review and implementation of innovative technologies is key to maintaining a cost-effective approach to characterization. The following technologies are promising characterization tools that are currently under development. Deployment of these technologies is expected by the year 2001 and should be considered in the WMA addenda.

- A laser-induced breakdown spectroscopy (LIBS) system can perform in situ measurements of metals including selected radionuclides in soils . The LIBS is delivered by a cone penetrometer to the required depth and performs in situ measurements from the bottom of the penetration to the surface as it is being removed. Although a recent (1998) onsite demonstration for the collection of in situ information on lead, barium, and uranium was not successful, LIBS has been shown in principle to be a potentially viable tool.

- In fission-neutron logging, a pulsed neutron generator is used to produce a burst of 14 MeV neutrons in the formation. The moisture in the formation moderates these neutrons to thermal energies and if U-235 or Pu-239 is present, epithermal fission neutrons are produced. The epithermal neutrons are detected with a Cd-wrapped He-3 detector providing a measure of fissionable radionuclide content. Pu-239 can be detected in cased boreholes to the 10 nCi/g level with this method. The fast neutrons and inelastic gamma rays produced in earth formations by a pulsed neutron generator (pulsed-neutron logging) can be used to measure formation moisture content and bulk density. Thermal

neutron capture gammas can be used to measure the concentration of many major elements (Si, Al, Na, Fe, Cl, S) and certain trace elements (Cd and Hg). The cost to develop the components of a fission-neutron logging tool that were acquired from the DOE Grand Junction Project Office into a calibrated system is estimated at $.5 million with a development time of 6 months.

- Neutron enhanced spectral gamma logging utilizes a neutron source to activate atoms of elements in sediments surrounding a borehole. The activated atoms emit gamma rays that are detected with a HPGe detector, and the identity of the emitting atoms can be determined from the energies of the particular gamma rays. This logging technology can be utilized to detect non-radioactive elements such as chlorine and nitrogen which may constitute significant portions of waste streams, as well as aluminum and calcium, the presence of which may be important in determining lithologic features for geologic mapping. This logging technology has been utilized in a characterization project at the Hanford Site SX Tank Farm, and is scheduled for use at the Plutonium Finishing Plant and the DOE Idaho National Engineering Laboratory Site.

- A ground-penetrating holography (GPH) system enhances existing GPR technology by providing location and algorithm data that produce a volumetric image of objects beneath the ground surface. A single-channel system was successfully demonstrated at the 618-4 Burial Ground in the 300-FF-1 Operable Unit. The information gained from this demonstration will support the development of a multi-channel real-time system. The existing single-channel system is currently supporting cultural resource investigations at the Hanford Site and can support other GPR activities.

- A pipe explorer system can transport characterization sensors into piping systems that are radiologically contaminated. The system deploys an airtight membrane into the pipe to minimize the potential for contamination of the characterization detector and its cabling. The system can be deployed through pipe constrictions, around 90-degree bends, vertically (up and down), and in wet conditions. Characterization tools that have been demonstrated with the system include gamma detectors, beta detectors, and video cameras. Alpha measurement capability is under development. The explorer system can be deployed in pipes as small as 50 mm (2 in.) in diameter and up to 76.3-m (250-ft) long.

- Soil gas sampling has been used to monitor changes in volatile and semi-volatile organic compounds at selected waste sites, notably in the 200 West Area, as a means of measuring carbon tetrachloride in the vadose zone. A calibrated infrared photo-acoustic spectrometer is being used either in a mobile laboratory or at boreholes to examine concentrations of volatile organic analytes. Sampling networks using existing boreholes and shallow soil probes can examine volatile organic contaminant concentrations at desired depths in the soil column.

A process for evaluating technology needs has been integrated into the applied Science and Technology (S&T) actives and coordinated with the Site Technology Coordination Group (STCG). The S&T, specific to the vadose zone technical element, is intended to address and

resolve scientific problems related to the leakage of radioactive and hazardous constituents. A plan has been developed that provides a path forward to address the various technical issues (e.g., improved characterization tools) (*Groundwater/Vadose Zone Integration Project Science and Technology Summary Description*, DOE/RL-98-48 [DOE-RL 1999c]).

The STCG has been created for each DOE complex site to understand, evaluate, and support technologies for the ER mission. The STCG is composed of stakeholders, regulators, and DOE site and contractor managers. A document is prepared on a yearly basis providing technology needs descriptions for ER. These needs can be accessed on the Hanford Site homepage, http://www.hanford.gov, and the STCG web site, http://www.pnl.gov/stch.

Figure 6-1. Data Quality Objectives Process.

Tasks	DQO Participants				
	Technical Team	DOE	Regulators	Tribal Nations	Integration Project
1: WMA Planning	✓				
2: WMA Scoping	✓	✓			
3: Decision-Maker Interview Workshop	✓	✓	✓		
4: Tribal Nations/Integration Project Interview Workshop	✓	✓	✓	✓	✓
5: Global Issues Meeting	✓	✓	✓		
6: Project Team Briefing	✓	✓	✓		
7: Tribal Nations/Integration Project Briefing	✓	✓	✓	✓	✓
8: Prepare Strawman DQO Report (Steps 1-7)	✓				
9: Author Review/ Revise Cycle	✓				
10: Senior Review/ Revise Cycle	✓	✓			
11: Decision-Maker and Tribal Nations/Integration Project Review/Revise Cycle	✓	✓	✓	✓	✓
12: Tribal Nations/Integration Project Briefing	✓	✓	✓	✓	✓
13: Issue Final DQO Report	✓	✓			

7.0 PROJECT MANAGEMENT AND PROGRAM INTEGRATION

This section describes the RCAP management and integration activities necessary to ensure program objectives are achieved. The objectives of project management during the RFI/CMS implementation are to (1) ensure the safety of the work force and the affected environment, (2) direct and document project activities, (3) ensure that project goals and objectives are met and to (4) administer the project within budget and schedule. As WMA-specific DQO workshops are conducted, the specific scope and schedule elements will be defined. These elements, as well as others defined during the DQO workshop, will result in the development of the WMA addendum.

Sections 7.1 and 7.2, respectively, present a general discussion of the WBS and areas of project management that will be common to all aspects of the program and subsequent WMA addenda. Section 7.3 discusses the overall approach to integration of the master work plan with other Hanford Site programs such as the GW/VZ Integration Project and other interested entities. Section 7.4 provides a general discussion of the schedules for the RCAP activities, including proposed milestones. Processes for Tribal Nation and public involvement, an important and necessary part of DOE activities on the Hanford Site, are discussed in Sections 7.5 and 7.6, respectively.

7.1 WORK BREAKDOWN STRUCTURE

The work breakdown structure is developed in a manner that is consistent with other Hanford Site projects. Based on DOE guidance for establishing a baseline scope, schedule, and budget document, the use of a multi-year work plan (MYWP) was adopted. The MYWP is updated annually and describes the specific details associated with each proposed project. The MYWP incorporates milestones defined in the Tri-Party Agreement (Ecology et al. 1998) and reflects the schedule and commitments made therein. It is anticipated that for each WMA addendum that is to be developed, the MYWP will define the scope, schedule, and budget to a level of detail that will be adequate for the planning and management of that project. Inherent with this approach is the assumption that a DQO workshop will be held to define the specific scope associated with each WMA. This information will be used to define or refine the information presented in the MYWP and will be used to update the integrated site baseline. The integrated site baseline provides an integrated technical, cost, and schedule life-cycle baseline for the various projects. It is a tool that is used to forecast activities into the future so appropriate staffing, funding, and schedule needs can be assessed.

A definition of the overall WBS associated with the common and WMA-specific activities has been developed based on PHMC directives. This WBS framework is consistent with the *Phased Based Hazardous, Toxic, and Radiological Work Breakdown Structure* (HTRW) (ICEG 1998) and provides a uniform structure for collecting and reporting costs on a project's life-cycle basis. The HTRW is being implemented throughout the DOE complex (e.g., Hanford ER Project), by other government agencies (e.g., EPA and U.S. Department of Defense), and by industry with the objective of promoting communication and sharing lessons learned throughout various

projects. The project phase level WBS elements, specific to the RCAP subprojects include the following:

- Phase 1 Work Plan
- WMA Addenda
- Field Characterization
- Phase 1 RFI Report
- Phase 1 Corrective Measure Study
- Corrective Measure Implementation.

7.2 PROJECT MANAGEMENT

This section addresses the basic concepts of project management that occur throughout the project's life cycle. Specific tasks that will occur throughout the RCAP, including each of the WMA-specific activities, are described in the following sections. Individuals that are associated with the project and interface with other organizations are also described.

Further guidance on schedule control, cost control, meetings, and reporting can be found in the *Management and Integration Plan* (FDH 1997a) and the *Tri-Party Agreement Action Plan* (Ecology et al. 1998).

7.2.1 Project Organization and Responsibilities

The project organization for implementing activities outlined in this master work plan is shown in Figure 7-1. The following sections describe the responsibilities of the individuals shown in Figure 7-1. The positions described here have overall management authority for the project. Additional functional support roles are described in further detail in the project management section of the QAPjP in Appendix A.

7.2.1.1 Regulatory Agencies and the U.S. Department of Energy

Senior Project Managers. Ecology, EPA, and DOE have each designated senior project managers with responsibilities for the RCAP activities. These senior project managers will serve as their agency's primary point of contact for the program under the Tri-Party Agreement. The responsibilities of the senior project managers and project managers are defined in Section 4.1 of the Tri-Party Agreement.

Project Managers. Ecology, EPA, and DOE will each designate project managers for each WMA. Ecology is designated as the lead regulatory agency for all WMAs, as indicated in the Tri-Party Agreement. The project manager from DOE will be responsible for maintaining and controlling the schedule and budget and keeping the Ecology and EPA project managers informed of the status of the activities, particularly the status of agreements and commitments.

7.2.1.2 River Protection Program Contractor

SST Program Manager. As requested by DOE, the SST program manager has the overall responsibility for safe and successful execution of all activities within the SST Program (e.g., corrective action, retrieval, and closure).

RPP Vadose Zone Project Manager. A project manager has been assigned by the SST program manager and is responsible for day-to-day management of the project. The responsibilities of the RPP Vadose Zone Project Manager will be to plan, authorize, and control work so it can be completed on schedule and within budget, and to ensure that all planning and work performance activities are technically sound. The RPP Vadose Zone project manager works closely with project controls, quality assurance, health and safety, and the field engineer to ensure that the work scope is being performed in accordance with each of these areas of responsibility. Other duties include coordinating communications with DOE, EPA, and Ecology. The RPP Vadose Zone project manager reports to the SST program manager and the DOE project manager.

7.2.2 Work Control

The primary goals of work control are to provide methods for planning, authorizing, integrating, and controlling work so tasks can be completed on schedule and within budget. The RPP ensures that all planning and work performance activities are technically sound and conform to management and quality requirements (FDH 1997a). The RPP Vadose Zone project manager will have the overall responsibility for planning and controlling investigation activities and for providing effective technical, cost, and schedule baseline management. If a subcontractor is used, the RPP Vadose Zone project manager will maintain overall project management responsibilities. The management control system used for this project must meet the requirements of DOE Order 4700.1A, *Project Management System,* or other applicable requirements and guidance (e.g., life-cycle asset management).

7.2.2.1 Cost Control. Project costs including labor, other direct costs, and subcontractor expenses (e.g., drilling and laboratory analyses) will be assessed monthly. The budget tracking activity is computerized and provides the basis for invoice preparation and review, and for preparation of cost performance reports. These reports assess the status of each project task against projected budgets, determine performance, and describe any recovery plans that may be required. Any adjustments to budgets are controlled through a formal management process, which includes the use of baseline change proposals to modify baseline budgets. The DOE project manager will update the EPA and Ecology project managers about their respective project costs to date (i.e., WMA) at the monthly unit managers' meetings.

7.2.2.2 Schedule Control. The status of scheduled milestones will be updated, at a minimum, on a monthly basis for each task on a given project. This will be performed in conjunction with cost performance reporting associated with cost tracking. The status of milestones will also be updated monthly at unit managers' meetings.

The life-cycle or total project schedule developed for the SST Program will be updated at least annually to expand the new current fiscal year and the following year. In addition, any approved schedule changes (see Section 12.0 of the Tri-Party Agreement for the formal change control system) would be incorporated at this time, if not previously incorporated. This update will be performed in the fourth quarter of the previous fiscal year (e.g., July to September) for the upcoming fiscal year in conjunction with preparation of the MYWP. Individual WMA-specific schedules are detailed in the MYWP and are summarized at a higher level of WBS in the long-range plan. In this manner, the life-cycle schedule is considered in the long-range planning efforts for the project.

7.2.3 Meetings

Project managers from DOE, EPA, and Ecology will meet monthly at unit managers' meetings to discuss progress and project costs, address issues, and review near-term plans pertaining to their respective WMA. The meetings shall be technical in nature, with emphasis on technical issues and work progress. The assigned DOE project manager for the WMA will be responsible for preparing revisions to the schedule prior to the meeting. The schedule shall address all ongoing activities associated with active WMAs. This schedule will be provided to all parties and reviewed at the meeting. Any agreements and commitments (within the project managers' level of authority) resulting from the meeting will be prepared and signed by all parties as soon as possible after the meeting. Unit managers' meeting minutes will be issued by the DOE project manager and will summarize the discussion at the meeting, with information copies provided to the project managers.

As indicated by proposed Tri-Party Agreement Milestone M-45-56 (Ecology et al. 1999), Ecology and DOE will, at a minimum, meet yearly (i.e., by July or as needed to support the MYWP) to discuss IMs. These discussions will focus on defining and determining the need for implementing IMs. As appropriate, interim milestones will be established in coordination with these activities.

Other meetings will be held, as necessary, with subcontractors and other appropriate entities (e.g., integrating projects identified in Section 7.3) to communicate information, assess project status, and resolve issues. The DOE, Ecology, and EPA project managers will be requested to participate in these meetings as part of the integration effort (e.g., WMA-specific DQO activities will include an invitation to the GW/VZ Integration Project, DOE, Ecology, and EPA project managers).

7.2.4 Records Management

The Tri-Party Agreement specifies documentation and records management requirements for remediation activities at the Hanford Site. The Tri-Party Agreement categorizes applicable supporting documents based on the importance of documenting final data or use in decision making to support remediation. Under the Tri-Party Agreement, these applicable documents are categorized as either primary or secondary documents. Tables 8-1 and 8-2 of the Tri-Party Agreement provide a general list of primary and secondary documents, respectively. Specific to the RCAP, primary documents include this master work plan, the various WMA addenda, the

RFI report, and the CMS. Currently, the field investigation report is the only defined secondary document.

The Tri-Party Agreement describes the process for review, comment, and revision of documents supporting cleanup of a WMA. The information management overview (Appendix C of this master work plan) details the applicable programs for records management. As noted in Subsection 7.2.1, project managers are responsible for implementing Tri-Party Agreement requirements for the RCAP. Revisions, should they become necessary after finalization of any document, will be in accordance with Section 9.3 of the Tri-Party Agreement. Changes in the work schedule, as well as minor field changes, can be made without having to process a formal revision. The process for making these changes will be as stated in Section 12.0 of the Tri-Party Agreement. The Administrative Record will be maintained to support activities in accordance with Section 9.4 of the Tri-Party Agreement.

The project file will be maintained in an organized and secure manner and will be accessible to the appropriate project personnel. All field reports, field logbooks, health and safety documents, QA and quality control (QC) documents, laboratory data, memoranda, correspondence, and reports will be logged into the project file upon receipt or transmittal.

7.2.5 Progress and Final Reports

Monthly progress will be documented at unit managers' meetings. Meeting minutes will be prepared, distributed to the appropriate personnel and entities (e.g., project managers, coordinators, contractors, and subcontractors), and entered into the project file. The process for document review and comment, and maintenance of the Administrative Record is covered by the *Tri-Party Agreement Action Plan* (Ecology et al. 1996).

7.2.6 Quality Assurance

The specific planning documents required to support the RCAP will be developed within the overall QA program structure mandated by the DOE for all activities at the Hanford Site. Within that structure, the documents are designed to meet current EPA guidelines for format and content, and are supported and implemented through the use of standard operating procedures drawn from the existing program or procedures that have been developed specifically for environmental investigations (see various appendices).

To ensure that the objectives of the RCAP are met in a manner consistent with applicable DOE guidelines, all work conducted will be performed in compliance with the *Quality Assurance Program Plan* (LMHC 1997), which specifically describes the application of requirements to environmental investigations. The QAPjP (provided in Appendix A of this master work plan) supports the overall approach described in this section. The QAPjP defines the specific means that will be used to help ensure that the sampling and analytical data are defensible and will effectively support the investigation DQOs. Details that are specific to each WMA under investigation will be documented in a QAPjP section of the WMA addendum, which will be reviewed and approved by the Ecology project manager for the respective WMA.

7.2.7 Health and Safety

The health and safety plan (HASP) (see Appendix B) will be used to implement standard health and safety procedures for employees and contractors engaged in RCAP activities. More specific details on the management aspects of the HASP are found in the Appendix B. A WMA-specific HASP will be written for each addendum or field activity, as necessary, and as determined by the health and safety officer assigned to the project. Minor activities that do not require the level of detail found in the HASP will be covered by an activity hazard analysis.

7.2.8 Community Relations

Community relations activities will be conducted in accordance with the *Community Relations Plan for the Hanford Federal Site Facility Agreement and Consent Order* (Ecology et al. 1997). All community relations activities associated with the RCAP will be conducted under this overall Hanford Site community relations plan.

7.3 INTEGRATION WITH OTHER PROGRAMS AND AGENCIES

Several ongoing Hanford Site characterization, remediation, and other activities may impact or be impacted by the RCAP activities. Integration of these activities is important to optimize the use of resources and provide an understanding of cumulative impacts. Recently, DOE formed the GW/VZ Integration Project to ensure the integration of groundwater and vadose zone activities on the Hanford Site. The GW/VZ Integration Project is managed by the Environmental Restoration Contractor (ERC). The RCAP is committed to integrating the planning, field activities, and analyses with principal interfaces in support of these integration projects. The following sections discuss project scope, points of contact, and integration needs associated with the following principal interfaces:

- GW/VZ Integration Project
- Groundwater Management Project
- 200 Areas remedial action assessment
- Other RPP projects
- Other related Hanford Site projects
- Other organizations.

Integration will primarily occur through monthly project reporting and coordination and involvement during DQO activities. Additional benefit can be gained through communication on innovative technology lessons learned and by coordinating resources. A summary of the integration points is provided in Table 7-1.

7.3.1 Groundwater/Vadose Zone Integration Project

The GW/VZ Integration Project was established by the DOE to ensure the protection of water resources, the Columbia River environment, river-dependent life, and the users of Columbia River Resources, as defined in the *Groundwater/Vadose Zone Project Management Plan,* (DOE-RL 1998e). The role of the GW/VZ Integration Project is to integrate on a Hanford Site-wide basis the (1) vadose zone and groundwater characterization and remediation efforts, and (2) composite cumulative impact assessments of Hanford Site-derived contamination for use in making cleanup decisions. The three work areas associated with this role include the following:

- The work scope directly funded and managed by the GW/VZ Integration Project, such as the SAC, science and technology (S&T), peer review, and public involvement
- The projects (e.g., RCAP) funded and executed by other organizations
- Other Hanford Site activities that may interface with groundwater and vadose zone activities.

The key contact points for the GW/VZ Integration Project, and the responsible organization, (e.g., PNNL, ERC, and LMHC) include the following:

- Project Manager, ERC
- Project Engineer, ERC
- SAC Integration Project Lead, PNNL
- S&T Integration Project Lead, PNNL
- RPP Vadose Zone Project Manager, LMHC.

Several important integration points are identified as follows:

- Coordinating conceptual, groundwater flow, groundwater transport, vadose transport, and risk assessment models with the SAC
- Coordinating inventory, groundwater, and vadose data model inputs with the SAC
- Coordinating the tank farm vadose zone database with the SAC
- Identifying cost-effective characterization methods in coordination with S&T
- Identifying a common set of QA/QC requirements for vadose zone and groundwater information
- Identifying data deficiencies and resolution priority.

7.3.2 Groundwater Management Project

The Groundwater Management Project includes the Hanford Site groundwater remediation, assessment, and monitoring activities. The groundwater management activity provides an integrated site-wide assessment of groundwater quality on the Hanford Site and an assessment of potential offsite impacts. Specific activities and the responsible organization (e.g., PNNL or ERC) include the following:

- SST RCRA Groundwater Monitoring, PNNL – This program monitors the impacts of SST farm leaks on the groundwater in accordance with RCRA groundwater monitoring requirements.

- Groundwater and Vadose Remediation Systems, ERC – This consists of GW/VZ vapor monitoring to support groundwater remediation and vapor extraction systems in the 200 West Area.

- Hanford Site Groundwater Monitoring, PNNL – This consists of the Site-wide groundwater monitoring to track contaminant plume movement from non-RCRA past liquid disposal operations, and documents the overall distribution and movement of contaminants in groundwater beneath and adjacent to the Hanford Site. Also included is vadose monitoring to investigate contaminant distribution and movement above the water table disposal sites that are not part of the tank farm.

- Site-wide Groundwater and Vadose Modeling, PNNL – Groundwater and vadose modeling focuses on the development of conceptual and numerical models of Hanford Site geology and hydrology.

- Hanford Well Information System Database, ERC – This database consists of a compilation of existing well information (e.g., well data, well identification, and status) for the Hanford Site.

- Hanford Environmental Information System, ERC – A computer-based information system used as a resource for the storage, statistical analysis, and display of investigative data collected for use in site characterization and remediation activities. Subject areas include geophysics and soil gas, vadose zone soil (geologic), groundwater, atmospherics, and biota.

The key contact points for this project, and the responsible organization, are identified below:

- Groundwater Management Project Lead, ERC
- Sampling and Analyses, PNNL
- Sample Collection, Waste Management Northwest
- Drilling, Well Maintenance, and Abandonment, Waste Management Northwest
- SST RCRA Groundwater Monitoring Project Lead, PNNL.

Several important integration needs are identified below:

- Integrating sources (i.e., waste sites and associated vadose zone contamination) with the groundwater projects will be required to implement RCAP for the RPP and ER projects (e.g., waste site ownership constraints, complimentary activities)

- Understanding the activities and strategies of the 200 Area groundwater operable unit (OU) assessment, and remedial actions to assist in the planning and integration of the RCAP, retrieval, and closure projects

- Ensuring that the objectives of the Assessment Monitoring Program, RCAP, and Hanford Site Groundwater Monitoring Program are integrated and aligned

- Involving RCAP in the review of the Assessment Monitoring Program for the WMAs.

7.3.3 200 Areas Remedial Action Assessment

The 200 Areas Remedial Action Assessment project is a core project under the Groundwater and Vadose Zone Integration Project that manages the assessment and remediation of ER waste sites in and around the 200 Areas. The project's focus is on approximately 700 contaminated soil sites that resulted from the discharge of liquids and solids from 200 Area processing facilities including ponds, ditches, cribs, trenches, french drains, burial grounds and unplanned releases.

The framework and approach to conducting 200A ER assessment and remediation activities has been defined in the 200 Areas RI/FS Implementation Plan (DOE-RL 1999). The regulatory framework integrates past-practice and RCRA TSD requirements into a single approach based on the CERCLA process. This process includes the following activities for each OU:

- Preparation of a RI/FS work plan (and RCRA TSD sampling, if applicable), based on DQOs, that defines the scope of the remedial investigation

- Conduct the remedial investigation

- Preparation of a RI report that includes a summary of the RI results, refinement of the contaminant distribution model and an assessment of risks

- Preparation of an FS report (and RCRA TSD closure plans, if applicable) that evaluates a range of remedial alternatives and identifies a preferred alternative

- Preparation of a proposed plan (and draft RCRA permit modification, if applicable) that presents a preferred approach to remediation to the public

- Issuance of a ROD (RCRA permit modification, if applicable)

- Conduct confirmatory sampling and preparation of remedial design documents

- Perform the remedial action

- Conduct verification sampling and preparation of post-remediation O&M plans (and RCRA TSD post-closure plans, if applicable)

- Perform waste-site closeout activities.

The characterization framework to support the initial assessment (RI/FS) phase of work includes the grouping of waste sites into 23 process-based Ous that facilitates the application of the analogous site concept. The analogous site concept allows a more focused characterization effort on waste sites that best represent the OU. Typical and worst case representative waste sites have been tentatively identified in DOE-RL 1999 and are subsequently finalized during the DQO process to define the scope of the initial remedial investigation. Characterization data from the representative waste sites are then used to support cleanup decisions for the entire OU. Characterization data will ultimately be collected on all waste sites under a confirmatory sampling phase coinciding with remedial design activities. Following remediation, verification sampling will be performed to confirm that cleanup goals have been achieved.

The 200 remedial action project has also taken the lead in the development and evaluation of engineered surface barriers for remediating waste sites. Three surface barrier designs have been developed for Hanford Site climatic conditions for various categories of waste types that provides a range of protection levels (i.e., graded approach). Four years of performance monitoring has recently been completed on a full-scale prototype of the Hanford Barrier design constructed in the 200 east Area (*200-BP-1 Prototype Barrier Treatability Test Report*, DOE/RL-99-11 [DOE-RL 1999b).

The point of contact for this project is the ERC Task Lead.

A list of integration needs are identified below:

- Consistent set of criteria to establish consistent priorities to facilitate the coordination of activities that would initially include the sequencing of OUs and selection of associated representative waste sites. In the longer-term, this would facilitate the coordination of risk based goals, approach, and sequence. An initial effort would be required to establish the criteria followed by an annual review of the criteria and priorities to support integrated work planning. The GW/VZ Integration Project would facilitate this integration need by FY 2000.

- Coordination of characterization activities, starting with DQO development, to leverage characterization performed by both parties.

7.3.4 Other Projects Under the River Protection Project

Other projects within RPP that interface with the RCAP are the immobilized waste program, tank farm waste storage, tank farm waste retrieval, tank farm closure, and surveillance activities.

The goal of the RPP immobilized waste program is to store the immobilized high-activity waste product until it is shipped to a federal repository and to dispose of the immobilized low activity waste (ILAW) product at the Hanford Site. To support planned disposal of low-activity waste, information is being assembled to assess the performance and risk associated with ILAW.

The goals of the waste storage, retrieval, and closure projects are safe storage of tank waste, retrieval of tank waste for treatment and immobilization, and closure of the tank farms. Waste storage provides data on the tank contents, tank farm configuration, and tank integrity, and establishes the rules under which RCAP activities (e.g., borehole drilling and IMs) are conducted to ensure safety. The closure project must ensure the long-term protection of water resources, which will depend on a sufficient understanding of transport processes through the vadose zone.

The scope for waste retrieval includes evaluating the retrieval technologies and establishing leak loss limits and detection (i.e., LDMM) during retrieval. The LDMM activity is an ongoing effort to identify technologies and establish the strategy to detect, monitor, and mitigate leakage during the retrieval of the tank waste. The objective of the program is to identify and develop technologies and procedures that ensure retrieval operations are conducted in a manner that protects human health and the environment from potential leakage during retrieval activities.

In addition, spectral gamma logging is an ongoing activity in support of tank farm surveillance. Gamma-logging data are used to detect leaks, identify the leak movement, and determine the leak source.

The key contact point for other RPP projects or tasks, and the responsible organization (e.g., LMHC or DOE-GJO), include the following:

- RPP SST Tank Retrieval Project Lead, LMHC
- RPP SST Tank Closure Project Lead, LMHC
- RPP Waste Storage Project Lead, LMHC
- RPP Immobilized Waste Project Lead, LMHC
- RPP Leak Detection, Mitigation, and Monitoring Project Lead, LMHC
- RPP Tank Farm Operation Manager, LMHC
- RPP Surveillance Activities, LMHC
- Spectral Gamma Survey Project Lead, DOE-GJO.

Important integration needs are identified below:

- Determine applicable and endorsed conceptual, groundwater flow, groundwater transport, vadose transport, and risk assessment models (e.g., applicability of the AX tank farm RPE[1] criteria assessment as a model for WMAs).

- Develop and implement common database configuration.

- Evaluate the spectral gamma information with respect to possible leak detection and contamination migration.

- Integrate information to assist in assessing fate and transport, and the nature and extent of contamination.

- Improve investigation techniques (e.g., borehole surveillance, subsurface sampling, and analysis).

7.3.5 Other Related Hanford Site Projects

Waste will be generated during tank farm vadose zone and groundwater characterization. Several waste management programs are available to support the management of waste during characterization activities. These programs include the Liquid Waste Processing Facilities Program, the ERDF, and the Solid Waste Management Program.

The Liquid Waste Processing Facilities Program provides integrated liquid effluent management to support cleanup of the Hanford Site. Effluent streams generated in the 200 Areas are retained, processed, and disposed at the Liquid Effluent Retention Facility (LERF), the 200 Area Effluent Treatment Facility (ETF), the 200 West and 200 East Treatment Effluent Disposal Facility (TEDF), respectively. These effluents include condensates from the 242-A Evaporator liquids related to DST wastes, the 200-UP-1 pump-and-treat project, 222-S Laboratory wastes, and leachate from the ERDF. Databases used by the program include HEIS and the Liquid Effluent Monitoring Information System.

The ERDF is used for disposing of low-level radioactive remediation waste, chemically contaminated remediation waste, and remediation waste that contains both chemical and radioactive constituents (i.e., mixed remediation waste). The waste is generated during environmental remediation of CERCLA past-practice units. The ERDF also interfaces with the liquid waste program for treatment of the ERDF leachate. Waste disposal is performed for ERC by the subcontractor, Waste Management Federal Services.

The Solid Waste Management Program is responsible for operating the low level burial grounds which accepts low-level waste for disposal, the Central Waste Complex (CWC) for storing

[1] The RPE is a demonstration of a methodology that considers waste retrieval technologies, potential leak losses, closure strategies, and end state variations using contaminant transport and risk evaluation models.

transuranic (TRU) and mixed waste, T Plant for decontaminating equipment, and the Waste Retrieval and Processing Facility (WRAP) for treating TRU waste.

The key contact points for these projects, and the responsible organization (e.g., PHMC or ERC) include the following:

- Liquid Effluent Treatment and Disposal Program Manager, PHMC
- ERDF Project Manager, ERC
- Solid Waste Management Project Manager, PHMC.

7.3.6 Other Organizations

In addition to other projects operating at the Hanford Site, a number of organizations participate in providing recommendations that can affect the path of the RCAP. These organizations include the Hanford Advisory Board, the Interagency Management Integration Team, the Washington State Department of Health, Tribal Nations, the State of Oregon, and other interested stakeholders. This participation in project activities is defined in Sections 7.5 and 7.6.

7.4 SCHEDULE

Figure 7-2 provides a schedule that identifies the anticipated Tri-Party Agreement milestone dates. During the fiscal year planning effort (i.e., MYWP), this milestone schedule will be updated. The detailed project schedule will implement the WBS (see Section 7.1) and will be updated during monthly unit managers' meetings.

7.5 TRIBAL NATION ROLE AND INVOLVEMENT

The Hanford Site is located on land ceded to Federal government by treaties in the year 1855 with the Yakama Nation and the Confederated Tribes of the Umatilla Indian Reservation (i.e., the Umatilla, Cayuse, and Walla Walla Tribes). The Nez Perce Tribe has treaty rights on the Columbia River. The Yakama Nation and Confederate Tribes of the Umatilla Indian Reservation retain rights and privileges in the ceded areas, including the right to take fish at usual and accustomed places, to erect temporary buildings, to hunt, to gather roots and berries, and to pasture horses and cattle on open and unclaimed land.

In addition to the treaties of 1855, the following laws apply to Native American rights and culture at the Hanford Site: the *American Indian Religious Freedom Act of 1978*, the *Archaeological Resources Protection Act of 1974*, the *National Historic Preservation Act of 1966*, the *Native American Graves Protection and Repatriation Act*, and the *American Antiquities Preservation Act of 1906*.

The DOE provides grants to the Yakama Nation, the Confederated Tribes of the Umatilla Indian Reservation, and the Nez Perce Tribe to ensure their involvement in the environmental restoration and waste management activities for cleanup of the Hanford Site. The tribes will

advise the RCAP activities through direct consultation and project involvement (e.g., DQO meetings). The tribes also participate in formal groups such as the State and Tribal Government Working Group, the Hanford Advisory Board, the Hanford Summit Steering Committee, and the Hanford Environmental Dose Reconstruction Project's Native American Working Group.

7.6 PUBLIC INVOLVEMENT

Public involvement is an integral and necessary part of DOE activities on the Hanford Site to ensure that decisions are made with the benefit and consideration of important public perspectives. Public involvement creates a mechanism that brings a broad range of diverse viewpoints and values into the DOE decision-making process, which enables DOE to make more informed decisions, improve quality through collaborative efforts, and build mutual understanding and trust between DOE and the public. Within the RCAP, opportunities for public involvement will occur throughout the process. Specific areas of public involvement are discussed in Section 2.3.

Public participation opportunities are available through a number of organizations such as those discussed in Section 7.3. In addition, the community relations plan (Ecology et al. 1997) specifies how the public can be involved in the processes that are followed on the Hanford Site. This is discussed further in Section 10.0 of the *Tri-Party Agreement Action Plan* (Ecology et al. 1996).

Figure 7-1. Project Organization for the RCRA Corrective Action Program.

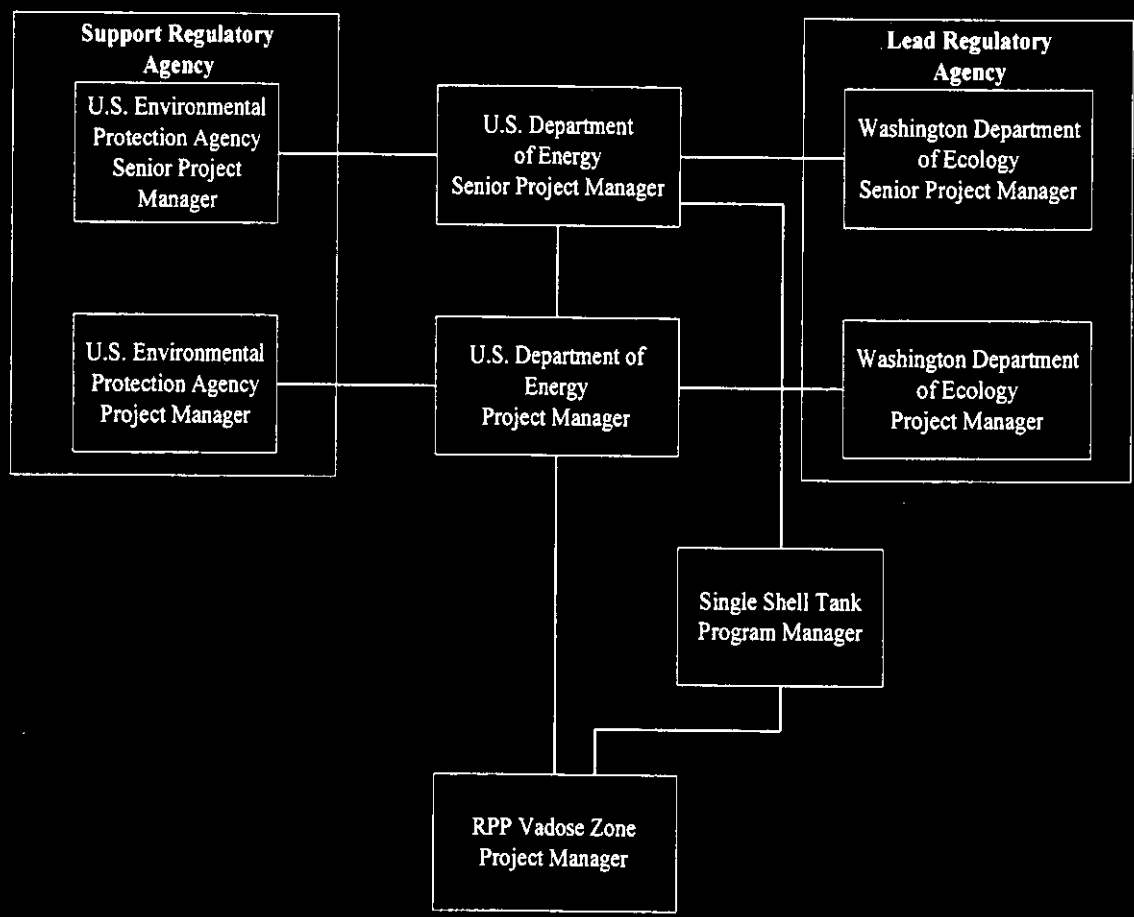


Figure 7-2. RCRA Corrective Action Program Schedule.

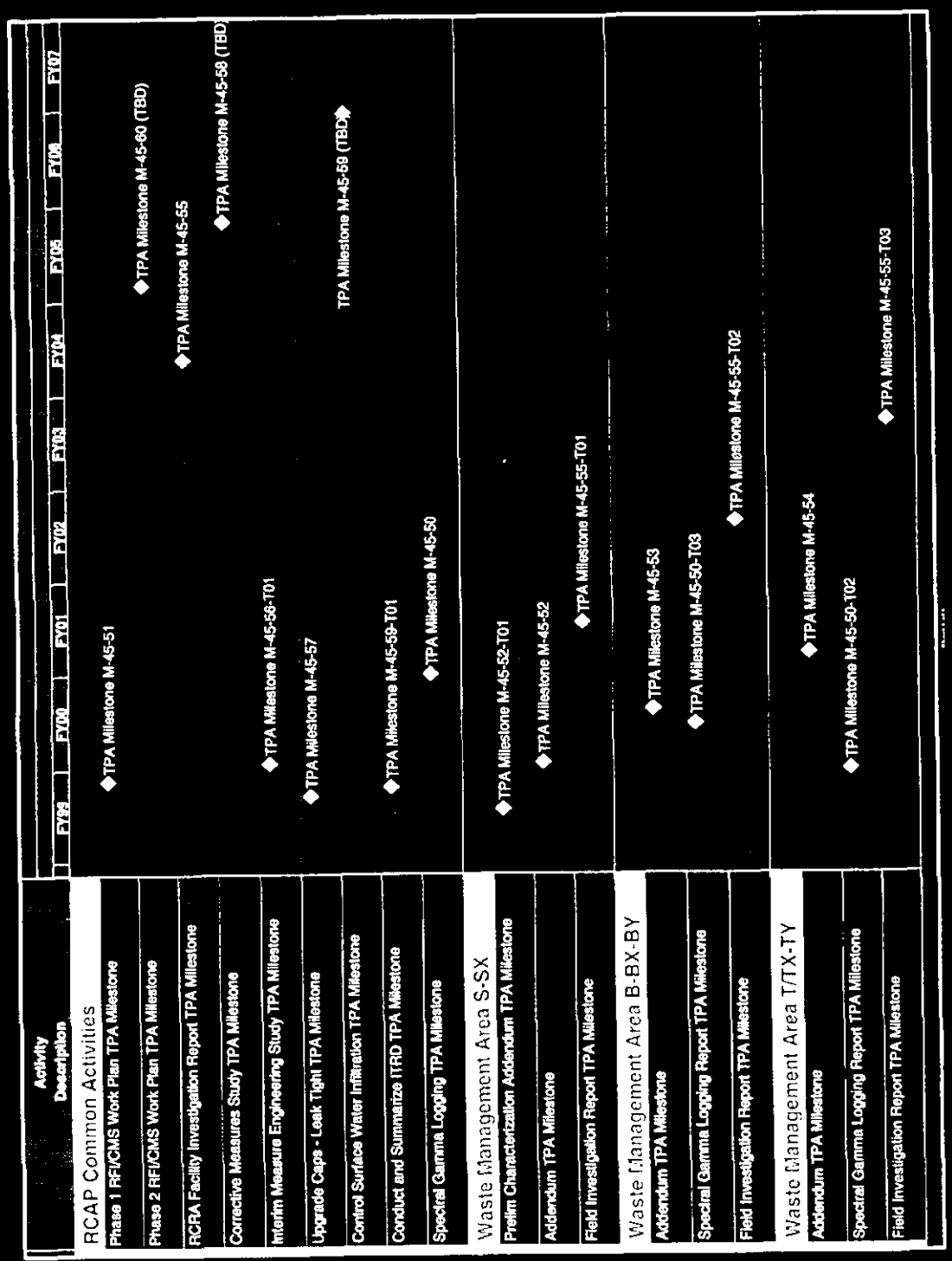


Table 7-1. Summary of RCAP Integration Points.

Integration Points	Groundwater/ Vadose Zone Integration Project	Groundwater Management Project	200 Areas Remedial Action Assessment	Other Projects Under the River Protection Project	Other Related Hanford Site Projects
	Principal Interfaces				
Conceptual Models	*	*	--	*	
Groundwater Flow Models	*	*	--	*	
Groundwater Transport Models	*	*	--	*	
Vadose Zone Transport Models	*		--	*	
Risk Assessment Models	*	--	--	*	
Contaminant Inventory	*	--	*	*	--
Model Inputs	*	*	--	*	
Databases	*	--	--	*	
Characterization Methods	*	*	--	*	
QA/QC Requirements	*	--	--	--	
Data Deficiencies and Resolution Priorities	*	--	--	--	
Integrating Source Impacts	*	*	*	--	
Waste Management					*
Schedule Coordination	*	*	*	*	
Project Objectives and Priorities	*	*	*	*	
Project Reviews	*	*	--		

* Key Integration Points
-- Secondary Integration Points

8.0 REFERENCES

10 CFR Parts 0 through 199, "Nuclear Regulatory Commission," *Code of Federal Regulations*, as amended.

10 CFR Part 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories," *Code of Federal Regulations,* as amended.

10 CFR Part 835, "Occupational Radiation Protection," *Code of Federal Regulations,* as amended.

10 CFR Part 1021, "National Environmental Policy Act Implementing Procedures," *Code of Federal Regulations,* as amended.

40 CFR Parts 190 through 195, "Radiation Protection Programs" (Subchapter F), *Code of Federal Regulations,* as amended.

40 CFR Parts 260 through 280, "Solid Wastes" (Subchapter I), *Code of Federal Regulations,* as amended.

40 CFR Part 300, "National Oil and Hazardous Substances Pollution Contingency Plan," *Code of Federal Regulations,* as amended.

40 CFR Parts 1500 through 1508, "Council on Environmental Quality," *Code of Federal Regulations,* as amended.

52 FR 2923, 1987, "Superfund Implementation," *Federal Register,* pp. 2923-2978, Executive Order 12580, January 1987.

55 FR 30798, 1990, "Corrective Action for Solid Waste Management Units (SWMUs) at Hazardous Waste Management Facilities, USEPA, Proposed Rule," *Federal Register*, pp. 30798-30810 (July 27).

62 FR 8693, 1997, "Record of Decision for the Tank Waste Remediation System, Hanford Site, Richland, Washington, U.S. Department of Energy," *Federal Register*, Volume 62, pp. 8693-8704 (February 26).

Adams, M. R., 1998, *Fiscal Year 1999, Waste Information Requirements Document*, HNF-3136, Rev. 0, Lockheed Martin Hanford Corporation, Richland, Washington.

Agnew, S. F., R. A. Corbin, F. B. Duran, K. A. Jurgensen, T. P. Ortiz and B. L. Young, 1995, *Waste Status and Transaction Record Summary*, WHC-SD-WM-TI-614, -615, -669, and –689, Rev. 2, Chemical Science and Technology Division, Los Alamos National Laboratory, Los Alamos, New Mexico.

Agnew, S. F., 1997, *Hanford Tank Chemical and Radionuclide Inventories: HDW Model*, Rev. 4, LA-UR-96-3860, Chemical Science and Technology Division, Los Alamos National Laboratory, Los Alamos, New Mexico.

Agnew, S. F., and R. A. Corbin, 1998, *Analysis of SX Farm Leak Histories—Historical Leak Model (HLM)*, LA-UR-96-3537, Chemical Science and Technology Division, Los Alamos National Laboratory, Los Alamos, New Mexico.

American Antiquities Preservation Act of 1906, 16 U.S.C. 431, 432, 433.

American Indian Religious Freedom Act of 1978, 42 U.S.C. 1996, et seq.

Anderson, J. D., 1990, *A History of the 200 Area Tank Farms*, WHC-MR-0132, Westinghouse Hanford Company, Richland, Washington.

ARHCO, 1973, *241-T-106 Tank Leak Investigation*, ARH-2874, Atlantic Richfield Hanford Company, Richland, Washington.

Archeological Resources Protection Act of 1974, and Historic Preservation Act of 1974, 16 U.S.C. 469, et seq.

Atomic Energy Act of 1954, 42 U.S.C. 2011, et seq.

Baker, V., B. N. Bjornstad, A. J. Busacca, K. R. Fecht, E. P. Kiver, U. L. Moody, J. G. Rigby, D. F. Stradling, and A. M. Tallman, 1991, *Quarternary Geology of the Columbia Plateau.* In Morrison, R. B. (ed.), *Quarternary Nonglacial Geology; Conterminous U.S.*, The Geological Society of America, v. K-2, pp. 215-250.

Barnett, D. B., C. J. Chou, P. E. Dresel, B. M. Gillespie, H. Hampt, D. G. Horton, V. G. Johnson, J. W. Lindberg, J. P. McDonald, R. B. Mercer, D. A. Myers, S. H. Narbutovskih, D. R. Newcomer, R. E. Peterson, R. Randall, S. P. Reidel, J. T. Rieger, V. J. Rohay, R. J. Serne, D. S. Sklarew, D. L. Stewart, L. C. Swanson, M. D. Sweeney, C. J. Thompson, P. D. Thorne, E. C. Thornton, W. D. Webber, R. L. Weiss, B. A. Williams, M. D. Williams, and S. K. Wurstner, 1999, *Hanford Site Groundwater Monitoring for Fiscal Year 1998*, PNNL-12086, Pacific Northwest National Laboratory, Richland, Washington.

Bauer, R. G., D. Erb, C. D. Wittreich, 1999, *200-CW-1 Gable/B-Pond and Ditches Cooling Water Waste Group Remedial Investigation DQO Summary Report*, BHI-01239, Bechtel Hanford, Inc., Richland, Washington.

Baumhardt, R. J., 1989, *Single-Shell Tank Leak Volumes*, letter 8901832B R1 to R. E. Gerton, U.S. Department of Energy, Richland Field Office, dated May 15, 1989, Hanford Engineering Development Laboratory, Richland, Washington.

Berube, R. P., 1997, *Guidance on National Environmental Policy Act (NEPA) Review for Corrective Actions under the Resource Conservation and Recovery Act (RCRA),* dated December 23, 1987, U.S. Department of Energy, Washington, D.C.

BHI, 1994, *Engineering Evaluation of the GAO-RCED-89-157, Tank 241-T-106 Vadose Zone Investigation*, BHI-00061, Rev. 00, Bechtel Hanford, Inc., Richland, Washington.

BHI, 1995, *Miocene- to Pliocene-Aged Suprabasalt Sediments of the Hanford Site, South-Central Washington*, BHI-00184, Bechtel Hanford, Inc., Richland, Washington.

Bjornstad, B. N., K. R. Fecht, and A. M. Tallman, 1987, *Quaternary Stratigraphy of the Pasco Basin Area, South-Central Washington,* RHO-BW-SA-563A, Rockwell Hanford Operations, Richland, Washington.

Chatters, J. C., and N. A. Cadoret, 1990, *Archaeological Survey of the 200 East and 200 West Areas, Hanford Site, Washington*, PNL-7264, Pacific Northwest Laboratory, Richland, Washington.

Clean Water Act of 1977, 33 U.S.C. 1251, et seq.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), 42 U.S.C. 9601, et seq.

Connelly, M. P., J. V. Borghese, C. D. Delaney, B. H. Ford, J. W. Lindberg, and S. J. Trent, 1992a, *Hydrogeologicic Model for the 200 East Groundwater Aggregate Area,* WHC-SD-EN-TI-019. Westinghouse Hanford Company, Richland, Washington.

Dirkes, R. L., and R. W. Hanf, 1998, *Hanford Site Environmental Report for Calendar Year 1997*, PNNL-11472, Pacific Northwest National Laboratory, Richland, Washington.

DOE Order 435.1, *Radioactive Waste Management*, as amended, U.S. Department of Energy, Washington, D.C.

DOE Order 451.1A, *National Environmental Policy Act Compliance Program*, as amended, U.S. Department of Energy, Washington, D.C.

DOE Order 4700.1A, *Project Management System*, as amended, U.S. Department of Energy, Washington, D.C.

DOE Order 5400.1, *General Environmental Protection Program*, as amended, U.S. Department of Energy, Washington, D.C.

DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, as amended, U.S. Department of Energy, Washington, D.C.

DOE Order 5820.2A, *Radioactive Waste Management*, as amended, U.S. Department of Energy, Washington, D.C.

DOE, 1988, *Site Characterization Plan*, Consultation Draft, DOE/RW-0164, U.S. Department of Energy, Office of Civilian Radioactive Waste Management, Washington, D.C.

DOE, 1996, *Tank Waste Remediation System, Hanford Site, Richland, Washington, Final Environmental Impact Statement*, DOE/EIS-0180, U.S. Department of Energy, Washington, D.C.

DOE, 1997, *DOE Preferred Alternatives Matrices Remediation/Waste Processing*, Rev. 4, http://www.em.doe.gov/define/r_pam.html, dated June 30, 1997, U.S. Department of Energy, Washington, D.C.

DOE, 1999a, *Radioactive Waste Management Manual*, DOE M 435.1-1, U.S. Department of Energy, Washington, D.C.

DOE, 1999b, *Revised Draft Hanford Remedial Action Environmental Impact Statement and Comprehensive Land-Use Plan*, DOE-EIS-0222D, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-GJO, 1996, *Vadose Zone Characterization Project at the Hanford Tank Farms, SX Tank Farm Report,* GJ-HAN-DOE/ID/12584-268 (GJO-HAN-4), U.S. Department of Energy, Grand Junction Projects Office, Grand Junction, Colorado.

DOE-GJO, 1997a, *Vadose Characterization Project at Hanford Tank Farms BY Tank Farm*, GJO-HAN-6, U.S. Department of Energy Grand Junction Office, Grand Junction, Colorado.

DOE-GJO, 1997b, *Hanford Tank Farms Vadose Zone TX Tank Farm Report,* GJO-97-13-TAR (GJO-HAN-6), U.S. Department of Energy Grand Junction Office, Grand Junction, Colorado.

DOE-GJO, 1998a, *Hanford Tank Farms Vadose Zone BX Tank Farm Report,* GJO-98-40-TAR (GJO-HAN-19), U.S. Department of Energy Grand Junction Office, Grand Junction, Colorado.

DOE-GJO, 1998b, *Hanford Tank Farms Vadose Zone S Tank Farm Report,* GJO-97-31-TAR (GJO-HAN-17), U.S. Department of Energy Grand Junction Office, Grand Junction, Colorado.

DOE-GJO, 1998c, *Hanford Tank Farms Vadose Zone TY Tank Farm Report,* GJO-97-30-TAR (GJO-HAN-16), U.S. Department of Energy Grand Junction Office, Grand Junction, Colorado.

DOE-RL, 1989, *Draft Single-Shell Tanks System Closure/Corrective Action Work Plan*, DOE/RL-89-16, Draft A, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1992a, *S Plant Aggregate Area Management Study Report*, DOE/RL-91-60, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1992b, *T Plant Aggregate Area Management Study Report*, DOE/RL-91-61, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1992c, *U Plant Source Aggregate Area Management Study Report*, DOE/RL-91-52, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1992d, *Z Plant Source Aggregate Area Management Study Report*, DOE/RL-91-58, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1993a, *200 East Groundwater Aggregate Area Management Study Report*, DOE/RL-92-19, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1993b, *200 West Groundwater Aggregate Area Management Study Report*, DOE/RL-92-16, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1993c, *B Plant Source Aggregate Area Management Study Report*, DOE/RL-92-05, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1993d, *PUREX Source Aggregate Area Management Study Report*, DOE/RL-92-04, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1993e, *Semiworks Source Aggregate Area Management Study Report*, DOE/RL-92-18, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1994, *Hanford Site Background Data Applications Guide: Part 1, Soil*, DOE/RL-94-72, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1995a, *Hanford Site Risk Assessment Methodology*, DOE/RL-91-45, Rev. 3, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1995b, *Hanford Sitewide Background, Part 1: Soil Background for Nonradioactive Analytes*, DOE/RL-92-24, Rev. 3, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1995c, *Limited Field Investigation for the 200-UP-2 Operable Unit*, DOE/RL-95-13, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1996a, *Draft Hanford Site Background: Part 2, Soil Background for Radionuclides*, DOE/RL-96-12, Rev 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1996b, *Draft Hanford Site Biological Resources Management Plan*, DOE/RL-96-32, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1996c, *Hanford Site Radiological Control Manual* (HSRCM), DOE/RL-96-109, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1996d, *Programmatic Agreement Among the U.S. Department of Energy, Richland Operations Office, the Advisory Council on Historic Preservation, and the Washington State Historic Preservation Office for the Maintenance, Deactivation, Alteration, and Demolition of the Built Environment on the Hanford Site, Washington*, DOE/RL-96-77, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1996e, *Limited Field Investigation for the 200-UP-1 Operable Unit*, DOE/RL-96-33, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1997a, *Hanford Facility Dangerous Waste Part A Permit Application, Single-Shell Tank System*, DOE/RL-88-21, Rev, 4, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1997b, *Inventory of Miscellaneous Waste Streams*, DOE/RL-95-82, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1997c, *TWRS Vadose Zone Contamination Issues, Expert Panel Status Report*, DOE/RL-97-49, Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1998a, *Hanford Immobilized Low-Activity Tank Waste Performance Assessment*, DOE/RL-97-69, U.S. Department of Energy, Richland Office, Richland, Washington.

DOE-RL, 1998b, *Hanford Site Manhattan Project and Cold War Era Historic District Treatment Plan*, DOE/RL-97-56, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1998d, *Tank Waste Remediation System Vadose Zone Program Plan*, DOE/RL-98-49, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1998e, *Groundwater/Vadose Zone Project Management Plan*, DOE/RL-98-56, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1999, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan, Environmental Restoration Program*, DOE/RL-98-28, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1999a, *Retrieval Performance Evaluation Methodology for the AX Tank Farms*, DOE/RL-98-72, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1999b, *Prototype Barrier Treatability Test Report*, DOE/RL-99-11, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1999c, *Groundwater/Vadose Zone Integration Project Science and Technology Summary Description*, DOE/RL-98-48, Vol. III, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL and Ecology, 1996, *Tank Waste Remediation System*, Hanford Site, Richland, Washington, Final Environmental Impact Statement, DOE/EIS-0180, U.S. Department of Energy, Richland Operations Office, and Washington Department of Ecology, Richland, Washington.

Ecology, 1992, *Statistical Guidance for Ecology Site Managers*, Ecology Publication No. 92-54, Washington State Department of Ecology, Toxic Cleanup Program, Olympia, Washington.

Ecology, 1998, *Revision 4A of the Hanford Facility RCRA Permit*, Permit Number WA7890008967, Washington State Department of Ecology, Nuclear Waste Program, Olympia, Washington

Ecology, EPA, and DOE, 1994, *Hanford Federal Facility Agreement and Consent Order*, Fourth Amendment, 89-10, Washington Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

Ecology, EPA, and DOE, 1996, *Tri-Party Agreement Action Plan*, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

Ecology, EPA, and DOE, 1997, *Community Relations Plan for the Hanford Federal Facility Agreement and Consent Order*, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

Ecology, EPA, and DOE, 1998, *Hanford Federal Facility Agreement and Consent Order*, Fifth Amendment, 89-10, Washington Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

Ecology, EPA, and DOE, 1999, *Hanford Federal Facility Agreement and Consent Order, draft Change Control Form,* Change Number M-45-98-03, dated January 8, 1999, Washington Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

Endangered Species Act of 1973, 16 U.S.C. 1531, et seq.

EPA, 1989, *Risk Assessment Guidance for Superfund Human Health Evaluation Manual Part A*, EPA 9285.701A, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1992, *Framework for Ecological Risk Assessment,* EPA/630/R-92/001, U.S. Environmental Protection Agency, Risk Assessment Forum, Washington, D.C.

EPA, 1993a, *The Data Quality Objectives Process for Superfund Interim Final Guidance,* EPA/540/R-93/071, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1994, *RCRA Corrective Action Plan*, Directive No. 9902.3-2A, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1997, *Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination*, EPA OSWER Directive No. 9200.4-18, U.S. Environmental Protection Agency, Washington, D.C.

Fayer, M. J., and T. B. Walters, 1995, *Estimated Recharge Rates at the Hanford Site*, PNL-10285, Pacific Northwest Laboratory, Richland, Washington.

Fayer, M. J., R. E. Lewis, R. E. Engelman, A. L. Pearson, C. J. Murray, J. L. Smoot, R. R. Randall, W. H. Wegener, and A. H. Lu. 1995, *Re-Evaluation of a Subsurface Injection Experiment for Testing Flow and Transport Models*, PNL-10860, Pacific Northwest Laboratory, Richland, Washington.

FDH, 1997a, *Management and Integration Plan,* HNF-MP-001, Fluor Daniel Hanford Incorporated, Richland, Washington.

FDH, 1997b, *Safety Analysis and Technical Safety Requirements*, HNF-PRO-700, Fluor Daniel Hanford Incorporated, Richland, Washington.

Fecht, K. R., M. C. Marratt, and A. M. Tallman, 1979, *Geology of the Separations Areas, Hanford Site, South-Central Washington*, RHO-ST-23, Rockwell Hanford Operations, Richland, Washington.

Fecht, K. R., S. P. Reidel, and A. M. Tallman, 1987, "Paleodrainage of the Columbia River System on the Columbia Plateau of Washington State-A Summary," *Selected Papers on the Geology of Washington*, Bulletin 77, pp. 219-248, Schuster, J. E. (ed.), Washington State Division of Geology and Earth Resources, Olympia, Washington.

Fecht, K. R., K. A. Lindsey, B. N. Bjornstad, D. G. Horton, G. V. Last, and S. P. Reidel, 1998, *Clastic Infection Dikes of the Pasco Basin and Vicinity: Geologic Atlas Series,* BHI-01103, Draft A, Bechtel Hanford, Inc. Richland, Washington.

FSUWG, 1992, *The Future of Hanford: Uses and Cleanup, The Final Report of the Hanford Future Site Uses Working Group*, Hanford Future Site Uses Working Group, Westinghouse Hanford Company, Richland, Washington.

Gee, G. W., M. J. Fayer, M. J. Rockhold, and M.D. Campbell, 1992, "Variations in Recharge at the Hanford Site," *Northwest Science*, Vol. 66, pp. 237-250.

Hakonson, T. E., J. L. Martinez, and G. C. White, 1982, "Disturbance of a Low-Level Waste Burial Site Cover by Pocket Gophers," *Health Physics*, 42:868-871.

Hanlon, B. M., 1999, *Waste Tank Summary Report for Month Ending April 30, 1999*, HNF-EP-0182-126, Lockheed Martin Hanford Corporation for Fluor Daniel Hanford, Inc., Richland, Washington.

Hartman, M. J., and P.E. Dresel, 1998, editors, *Hanford Site Groundwater Monitoring for Fiscal Year 1997*, PNNL-11793, Pacific Northwest National Laboratory, Richland, Washington.

Hazardous and Solid Waste Amendments of 1984, Public Law 98-616, as amended.

HNF, 1999, *Tank Farm Soil Remediation Study,* HNF-3913, Rev. 0, COGEMA, Richland, Washington.

Hodges, F. N., 1998, *Results of Phase I Groundwater Quality Assessment for Single-Shell Tank Waste Management Area T and TX-TY at the Hanford Site*, PNNL-11809, Pacific Northwest National Laboratory, Richland, Washington.

Hoitink, D. J., and K. W. Burk, 1997, *Climatological Data Summary 1996 with Historical Data*, PNNL-11471, Pacific Northwest National Laboratory, Richland, Washington.

Hoitink, D. J., and K. W. Burk, 1998, http://hms.rl.gov/products.htm.

ICEG, 1998, *Phased Based Hazardous, Toxic, and Radiological Work Breakdown Structure*, First Draft, dated April 1998, Interagency Cost Estimating Group.

Isaacson, R. E., 1982, *Supporting Information for the Scientific Basis for Establishing Dry Well Monitoring Frequencies*, RHO-RE-EV-4 P, Rockwell Hanford Operations, Richland, Washington.

Isaacson, R. E., and K. A. Gasper, 1981, *A Scientific Basis for Establishing Dry Well-Monitoring Frequencies*, RHO-ST-34, Rockwell Hanford Operations, Richland, Washington.

Johnson, V. G., and C. J. Chou, 1998, *Results of Phase I Groundwater Quality Assessment for Single-Shell Tank Waste Management Areas S-SX at the Hanford Site*, PNNL-11810, Pacific.Northwest National Laboratory, Richland, Washington.

Jones, T. E., R. Khaleel, D. A. Myers, I. W. Shade, M. I. Wood, 1998, *A Summary and Evaluation of Hanford Site Tank Farm Subsurface Contamination*, HNF-2603, Rev. 0, Lockheed Martin Hanford Company Corporation, Richland, Washington.

Kaplan, D. I., and R. J. Serne, 1995, *Distribution Coefficient Values Describing Iodine, Neptunium, Selenium, Technetium, and Uranium Sorption to Hanford Sediments*, PNL-10379, Supplement 1, Pacific Northwest Laboratory, Richland, Washington.

Kaplan, D. I., R. J. Serne, and M. G. Piepho, 1995, *Geochemical Factors Affecting Radionuclide Transport Through Near and Far Fields at a Low-Level Waste Disposal Site*, PNL-10379, Pacific Northwest Laboratory, Richland, Washington.

Kincaid, C. T., M. P. Bergeron, C. R. Cole, M. D. Freshley, N. L. Hassig, V. G. Johnson, D. I. Kaplan, R. J. Serne, G. P. Streile, D. L. Strenge, P. D. Thorne, L. W. Vail, G. A. Whyatt, and S. K. Wurstner, 1998, *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*, PNNL-11800, Pacific Northwest National Laboratory, Richland, Washington.

Kupfer, M. J., A. L. Boldt, B. A. Higley, K. M. Hodgson, L. W. Shelton, B. C. Simpson, and R. A. Watrous (LMHC); S. L. Lambert and D. E. Place (SESC); R. M. Orme (NHC); G. L. Borsheim (Borsheim Associates); N. G. Colton (PNNL); M.D. LeClair (SAIC); R. T. Winward (Meier Associates); and W. W. Schultz (W^2S Corporation); 1999, *Standard Inventories of Chemicals and Radionuclides in Hanford Site Tank Wastes*, HNF-SD-WM-TI-740, Rev. 0C, Lockheed Martin Hanford Corporation for Fluor Daniel Hanford, Inc., Richland, Washington.

Last, G. V., B. N. Bjornstad, M. P. Bergeron, D. W. Wallace, D. R. Newcomer, J. A. Schramke, M. A. Chamness, C. S. Cline, S. P. Airhart, and J. S. Wilbur, 1989, *Hydrogeology of the 200 Areas Low-Level Burial Grounds – An Interim Report*, PNL-6820, Pacific Northwest Laboratory, Richland, Washington.

Lerchen, M. E., K. Meier, M. Miller, and K. D. Wiemars, 1998, *Regulatory Data Quality Objectives Supporting Tank Waste Remediation System Privatization Project*, PNNL-12040, Pacific Northwest National Laboratory, Richland, Washington.

Lindsey, K. A., B. N. Bjornstad, and M. P. Connelly, 1991, *Geologic Setting of the 200 West Area: An Update,* WHC-SD-EN-TI-008, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

LMHC, 1997, *Quality Assurance Program Plan*, HNF-IP-0842, Lockheed Martin Hanford Corporation, Richland, Washington.

LMHC, 1999, *Tank Leak Assessment Process Applicability: For Compliance*, HNF-SD-WM-PROC-021, 26.1, Rev. 2B, Lockheed Martin Hanford Corporation, Richland, Washington.

LMHC, 1999a, *Preliminary Site-Specific SST Phase 1 RFI/CMS Work Plan Addendum for WMA S-SX*, HNF-4380, Rev. 0, Lockheed Martin Hanford Corporation, Richland, Washington.

LMHC, 1999b, *Summary Report for the Hanford Single-Shell Tank RFI/CMS Planning Workshop*, transmitted from R. E. Day, dated May 19, 1999.

Martin, W. J., 1996, *Integration of Risk Analysis and Sorption Studies in the Subsurface Transport of Aqueous Carbon-14 at the Hanford Site*, Ph.D. Dissertation, Washington State University.

Maxfield, H. L., ed., 1979, *Handbook, 200 Areas Waste Sites*, RHO-CD-673, Rockwell Hanford Operations, Richland, Washington.

McGraw M. A., and D. I. Kaplan, 1997, *Colloid Suspension Stability and Transport Through Unsaturated Porous Media*, PNNL-11565, Pacific Northwest National Laboratory, Richland, Washington.

Migratory Bird Treaty Act of 1918, 16 U.S.C. 703, et seq.

Myers, D. A., D. L. Parker, G. Gee, V. G. Johnson, G. V. Last, R. J. Serne, D. J. Moak, 1998, *Findings of the Extension of Borehole 41-09-39, 241-SX Tank Farms*, HNF-2855, prepared by Lockheed Martin Hanford Company Corporation for Fluor Daniel Hanford, Inc., Richland, Washington.

Narbutovskih, S. M., R. K. Price, and V. J. Rohay, 1997, "Vadose-Zone Contamination," Section 4 in *Hanford Site Groundwater Monitoring for Fiscal Year 1996*, M. J. Hartman and P.E. Dresek, eds., PNNL-11470, Pacific Northwest National Laboratory, Richland, Washington.

Narbutovskih, S. M., 1998, *Results of Phase I Groundwater Quality Assessment for Single-Shell Tank Waste Management Area B-BX-BY at the Hanford Site*, PNNL-11826, Pacific Northwest National Laboratory, Richland, Washington.

National Environmental Policy Act of 1969, 42 U.S.C. 4321, et seq.

National Historic Preservation Act of 1966, 16 U.S.C. 470, et seq.

Native American Graves Protection and Repatriation Act, 26 U.S.C. 3001, et seq.

Neitzel, D. A., (editor), 1998, *Hanford Site National Environmental Policy Act (NEPA) Characterization,* PNL-6415, Rev. 10, Pacific Northwest National Laboratory, Richland, Washington.

NRC, 1995, *Ward Valley: An Examination of Seven Issues in Earth Sciences and Ecology,* National Research Council, National Academy Press, Washington, D.C.

Nuclear Waste Policy Act of 1982, 42 U.S.C. 10101, et seq.

O'Farrell, T. P., R. E. Fitzner, and R. O. Gilbert, 1973, *Distribution of Radioactive Jackrabbit Pellets in the Vicinity of the B-C Cribs, U.S.A.E.C. Hanford Reservation*, BNWL-1794, Pacific Northwest National Laboratory, Richland,Washington.

Parker, P. L. and T. F. King, 1990, *Guidelines for Evaluating and Documenting Traditional Cultural Properties*, National Register Bulletin 38, National Park Service, Washington, D.C.

PNNL, 1999, *Reducing Water Infiltration Around Hanford Tanks*, Forum Proceedings, Vols. I and II, Held at Hills Conference Center, Richland, Washington, May 4-6, 1999, TechCon Program, Richland, Washington, http://web.ead.anl.gov/techcon/corproj.cfm.

Raymond, J. R., and E. G. Shdo, 1966, *Characterization of Subsurface Contamination in the SX Tank Farm*, BNWL-CC-701, Pacific Northwest National Laboratory, Richland, Washington.

RCW 43.21C, "State Environmental Policy Act," *Revised Code of Washington*, as amended.

RCW 70.105, "Hazardous Waste Management Act of 1976," *Revised Code of Washington*, as amended.

Reidel, S. P., K. D. Reynolds, and D. G. Horton, 1998, *Immobilized Low-Activity Waste Site Borehole, 299-E17-21*, PNNL-11957, Pacific Northwest National Laboratory, Richland, Washington.

Resource Conservation and Recovery Act of 1976 (RCRA), 42 U.S.C. 6901, et seq.

Rice, D. G., 1968, *Archaeological Reconnaissance: Ben Franklin Reservoir Area, 1968,* Washington State University, Laboratory of Anthropology, Pullman, Washington.

Rice, D. G., 1987, *Archaeological Reconnaissance of Gable Butte and Gable Mountain on the Hanford Site, Washington,* Westinghouse Hanford Company, Richland, Washington.

Routson, R. C., W. H. Price, D. J. Brown, and K. R. Fecht, 1979, *High-Level Waste Leakage from the 241-T-106 Tank at Hanford*, RHO-ST-14, Rockwell Hanford Operations, Richland, Washington.

Routson, R. C., G. S. Barney, R. H Smith, C. H. Delegard, and L. Jenson, 1981, *Fission Product Sorption Parameters for Hanford 200 Area Sediment Types*, RHO-ST-35, Rockwell Hanford Operations, Richland, Washington.

Safe Drinking Water Act of 1974, 42 U.S.C. 300, et seq.

Schmittroth, F. A., and T. H. Delorenzo, 1995, *Consequence Ranking of Radionuclides in Hanford Tank Waste*, WHC-SD-WM-RPT-163, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Serne, R. J., and M. I. Wood, 1990, *Hanford Waste-Form Release and Sediment Interaction -- A Status Report with Rationale and Recommendations for Additional Studies*, PNL-7297, Pacific Northwest Laboratory, Richland, Washington.

SESC, 1997, *Tank Removal Engineering Study I,* SESC-EN-RPT-003, Rev. 0, SGN Eurisys Services Corporation, Richland, Washington.

Sisson, J. B., and A. H. Lu, 1984, *Field Calibration of Computer Models for Application to Buried Liquid Discharges: A Status Report,* RHO-ST-46P, Rockwell Hanford Operations, Richland, Washington.

Slate, J. L., 1996, "Burial Carbonate Palesols Developed in Pliocene-Pleistocene Deposits of the Pasco Basin, South Central Washington, USA," *Quaternary International*, Vols. 34-36, pp. 191-196.

Smith, R. M., 1980, *216-B-5 Reverse Well Characterization Study*, RHO-ST-37, Rockwell Hanford Operations, Richland, Washington.

Spane Jr., F. A. and V. E. Vermeul, 1994, *Summary and Evaluation of Hydraulic Property Data Available for the Hanford Site Upper Basalt Confined Aquifer System*, PNL-10158, Pacific Northwest National Laboratory, Richland, Washington.

Spane Jr., F. A. and W. D. Webber, 1995, *Hydrochemistry and Hydrogeologic Conditions Within the Hanford Upper Basalt Confined Aquifer System,* PNL-10817, Pacific Northwest National Laboratory, Richland, Washington.

Stephens, D. B., 1996, *Vadose Zone Hydrogeology*, Lewis Publishers, CRC Press, Boca Raton, Florida.

Swanson, D. A., J. L. Anderson, R. D. Bentley, V. E. Camp, J. N. Gardner, and T. L. Wright, 1979, *Reconnaissance Geologic Map of the Columbia River Basalt Group in Washington and Adjacent Idaho*, Open-File Report 79-1363, U.S. Geological Survey, Washington, D.C.

WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code*, as amended.

WAC 173-340, "Model Toxics Control Act - Cleanup," *Washington Administrative Code*, as amended.

WAC 173-463, "Controls for New Sources of Toxic Air Pollutants," *Washington Administrative Code*, as amended.

WAC 197-11, "SEPA Rules," *Washington Administrative Code*, as amended.

Washington Natural Heritage Program, 1998, *Washington Rare Plant Species by County, Washington*, http://www.wa.gov/dnr/htdocs/fr/nhp/plantco.html#benton.

WHC, 1984, *Preliminary Estimation of Waste Tank Inventories in Hanford Tanks through 1980*, WHC-SD-WM-TI-057, Westinghouse Hanford Company, Richland, Washington.

WHC, 1988, *Waste Storage Tank Status and Leak Detection Criteria*, WHC-SD-WM-TI-356, Vols. 1 and 2, Westinghouse Hanford Company, Richland, Washington.

WHC, 1989a, *20 CFR 265, Interim-Status Groundwater Monitory Plan for the Single-Shell Tanks*, WHC-SD-EN-AP-012, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

WHC, 1989b, *Waste Characterization Plan for Hanford Site Single-Shell Tanks*, WHC-EP-0210, Westinghouse Hanford Company, Richland, Washington.

WHC, 1991a, *Interim-Status Groundwater Monitoring Plan for the Single-Shell Tanks*, WHC-SD-EN-AP-012, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

WHC, 1991b, *Tank 241-A-105 Leak Assessment*, WHC-MR-0264, Westinghouse Hanford Company, Richland, Washington.

WHC, 1991c, *Tank Wastes Discharged Directly to the Soil at the Hanford Site*, WHC-MR-0227, Westinghouse Hanford Company, Richland, Washington.

WHC, 1991d, *Revised Stratigraphy for the Ringold Formation, Hanford Site, South-Central Washington*, WHC-SD-EN-EE-004, Westinghouse Hanford Company, Richland, Washington.

WHC, 1991e, *Geology and Hydrology of the Hanford Site: A Standardized Text for Use in Westinghouse Hanford Company Documents and Reports*, WHC-SD-ER-TI-003, Westinghouse Hanford Company, Richland, Washington.

WHC, 1992a, *Tank 241-SX-108 Leak Assessment*, WHC-MR-0300, Westinghouse Hanford Company, Richland, Washington.

WHC, 1992b, *Tank 241-SX-109 Leak Assessment*, WHC-MR-0301, Westinghouse Hanford Company, Richland, Washington.

WHC, 1992c, *Tank 241-SX-115 Leak Assessment*, WHC-MR-0302, Westinghouse Hanford Company, Richland, Washington.

WHC, 1992d, *Field Trip Guide to the Hanford Site,* WHC-MR-0391, Westinghouse Hanford Company, Richland, Washington.

WHC, 1993, *Waste Level Discrepancies Between Manual Level Reading and Current Waste Inventory for Single-Shell Tanks*, Internal Memo 7C242-93-0038, from S. L. Swaney, to G. T. Frater, dated December 10, 1993, Westinghouse Hanford Company, Richland, Washington.

WHC, 1994, *Historical Records of Radioactive Contamination in Biota at the 200 Areas of the Hanford Site*, WHC-MR-0418, Westinghouse Hanford Company, Richland, Washington.

WHC, 1996, *Engineering Study of Tank-Fill Alternative for Closure of Single-Shell Tanks,* WHC-SA-WM-ES-399, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Womack, J. C., and D. J. Larkin, 1971, *Investigation and Evaluation of 102-BX Tank Leak*, ARH-2035, Atlantic Richfield Hanford Company, Richland, Washington.

Zimmerman, D. A., A. E. Reisnauer, G. D. Black, and M. A. Young, 1986, *Hanford Site Water Table Changes 1950 through 1980, Data Observations and Evaluation*, PNL-5506, Pacific Northwest National Laboratory, Richland, Washington.

1

APPENDIX A

QUALITY ASSURANCE PROJECT PLAN

CONTENTS

A1.0 INTRODUCTION A-1

A2.0 PROJECT MANAGEMENT A-1
A2.1 PROJECT ORGANIZATION AND RESPONSIBILITIES A-1
A2.1.1 RPP Vadose Zone Project Manager A-2
A2.1.2 RPP Vadose Zone Project Task Lead A-2
A2.1.3 Quality Assurance Organization A-2
A2.1.4 Person in Charge/Field Team Leader A-2
A2.1.5 Health and Safety Organization A-3
A2.1.6 Radiological Controls Organization A-3
A2.1.7 Sample Management Organization A-3
A2.1.8 Waste Management A-4
A2.1.9 Subcontractor Support A-4
A2.2 PROBLEM DEFINITION/BACKGROUND A-4
A2.3 PROJECT/TASK DESCRIPTION A-4
A2.4 PROJECT QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT PERFORMANCE DATA A-5
A2.5 SPECIAL TRAINING REQUIREMENTS/CERTIFICATION A-5
A2.6 DOCUMENTATION AND RECORDS A-5

A3.0 MEASUREMENT/DATA ACQUISITION A-7
A3.1 SAMPLING METHODS A-7
A3.2 SAMPLE HANDLING AND CUSTODY A-7
A3.3 SAMPLE PRESERVATION, CONTAINERS, AND HOLDING TIME A-7
A3.4 ANALYTICAL METHODS A-8
A3.4.1 Characterization Data A-8
A3.4.2 Data Generated During Corrective Action A-9
A3.5 QUALITY CONTROL A-9
A3.5.1 Field Quality Control A-9
A3.5.2 Onsite Measurements Quality Control A-11
A3.5.3 Laboratory Quality Control A-11
A3.6 INSTRUMENT CALIBRATION AND MAINTENANCE A-13
A3.7 FIELD DOCUMENTATION A-13
A3.8 DATA MANAGEMENT A-13

A4.0 ASSESSMENT/OVERSIGHT A-14

A5.0 DATA VALIDATION AND USABILITY A-14

A6.0 DATA QUALITY ASSESSMENT A-15

A7.0 REFERENCES A-16

ACRONYMS

AHA	activity hazard analysis
ARARs	applicable or relevant and appropriate requirements
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
DOE	U.S. Department of Energy
DQA	data quality assessment
DQO	data quality objective
DST	double-shell tank
EPA	U.S. Environmental Protection Agency
FDH	Fluor Daniel Hanford, Incorporated
HASQARD	*Hanford Analytical Services Quality Assurance Requirements Document*
LCS	laboratory control sample
LMHC	Lockheed Martin Hanford Corporation
MTCA	*Model Toxics Control Act*
NIST	National Institute of Standards and Technology
PHMC	Project Hanford Management Contractor
PIC	person in charge
QA	quality assurance
QAPjP	quality assurance project plan
QC	quality control
RCRA	*Resource Conservation and Recovery Act of 1976*
RDL	required detection limit
RPP	River Protection Program
RWP	radiological work permit
SS HASP	site-specific health and safety plan
SST	single-shell tank
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
WMA	waste management area
WMNW	Waste Management Federal Services, Inc., Northwest Operations

A1.0 INTRODUCTION

This quality assurance project plan (QAPjP) establishes the quality requirements for environmental data collection, including sampling and analysis, in support of the single-shell tank (SST) *Resource Conservation and Recovery Act of 1976* (RCRA) Corrective Action Program (RCAP). This QAPjP applies specifically to field and laboratory activities associated with evaluating subsurface contaminant impacts involving 200 Areas SST releases to the environment. The plan describes the means selected to implement the quality assurance program defined in Lockheed Martin Hanford Corporation (LMHC) quality assurance program plan, HNF-IP-0842 (LMHC 1997). This plan complies with the requirements of U.S. Department of Energy (DOE) Order 5700.6C, *Quality Assurance*; the *Code of Federal Regulations* (CFR), 10 CFR Part 830.120, "Quality Assurance Requirements;" *EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations* (EPA 1994a); the *Fluor Daniel Hanford Quality Assurance Program Description* (HNF-MP-599) (FDH 1997a); and, the *Hanford Analytical Services Quality Assurance Requirements Documents* (HASQARD) (DOE-RL 1998). The plan also identifies technical procedural requirements that will describe field data collection and sampling and analysis requirements to be implemented during the investigation. Technical procedures will be identified in the WMA addenda and address the requirements of the HASQARD (DOE-RL 1998).The purpose of this appendix is to provide a framework of the general requirements that apply to RCAP characterization efforts. The general requirements identified in this appendix shall be supplemented by WMA-specific requirements developed through the data quality objective (DQO) process and documented in each addendum. By following and referencing the guidelines in this appendix, site-specific sampling documents should not require individual QAPjPs.

A2.0 PROJECT MANAGEMENT

This section addresses the basic areas of project management and ensures that the project has a defined goal, that the participants understand the goal and the approach to be used, and that the planned outputs are appropriately documented. Also included in this section is a discussion of the quality objectives and background information on the sampling and analysis strategy for the RCAP.

A2.1 PROJECT ORGANIZATION AND RESPONSIBILITIES

The Project Hanford Management Contract establishes Fluor Daniel Hanford, Incorporated (FDH) as the Management and Integration Contractor and LMHC as a subcontractor to FDH. Under the contract, LMHC has the responsibility for managing the River Protection Project (RPP) in accordance with Contract 8023276-9-K001 with FDH. The scope of the RPP efforts primarily include the management of the double-shell tank (DST) and SST farms in the 200

Areas of the Hanford Site. This program also includes the RCAP. The RCAP is tasked with evaluating subsurface contaminant impacts associated with SST system releases to the environment and has responsibility for this scope. Data collected during this investigation will be used to support conceptual model development, short-term operations and retrieval decisions, and longer-term retrieval, disposal, and closure decisions.

The project organization responsible for implementing the RCAP is presented in this section and shown in Figure A-1. General responsibilities for regulatory agencies and the DOE are described in Section 7.2.1 of the master work plan. Regulatory agencies and the DOE have overall management authority for the project.

A2.1.1 RPP Vadose Zone Project Manager

The RPP Vadose Zone Project Manager has been assigned by the LMHC SST Program Manager and is responsible for management of the project. The RPP Vadose Zone Project Manager works closely with project controls, quality assurance, health and safety, and project staff to ensure that the work scope is being performed in accordance with this plan. The RPP Vadose Zone Project Manager will plan, authorize, and control work so it can be completed on schedule and within budget and ensures that all planning and work performance activities are technically sound. Other duties include the coordination of communications with the DOE and the regulatory agencies.

A2.1.2 RPP Vadose Zone Project Task Lead

The RPP Vadose Zone Project Task Lead is responsible for coordinating all activities related to the RCAP, including preparing the work plans, technical direction, data collection, analysis, and reporting. The RPP Vadose Zone Project Task Lead reports to the RPP Vadose Zone Project Manager.

A2.1.3 Quality Assurance Organization

The quality assurance (QA) organization is responsible for project QA issues and coordinating/ performing self-assessment, surveillance, and audit activities. Other duties include support for identifying and implementing corrective actions and communicating lessons learned information from other projects. This designated person shall have the necessary independence and authority to identify conditions adverse to quality and to systematically seek corrective action.

A2.1.4 Person in Charge/Field Team Leader

The person in charge (PIC)/field team leader has responsibility for the following:

- Allocating and administering resources to successfully comply with all technical and health and safety requirements

- Verifying that all permits, supporting documentation, and clearances are in place (e.g., electrical outage requests, welding permits, excavation permits, site-specific health and safety plan [SS HASP] or activity hazard analysis [AHA], sampling plan, and radiological work permit [RWP])

- Providing technical advice during routine operations and emergencies

- Informing the appropriate site management and safety personnel of the activities to be performed each day

- Coordinating resolution of any conflicts that may arise between RWP and implementing the SS HASP or AHA

- Handling emergency response situations as required

- Conducting pre-job meetings and daily tailgate safety meetings

- Interacting with adjacent building occupants and the public.

A2.1.5 Health and Safety Organization

The health and safety organization is responsible for the site health and safety program, safety oversight, and will assign a health and safety officer to the project. The health and safety officer is responsible for reviewing the generic health and safety plan (Appendix B) and identifying and documenting any site-specific health and safety needs for the project. The health and safety officer routinely provides input to the project to ensure safe execution of project operations. The health and safety officer is responsible for evaluating all potential health and safety hazards during field activities, including those associated with hazardous materials. This group will provide fire protection, industrial safety, industrial hygiene, and industrial hygiene technician resource coverage as needed for the project. The health and safety officer has the responsibility and authority to halt field activities resulting from unacceptable health and safety hazards.

A2.1.6 Radiological Controls Organization

The radiological control organization shall provide radiological control technician (RCT) coverage for the project. This group will prepare RWP documentation and will oversee work performed in controlled areas under a RWP.

A2.1.7 Sample Management Organization

The Sample Management organization is responsible for sample event coordination, sample identification and tracking, technical and administrative interface with analytical resources, sample return and disposition, data deliverable management, data validation, and data

assessment. In this role, Sample Management will serve as a central point of contact for field/onsite, and protocol analytical services support and will operate a tracking database which integrates the sample and data management process. All activities shall be in accordance with the requirements of HASQARD (DOE-RL 1998).

A2.1.8 Waste Management

The waste management organization is responsible for preparing site-specific waste management instructions in accordance with the tank farm operations procedures. This organization will also be responsible for waste profile evaluations, waste packaging, waste shipments, and incorporating waste minimization techniques into field operations..

A2.1.9 Subcontractor Support

Subcontractors will support the performance of activities such as the generation of WMA addenda, sampling plans, field activities (e.g., drilling), sample and data analysis, risk assessments, and other tasks in accordance with agreed upon scope, budget, and schedule. Subcontractors will inform the Vadose Zone Project Task Lead of work status and any problems that may arise and will participate in long-range planning activities related to these areas. Procurement of support services and supporting items, materials, or equipment shall comply with Project Hanford Management Contractor (PHMC)-wide procurement procedures such as HNF-PRO-268, *Procurement Planning* (FDH 1997d) and the HASQARD (DOE-RL 1998). All work shall comply with LMHC-approved QA plans and procedures and is subject to assessment in accordance with HASQARD.

A2.2 PROBLEM DEFINITION/BACKGROUND

An overview of the Hanford Site SST RCAP is presented in Section 1.0 and describes the purpose, objectives, and scope of the work plan.

A2.3 PROJECT/TASK DESCRIPTION

Tasks associated with the various phases of work for the tank farms characterization effort may include various investigation techniques. A list of potential tasks is presented in Table A-1. This list is intended for use during DQO sessions to assist in choosing appropriate tasks.

A2.4 PROJECT QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT PERFORMANCE DATA

Specific data quality requirements shall be developed for each WMA through the DQO process, as specified in *Guidance for the Data Quality Objective Process*, QA/G-4 (EPA 1994b) and Data Quality Objective for Sampling and Analysis, (LMHC 1997). A list of items that should be covered during the typical DQO process is presented in Table A-2.

The results of the DQO process shall be reflected within the document structure of WMA addenda as a summary table of data quality requirements. Suggested elements of the summary table include references to the measurement parameter (e.g., analyte), required action level, and required precision and accuracy criteria for each type of sample media (e.g., soil, water). Separate tables or references may be required to summarize the requirements for different types of data acquisition such as field screening and verification.

A2.5 SPECIAL TRAINING REQUIREMENTS/CERTIFICATION

Training or certification requirements for personnel on the RPP are described in HNF-PRO-065, *Environmental Training* (FDH 1997e). All personnel assigned to perform field work (e.g., sampling and analysis) and related task shall receive training commensurate with their responsibilities and duties. Personnel are qualified based on education, experience, training, and any specific requirements necessary to perform assigned duties.

Field personnel shall have completed Occupational Safety and Health Administration 40-Hour Hazardous Waste Worker Training, Hanford General Employee Training, Radiation Worker II Training, and tank farm-specific training before starting work. Personnel transporting samples from the various 200 Areas work sites to the designated sample storage facility or to laboratories shall have completed U.S. Department of Transportation shippers training. Any additional site-specific training requirements shall be specified in WMA addenda.

A2.6 DOCUMENTATION AND RECORDS

Sample collection and analysis activities shall be planned in accordance with procedures approved by LMHC. The sample analysis request requirements generated through the sample management sample event coordination process shall document the following for onsite measurements and laboratory test methods:

- Unique sample number
- Field data
- Date and time
- Name of collector
- Test method/analyte and holding time

- Sample media, type, and location
- Sample container type, size, and preservatives
- Turnaround times
- Data deliverable types.

Field documentation shall be maintained commensurate with requirements for control of the field logbook, chain of custody, onsite measurement, and laboratory analytical data deliverables as specified in this section.

The Field Logbook procedure establishes the methods to be used for obtaining, controlling, and dispositioning field logbooks and identify the requirements for using field logbooks. Field logbook entries must be made in a manner that provides a legally defensible record of work that has been performed. The procedure requires that, at a minimum, sufficient data and information should be recorded so the information can be used in the future to enable the participants to reconstruct the activities that occurred. Erroneous information is not to be obliterated. The field logbooks, or any portions thereof, are not to be thrown away or destroyed even if they are damaged, illegible, or contain inaccuracies that require annotation.

The Chain of Custody procedure establishes the methods for documenting and maintaining chain of custody for environmental samples. The information required on the chain-of-custody documentation (e.g., sample identification numbers, sample matrix, sample preservation used, and requested analysis performed by the support service organization) and activities from sample generation through receipt by the analytical laboratory (e.g., signatures and printed names of all individuals involved in the transfer of sample custody) are listed. The procedure requires that the chain-of-custody documentation remains with the related samples from the point of sample collection until the samples are received by the analytical laboratory.

Results of onsite measurement tests shall be managed in accordance with LMHC-approved procedures. This procedure shall establish guidance for preparation, content, review, and control of data deliverables to ensure consistent documentation of organic and inorganic onsite measurement data packages.

Data deliverables from the analytical laboratory shall be managed in accordance with procedures approved by LMHC, which include procedures from initiation of a sampling event through final disposition to the records holding area, inclusive of sample return and disposal. Any site-specific documentation requirements shall be specified in the WMA addenda.

Persons or organizations that generate project record material or media are responsible for the custodial care and protection of records. When records are completed, they shall be submitted to the official project file in accordance with HNF-PRO-232, *Project Files Management* (FDH 1997f). Project files shall be handled in accordance with HNF-PRO-210, *Records Management Program Standards* (FDH 1997g), and HNF-PRO-224, *Document Control Program Standards* (FDH 1997h).

A3.0 MEASUREMENT/DATA ACQUISITION

The following section presents the general requirements for sampling methods, sample handling and custody, analytical methods, and field and laboratory quality control (QC). The requirements for instrument calibration and maintenance, supply inspections, data acquisition, and data management are also discussed.

A3.1 SAMPLING METHODS

The type, location, and minimum number of samples collected will be determined in the WMA-specific DQO sessions. Sampling methods will typically be based on the character of the soil (e.g., unconsolidated or cobbles), depth of sample, type of analyses (e.g., volatile compounds, metals, and physical properties), and the volume of material required. Table A-3 presents typical methods of soil sampling and some of their advantages and limitations. This table is intended for use during the DQO process to assist in choosing the most appropriate technique to employ at the waste sites being considered. Sampling shall be performed in accordance with approved procedures that describe various soil and sediment sampling and groundwater sampling methods.

If any nonstandard sample collection is identified during the DQO process, a procedure will be prepared and identified in the sampling document prior to sample collection. Drilling and excavation shall be in compliance with procedures approved by LMHC.

A3.2 SAMPLE HANDLING AND CUSTODY

Sample handling, shipping, and maintaining sample custody shall be performed in accordance with procedures approved by LMHC. Chain of Custody requirements are described in Section A2.6.

Samples shall be packed and shipped to ensure they will be transported in a manner that protects sample integrity. Because of the complexity of the regulations, it is not possible to cover all situations; therefore, this procedure is used in conjunction with the relevant regulations published by the U.S. Department of Transportation (49 CFR Part 100) and the International Air Transport Association (1998).

A3.3 SAMPLE PRESERVATION, CONTAINERS, AND HOLDING TIME

The sample preservation, container, and holding time requirements for applicable test methods shall be specified on the sample analysis request form, as specified in Section A2.6 of this

appendix. This information shall be developed in WMA DQO sessions and shall be presented in a summary table in WMA addenda.

A3.4 ANALYTICAL METHODS

The analytical methods necessary to achieve the appropriate quality of data will vary according to the quality objectives developed during the DQO process for the different types of samples collected (e.g., characterization and verification). The general types of sampling data and associated levels of data quality are described in this section

The WMA-specific analytical methods shall be presented in WMA addenda as a summary table. Suggested elements of the summary table include references to the analytical method, measurement parameter (e.g., analyte), detection/quantitation limit, and precision and accuracy criteria. Separate tables or references may be required to summarize the requirements for different types of data acquisition (e.g., field screening and verification).

Additional detail on the type of analyses that should be implemented for the different types of samples and guidelines on data quality is provided below. Specific analytical methods and associated data quality (e.g., detection limits) will be established in the WMA-specific DQO session. Most of the required analyses are readily available through existing PHMC contracts with laboratories such as Quanterra Environmental Services, Inc. (PHMC Contract No. 615), and Thermo Analytical Services, Inc. (PHMC Contract No. 630). The sample management organization will also provide a need versus cost study for analyses that are not included in an existing contract.

A3.4.1 Characterization Data

The characterization data should be of sufficient quality to adjust or verify the conceptual geohydrologic model, to support analysis of a corrective measure selection, and for use in risk assessment, if appropriate. The analytical methods should have detection limit goals that are at least as low as the most restrictive hypothetical media cleanup standards that could be considered. For nonradionuclides, these are dictated by *Model Toxics and Control Act* (MTCA) cleanup values. Where these values are lower than standard detection limits (e.g., arsenic and beryllium), the cleanup value will equal the local Hanford Site-wide background concentration or the limit of quantification if a background value is not available. For radioactive constituents, cleanup values are typically calculated using an exposure model that estimates the dose an individual would receive in a specific land-use scenario.

It is reasonable to expect that some of the initial characterization samples will have very high concentrations of some chemicals, high activity, or both. In these cases, a low detection limit may be unobtainable for constituents present in lower concentrations due to interferences or dilutions required for analytical accuracy. Samples that are highly contaminated may not yield data that meet all the preferred goals for characterization samples.

To support the decision documents that authorize corrective action, the data must be of high quality. The appropriate analytical methods for nonradionuclides should follow the procedures outlined in *Test Methods for Evaluating Solid Waste* (SW-846) (EPA 1986). The requested documentation from the laboratory should be at least a summary report, which will support a level of validation that includes review of holding times, blank contamination, precision, and accuracy. There are no standard methods (e.g., SW-846) for radionuclide analysis, but common fixed laboratory techniques and practices produce adequately low detection limits and high QC.

A3.4.2 Data Generated During Corrective Action

It is anticipated that, for certain corrective actions, a large amount of data will be generated in the field during the course of the activity. These data will typically utilize field instruments to guide corrective action. The field instruments should yield data of high enough quality to support the corrective action and verify waste profiles. The LMHC or other approved subcontractor procedures identified during the DQO process shall define the operating procedures and standard QC processes used to conduct onsite measurement tests performed by field personnel to provide results of known and consistent quality for project use. Information regarding the use of the data should be provided through the WMA-specific DQO process, along with information regarding the analytical method, detection levels, data assessment requirements, QC levels, and data management requirements.

A3.5 QUALITY CONTROL

Quality control measures shall be followed in the field and laboratory to maximize the likelihood that reliable data are obtained. When performing field sampling, precaution shall be taken to prevent the cross-contamination of sampling equipment, sample bottles, and other equipment that could compromise sample integrity. During the DQO process, WMA addenda may require QC elements at a frequency other than those identified in this appendix. The applicable QC requirements shall be documented in WMA addenda.

A3.5.1 Field Quality Control

Several control samples are introduced into the collection system to monitor the adequacy of the sampling system and the integrity of samples from the field collection point through laboratory analysis. The frequency and type of QC samples to be collected shall be in WMA addenda. The following sections define QC samples according to their primary purpose.

A3.5.1.1 Field Quality Control Samples for Sampling Evaluation

- **Trip blanks.** Trip blanks are used to detect possible contamination during sample shipping and handling. A trip blank is typically a sample container filled with distilled/deionized water that is transported to the sampling site and then submitted to the

laboratory with the samples. Trip blanks are filled in the laboratory or at sample storage units and are not to be opened in the field. The frequency or use of the trip blank will be determined by the DQO and documented in the WMA addenda; generally, one trip blank per cooler or sample shipment is submitted to the laboratory. Each trip blank should be stored at the laboratory with associated samples and analyzed with those samples.

Trip blanks are primarily used when samples are to be analyzed for volatile organic compounds. However, trip blanks may be used for any parameter when there is concern that concentration of the parameter is biased by contamination. A trip blank will not only detect contamination during the shipping and handling of the containers but will also serve to detect contamination from containers (i.e., function as a bottle blank).

- **Equipment rinsate blanks.** Equipment rinsates are samples of silica sand or distilled/deionized water passed through decontaminated sampling equipment before use of the equipment. Rinsates are used as a measure of the effectiveness of the equipment decontamination process. Equipment rinsates should be collected in the field and at the rate specified in the sampling document. An equipment rinsate should be collected from each type of sampling equipment used to ensure that the decontamination procedures are applicable to all equipment types.

  Equipment rinsates are analyzed for the same analytes as samples collected using the equipment. All sample results should be evaluated to determine the possible effects of any contamination detected in the equipment rinsate blank.

- **Duplicate samples.** Duplicate samples are independent samples collected as close as possible to the same point in space and time and are intended to be identical. Duplicate samples provide information regarding the homogeneity of the matrix and may also provide an evaluation of the precision of the analysis process. A typical sampling frequency for duplicate samples is approximately one for every 20 regular samples, or one per borehole. Soil cores collected for volatile organic analysis should be sealed immediately and shipped to the laboratory.

A3.5.1.2 Field Quality Control Samples for Laboratory Evaluation.

- **Field splits.** Field split samples are two uniquely numbered samples produced through homogenizing a field sample and separating the sample material into two separate aliquots. Field split samples are usually routed to separate laboratories for independent analysis, generally for the purposes of auditing the performance of the primary laboratory relative to a particular sample matrix and analytical method. Collection and analysis of field split samples is generally not performed, as there are formal check procedures that are used to evaluate interlaboratory accuracy and precision.

- **Field blanks.** Field blanks are samples of analyte-free media similar to the sample matrix transferred from one vessel to another at the sampling site. This blank is

preserved and processed in the same manner as the associated samples and is used to document contamination in the sampling and analysis process (e.g., ambient volatile organic chemicals from operating machinery).

A3.5.2 Onsite Measurements Quality Control

Requirements for QC samples prepared and analyzed for onsite measurements (field screening) include blanks, background samples, duplicates, and standards. Further details regarding these samples can be found in Volume 3 of the HASQARD (DOE-RL 1998). The specific type(s) of QC sample(s) and frequency of collection will vary with the field analytical method and will be specified in WMA addenda.

- **Blanks.** A blank is defined as data acquisition without an actual sample, used to establish an instrument baseline. A minimum of one blank is typically collected per day or shift.

- **Background samples.** Background samples are used to measure a matrix-specific baseline. If background samples are needed, a minimum of two samples shall be collected and analyzed at a site.

- **Duplicates.** Duplicates are typically used as an indication of precision associated with the analytical process by calculating the relative percent difference between two results. At least one duplicate per field analytical method for each day of testing is recommended.

- **Matrix spikes.** A matrix spike is a field sample to which a compound with a known concentration is added. This sample is then carried through the entire analytical process to evaluate the interferences of other constituents in the field sample. Matrix spikes may not be practical where field preparation cannot be accomplished, the compounds involved are too hazardous to handle in the field, or another method can be used to determine proper functioning of the instrument or test kit.

- **Standards.** A standard is a sample with a known concentration that is used to determine the accuracy of the instrument. The use of standards varies with the specific field instrument.

A3.5.3 Laboratory Quality Control

Method and protocol specific QC requirements shall be followed as outlined in the laboratory procedures or laboratory statement of work. Laboratory QC samples must be run as part of the sample delivery group or analytical batch, as applicable. Types of laboratory QC samples are discussed below. Typical requirements for laboratory QC frequency and levels are provided; specific analytical techniques or protocols may have different requirements.

- **Laboratory control samples.** Laboratory control samples (LCSs) contain known quantities of analytes and are carried through the sample analysis procedure. Recovery (determined as the percentage of "found" analyte relative to the known amount introduced) is used to assess the accuracy (bias) of the analytical technique.

  As much as possible, LCSs shall be of a similar matrix and contain the same constituents of interest as the samples. Reference materials used to produce (e.g., spike) the LCS must be traceable to National Institute of Standards and Technology (NIST) (or equivalent) if possible and must be of known quality. The LCS concentrations shall be at least five times but not greater than 20 times the applicable required detection limits (RDLs). The LCSs shall be run at a minimum frequency of one in 20 samples, once per analytical batch, or once per sample delivery group, whichever is most frequent. The LCSs shall be prepared and analyzed in the same manner and have the same detection limit objectives as the samples.

- **Replicate analyses.** Replicate analyses consist of re-analysis of a sample, typically starting with the "raw" sample material. Replicate analyses are used to assess precision of the analysis. Some analytical techniques assess analytical precision via replicate measurement of "spiked" sample materials (see matrix spike).

  Replicate analyses shall be run at a minimum frequency of one in 20 samples, once per analytical batch, or once per sample delivery group, whichever is most frequent. Replicate samples shall be prepared and analyzed in the same manner as the samples and shall have the same detection limit objectives. If sufficient sample material has been provided, replicate samples shall use the same aliquot size as the original sample. It may be advantageous to request that the laboratory replicate a specific sample within a group of samples. This would typically be requested for the sample judged to have the highest concentrations of contaminants to minimize the possibility of replicating a sample that has contaminant levels below the detection limit. This approach would provide the maximum amount of information from the replicate.

- **Preparation blanks.** Preparation banks are materials known to be free from contamination that are carried through the same analytical procedure as the samples. Preparation blanks are used to evaluate potential laboratory contamination of samples that could result in reporting of false-positive results.

  Preparation blanks shall be run at a minimum frequency of one in 20 samples, once per analytical batch, or once per sample delivery group, whichever is most frequent. Preparation blanks shall be prepared and analyzed in the same manner and shall meet the same detection limit objectives as the samples.

- **Matrix spikes/matrix spike duplicates.** Matrix spikes consist of analysis of a replicate of an actual sample to which a known quantity of the analyte has been added. Recovery (determined as the percentage of "found" analyte relative to the known amount

introduced) provides information on sample specific matrix effects that result in an analytical bias for a given analysis batch. Matrix spike duplicates are an additional matrix spike sample required by some analyses where analysis of a simple replicate sample is inappropriate.

The spiking materials must be traceable (NIST, if possible) and of known quality. If possible, spikes shall be the same component as the samples. The matrix spike should be added at a concentration of at least five but not greater than 20 times the applicable RDL. Matrix spikes shall be prepared and analyzed at a minimum frequency of one per analytical batch, sample delivery group, or 20 samples of like matrix, whichever is most frequent. The matrix spike shall be prepared and analyzed in the same manner and shall have the same detection requirements as the client samples.

Matrix spikes are not required for radiochemical analyses if an isotopic tracer or chemical carrier is used in the analysis to determine chemical recovery (yield) for the chemical separation and sample mounting procedures. Matrix spikes shall be run on a separate sample aliquot using the same element as that being analyzed whenever possible. Matrix spikes are not required for gross alpha, gross beta, or gamma energy analysis.

A3.6 INSTRUMENT CALIBRATION AND MAINTENANCE

Onsite measurement test instruments shall be calibrated and maintained in accordance HNF-PRO-490, *Control and Measuring and Test Equipment* (FDH 1997i); HASQARD (DOE-RL 1998); and the manufacturer's test instructions. These procedures address calibration, standards, test equipment, onsite measurement procedures, data collection, reduction, and reporting.

The results from all instrument calibration and maintenance activities shall be recorded in a bound logbook in accordance with field logbook requirements outlined in Section A.2.6. Contract laboratory instruments shall be calibrated and maintained in accordance with the requirements specified by the applicable purchase requisition.

A3.7 FIELD DOCUMENTATION

Field documentation shall be managed as specified in Section A.2.6.

A3.8 DATA MANAGEMENT

Data resulting from the implementation of this QAPjP shall be managed and stored by the sampling and characterization organization in accordance with HASQARD (DOE-RL 1998); HNF-PRO-232, *Project Files Management* (FDH 1997f); HNF-PRO-210, *Records Management*

Program Standards (FDH 1997g); HNF-PRO-224, *Document Control Program Standards* (FDH 1997h); and Appendix C of this master work plan, Information Management Overview. At the direction of the RPP Vadose Zone Project Task Lead, all analytical data packages shall be subject to final technical review by qualified personnel before submittal to regulatory agencies or before inclusion in reports. Electronic data access, when appropriate, shall be via a database (e.g., the Hanford Environmental Information System or a project-specific database). Where electronic data are not available, hard copies shall be provided in accordance with Section 9.6 of the *Hanford Federal Facility Agreement and Consent Order* (Tri- Party Agreement) (Ecology et al. 1994).

A4.0 ASSESSMENT/OVERSIGHT

The QA organization may conduct random surveillance and assessments in accordance with HNF-PRO-246, *Management Assessment* (FDH 1997j); and HNF-PRO-651, *Surveillances* (FDH 1997k), to verify compliance with the requirements outlined in this appendix, project work packages, subcontractor procedures, and regulatory requirements. These surveillances may include review of plans, procedures, and records containing the results of inspections and tests for completeness, adequacy, and compliance with requirements; witnessing activities and operations in the process to verify accomplishment of required tasks; review of administrative records such as training records and process certification records; review of other types of documents such as field logbooks, calibration records, configuration control logbooks, records of previous accomplishment of corrective actions, and permits; personnel interviews; and physical walk-downs of operations or sites for compliance to specified requirements.

Deficiencies identified by assessments shall be reported and tracked in accordance with HNF-PRO-653, *Deficiency Tracking System* (FDH 1997l). This procedure describes the tracking and reporting of deficiencies identified during assessment activities and provides documentation substantiating the deficiency.

When appropriate, corrective actions shall be taken by the Vadose Zone Project Task Lead in accordance with the HASQARD, Volume 1, Section 4.0 (DOE–RL 1998), and HNF-PRO-052, *Corrective Action Management* (FDH 1997m), to minimize recurrence. The corrective action management procedure ensures that identified deficiencies are analyzed and resolved with attention commensurate with the relative risk of the finding and also provides a means for identifying performance trends.

A5.0 DATA VALIDATION AND USABILITY

Sample data shall be reviewed by the sample management organization to ensure that analyses were performed and reported as requested. A variety of validation levels are available through

the referenced procedure to meet the specific project needs. Specific validation requirements, including the validation frequency and level, should be developed through the DQO process and shall be defined in appropriate WMA addenda.

The data validation process will qualify analytically questionable data, but the reason for the qualifiers may be further considered and evaluated. For example, if an analysis is qualified because it exceeded the holding time called for by the analytical procedure, the analysis may nevertheless contain useful data. Consideration of the specific chemical, the condition that led to its qualifier, and the end use of the data may allow some data that are initially qualified to be used in support of the sampling objectives.

A6.0 DATA QUALITY ASSESSMENT

The data quality assessment (DQA) process may be used to evaluate the sampling and analysis process for the program. The DQA process compares the implemented sampling approach and resulting analytical data to the sampling and data quality requirements specified by the DQOs. Most of the elements of this process are applicable only to data collected by a random sampling design in DQA Step 2 (see below) dealing with QA/QC of the samples and can be applied to all data types. The results of the DQA process determine if the data are of adequate quality and quantity to support the decision-making process.

There are five steps to the DQA process:

- **Step 1, Review DQOs and sampling design.** This step requires a comprehensive review of the sampling and analytical requirements outlined in the WMA-specific DQO session and addenda.

- **Step 2, Conduct a preliminary data review.** In this step, a comparison is made between the actual data quality achieved (e.g., detection limits, precision, accuracy, and completeness) and the requirements determined during the DQO. Any significant deviations should be documented. Basic statistics should be calculated from the analytical data at this point, including an evaluation of the distribution of the data.

- **Step 3, Select the statistical test.** Using the data evaluated in DQA Step 2, select an appropriate statistical hypothesis test and justify the selection of this test.

- **Step 4, Verify the assumptions.** This step, which is optional, assesses the validity of the statistical hypothesis test by determining if the data support the underlying assumptions necessary for the selected test or if the data set must be modified (e.g., transposed or augmented with additional data) before further statistical analysis. If one or more assumptions are questioned, return to DQA Step 3 and re-evaluate the statistical test selected.

- **Step 5, Draw conclusions from the data.** The statistical test is applied in this step and the results either reject the null hypothesis or fail to reject the null hypothesis. If the latter is true, the data should be analyzed further. If the null hypothesis is rejected, the overall performance of the sampling design should be evaluated by performing a statistical power calculation to assess the adequacy of the sampling design.

A7.0 REFERENCES

10 CFR 830.120, "Quality Assurance Requirements," *Code of Federal Regulations*, as amended.

49 CFR 100, "Transportation," *Code of Federal Regulations*, as amended.

BHI-EE-01, *Environmental Investigations Procedures*, Bechtel Hanford, Inc., Richland, Washington.

DOE Order 5700.6C, *Quality Assurance*, as amended, U.S. Department of Energy, Washington, D.C.

DOE-RL, 1998, *Hanford Analytical Services Quality Assurance Requirements Documents*, DOE/RL-96-98, Rev. 2, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Ecology, EPA, and DOE, 1994, *Hanford Federal Facility Agreement and Consent Order*, Fourth Amendment, 89-10, Washington Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

EPA, 1986, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*, SW-846, 3rd ed., Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1994a, *EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations*, QA/R-5, U.S. Environmental Protection Agency, Quality Assurance Division, Washington, D.C.

EPA, 1994b, *Guidance for the Data Quality Objective Process*, QA/G-4, Environmental Protection Agency, Washington, D.C.

FDH, 1997a, *Fluor-Daniel Quality Assurance Program Description*, HNF-MP-599, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1997b, *Radioactive Material/Waste Shipment*, HNF-PRO-157, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1997c, *Responsibilities and Procedures for All Hazardous Materials*, HNF-PRO-154, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1997d, *Procurement Planning*, HNF-PRO-268, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1997e, *Environmental Training*, HNF-PRO-065, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1997f, *Project Files Management*, HNF-PRO-232, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1997g, *Records Management Program Standards*, HNF-PRO-210, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1997h, *Document Control Program Standards*, HNF-PRO-224, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1997i, *Control and Measuring and Test Equipment*, HNF-PRO-490, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1997j, *Management Assessment*, HNF-PRO-246, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1997k, *Surveillances*, HNF-PRO-651, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1997l, *Deficiency Tracking System*, HNF-PRO-653, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1997m, *Corrective Action Management,* HNF-PRO-052, Fluor Daniel Hanford, Incorporated, Richland, Washington.

IATA, 1998, *Dangerous Goods Regulations,* International Air Transport Association, as amended.

LMHC, 1997, *Quality Assurance Program Plan*, HNF-IP-0842, Vol. XI, Lockheed Martin Hanford Corporation, Richland, Washington.

WAC 173-340, "Model Toxics Control Act - Cleanup," *Washington Administrative Code*, as amended.

Figure A-1. Organization for the Tank Farm Vadose Zone Project

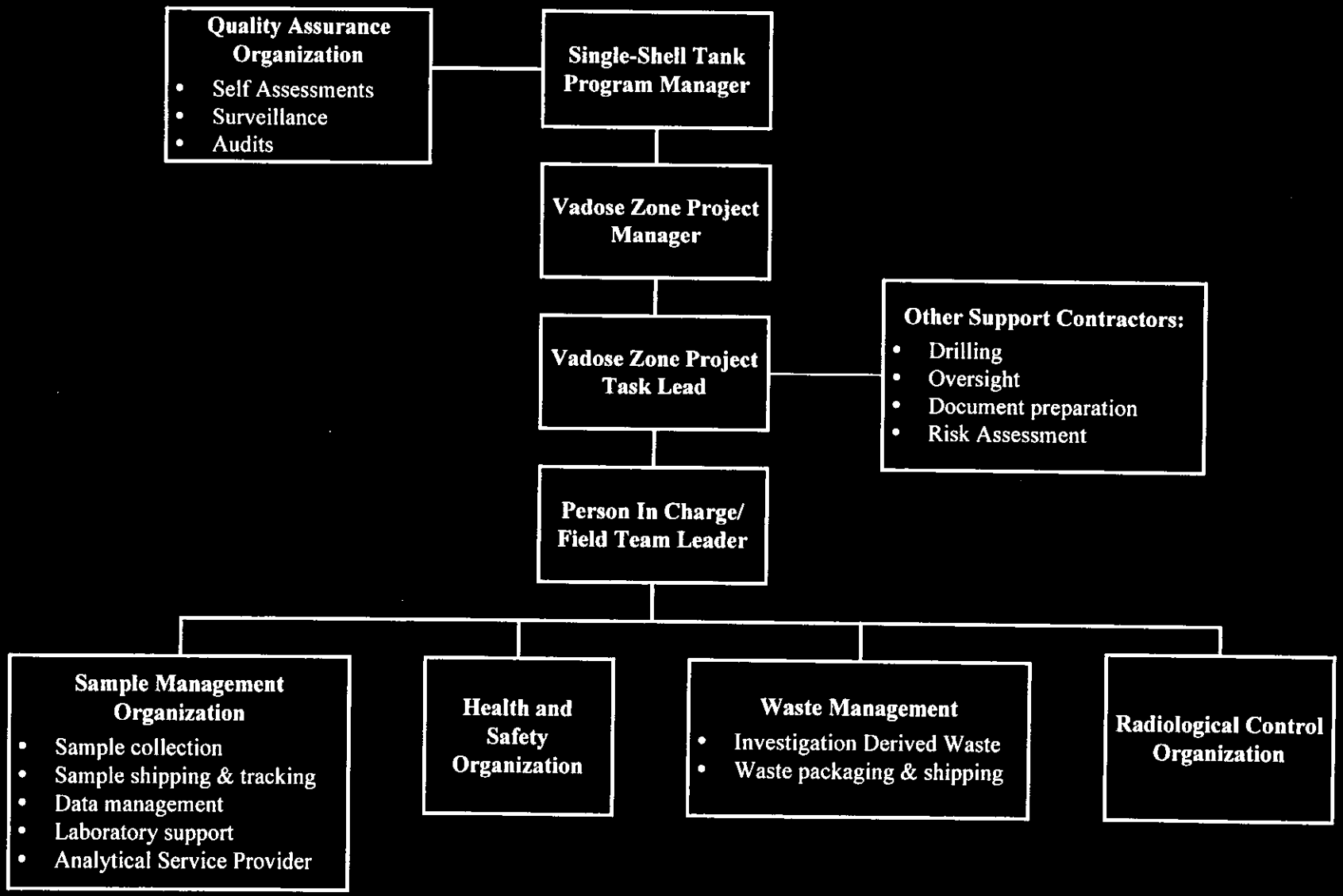


Table A-1. Potential Tasks and Investigation Methods for Soil Characterization. (7 Pages)

Task/ Method	Description	Uses/Benefits	Problems/Limitations	Value to Characterization at Stage of Application			
				Pre-Characterization Site Evaluation[a]	WMA Characterization[b]	Verify Remedial Design/ Corrective Action[c]	Post-Closure Monitoring[d] (Long Term)
Historical investigation	- Photographic imagery (ground and air) - Airborne gamma surveys - Stereo photography - WIDS database	- Document waste site locations and ground surface conditions - Document site changes over time - Quickly identify contaminated areas	- Photo and aerial survey coverage is incomplete and inconsistent over history of Hanford Site operations - Photo record is extensive but not well maintained, indexed or readily available	High	Low	Low	Low
Surface radiological surveys	- Analyze radiological activity of surface soils with hand-held instruments or mobile surface contamination monitor	- Qualitative/semi-quantitative determination of presence/absence of radionuclides (total gamma, beta, and alpha) - Standard, cost-effective method - Direct and noninvasive - Applicable to large areas	- Generally not capable of radioisotopic analysis - Generally not quantitative	Medium	Low	Medium	Medium
Surface soil sampling	- Collect soil samples for field or laboratory analysis	- Rapid and inexpensive collection of soils using simple tools and techniques - More detail provided in Table A-3	- Limited to near-surface - Sample only represents small portion of waste site	Medium	Low	High	Low

Table A-1. Potential Tasks and Investigation Methods for Soil Characterization. (7 Pages)

Task/ Method	Description	Uses/Benefits	Problems/Limitations	Value to Characterization at Stage of Application			
				Pre-Characterization Site Evaluation[a]	WMA Characterization[b]	Verify Remedial Design/ Corrective Action[c]	Post-Closure Monitoring[d] (Long Term)
Test pits/ trenching	- Soil excavation at waste sites to permit sampling of shallow contamination	- Relatively easy and quick method to examine subsurface geology and collect samples in the first 8 m (25 ft) of soil column - Standard, cost-effective method - Unlimited available sample volume	- Care required to ensure that sidewall sloughing does not cross-contaminate soil sample - Depth limited by size of available backhoe - May be difficult to collect samples from narrow discrete intervals - Disturbed sample limits physical properties tests that can be performed	N/A	High	Medium	Low
Boreholes	- Driven, cable tool, sonic push, or air rotary drilling methods to recover soil samples and/or deploy geophysical tools	- Can provide continuous or interval samples/record of soil column stratigraphy through observation of cuttings and/or split-spoon samples - Standard method available on site - Unlimited depth potential - Useful in all types of geologic media - More detail provided in Table A-3	- Expensive and time consuming process - Potentially non-representative samples for physical properties - Sample only represents small portion of waste site - Sample recovery and volume limited based on lithology	N/A	High	Medium	High

Table A-1. Potential Tasks and Investigation Methods for Soil Characterization. (7 Pages)

Task/ Method	Description	Uses/Benefits	Problems/Limitations	Value to Characterization at Stage of Application			
				Pre-Characterization Site Evaluation[a]	WMA Characterization[b]	Verify Remedial Design/ Corrective Action[c]	Post-Closure Monitoring[d] (Long Term)
Borehole geophysical logging	- Remote analysis of soil column around borehole or cone penetrometer with passive and active tools to evaluate soil moisture, porosity, gamma-emitting radionuclides, etc.	- Readily available on site; cost-effective for the amount of data collected - Several different tools are available for soil property characterization - Continuous logs can evaluate a substantial vertical profile - Data are accurate, near real-time - Spectral gamma analysis available (cone penetrometer)	- Borehole diameter and construction data are critical to use and interpretation of data - Significant interpretation and calibration required to ensure meaningful results	High (using existing boreholes)	High (using new boreholes)	Low	High

Table A-1. Potential Tasks and Investigation Methods for Soil Characterization. (7 Pages)

Task/ Method	Description	Uses/Benefits	Problems/Limitations	Value to Characterization at Stage of Application			
				Pre-Characterization Site Evaluation[a]	WMA Characterization[b]	Verify Remedial Design/ Corrective Action[c]	Post-Closure Monitoring[d] (Long Term)
Cone penetrometer	- Pushed or driven hollow rods used to provide access to subsurface	- Rod driving forces can be used to detect lithology changes - Cost effective compared to boreholes - Rods can be equipped for a number of sampling and characterization purposes, including geophysical logging - Relatively rapid borehole construction - Good for soil gas surveys - Developing technologies for tomographic subsurface imaging and in situ x-ray fluorescence - Sample techniques have been developed that allow collection of multiple samples using a wireline.	- Some limitation on depth of characterization, based on lithology and size of equipment - Collection of soil samples very limited; typically poor recovery - Most cone pushes limited to one sample per hole.	N/A	High	Medium	Low
GeoProbe	- Pushed and vibrated hollow rods of small diameter, used to provide access to subsurface	- Rapid and cost-effective - Available on site - Excellent for soil gas surveys - Can be used with some specially configured geophysical tools, several currently in development	- Severe limitation on depth due to small rod size and driving unit - Collection of soil samples depth limited; recovery is poor in some lithologies	N/A	Low	Medium	Low

Table A-1. Potential Tasks and Investigation Methods for Soil Characterization. (7 Pages)

Task/ Method	Description	Uses/Benefits	Problems/Limitations	Value to Characterization at Stage of Application			
				Pre-Characterization Site Evaluation[a]	WMA Characterization[b]	Verify Remedial Design/ Corrective Action[c]	Post-Closure Monitoring[d] (Long Term)
Field analysis	- In field chemical analysis of soil samples; portable or mobile laboratory/truck mounted field tests and equipment	- Wide variety of tests and instrumentation available - Relatively cost effective compared to fixed laboratory analysis. - Quick turnaround for results is possible - Available for volatile organics, semi-volatile organics, pesticides, herbicides, metals, PCBs, etc.	- Analytical accuracy and precision generally poor compared to fixed laboratory analysis - Results are not suitable for most regulatory decision-making (unless routine laboratory confirmation is specified) - Generates waste that must be dispositioned	N/A	Medium	High	Low
Laboratory analysis	- Routine, high-quality chemical and radiological analysis of soil samples using instrumentation and techniques that produce data of high precision and accuracy	- Laboratory analysis is the standard for highest quality, lowest detection level results, for virtually any target analyte - Standard for regulatory decision making - Use is assumed to occur with borehole, test pit, soil gas, or surface sampling activities	- Expensive and not timely - Rigorous sampling requirements necessary to ensure representative results	N/A	High	Medium	Low

Table A-1. Potential Tasks and Investigation Methods for Soil Characterization. (7 Pages)

Task/ Method	Description	Uses/Benefits	Problems/Limitations	Value to Characterization at Stage of Application			
				Pre-Characterization Site Evaluation[a]	WMA Characterization[b]	Verify Remedial Design/ Corrective Action[c]	Post-Closure Monitoring[d] (Long Term)
Surface geophysical methods	- Use of surface instrumentation to remotely evaluate the subsurface; methods include GPR, EMI, and magnetic techniques/ instrumentation to measure response to signals	- Evaluation of shallow subsurface to define boundaries of an excavation, and detect buried manmade materials such as drums, pipelines, etc. - Provides rapid, broad areal coverage - Cost effective, readily available, near real-time data - Works best where significant contrast in material property response exists (e.g., metal vs. soil)	- Generally limited to depths <6 m - Considerable interpretation of results may be necessary	High	High	Low	Low
Multi-borehole geo-physical techniques	- Crosshole geophysical measurements using electrical resistance, nuclear-magnetic resonance, and x-ray computed tomography tools/techniques	- Techniques are currently regarded as most useful in measuring soil moisture changes - Proposed as a method of monitoring for leak detection around tanks - Excellent areal and vertical coverage possible	- All systems are in preliminary stages of development and are very expensive to procure - Multiple boreholes required - Extensive computer modeling required to produce results	Low	Low	Low	High
Vadose Moisture Monitoring	- Moisture content within the vadose zone can be measured using lysimeters and tensiometers	- These devices permit the measurement of water draining through the soil; contaminant migration can also be assessed	- These environmental tools must be designed properly to provide meaningful information	Low	Medium	High	High

Table A-1. Potential Tasks and Investigation Methods for Soil Characterization. (7 Pages)

Task/ Method	Description	Uses/Benefits	Problems/Limitations	Value to Characterization at Stage of Application			
				Pre-Characterization Site Evaluation[a]	WMA Characterization[b]	Verify Remedial Design/ Corrective Action[c]	Post-Closure Monitoring[d] (Long Term)
Surface geophysical methods (for soil moisture content)	- Similar techniques to routine (GPR and EMI) methods, plus electrical resistivity - Instrumentation modifications and analysis is geared to examining greater depths in the soil column	- Greater depth penetration due to electrode spacing or antenna configuration - Used to evaluate relative moisture content differences, organic concentration in subsurface	- Qualitative rather than quantitative results - Specific limits and soil interferences for individual techniques - Limited to top 5 m of soil column, decreased resolution with depth	Low	Low	Low	High

[a] Pre-characterization is used to indicate simple, inexpensive, non-invasive activities that can be conducted around WMAs without the expectation of generating data suitable for site characterization.

[b] Characterization directed by WMA addenda. It is assumed that some invasive drilling/trenching activities will be performed to acquire samples in support of refining the conceptual model and determining a suitable corrective action strategy for the WMA.

[c] Verify remedial design/corrective action sampling is appropriate for designs/plans in WMAs primarily to be treated, by a remove, treat, and dispose corrective action option for contaminated soil. Here the limits of excavation and disposal are dictated by contaminant concentrations.

[d] Post-closure monitoring is a long-term examination of WMAs, primarily with respect to the movement of contaminants and moisture through the vadose zone. Requirements for this would be specified in the closure/post-closure plan. The primary concern is the movement of moisture through the soil column transporting contaminants to the groundwater table. Soil-moisture-content-based detection systems in boreholes are currently viewed as the best tools for this task.

N/A = not applicable
WIDS = Waste Information Data System
WMA = Waste management area
PCBs = polchlorinated biphenyls
GPR = ground-penetrating radar
EMI = eletromagnetic induction

1

Table A-2. Topics to be Considered During DQO Sessions.

Item	Aspect to be Considered
1.	Project assumptions (especially assumptions that could result in project failure).
2.	Identification of the regulatory pathway, phase, and logic.
3.	Identification of regulatory, legal, agreement, and statute obligations and constraints (e.g., (Tri-Party Agreement) (Ecology et al. 1994) milestones, applicable or relevant and appropriate requirements, waste acceptance criteria requirements).
4.	Development of legal positions or interpretations.
5.	Identification of regulatory quantitative limits (e.g., maximum contaminant levels, *Model Toxic Control Act* A, B, or C cleanup levels).
6.	Identification of *National Environmental Policy Act* of 1969 needs and constraints (e.g., clearances, surveys, impact analyses).
7.	Identification of cultural and biological constraints (e.g., clearances and surveys).
8.	Waste management requirements (e.g., applicable procedures, waste acceptance criteria, land disposal requirements, treatment standards).
9.	Air quality constraints.
10.	Health physics risks, hazards, and as low as reasonably achievable needs (e.g., isotopic profiles).
11.	Milestone requirements (e.g., Tri-Party Agreement, RCRA permit, project schedules).
12.	Availability and summation of all data available, historical information, waste inventories, contaminant analyses and concentration ranges, drilling records, geophysical data, background values, monitoring measurements, and ecological reports (e.g., HEIS data and data files).
13.	Evaluation and summary of process knowledge (e.g., historical baselines).
14.	Identification of potential data uses and users (e.g., data analysis plans, models, WIDS, HEIS, decision makers, public).
15.	List of contaminants of concern (e.g., process knowledge, ROD lists, limited field investigation/qualitative risk assessment reports, RCRA Part A Permit application).
16.	List of potential investigation method alternatives.
17.	List of potential remedial design criteria and alternative data needs.
18.	Maps and diagrams.
19.	Cost-estimating tools and documents.
20.	List of analytical methods and detection limits (e.g., *Test Methods for Evaluating Solid Waste* [SW-846], toxic characteristic leaching procedure, field screening).
21.	Risk assessment models, pathways, receptors, parameters, and fate and transport parameters.
22.	Radiation detection methods and detection limits.
23.	List of proposed agreements to be achieved (e.g., issues to be resolved).

Tri-Party Agreement = *Hanford Federal Facility Agreement and Consent Order*
RCRA = *Resource Conservation and Recovery Act of 1976*
HEIS = Hanford Environmental Information System
WIDS = Waste Information Data System
ROD = Record of Decision

2

1

Table A-3. Potential Soil Sampling Techniques. (2 pages)

Sampling Methods	Sampling Techniques	Advantages/ Disadvantages	Limitations
Test pits/trenching	Scoop, directly from pit/trench or backhoe bucket	Easy to use in unconsolidated soils; fast and cost effective. Good quality samples can be collected, but may not be as representative as split-spoon samples.	Manned entry into unsupported excavation limited to 1.5 m depth; effective depth of sampling from backhoe bucket is approximately 6 m.
Shallow surface sampling	Scoop/spade/shovel	Simple and effective in unconsolidated materials, recovery is generally good. Must use disposable tools or decontaminate between samples.	Effective depth of sampling is typically <15 cm. Difficult to sample consolidated materials.
	Hand auger	Simple in unconsolidated soils; portable. Cross-contamination is likely and collection of undisturbed sample is infeasible.	Effective for top 3 m of soil. May locally homogenize sample. Not recommended for volatile organic analytes, because augering motion facilitates volatilization.
	Hand corer/sediment punch	Useful in many soil types. Sample recovery difficult with small diameter core tube.	Not effective below approximately 60 cm. Difficult to sample consolidated materials.
	Split tube	May be used in conjunction with pits/trenches to obtain deeper samples. Requires heavy equipment (e.g., drill rig and backhoe) to drive tube.	Not effective below approximately 1 m.

Table A-3. Potential Soil Sampling Techniques. (2 pages)

Sampling Methods	Sampling Techniques	Advantages/ Disadvantages	Limitations
Deep soil sampling	Cone penetrometer/ GeoProbe	Relatively fast and inexpensive in unconsolidated formations; excellent contamination control. Rod driving forces may be used to detect lithology changes. Sample techniques have been developed that allow collection of multiple samples using a wireline.	Depth is limited to approximately 30 m in unconsolidated materials. Only small sample volume can be obtained; most cone pushes limited to one sample per hole.
	Auger drilling	Potentially fast and inexpensive. Hollow flights can be used in conjunction with a split-spoon sample to obtain representative samples. Cross-contamination is a potential problem.	Not practical for obtaining very deep samples. Relatively large volume of cuttings may create waste disposal problem.
	Cable tool drilling	Excellent contamination control and high-quality sample collection. Can be used under most environmental conditions.	Relatively slow and expensive. Recent data suggest the sample contamination can be significant.
	Sonic drilling	Fast and relatively inexpensive. Heat generated may alter chemical and physical properties of sample.	Sample quality is often poor. Collection of meaningful volatile organic analyte sample is difficult.
	Air rotary drilling	Fast, depending on sampling requirements. Quality samples can be collected.	Use in contaminated areas may create an air release issue.

APPENDIX B

GENERAL HEALTH AND SAFETY PLAN

CONTENTS

B1.0 GENERAL CONSIDERATIONS AND REQUIREMENTS B-1

B2.0 HEALTH AND SAFETY PROGRAM DESCRIPTION B-1
B2.1 DESIGNATED SAFETY PERSONNEL B-2
B2.2 HAZARD IDENTIFICATION B-3
B2.3 HAZARD MITIGATION AND CONTROL B-3
B2.3.1 Airborne Pathogens B-4
B2.3.2 Other Poisonous/Venomous Fauna B-4
B2.3.3 Bloodborne Pathogens B-4
B2.3.4 Confined Spaces B-4
B2.3.5 Cuts/Abrasions and Punctures B-4
B2.3.6 Electrical Shock B-4
B2.3.7 Falling/Falling Objects B-5
B2.3.8 Fire/Explosion B-5
B2.3.9 Noise B-6
B2.3.10 Stored Hazardous Energy (Lockout/Tagout) B-6
B2.3.11 Temperature Extremes B-6
B2.3.12 Tripping/Slipping B-6
B2.3.13 Radiation B-6
B2.3.14 Hazardous Substances B-7

B3.0 TRAINING B-7
B3.1 40-HOUR HAZWOPER TRAINING B-8
B3.2 INITIAL TRAINING B-8
B3.2.1 General Site Workers B-8
B3.2.2 Infrequent Workers B-8
B3.2.3 Exposures at Less Than Permissible Limits B-9
B3.2.4 Additional Training B-9
B3.2.5 Management and Supervisor Training B-9
B3.2.6 Trainer Qualifications B-9
B3.2.7 Training Certification B-9
B3.2.8 Emergency Response B-10
B3.2.9 Refresher Training B-10
B3.2.10 Visitor Training B-10
B3.2.11 Additional Training Requirements B-10

B4.0 PERSONAL PROTECTIVE EQUIPMENT B-11

B5.0 MEDICAL SURVEILLANCE B-11
B5.1 MEDICAL EXAMINATION FREQUENCY B-12
B5.2 MEDICAL EXAMINATION CONTENT B-12
B5.3 INFORMATION TO BE SUPPLIED TO THE EXAMINING PHYSICIAN B-12

CONTENTS (cont.)

B5.4 INFORMATION TO BE SUPPLIED BY THE EXAMINING PHYSICIAN B-13
B5.5 INFORMATION TO BE SUPPLIED TO THE EMPLOYEE B-13
B5.6 RECORDKEEPING B-13
B5.7 OTHER MEDICAL PROVIDERS B-13
B5.8 MONITORING B-13
B5.8.1 Radiological Monitoring B-13
B5.8.2 Chemical monitoring B-14
B5.8.3 Other monitoring B-15

B6.0 SITE CONTROL B-15
B6.1 DECONTAMINATION B-16
B6.2 EMERGENCY RESPONSE B-17
B6.3 CONFINED SPACE ENTRIES B-18
B6.4 SPILL CONTAINMENT PROGRAM B-19
B6.5 HAZARD COMMUNICATION PROGRAM B-19
B6.6 PROGRAM EFFECTIVENESS B-20

B7.0 PRE-ENTRY BRIEFINGS B-20

B8.0 REFERENCES B-21

ACRONYMS

AHA	activity hazard analysis
AJHA	automated job hazards analysis
ALARA	as low as reasonably achievable
BED	Building Emergency Director
CFR	*Code of Federal Regulations*
CMP	chemical management program
CMS	corrective measures study
DOE	U.S. Department of Energy
EJTA	employee job task analysis
FDH	Fluor Daniel Hanford, Incorporated
GFCI	ground fault circuit interrupter
HASP	health and safety plan
HEHF	Hanford Environmental Health Foundation
HSRCM	*Hanford Site Radiological Control Manual*
ISMS	Integrated Safety Management System
LMHC	Lockheed Martin Hanford Corporation
OSHA	Occupational Safety and Health Administration
PIC	person in charge
PPE	personal protective equipment
RCRA	*Resource Conservation and Recovery Act of 1976*
RCT	radiological control technician
RFI	RCRA facility investigation
RWP	radiological work permit
SHSO	site health and safety officer
SS HASP	site-specific health and safety plan
SST	single-shell tank
WMA	waste management area

B1.0 GENERAL CONSIDERATIONS AND REQUIREMENTS

The purpose of this general health and safety plan (HASP) is to outline standard health and safety requirements for participants and contractors performing fieldwork in support of the single-shell tank (SST) *Resource Conservation and Recovery Act of 1976* (RCRA) Corrective Action Program (RCAP). Objectives of the RCAP and background information (e.g., site description and history) pertaining to this effort are described in Sections 1.0, 2.0, and 3.0 of this master work plan. Field investigation may include surface investigation, groundwater wells drilling, test pits construction, and environmental sampling in areas of known chemical and radiological contamination. Field efforts supporting the RCAP will be detailed in waste management area (WMA) addenda.

Primary hazards associated with RFI/CMS activities may include direct radiation exposures, heat stress, exposures to hazardous substances, potential personnel contamination, and potential inhalation of airborne concentrations of radioactive materials. Other hazards may include moving or stationary objects and exposures to hazardous stored-energy systems/devices. Appropriate site-specific safety documents (e.g., site-specific health and safety plan [SS HASP] and a job hazard analysis will be prepared to minimize these and other hazards for each task or group of tasks identified in WMA addenda.

B2.0 HEALTH AND SAFETY PROGRAM DESCRIPTION

To assist in the development of SS HASP, the automated job hazards analysis (AJHA) will be used in accordance with HNF-PRO-079, *Job Hazard Analysis* (FDH 1998a). The AJHA is a computer-based application to assist planners in identifying the potential hazards associated with a job task and in implementing the proper controls based on the hazards identified. The program accomplishes this task by presenting the user with a panel of questions, which lead to controls based on the user's responses. Additional assistance is provided through a library of previous AJHAs, a set of Hanford Site forms and permits that can be completed and stored electronically, and a method of indicating the involvement of subject matter experts' involvement electronically. At a minimum, the AJHA system, combined with the PHMC's Integrated Safety Management System (ISMS), will accomplish the program elements/objectives summarized in Table B-1.

Proper use of the AJHA in conjunction with this HASP, as well as specifics associated with the task, will constitute an acceptable SS HASP. The SS HASP need not duplicate subject matter covered in this HASP, such as general medical surveillance requirements, basic training requirements, etc. In accordance with the *Code of Federal Regulations* (CFR), 29 CFR Part 1910.12(6)(1)(v), this HASP shall be made available to employees and any contractor/subcontractor involved with hazardous waste operations.

B2.1 DESIGNATED SAFETY PERSONNEL

This section describes the responsibilities of designated site safety personnel and staff. The supporting project organization is described in Section 7.2.1 of the master work plan and also in Appendix A.

The person in charge (PIC)/field team leader, the site health and safety officer (SHSO), and the radiological control technicians (RCTs) are responsible for site safety and health. Specific individuals will be assigned on a task-by-task basis by project management. The names of these individuals will be properly recorded before tasks are initiated in the SS HASP. All onsite activities must be cleared through the PIC/field team leader. The PIC/field team leader has responsibility for the following:

- Allocating and administering resources to successfully comply with all technical and health and safety requirements.
- Verifying that all permits, supporting documentation, and clearances are in place (e.g., electrical outage requests, welding permits, excavation permits, SS HASP or activity hazard analysis (AHA), sampling plan, and radiological work permits [RWPs]).
- Providing technical advice during routine operations and emergencies.
- Informing the appropriate site management and safety personnel of the activities to be performed each day.
- Coordinating resolution of any conflicts that may arise between RWPs and implementing the SS HASP or AHA.
- Handling emergency response situations as required.
- Conducting pre-job meetings and daily tailgate safety meetings.
- Interacting with adjacent building occupants and/or the public.

The SHSO is responsible for implementing the SS HASP at the site. The SHSO shall ensure the following functions are performed:

- Evaluate chemical, physical, and (in conjunction with the RCT) radiation hazards to assess the degree of hazards present; monitoring shall specifically include organic vapor detection, radiation screening, and confined space evaluation where appropriate.
- Determine protection levels, clothing, and equipment needed to ensure the safety of personnel (in conjunction with the Radiological Control organization).
- Monitor the performance of all personnel to ensure that the required safety procedures are followed.

- Halt operations immediately, if necessary, due to safety or health concerns.
- Conduct safety briefings, as necessary.
- Assist the PIC/field team leader in conducting safety briefings as necessary.

The PIC/field team leader is responsible for site safety and health. The PIC/field team leader will use the Lockheed Martin Hanford Corporation (LMHC) Radiological Control organization to ensure that all radiological monitoring and protection procedures are being followed as specified in the *Hanford Site Radiological Control Manual* (HSRCM) (DOE-RL 1996) and in the appropriate RWP. The Radiological Control organization is responsible for all radiological evaluations and monitoring. A safety overview will be provided by LMHC safety and health personnel during work site activities consistent with U.S. Department of Energy (DOE) policy and will provide technical advice, as requested. Personnel monitoring and downwind air monitoring for hazardous materials and radiological or other contaminants may be requested from appropriate project or contractor personnel as required.

The ultimate responsibility and authority for employees' health and safety lies with the employee and the employee's colleagues. Each employee is responsible for exercising the utmost care and good judgment in protecting his/her personal health and safety and the health and safety of fellow employees. Should any employee observe a potentially unsafe condition or situation, it is the responsibility of that employee to immediately bring the observed condition to the attention of the appropriate health and safety personnel, as designated previously. In the event of an immediately dangerous or life-threatening situation, the employee has "stop work" authority and the responsibility to immediately notify the PIC/field team leader or the SHSO. When work is temporarily halted because of a safety or health concern, personnel will exit the exclusion zone and will meet at a predetermined place in the support zone. The PIC/field team leader, SHSO, and RCT will determine the next course of action.

B2.2 HAZARD IDENTIFICATION

A walk-down of the WMA shall be conducted to qualitatively assess the applicability and nature of various potential industrial hazards intrinsic to the work site. The objective of the facility walk-down is to provide relevant data and descriptions of potential facility hazards, as well as the accompanying engineered and administrative mitigators. The observations should be divided into four broad categories and shall be used as a basis for the SS HASP: (1) kinetic energy hazards, (2) chemical hazards, (3) radiation hazards, (4) electrical hazards, and (5) other industrial hazards.

B2.3 HAZARD MITIGATION AND CONTROL

This section describes common hazard mitigation and control. The SS HASP shall identify WMA-specific hazard mitigation measures.

B2.3.1 Airborne Pathogens

The potential for exposure to either the Hantavirus or the *Histoplasma capsulatum* fungus is considered to be low to very low, but the potential for exposure is not nonexistent. If removal/decontamination of rodent and/or bird/bat droppings is to be undertaken, affected personnel will be afforded appropriate personal protective equipment (PPE), will be appropriately trained, and will be provided with the appropriate medical surveillance. If rodent droppings are observed, traps and poisons shall be used in the affected areas.

B2.3.2 Other Poisonous/Venomous Fauna

Work spaces will be surveyed daily for infestations of spiders, wasps, bees, and snakes. Poisons will be used to kill insects. Egg sacs, webs, combs and other such residence structures will be destroyed as they are discovered. Employee training will include recognition, avoidance, and reporting requirements.

B2.3.3 Bloodborne Pathogens

The potential for exposure to bloodborne pathogens is considered to be low. Standard precautionary measures such as cleaning and sanitizing of respirators and the use of barriers and PPE in the administration of first aid will be exercised. Only properly trained employees will administer first aid. Only respirators cleaned and sanitized according to the manufacturer's recommendations will be used. Bloodborne pathogens shall be controlled in accordance with HNF-PRO-584, *Bloodborne Pathogens* (FDH 1997a).

B2.3.4 Confined Spaces

All entries into confined spaces will require that a confined space hazard identification be completed, and compliance with applicable conditions of HNF-PRO-110, *Confined Space* (FDH 1997b).

B2.3.5 Cuts/Abrasions and Punctures

Preventive measures will be taken to eliminate or minimize worker exposure to sharp edges and/or points. Personal protective equipment shall be used where exposure to sharp edges and/or points cannot be eliminated. Personnel training shall be conducted in the proper use of selected or designated PPE.

B2.3.6 Electrical Shock

All electrical equipment shall be Underwriters' Laboratories (UL) listed or equivalent. Ground fault circuit interrupters (GFCIs) shall be used on all receptacles that are not part of the permanent structure wiring, and in damp or wet working areas. All electrical work shall be performed in compliance with HNF-PRO-088, *Electrical Work Safety* (FDH 1998b).

B2.3.7 Falling/Falling Objects

Working and walking surfaces that have openings from which there is a drop of more than 1.2 m (4 ft) shall be guarded by standard slats, standard grill work (as specified in Paragraph (e)(11) of 29 CFR Part 1910.23), or standard railing. Where it is impractical to provide such engineered barriers, alternative fall protection will be provided. Such alternatives protection shall conform to the standards specified in Occupational Safety and Health Administration (OSHA) Directive No. 75-40 (see 29 CFR Part 1910.23). Whenever persons can pass beneath the open sides, there is moving machinery beneath the open sides, or there is equipment with which falling materials could create a hazard, installed guards shall also include toe boards. Project activities will comply with all provisions of HNF-PRO-092, *Fall Protection* (FDH 1997c) and this section.

B2.3.8 Fire/Explosion

Project activities and procedures will focus on preventing fires and explosions through adherence to the following precautions and procedures:

- **Combustibles:** The accumulation and/or use of combustible materials will be controlled in accordance with the provisions of HNF-PRO-359, *Control of Combustibles* (FDH 1997d), and HNF-PRO-358, *Flammable/Combustible Liquids* (FDH 1997e). Accumulations of combustible materials in areas of high radioactive materials inventories shall not be permitted.

- **Welding, cutting, and grinding:** Both high-hazard hot work (i.e., electric arc welding, oxy-fuel gas welding/cutting, heavy grinding, etc.) and low-hazard hot work (i.e., brazing, tig-welding, light grinding, etc.) shall be conducted in accordance with the provisions of HNF-PRO-356, *Controlling Hotwork* (FDH 1998c).

- **Fire watch:** Fire watches shall be established and maintained in accordance with the provisions of HNF-PRO-356, *Controlling Hotwork* (FDH 1998c).

- **Periodic inspections:** When non-routine project activities dictate the generation or use of combustible materials, a fire protection engineer will specify locations for accumulation of waste combustible materials in accordance with HNF-PRO-349, *Fire Protection Design Criteria* (FDH 1997n). In addition, the fire protection engineer will conduct random inspections of work areas and facilities for transient combustibles in accordance with HNF-PRO-684, *Fire Protection Facility Assessments* (FDH 1997o).

- **Portable heaters:** The use of portable heaters in the close proximity of combustible materials shall be prohibited. Use of portable heaters shall be in accordance with the provisions of HNF-PRO-355, *Portable Heaters* (FDH 1997f).

- **Monitoring:** Monitoring for combustible gases shall be required immediately before any hot work commences, provided that a combustion potential exists in accordance with HNF-PRO-356, *Controlling Hotwork* (FDH 1998c).

B2.3.9 Noise

Workers shall be provided approved hearing protection devices any time that continuous, intermittent, impulsive and/or impact noise levels attain or exceed a time-weighted average of 85 decibels on the A-weighting scale (dBA), as measured with a sound meter at slow response. Additional permissible levels for exposure durations less than 8 hours are provided in Table B-2. Hearing protection shall also be provided to employees who have experienced a standard threshold shift. The hearing conservation program including monitoring, employee training, and medical surveillance, shall be conducted in accordance with the provisions of HNF-PRO-115, *Hearing Conservation* (FDH 1997g).

B2.3.10 Stored Hazardous Energy (Lockout/Tagout)

Workers shall be protected against unexpected releases of stored energy and/or hazardous materials through the use of locking or tagging energy isolating devices, or use of devices that prevent the release of hazardous materials. A hazardous energy control program shall be prepared for the project in accordance with the provisions of HNF-PRO-081, *Hazardous Energy Control Program* (FDH 1997h).

B2.3.11 Temperature Extremes

Workers shall be protected against exposures to temperature extremes. To the maximum extent practicable, protection will be engineered into work place environments. Where engineered controls are not practicable, or where other work requirements reduce the effectiveness of engineered controls (e.g., the use of PPE), measures shall be taken to mitigate the effects of heat and cold stress and to prevent the occurrence of heat exhaustion and hypothermia. The occurrence of heat stress is considered to be of a higher probability (medium to high) than the occurrence of hypothermia (low). The project shall conduct operations in accordance with the provisions of HNF-PRO-121, *Heat Stress Control* (FDH 1997i). Workers involved in cold weather operations conducted outside of protective structures shall be afforded appropriate protective clothing; be briefed in the recognition of the symptoms of frost nip, frost bite and hypothermia; and be provided the latitude to take advantage of rest periods inside of heated protective structures. Hot and cold stress controls will be included in the AJHA.

B2.3.12 Tripping/Slipping

Work areas shall be maintained in an orderly condition and kept free of tripping hazards. To the extent practicable, all working surfaces shall be kept clean and dry. Liquid spills shall be cleaned as soon after occurrence as may be practicable. Means of access and egress shall be well identified and kept clear of obstacles. The project shall adhere to such other controls and practices as specified in HNF-PRO-092, *Fall Protection* (FDH 1997c).

B2.3.13 Radiation

Fluor Daniel Hanford, Incorporated (FDH) has a robust and mature radiation protection program. This program is described in the HSRCM (DOE-RL 1996). The HSRCM fully implements 10 CFR Part 835, "Occupational Radiation Protection," as currently amended. The planning of

work involving radiation and radioactive materials hazards is further described in HNF-PRO-1623, *Radiological Work Planning Process* (FDH 1998d). Implementation of radiological work and radiation protection activities is detailed in more than 70 procedures. These procedures address all aspects of the Hanford Site Radiation Protection Program, including roles and responsibilities, qualifications, training, implementation of the as low as reasonably achievable (ALARA) philosophy, external and internal dosimetry, monitoring and surveillance, work control mechanisms (e.g., RWPs and access and entry requirements), self-assessments, and use of specific radiation monitoring devices and meters. Project-specific radiological hazard controls are identified through the use of the AJHA (described in Section B2.0).

The FDH Radiation Protection Program satisfies all of the requirements of 29 CFR Part 1910.120 for a health and safety program for radiological hazards. As a consequence, this HASP will not impose any new or different requirements. The program will be implemented so personnel radiation exposures are maintained ALARA.

B2.3.14 Hazardous Substances

The FDH Chemical Management Program (CMP) (as described in HNFPRO2258, *Chemical Management* [FDH 1998e]), in conjunction with implementation of the AJHA, will be relied upon to protect the worker, the general public, and the environment. The CMP provides direction for the acquisition, storage, transportation, use, final disposition, record keeping, and management review of program performance for chemicals at the Hanford Site. Sub-elements of the CMP are provided in Table B-3.

While the CMP provides for general provisions for procurement, transportation, storage, and use of hazard chemicals, materials, and substances, it does not provide the specificity required by 29 CFR Part 1910.120; that specificity is satisfied, however, through use of the AJHA, as summarized in Section B2.0. As a consequence, hazard mitigation and control for specific hazardous chemicals will be detailed SS HASP.

B3.0 TRAINING

The Hanford Site has an established training system covering most, if not all, operational and safety aspects of site operations, including the training required by this section. The following subsections specify the minimum regulatory training requirements for individuals whose work assignments involve exposures to hazardous substances, health hazards, or safety hazards. All such individuals, their supervisors, and management responsible for the site shall receive training meeting the requirements of this section before they are permitted to engage in hazardous waste operations that could cause exposure to hazardous substances, safety hazards, or health hazards.

Initial HAZWOPER training for general site workers is a 40-hour class, but there is a provision in 29 CFR Part 1910.120(e)(3)(iii) to reduce the length of training to 24 hours in cases where respiratory protection is not required and the hazards are monitored and fully characterized, indicating that exposures are under permissible exposure limits. The training requirements of

this section apply to employees of Fluor Daniel Hanford, Incorporated, its major subcontractors, lower tier subcontractors, vendors and suppliers who may be onsite, and Federal employees.

B3.1 40-HOUR HAZWOPER TRAINING

At a minimum, the following topical areas shall be included in the training:

- Names of personnel and alternates responsible for site safety and health
- Safety, health, and other hazards present on the site; including the nature and extent of exposures likely as a result of participation in the RFI/CMS
- Use of PPE
- Work practices by which the employee can minimize risks from hazards
- Safe use of engineering controls and equipment on the site
- Medical surveillance requirements including recognition of symptoms and signs that might indicate over exposure to hazards
- The emergency response, confined space entry, and spill containment program elements of the site safety and health plan. (**Note:** This element may also be covered during the on-the-job training at the project.)

B3.2 INITIAL TRAINING

B3.2.1 General Site Workers

General site workers engaged in hazardous substance removal or other activities that expose or potentially expose workers to hazardous substances and health hazards shall receive a minimum of 40 hours of instruction and a minimum of three days of actual field experience under the direct supervision of a trained, experienced supervisor.

B3.2.2 Infrequent Workers

Workers on the site only occasionally for a specific limited task and who are unlikely to be exposed over permissible exposure limits and published exposure limits shall receive a minimum of 24 hours of instruction off the site, and the minimum of one day of actual field experience under the direct supervision of a trained, experienced supervisor.

B3.2.3 Exposures at Less Than Permissible Limits

Workers regularly on the site who work in areas that have been monitored and fully characterized indicating that exposures are under permissible exposure limits and published exposure limits where respirators are not necessary, and the characterization indicates that there are no health hazards or the possibility of an emergency developing, shall receive a minimum of 24 hours of instruction and the minimum of one day of actual field experience under the direct supervision of a trained, experienced supervisor.

B3.2.4 Additional Training

Workers with 24 hours of training who become general site workers or are required to wear respirators shall have the additional 16 hours and two days of training necessary to meet the specified training requirements.

B3.2.5 Management and Supervisor Training

Onsite management and supervisors directly responsible for or who supervise individuals engaged in hazardous waste operations shall receive 40 hours initial and three days of supervised field experience[1], and at least eight additional hours of specialized training at the time of job assignment on such topics as, but no limited to, the employer's safety and health program, PPE program, spill containment program, and health hazard monitoring procedures and techniques.

B3.2.6 Trainer Qualifications

Trainers involved in the training program shall be qualified to instruct employees on the subject matter that is being presented in training. Trainers shall have satisfactorily completed a training program for teaching the subjects they are expected to teach or shall have the academic credentials and instructional experience necessary for teaching the subjects. Instructors shall demonstrate competent instructional skills and knowledge of the applicable subject matter.

B3.2.7 Training Certification

Employees and supervisors that have received and successfully completed the training and field experience specified in the previous subsections shall be certified by their instructor or the head instructor and trained supervisor as having completed the necessary training. A written certificate shall be given to each certified person. Any person who has not been certified or who does not meet the training requirements shall be prohibited from engaging in hazardous waste operations.

Note: The FDH's electronic training database, in combination with the training data wallet card, satisfies the OSHA criteria for a written certificate.

---

[1] The training may be reduced to 24 hours and one day if the only area of their responsibility is employees covered by as described under Section 3.2.1, "Infrequent Workers," and Section B3.2.3, "Exposures at Less Than Permissible Limits."

B3.2.8 Emergency Response

Employees who are engaged in responding to hazardous emergency situations at hazardous waste cleanup sites that may expose them to hazardous substances shall be trained in how to respond to potential emergencies.

B3.2.9 Refresher Training

Employees, managers, and supervisors shall receive eight hours of refresher training annually on the items specified under in Section B3.1 and/or B3.2.5, any critique of incidents that have occurred in the past year that can serve as training examples of related work, and other relevant topics.

B3.2.10 Visitor Training

Visitors who are not medically qualified, and who have not received the appropriate training as specified herein, shall not be permitted access to the exclusion and contamination-reduction zones. Visitors who are medically qualified as specified in Section B5.0 of this HASP and who have hazardous waste and other training as specified in this section may be permitted access to these zones provided that the visitors are escorted by a fully trained individual when in these zones. All visitors, irrespective of their individual qualifications, shall receive training in the following subject areas:

- The facility emergency evacuation procedures, including audible signals, evacuation routes, and assembly area locations
- Hanford General Employee Training, General Employee Radiation Training, or visitor/vendor orientation
- Review of the applicable AJHA and RWP
- Work area ALARA guidelines (e.g., low radiation dose rate areas suitable for viewing and observation purposes)
- Personal conduct requirements while in support, contamination-reduction, and exclusion zones.

B3.2.11 Additional Training Requirements

Additional training shall be required for exposures or potential exposures to hazardous substances and conditions not specifically covered by the general training required in the foregoing subsections. At a minimum, this training shall include Radiation Worker I or Radiation Worker II. Additional training may be required and includes the following:

- First aid
- Criticality safety, if applicable
- OSHA-required training for specific substances (e.g., asbestos worker, asbestos awareness, lead worker, or carcinogens)
- Pre-entry briefing on the SS HASP and RWP.

B4.0 PERSONAL PROTECTIVE EQUIPMENT

The specification of PPE shall be divided into three separate categories: industrial safety; chemical safety/industrial hygiene; and radiological. In some instances, the existence of two or more hazard categories (e.g., hazardous chemical and radiological) may necessitate special consideration of the PPE ensemble. Such consideration is normally solved by selecting the most conservative ensemble. In certain instances, however, additional consideration may be required, such as exposure to both an airborne organic solvent and airborne radioactive materials. The information contained in Table B-4 shall be used as a guide when selecting PPE for specific tasks.

The PPE ensembles specified in Table B-4 are to be used as guidelines and should be viewed as standard minimum requirements. Actual PPE selection shall be based on detailed (AJHA) evaluation of the hazards associated with work activities. Existing mechanisms shall be used to implement and communicate PPE requirements to the effected work force, such as the RWP.

B5.0 MEDICAL SURVEILLANCE

Medical examinations, consultations, and determinations are conducted by the Hanford Environmental Health Foundation (HEHF). An occupational medicine program has been implemented by HEHF in accordance with HNF-PRO-111, *Occupational Medical Qualification and Monitoring* (FDH 1997j) with attending physicians who are qualified in the practice of occupational medicine and who are familiar with the requirements of 29 CFR Part 1910.120. The HEHF physicians are also familiar with the types of hazards routinely encountered at the Hanford Site. The content and extent of medical examinations and consultations are based on an evaluation of the hazards to which the employee is or can reasonably be expected to be exposed. The method for determining the hazards associated with any given individual's job function is the completion of the employee job task analysis (EJTA). The EJTA is a computer-based questionnaire that identifies substances and actions involved with individual work assignments. The electronic version of the completed and approved EJTA is automatically reviewed by HEHF staff. The affected individuals are then scheduled by HEHF for the appropriate medical examinations. The following medical surveillance program requirements are based on this existing system.

B5.1 MEDICAL EXAMINATION FREQUENCY

Medical examinations shall be conducted as follows:

- Prior to an individual's project assignment involving hazardous substances or work conditions
- At least once every 12 months for each effected individual (this requirement may be relaxed to a biennial exam at the physician's discretion)
- Upon termination of employment or reassignment to an area not requiring comparable medical surveillance[1]
- As soon as possible upon notification by an employee that the employee has developed signs or symptoms indicating possible overexposure to hazardous substances or health hazards
- As soon as possible after the employee has been injured or exposed above the permissible exposure limits or published exposure levels in an emergency situation
- As frequently as necessary if the examining physician determines that an increased frequency of examination is medically necessary.

B5.2 MEDICAL EXAMINATION CONTENT

Medical examinations conducted by HEHF include a medical and work history (or updated history if one is already in the individual's file) with special emphasis on symptoms related to the handling of hazardous substances and health hazards, and to fitness for duty, including the ability to wear any required PPE under extreme conditions (e.g., temperature extremes) that may be expected at the work site.

B5.3 INFORMATION TO BE SUPPLIED TO THE EXAMINING PHYSICIAN

The EJTA provides sufficient information to the examining physician to satisfy the requirements of 29 CFR Part 1910.120(f)(6). The EJTA may not, however, cover non-routine or unusual hazards and/or hazard controls. To preclude inadvertent omission of a medical surveillance requirement in such instances, line management in cooperation with the SHSO shall review AJHAs and new work/task assignments for special exposure conditions that may have non-routine medical surveillance requirements (e.g., OSHA vertical standard requirements) prior to initiating the task or assigning the individual.

[1] This requirement may be waived if the individual has undergone a medical examination less than six months prior to the termination or reassignment.

B5.4 INFORMATION TO BE SUPPLIED BY THE EXAMINING PHYSICIAN

The HEHF provides Hanford Site employers with opinions as to whether the employee has any detected medical conditions which would place the employee at increased risk of material impairment of the employee's health from work in hazardous waste operations or emergency response, or from respirator use. Based on this opinion, the examining physician may recommend work (e.g., lifting or other types of heavy labor) or hazard control (e.g., use of respirators) restrictions. Information supplied by the examining physician shall not include specific findings or diagnoses unrelated to occupational exposure. The examining physician shall also include a statement that the individual has been informed by the physician of the results of the medical examination and any medical conditions which require further examination or treatment. Restrictions recommended by the examining physician shall be implemented by the Project.

B5.5 INFORMATION TO BE SUPPLIED TO THE EMPLOYEE

Upon request, all information relating to the medical examination, including all test results, shall be provided to the individual employee.

B5.6 RECORDKEEPING

Records of medical examinations and consultations are maintained by HEHF in accordance with the requirements of 29 CFR Part 1910.120(f)(8).

B5.7 OTHER MEDICAL PROVIDERS

Medical providers other than HEHF may be used. The examining physician's protocols, test results, and findings must, however, be reviewed and concurred with by HEHF before the individual is authorized to begin onsite work on the project.

B5.8 MONITORING

Monitoring is divided into three substance/condition categories: radiological, chemical, and other. The following subsections specify the minimum monitoring requirements for each category.

B5.8.1 Radiological Monitoring

Radiological monitoring is further divided into the subcategories identified in the following subsections.

B5.8.1.1 Personnel Monitoring. Routine external radiation monitoring shall be conducted for all individuals whose job functions have a potential for whole body exposures of more than 100 mrem/yr; or more than 5 rem/yr to the skin, extremities, or a deep dose to any individual organ or tissue other than the lens of the eye; and more than 1.5 rem/yr to the lens of the eye. Assignment of dosimeters and the frequency of dosimeter exchange shall comply with the provisions of HNF-PRO-379, *External Dosimetry Program* (FDH 1998f), and HNF-PRO-320, *Personal Nuclear Accident Dosimetry* (FDH 1998g).

Routine internal radiation exposure monitoring shall be conducted for all individuals whose job functions have a potential to receive intakes resulting in a committed effective dose equivalent of 100 mrem/yr or more. Routine internal dosimetry may consist of any combination of excreta analysis (bioassays) and in vivo analysis (whole body and/or lung counting). Determination of the type of bioassay and/or in vivo analysis required, the monitoring frequency, and action or trigger levels shall comply with the provisions of HNF-PRO-380, *Internal Dosimetry Program* (FDH 1998h).

Routine breathing zone air sampling for airborne radioactive materials may be conducted at the discretion of the SHSO or designee. Breathing zone air sampling results shall be used to document the effectiveness of the respiratory protection and bioassay programs.

B5.8.1.2 Area Monitoring. Physical surveys shall be conducted to assess direct radiation levels, surface contamination levels, and airborne contamination levels. The frequency of each type of survey shall be based on potential radiological conditions, probability of change in conditions, and occupancy factors. Routine surveys shall be conducted to facilitate tracking and trending of radiological conditions in work areas. Special surveys may be conducted as conditions dictate (e.g., to assess the nature and extent of spills, to document the effectiveness of decontamination, etc.). Area monitoring shall be conducted in accordance with the provisions of HNF-PRO-435, *Required Radiological Surveillances* (FDH 1997k).

B5.8.1.3 Special Surveys. Several different types of personnel monitoring may be conducted for unusual or non-routine circumstances. These circumstances include potential skin contamination, potential accidental intake of radioactive materials, potential direct radiation exposure in excess of established action levels and/or limits, and injuries involving potentially contaminated items (e.g., puncture wounds by contaminated articles). Surveys that support assessment of potential unanticipated exposure shall adhere to the provisions of HNF-PRO-688, *External Dosimetry Investigations* (FDH 1998i); HNF-PRO-384, *Skin Contamination Dose Assessment* (FDH 1998j); and HNF-PRO-380, *Internal Dosimetry Program* (FDH 1998h).

B5.8.2 Chemical Monitoring

The preliminary hazard assessment will be used to determine the need for personnel monitoring for hazardous substances or materials. The need for monitoring will also be periodically evaluated as site and work area conditions change. Determination of need will be identified by through assessment of the applicable material safety data sheets and the AJHA. Monitoring methods, frequencies, and action levels will be specified by the SS HASP.

Types of monitoring may include organic vapor monitor with both the 10.6 eV and 11.7 eV lamps, organic vapor analyzer, combustible gas indicator/oxygen meter, colorimetric detector tubes for semi-quantitative assessments of gases and vapors, and pH meters. Personal air monitors (badges) and breathing zone air sampling may be used at the discretion of the SHSO.

B5.8.3 Other Monitoring

Other types of monitoring that may be required include special radiation monitoring for declared pregnant workers, heat stress monitoring, lighting levels, and noise. Special radiation monitoring for declared pregnant workers shall include the following constraints:

- Immediately after the pregnancy has been declared, determine the radiation exposure since the estimated date of conception.

- The radiation exposure to the fetus shall be limited to a total of 500 mrem for the full term of the pregnancy.

  WARNING: If the worker has received 500 or more mrem since conception at the time of declaration, the worker shall not be assigned to areas wherein additional occupational radiation exposure might occur.

- Reasonable efforts shall be made to limit the worker's exposure rate to not more than 50 mrem/month.

An assessment of the need for other types of monitoring (e.g., heat stress, noise, and lighting levels) shall be conducted via the AJHA. Monitoring will be initiated whenever the AJHA indicates that a hazard may exist. The SHSO shall determine the appropriate monitoring methods and frequencies. Action levels are specified as OSHA permissible exposure limits or American Conference of Governmental Hygienist threshold limit values, whichever is the most conservative. Action levels are implemented by procedure (e.g., HNF-PRO-121 [FDH 1997i]).

B6.0 SITE CONTROL

The PIC/field team leader, SHSO, and RCT are responsible for coordinating access control and security at the work site. Because public access is tightly controlled in the 200 Areas, particularly in the tank farms, additional control measures to restrict public access is unlikely to be necessary. If the controlled zone is also a radiological area, all members of the team must also heed the criteria of the RWP.

Controlled areas will be clearly marked with rope and/or appropriate signs. Physical control devices shall be used to prevent inadvertent entry into high hazard areas (e.g., high radiation areas and very high radiation areas). Physical controls shall be designed in such a manner that will not preclude an individual from exiting the high hazard area. Controlled zone boundary size and shape may increase or decrease based on field monitoring results, climatic changes, or

revisions in operational technique. The site command post and staging area will be established upwind of the control zone, as determined by an onsite windsock. Vehicle access and accessibility to utilities and sampling locations may also be a consideration in the location of the command post. All personnel authorized entry into a particular zone shall be trained on entry qualifications and requirements.

The following relationship between the existing site control program as defined in HNF-PRO-1623, *Radiological Work Planning Process* (FDH 1998d) and the requirements of 29 CFR Part 1910.120 is provided for reference and clarity:

- **Exclusion zone:** The exclusion zone is defined as an inner work area where this is a probability of exposure. Any area designated as a radiation area, high radiation area, very high radiation area, contamination area, high contamination area, airborne radioactive materials, or airborne hazardous materials area shall be similarly designated as the exclusion zone.

- **Buffer zone:** The buffer zone is an area immediately adjacent to (and usually surrounding) the exclusion zone. The purpose of the buffer zone is to control the spread of contamination, and personnel exposures to radiation. The buffer zone shall be equivalent to the radiological buffer zone.

- **Support zone:** The support zone is an area immediately adjacent to the buffer zone boundary, but within the site boundary. The purpose of the support zone is to aid in job preparation and support (e.g., materials and equipment staging and short-term storage).

B6.1 DECONTAMINATION

Precautions are routinely exercised to avoid skin contamination by radioactive materials and hazardous substances. These precautions start with personnel training (i.e., Hanford General Employee Training, Radiation Worker I, and Radiation Worker II), continue with the use of PPE ensembles designed to act as a barrier between the worker and the contamination, and conclude with physical surveys conducted during and after doffing of the PPE. The major deviation between the methods used for protection against contamination required by 29 CFR Part 1910.120(k) and those employed for radioactive materials, is the routine decontamination of PPE prior to doffing.

Should skin contamination occur, decontamination, and the radiation dose assessment resulting from the contamination, shall be conducted in accordance with HNF-IP-0718, *Health Physics Technical Practices and Procedures* (FDH 1997l), and HNF-PRO-384, *Skin Contamination Dose Assessment* (FDH 1998j), respectively.

> **WARNING:** Serious personal injury takes priority over decontamination procedures. Do not attempt personal decontamination if the injury will be aggravated. An injured person should first be removed from immediate danger. Then, if it is determined to be necessary by the SHSO and the RCT, decontamination may be accomplished prior to leaving the site for medical

treatment. Emergency decontamination facilities will be identified in the SS HASP. The RCT and the SHSO may be required to escort the injured person to the hospital.

Decontamination shall be required any time that contamination monitoring indicates detectable radioactivity. Table B-5 provides the maximum permitted detection levels.

If future operations require the use of hazardous substances such that a PPE ensemble equivalent to Level B or greater is required, decontamination procedures shall become mandatory. The following decontamination elements shall be included in the decontamination procedures:

- Written procedures shall be developed to minimize worker exposure to hazardous substances, and to effectively conduct decontamination.
- Each individual leaving the exclusion zone shall be decontaminated.
- Decontamination methods and materials shall be determined by the SHSO during the job-planning phase.
- The location of the decontamination station shall be at the border of the exclusion zone and the buffer zone.
- Decontamination procedures shall be communicated to involved individuals, included all individuals who may assist in personnel decontamination.
- Hazardous chemical decontamination materials and PPE shall either be properly disposed of, or decontaminated such that unprotected handling will not further exposure individuals to hazardous substances.
- Decontamination practices shall be monitored by the SHSO to determine their effectiveness. When such practices are found to be ineffective, appropriate steps shall be taken to correct any deficiencies.

B6.2 EMERGENCY RESPONSE

The Hanford Site has a mature and sophisticated emergency response program. This program is described in *Hanford Emergency Response Plan* (DOE-RL 1995), and implemented by DOE-0223, *Emergency Plan Implementing Procedures* (DOE 1997). This program is further refined by FDH in HNF-PRO-424, *Emergency Preparedness Program* (FDH 1998k).

The following minimum requirements shall be implemented to ensure that emergency actions will be effective in the protection of personnel involved in the RCAP:

- Prior to working on the project, personnel will review applicable plans and procedures, demonstrate that they are familiar with emergency alarms, and attend pre-job safety meetings. Pre-job safety meetings shall be conducted to discuss project-specific hazards;

and the appropriate emergency response, including precautions specifically addressing individuals in PPE or individuals who may be potentially contaminated evacuation routes, and notifications.

- If an emergency or abnormal event occurs, or an alarm annunciates that requires emergency egress, individuals will evacuate the effected area or building, and communicate the abnormal condition to the Patrol Operations Center (dial **911**, or **373-3800** by cellular telephone) and the Building Emergency Director (BED).

- The BED or designated alternate(s) has overall responsibility for implementing emergency procedures, to mitigate an emergency, and all other responsibilities designated in the emergency implementing procedures.

- The BED has the authority to commit all necessary resources (e.g., personnel, equipment and materials) to respond to any emergency[1].

- Upon notification of an abnormal incident (e.g., release of hazardous material), the BED will notify necessary emergency resources, if required, and will ensure that all other required notifications are completed.

- The BED will respond to a declared emergency to mitigate the incident using emergency response plan implementing procedures, to ensure effective decision making (e.g., ensure that effective mitigative actions are initiated), and to initiate recovery actions.

Emergency telephone and pager numbers shall be provided in the SS HASP. Alarm descriptions and general emergency instructions are illustrated in Figure B-1.

B6.3 CONFINED SPACE ENTRIES

Confined space entries shall be conducted in accordance with HNF-PRO-110, *Confined Space* (FDH 1997b). Therein, the term "confined space" is subcategorized into *permit required* and *non-permit* confined spaces. The HNF-PRO-110 procedures meet the intent of 29 CFR Part 1910.146, "Permit-Required Confined Spaces." The following sequence of events shall be adhered to whenever there is a potential for a confined space entry dictated by the detailed work plan:

- Walk down the work area(s) specified in the work plan.

- Locate and identify any area which has already been classified as a confined space or which may be classified as a confined space.

[1] Authority to act in the BED's absence or during periods when the BED is otherwise occupied has been delegated to the Hanford Fire Department and the Hanford Patrol, including acting as incident commanders.

- Identify confined space entry as a hazard when completing the AJHA, and document on the Confine Space Hazard Identification form.

- Prepare a confined space entry permit, if required.

- Ensure that all involved personnel are properly trained and qualified.

- Ensure that the proper notifications have been made (e.g., the Hanford Fire Department), if required.

- Complete a survey of the confined space prior to the entry to determine the presence or absence of hazardous substance and vapors, the presence/absence of adequate levels of oxygen, and the presence/absence of physical hazards.

The SHSO shall monitor all permit-required confined space entries to ensure compliance with all of the applicable requirements of HNF-PRO-110 (FDH 1997b).

B6.4 SPILL CONTAINMENT PROGRAM

The project shall use engineered containment systems whenever practical to ensure that significant amounts of hazardous materials do not escape their primary containment. When it becomes impractical to use engineered containment controls, the project shall implement the following:

- Written procedures shall be prepared specifying the minimum requirements for the containment of spills, the recovery of spilled materials, the decontamination of areas/equipment effected by the spilled material, the materials and equipment used during the recovery process, and the proper disposal of recovered and contaminated materials and equipment.

- Individuals shall be trained in the safe recovery of spilled materials, and only qualified individuals will be assigned to spill recovery tasks.

- Sufficient materials will be located at or near the work location to contain the entire volume of materials at risk, plus any materials used in the recovery process (e.g., absorbents and mops).

B6.5 HAZARD COMMUNICATION PROGRAM

The PHMC has a robust hazard communication program as defined in HNF-PRO-578, *Hazard Communication* (FDH 1997m), which conforms with the requirements of 29 CFR 1910.1200. The hazard communication program includes a variety of communication methods, including material safety data sheets, vendor labeling, and area posting. In addition, the Hanford Site hazard label is used to further communicate hazards to using individuals. The Hanford Site hazard label is color-coded as follows:

- Health hazard = blue
- Fire hazard = red
- Reactivity hazard = yellow
- Other hazards = white.

Next to the color-coded area on the Hanford Site hazard label is a box reserved for the hazard severity code, indicated as follows:

- 0 = minimal or no hazard
- 1 = slight hazard
- 2 = moderate hazard
- 3 = serious hazard
- 4 = severe hazard.

Individuals who have or may have occasion to use hazardous substances shall receive documented facility- and job-specific hazard training. Training formats may include formal HAZWOPER training, pre-job briefings, and/or team safety meetings as described in the foregoing.

B6.6 PROGRAM EFFECTIVENESS

The SHSO or designee shall conduct periodic inspections to assess the effectiveness of project HASPs. This shall include this HASP and any SS HASPs developed for WMA specific tasks. These inspection shall be separate from any other form of self-assessment that may be conducted by the project.

B7.0 PRE-ENTRY BRIEFINGS

A pre-entry or pre-job briefing shall be conducted prior to initiating any new activity, and at other times as necessary to ensure that employees are apprised of hazards and/or changes that may effect safety. The pre-entry briefing shall cover the following minimum topics:

- The scope and details of work to be performed
- The identified hazards associated with, and/or caused by, the work and the environment within which the work is conducted
- Physical and/or administrative hazard controls implemented for the work activity, including specified PPE
- The required use of any non-routine personnel monitoring equipment, devices or routines

- Any special permits prepared for the work activity (e.g., confined space, hot work, and electrical work)

- Any changes in routes of access and egress that may be necessitated by the work activity.

B8.0 REFERENCES

10 CFR 835, "Occupational Radiation Protection," *Code of Federal Regulations*, as amended.

29 CFR 1910, "Occupational Safety and Health Standards," *Code of Federal Regulations*, as amended.

DOE, 1997, *Emergency Plan Implementing Procedures*, DOE-0223, U.S. Department of Energy, Washington, D.C.

DOE-RL, 1995, *Hanford Emergency Response Plan*, DOE/RL-94-02, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1996, *Hanford Site Radiological Control Manual* (HSRCM), DOE/RL-96-109, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

FDH, 1997a, *Bloodborne Pathogens*, HNF-PRO-584, Rev. 0, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1997b, *Confined Space*, HNF-PRO-110, Rev. 0, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1997c, *Fall Protection*, HNF-PRO-092, Rev. 1, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1997d, *Control of Combustible*, HNF-PRO-359, Rev. 0, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1997e, *Flammable/Combustible Liquids*, HNF-PRO-358, Rev. 0, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1997f, *Portable Heaters*, HNF-PRO-355, Rev. 0, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH,1997g, *Hearing Conservation*, HNF-PRO-115, Rev. 0, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1997h, *Hazardous Energy Control Program*, HNF-PRO-081, Rev. 2, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1997i, *Heat Stress Control*, HNF-PRO-121, Rev. 0, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1997j, *Occupational Medical Qualification and Monitoring*, HNF-PRO-111, Rev. 0, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1997k, *Required Radiological Surveillances*, HNF-PRO-435, Rev. 0, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1997l, *Health Physics Technical Practices and Procedures*, HNF-IP-0718, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1997m, *Hazard Communication*, HNF-PRO-578, Rev. 1, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1997n, *Fire Protection Design Criteria,* HNF-PRO-349, Rev. 0, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH 1997o, *Fire Protection Facility Assessments*, HNF-PRO-684, Rev. 0, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1998a, *Job Hazard Analysis*, HNF-PRO-079, Rev. 2, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1998b, *Electrical Work Safety*, HNF-PRO-088, Rev. 2, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1998c, *Controlling Hotwork*, HNF-PRO-356, Rev. 1, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1998d, *Radiological Work Planning Process*, HNF-PRO-1623, Rev. 0, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1998e, *Chemical Management*, HNF-PRO-2258, Rev. 0, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1998f, *External Dosimetry Program*, HNF-PRO-379, Rev. 2, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1998g, *Personal Nuclear Accident Dosimetry*, HNF-PRO-320, Rev. 2, Fluor Daniel Hanford, Incorporated. Richland, Washington.

FDH, 1998h, *Internal Dosimetry Program*, HNF-PRO-380, Rev.1, Fluor Daniel Hanford, Incorporated, Richland. Washington.

FDH, 1998i, *External Dosimetry Investigations*, HNF-PRO-688, Rev.1, Fluor Daniel Hanford, Incorporated, Richland. Washington.

FDH, 1998j, *Skin Contamination Dose Assessment*, HNF-PRO-384, Rev. 1, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1998k, *Emergency Preparedness Program*, HNF-PRO-424, Rev. 2, Fluor Daniel Hanford, Incorporated, Richland, Washington.

1

Figure B-1. Hanford Site Emergency Instructions. [a]

Hanford Site Emergency Instructions

The Staging Area for the [ ] Bldg is [ ]

EMERGENCY SIGNALS			EMERGENCY AID
WARNING SIGNAL	EVENT OCCURRENCE	YOUR RESPONSE	EMERGENCY PHONE NO. 911 TELL: • What has Happened • Where it Happened • What Help is Needed
GONG	FIRE	Evacuate building, move upwind or to staging area or follow plant specific instructions.	
SIREN WAVY	EVACUATION	Evacuate to staging area and wait for further instructions.	
SIREN WAVERING	TAKE COVER	Go inside the nearest building. Shut doors and windows.	WHEN YOU DISCOVER A FIRE
HOWLER AH-OO-GAH	NUCLEAR EXCURSION (CRITICALITY)	Run "at least" 100 feet away from signal. Proceed to staging area.	
RED LIGHT BELL	AIR CONTAMINATION	•Stop breathing •Immediately leave the room and shut the door •Contact Health Physics	1. Pull Alarm 2. Call 911 3. Notify Manager and Building Emergency Director/ Building Warden

A recording of emergency signals may be heard by calling 373-2345: Employees in the 400 Area should call 376-4444.

25408032.1Rev

[a] If using a cell phone, dial 373-3800 in emergencies.

1

1

Table B-1. AJHA/ISMS Program Elements and Objectives.

Program Element	Action/Activity
Identify the hazards	○ Perform a pre-job safety walk down of the work area. ○ Analyze each work element for identification of hazards.
Analyze hazards and implement controls	○ Involve appropriate subject matter experts, as may be required to determine specific controls. ○ Ensure that personnel qualifications are specified. ○ Identify engineering and/or administrative controls that will mitigate the identified hazards, or personal protective equipment that must be used to guard against the identified hazard. ○ Develop necessary methods and content for communicating the hazards analysis to involved personnel. ○ When work activities are expected or have the potential to exceed the substance-specific medical surveillance criteria, complete the AJHA potential exposure hazard screen[a]. This action will activate the appropriate medical surveillance when transmitted to the occupational medical provider.
Perform the work within controls	○ Communicate identified hazards and specified controls to personnel performing the work. • Ensure that involved personnel are adequately qualified to perform the work. ○ Verify that workers executing the task are medically qualified. ○ Ensure that all individuals involved in the work receive required training for the task. ○ Monitor specified work practice(s) and control(s).
Feedback and continuous improvement	○ Obtain worker feedback for the identification of unforeseen hazards, and work practices that can be made safer. ○ Use lessons learned feedback to improve the effectiveness of work controls, and as an opportunity to clarify work instructions and procedures. ○ Perform self-assessments of the health and safety program implementation to determine effectiveness. ○ Implement corrective actions as may be necessary to enhance safety.

[a] Medical surveillance criteria are based on exposure information contained in the employee job task analysis (EJTA). In the absence of EJTA substance-specific information, the Occupational Safety and Health Administration's permissible exposure limit or the American Conference of Governmental Industrial Hygienists threshold limit value, whichever is lower, shall be used.

AJHA = automated job hazards analysis

ISMS = Integrated Safety Management System

2

Table B-2. Permissible Noise Exposures.[a]

Duration per Day (in hours)	Sound Level (dBA, slow response)
24	80
16	82
8	85
4	88
2	91
1	94
½	97
¼	100

[a] Additional limits for exposure periods less than 15 minutes (0.25 hour) are provided in HNF-PRO-115, *Hearing Conservation* (FDH 1997g).

1

Table B-3. Chemical Management Program Attributes.

Program Element	Required Action
Acquisition	○ Determine if excess chemicals from onsite contractors can be used in lieu of new chemical purchases ○ Justify the need for the chemical ○ Specify amount required ○ Explore a non-hazardous or less hazardous alternative ○ Specify plans for final disposition ○ Determine suitability of storage facilities ○ Specify the chemical's stability/shelf life ○ Obtain required safety documentation (e.g., material safety data sheets) ○ Input chemical information into the CMS tracking system
Transportation	○ Ensure compliance with all applicable regulatory and procedural requirements ○ Ensure that chemical records are updated as may be appropriate
Use	• Perform appropriate hazard analysis: generically (e.g., for a store stock item), or as part of a facility-/task-specific process or operation ○ Implement use of appropriate controls in the following hierarchy: engineered controls, administrative controls, and the use of PPE • Implement tracking, if new chemicals are created and not immediately used ○ Ensure that use is covered by either procedure or material safety data sheets
Final disposition	○ Ensure compliance with all applicable laws and regulations ○ Make available for use by others, or for recycle, before relegating to disposal ○ Transfer relevant documentation and information to the appropriate infrastructure functions
Records	• Create and maintain records to show the following minimum information: ○ Location ○ Amount ○ Uses ○ Hazards ○ Custodian(s)
Management review	○ Periodic assessment of program performance, including: ○ Establishing performance objectives ○ Identification of nonconformance(s) ○ Implementation/conformation of corrective actions

2

Table B-4. Personal Protective Equipment Ensembles. (2 pages)

Type of Hazard	Basic Personal Protective Equipment	Optional Personal Protective Equipment[a]
Industrial/Level D	• Substantial footwear • Safety glasses with side shields • Hard hat	○ Steel-toed boots ○ Work gloves ○ Fall arrestor ○ Face shield with approved safety glasses and side shields ○ Ear plugs/muffs ○ Coveralls
Hazardous Chemical Level C	• Full face piece air purifying respirator • Hooded chemical-resistant clothing (overalls and long-sleeved jacket; coveralls; one- or two-piece chemical-splash suit; disposable chemical-resistant overalls) • Chemical-resistant inner gloves • Chemical-resistant outer gloves	○ Coveralls (additional) ○ Chemical-resistant, steel-toed and shank outer boots ○ Chemical-resistant outer boot covers • Hard hat ○ Escape mask ○ Face shield with approved safety glasses and side shields
Hazardous Chemical Level B	• Positive-pressure, full-face piece self-contained breathing apparatus (SCBA), or positive-pressure-supplied air respirator with escape SCBA-approved by the National Institute for Occupational Safety and Health (NIOSH) • Hooded chemical-resistant clothing (overalls and long-sleeved jacket; coveralls; one or two-piece chemical-splash suit; disposable chemical-resistant overalls) • Chemical-resistant inner gloves • Chemical resistant outer gloves • Chemical-resistant, steel-toed, and shank outer boots	○ Coveralls (additional) ○ Chemical-resistant outer boot covers ○ Hard hat ○ Escape mask

Table B-4. Personal Protective Equipment Ensembles. (2 pages)

Type of Hazard	Basic Personal Protective Equipment	Optional Personal Protective Equipment[a]
Hazardous Chemical Level A	• Positive-pressure, full face-piece self-contained breathing apparatus (SCBA), or positive pressure supplied air respirator with escape SCBA, approved by NIOSH • Totally encapsulating chemical-protective suit • Chemical-resistant inner gloves • Chemical-resistant outer gloves • Chemical-resistant, steel toe and shank outer boots • Disposable protective suit, gloves and boots (depending on suit construction, may be worn over totally encapsulating suit)	• Coveralls (additional) • Long underwear • Hard hat (to be worn under the totally encapsulating suit)
Radiological Contamination Area	• Coveralls • Surgeon's gloves, or as required by RWP • Gloves, or as required by RWP • Shoe covers • Rubber overshoes • Hood	• Cotton glove liners • Negative pressure, air purifying, full face piece respirator (as required by RWP) • Splash-resistant outer coveralls or suit
Radiological High Contamination Area Airborne Radioactivity Area	• Coveralls – two pairs • Surgeon's gloves, or as required by RWP • Gloves – two pairs, or as required by RWP • Shoe covers – two pairs • Rubber overshoes • Hood • Powered air purifying respirator where airborne concentrations of radioactive materials is <100 times the DAC • Supplied air respirator with self contained breathing apparatus where airborne concentrations of radioactive materials is >100 times the DAC	• Cotton glove liners • Splash-resistant outer coveralls or suit

[a] As specified by the activity job hazard analysis.
RWP = radiological work permit
DAC = derived air concentration

Table B-5. Summary of Contamination Values.

Radionuclide[a]	Removable (dpm/100 cm^2)[b]	Total (Fixed + Removable) dpm/100 cm^2)[c]
U-Natural, U-235, U-238, and associated decay products.	1,000 alpha	5,000 alpha
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-129.	20	500
Th-natural, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-125, I-126, I-131, I-133.	200	1,000
Beta-gamma emitters (decay modes other than alpha emission or spontaneous fission) except Sr-90 and other noted above. Includes mixed fission products containing Sr-90.	1,000 beta-gamma	5,000 beta-gamma
Tritium organic compounds, surfaces contaminated by tritium and metal tritide aerosols.	10,000	10,000

[a] The values in this table apply to radioactive material contamination deposited on, but not incorporated into the interior of the contaminated item. Where contamination by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for the alpha- and beta-gamma-emitting radionuclides apply independently.

[b] The amount of removable radioactive material per 100 cm^2 of surface area should be determined by swiping the area with a dry filter or soft absorbent paper while applying moderate pressure and then assessing the amount of radioactive material on the swipe with an appropriate instrument of known efficiency. For objects with a surface area less than 100 cm^2, the entire surface areas should be swiped, and the activity per unit area should be based on the actual surface area. Except for transuranics, Ra-228, Ac-227, Th-228, Th-230, Pa-231, and alpha emitters, it is not necessary to use swiping techniques to measure removable contamination levels if direct scan surveys indicate that the total residual contamination levels are below the values for removable contamination.

[c] The levels may be averaged over a square meter provided the maximum activity in any area of 100 cm^2 is less than three times the values shown in this table.

APPENDIX C

INFORMATION MANAGEMENT OVERVIEW

CONTENTS

C1.0 INTRODUCTION AND OBJECTIVES C-1
C1.1 INTRODUCTION C-1
C1.2 OBJECTIVES C-1

C2.0 TYPES OF DATA C-2
C2.1 DATA COLLECTION C-2
C2.2 DATA STORAGE AND ACCESS C-2
C2.3 DATA QUANTITY C-3

C3.0 DATA MANAGEMENT C-3
C3.1 OBJECTIVE C-3
C3.2 ORGANIZATIONS CONTROLLING DATA C-4
C3.2.1 Waste Management Area Project Team C-4
C3.2.2 Tri-Party Agreement Unit Managers C-4
C3.2.3 Sample and Data Management Process C-4
C3.2.4 RIM Document and Information Services C-6
C3.2.5 Hanford Environmental Health Foundation C-7
C3.2.6 LMHC Quality, Safety, and Health Organization C-7
C3.2.7 Functional Organizations C-7
C3.2.8 Pacific Northwest National Laboratory C-7
C3.3 DATABASES C-7
C3.3.1 Meteorological Data C-7
C3.3.2 Nonradiological Exposure and Medical Records C-8
C3.3.3 Radiological Exposure Records C-8
C3.3.4 Training Records C-8
C3.3.5 Document and Records Tracking System C-8
C3.3.6 Sample and Data Tracking C-8
C3.3.7 Hanford Environmental Information System C-9
C3.3.8 Hanford Geographic Information System C-9
C3.3.9 Waste Information Data System C-9

C4.0 REFERENCES C-10

ACRONYMS

AR	Administrative Record
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CMS	corrective measures study
DOE	U.S. Department of Energy
DQO	data quality objective
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FDH	Fluor Daniel Hanford, Incorporated
HEHF	Hanford Environmental Health Foundation
HEIS	Hanford Environmental Information System
HGIS	Hanford Geographic Information System
HLAN	Hanford local area network
HMS	Hanford Meteorological Station
IMO	information management overview
LMHC	Lockheed Martin Hanford Corporation
LMSI	Lockheed Martin Services Incorporated
PNNL	Pacific Northwest National Laboratory
QA	quality assurance
QC	quality control
QAPjP	quality assurance project plan
QS&H	quality, safety, and health
RCAP	RCRA Corrective Action Program
RCRA	*Resource Conservation and Recovery Act of 1976*
RFI	RCRA facility investigation
RIM	Records and Information Management
RPP	River Protection Project
SST	single-shell tank
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
WIDS	Waste Information Data System
WMA	waste management area

DEFINITIONS OF TERMS

Action plan. Action plan for implementation of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1998). The action plan defines the methods and processes by which hazardous waste permits will be obtained, and by which closure and post-closure actions under the *Resource Conservation and Recovery Act of 1976* (RCRA) and by which remedial actions under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) will be conducted on the Hanford Site.

Administrative Record. The Administrative Record is the body of documents and information that is considered or relied upon in arriving at a final decision for a remedial action, removal action, corrective measure, interim measure, RCRA permit, or approved RCRA closure plan.

Data management. The planning and control of activities affecting information (including data, records, documents, etc.).

Data validation. The process whereby data are reviewed based on a set of criteria. This aspect of quality assurance involves establishing specified criteria for data validation. The quality assurance project plan (QAPjP) must indicate the specified criteria that will be used for data validation.

Records and Information Management. The central facility and services that provide a file management system for processing information.

Hanford Environmental Information System. A computer-based information system used as a resource for the storage, statistical analysis, and display of investigative data collected for use in site characterization and remediation activities. Subject areas include geophysics/soil gas, vadose zone soil (geologic), groundwater, atmospherics, and biota.

Lead agency. The regulatory agency (e.g., U.S. Environmental Protection Agency [EPA] or Washington State Department of Ecology [Ecology]) that is assigned the primary administrative and technical responsibility with respect to actions at a particular operable unit.

Primary document. A document that contains information, documentation, data, and proposals upon which key decisions will be made with respect to the remedial action or permitting process. Primary documents are subject to dispute resolution and are part of the Administrative Record.

Project manager. The individual responsible for implementing the terms and conditions of the Action Plan on behalf of his/her respective party. The U.S. Department of Energy (DOE), EPA, and Ecology will each designate one project manager.

Secondary document. As distinguished from a primary document, a secondary document is considered to be a supporting document providing information or data and does not, in itself, reflect key decisions. A secondary document is subject to review by the regulatory agencies and is part of the Administrative Record; it is not subject to dispute resolution.

1

C1.0 INTRODUCTION AND OBJECTIVES

C1.1 INTRODUCTION

An extensive amount of data will be generated over the next several years in connection with the *Resource Conservation and Recovery Act of 1976* (RCRA) Corrective Action Program (RCAP) for single-shell tank (SST) farms. Data quality is extremely important to the project in waste retrieval, disposal, and closure decisions as agreed by the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), the Washington State Department of Ecology (Ecology), and interested parties.

This information management overview (IMO) provides an overview of the data management activities at the project level and identifies procedures and plans that control the collection and handling of these data. The IMO provides information for the unit managers, project manager, task lead, and other involved personnel and reviewers to fulfill their respective roles. All data will be collected in accordance with the Lockheed Martin Hanford Corporation (LMHC) or other approved subcontractor procedures.

Data Management Plans for Hanford Site Business Functions (DOE-RL 1995); and HNF-PRO-232, *Project Files Management* (Fluor Daniel Hanford, Incorporated [FDH] 1997a); HNF-PRO-210, *Records Management Program Standard* (FDH 1997b); and HNF-PRO-224, *Document Control Program Standards* (FDH 1997c), directs the management of environmental data and documents generated for the RCRA field investigation (RFI)/corrective measures study (CMS). The purpose of these documents is to identify and fulfill the document and data control requirements of the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1998), LMHC, and the RCAP.

C1.2 OBJECTIVES

This IMO describes the process for the collection and control procedures for data, records, documents, correspondence, and other information associated with the RCAP. This IMO addresses the following:

- Types of data to be collected
- Plans for managing data
- Organizations controlling data
- Databases used to store the data.

C2.0 TYPES OF DATA

The general types of technical data that may be collected during characterization efforts will be generated from the following activities:

- Surface radiological surveys
- Surface geophysical surveys
- Soil sampling
- Test pit excavation
- Cone penetrometer
- Well installation
- Groundwater sampling and water level measurement
- Air monitoring
- Ecological monitoring.

Technical procedures provide the necessary controls for the management of site characterization efforts. Documents controlling activities will be identified in WMA addenda.

Persons or organizations that generate data are responsible for the custodial care and protection of data. All such data are submitted to the Lockheed Martin Services Incorporated (LMSI) Records and Information Management (RIM) for retention in the official project file (i.e., Administrative Record [AR]), if appropriate, in accordance with HNF-PRO-232 (FDH 1997a); HNF-PRO-210 (FDH 1997b), and HNF-PRO-224 (FDH 1997c).

C2.1 DATA COLLECTION

Data collection activities are described in waste management area (WMA) addenda. Additional direction and detail may be provided in sampling and analysis plans. All data collection will be conducted in accordance with the quality assurance project plan (QAPjP) (Appendix A) and technical procedures. All procedures for data collection efforts shall be approved for use by LMHC.

C2.2 DATA STORAGE AND ACCESS

The RIM is responsible for central file management and the process facility. Public access to applicable documents is through the Administrative Record Public Access Room located in the 2440 Stevens Center facility, Richland, Washington. This facility is responsible for project data, including identified guidance documents and technical literature. Data submitted to the RIM will be indexed, recorded, and placed into safe and secure storage. Data designated for placement into the official project file will be copied and placed into the Hanford Site AR file, if appropriate. Retrieval of information may be accomplished through hard copy or by electronic data.

The AR documents consist of the documents and information considered or relied upon to arrive at decisions for site cleanup or closure. Tri-Party Agreement unit managers determine what additional documents, including sampling and analysis results, sample validation, technical studies, inspection, and other studies may be appropriate for inclusion as part of the AR. The Tri-Party Agreement defines a number of these documents as primary and secondary documents. Definition as a primary or a secondary document determines administrative requirements applicable to the document.

Unit managers may access data that are not in the AR by contacting the River Protection Project (RPP) Vadose Zone Project Task Lead. As the project moves towards the permit modification, all relevant data will be contained in the AR and the need to access data by request will be minimal.

In addition to the AR, the following types of data will be accessed from, and reside in, locations other than the RIM storage area:

- Quality assurance (QA)/quality control (QC) laboratory data
- Sample status
- Training records
- Meteorological data
- Radiological exposure.

C2.3 DATA QUANTITY

Data quantities for the investigative activities will be estimated in each WMA addenda. Appendix A of the master work plan describes the general field investigation activities that may occur.

C3.0 DATA MANAGEMENT

C3.1 OBJECTIVE

A considerable amount of data will be generated through the implementation of addenda. This section identifies responsible organizations and databases available to manage data in support of the RCAP efforts. The QAPjP (Appendix A) will provide the procedural direction and control for obtaining and analyzing samples to conform with requirements to ensure quality data results. For sampling activities, WMA addendum will provide the basis for selecting the locations, depth, and frequency of collection as guided by the data quality objective (DQO) process. Figure C-1 displays the general sample and data management process for data generated through work plan activities.

C3.2 ORGANIZATIONS CONTROLLING DATA

This section identifies organizations that are involved in the management of data generated during the RFI/CMS.

C3.2.1 Waste Management Area Project Team

The task lead is responsible for interfacing with personnel who maintain and transmit data to the RIM. The WMA project team is responsible for transmitting the laboratory analytical data to Ecology and EPA per Section 9.6 of the Tri-Party Agreement (Ecology et al. 1998).

C3.2.2 Tri-Party Agreement Unit Managers

Tri-Party Agreement unit managers are responsible for identifying AR documents and requesting the inclusion of these documents in the AR.

C3.2.3 Sample and Data Management Process

The sample and data management process consists of 10 integrated steps as ideally shown in Figure C-1. Steps 1 and 2 are planning steps. Steps 3 through 10 are production steps and are integrated electronically. The detailed plans, procedures, and systems used day-to-day in the sample and data management process are found in LMHC and other subcontractor procedures.

- **Step 1 – Data Quality Objectives.** The DQO process establishes the requirements for collecting the correct type of information with the appropriate people. A streamlined approach can then be used for planning environmental data acquisition. By following the DQO process, a collective review of the project, available data, regulatory concerns, sampling and analytical approaches, technical issues can be performed. Once the process is completed, the agreements reached are documented in a DQO summary report. This report forms the basis for all project sampling documents.

- **Step 2 – Sampling Documents.** Sampling documents are designed to provide the performance details for the collection and analysis of appropriate quality and quantity of data. A graded approach is used to determine the types of sampling documents needed to implement sampling and analysis activities. The most formal sampling documents are WMA addenda and sampling and analysis plans, which implement the DQOs.

- **Step 3 – Sample Event Coordination.** Sample event coordination uses the sampling and analytical information generated in Step 1 and Step 2 and coordinates the sampling event with the sample management organization. The RPP Vadose Zone Project Task Lead initiates services by contacting the sample management organization. The information provided in WMA addenda are used to plan sample collection efforts and select sample management organizations.

- **Step 4 – Sample Collection.** Sample collection is conducted after sample event coordination is completed. Sampling activities are conducted in accordance with approved procedures and an approved QAPjP.

Step 5 – Sample Shipment. Offsite sample shipments are transported from the field to a central receiving and shipping facility. Samples for onsite analysis are typically transported directly from the field to the identified laboratory. The LMHC approves all hazardous or radioactive sample shipments.

Step 6 – Sample Analysis. Sample analysis can be provided at the job site using onsite measurements. Analyses of this type are conducted in accordance with approved procedures and an approved QAPjP. Analyses of this type generally have higher detection limits and are less accurate; however, turnaround time is within minutes or hours.

Sample analysis may also be conducted at on-site laboratories, commercial laboratories, or other contracted laboratories. Turnaround times for these analyses can be as short as 24 hours, or more typically several days. Analyses of this type generally have lower detection limits. These laboratories are audited annually to assure the projects that appropriate procedures and quality assurance programs are in place to meet customer needs.

Appropriate sample analysis providers are selected during sample event coordination. The LMHC will approve the analytical methods and providers to be used.

Step 7 – Data Receipt and Sample/Waste Return. During the data receipt step, the analytical results (i.e., hard copy and/or electronic) are received from the onsite measurements or laboratory providers. Hard copies of the data are stored for a minimum of six months for the convenience of project customers and to aid in resolving any questions regarding the analytical results. After analyses have been completed, sample waste may be returned to the RPP Vadose Zone Project for disposal.

Step 8 – Data Management. Data Management furnishes electronic copies of environmental data reports to customers using project-specific databases or the Hanford Environmental Information System (HEIS). Reports are generated from HEIS with the current analytical data for soils, biota, and groundwater. Project-specific databases may be developed to assist projects with DQOs, site closeout, and customized data reports.

In addition to analytical reports, Data Management also provides the Hanford Site with geographic and waste information summaries and maps. The Waste Information Data System (WIDS) is the official summary of the history and status of the Hanford waste sites. The Hanford Geographic Information System (HGIS) contains detailed, accurate maps of the Hanford Site.

Step 9 – Data Verification/Validation. Verification is performed on selected data packages to ensure copy quality and completeness prior to transmittal to RIM. Verification is not a required process step and is normally conducted on selected data packages based on the following conditions:

1. Use of a new analytical resource that a performance history has not been established.

2. Observation during the data receipt process of a poor quality and/or poor completeness performance trend with an established analytical provider.

Validation is the process where the data package provided by the analytical provider is subjected to a rigorous review to ensure the total data package is suitable for its intended purpose. Data that are subjected to validation are usually a subset of the total number of data packages used to make project decisions. The validation process is currently implemented through subcontracts. Validation requirements are identified in WMA addenda.

Step 10 – Data Quality Assessment. Data quality assessment is used to determine if the type, quantity, and quality of data needed to support decisions has been achieved. This step presumes that the appropriate DQO has been established and that planning for sampling has been achieved using a scientifically-based information collection strategy. Data quality assessment steps include the following:

1. Review the DQO.
2. Conduct preliminary data review.
3. Select statistical test.
4. Verify the assumptions.
5. Draw conclusions from the data.

This approach is not intended to be a definitive analysis of a project or problem but provides an initial assessment of the "reasonableness" of the data that have been generated. Detailed guidance on conducting data quality assessment is found in the *Guidance for Data Quality Assessment, Practical Methods for Data Analysis* (EPA 1996).

C3.2.4 RIM Document and Information Services

The RIM provides consistent processing and retrieval of environmental restoration information (e.g., data, documents, and records) utilizing management systems for document control and records management. Document and Information Services will utilize the AR information repository system to meet Tri-Party Agreement records requirements and information access. It is the responsibility of all personnel and subcontractors to submit documents/records to the RIM for appropriate processing according to applicable procedures.

C3.2.5 Hanford Environmental Health Foundation

The Hanford Environmental Health Foundation (HEHF) performs analyses on the nonradiological health and exposure data (Section C3.3.2) and forwards summary reports to the Fire and Protection group and the Quality, Safety and Health group. Nonradiological and health

exposure data are also maintained for other Hanford Site contractors associated with other environmental efforts. The HEHF provides summary data to the appropriate site contractor.

C3.2.6 LMHC Quality, Safety, and Health Organization

The FDH Quality, Safety, and Health (QS&H) organization maintains nonradiological health field exposure data for Hanford Site contractors. Summary data reports are provided upon request to LMHC personnel. The organization is also responsible for QA interface with analytical resources on quality issues and for monitoring LMHC data management activities to ensure compliance with designated requirements.

C3.2.7 Functional Organizations

Training records and scheduling of employees for recertifications are currently maintained by secretarial staff in the organization to which the employee is functionally assigned. Additional information on training records in provided in Section C3.3.4.

C3.2.8 Pacific Northwest National Laboratory

The Hanford Meteorological Station (HMS), operated by PNNL, collects and maintains meteorological data (Section C3.3.1). Data management of meteorological data is discussed in Andrews (1988).

Radiation exposure data (Section C3.3.3) are collected and maintained by PNNL.

C3.3 DATABASES

This section addresses databases that will receive data generated from the characterization effort. All of these databases exist independently of the 200 Areas activities and serve other site functions. Additional databases that are also available are identified in DOE-RL (1995).

C3.3.1 Meteorological Data

The HMS collects and maintains meteorological data. The HMS database contains meteorological data from 1943 to the present, and Andrews (1988) contains meteorological data management information.

C3.3.2 Nonradiological Exposure and Medical Records

The HEHF collects and maintains data for all nonradiological exposure records and medical records.

C3.3.3 Radiological Exposure Records

Occupational radiation exposure data are collected and maintained by PNNL.

C3.3.4 Training Records

Training records for LMHC and subcontractor personnel are managed in accordance with HNF-PRO-065, *Environmental Training* (FDH 1997d).

Training records in the database include the following:

- Initial 40-Hour Hazardous Waste Worker Training
- Annual 8-Hour Hazardous Waste Worker Training Update
- Hazardous Waste Generator Training
- Hazardous Waste Site-Specific Training
- Radiation Safety Training
- Cardiopulmonary resuscitation training
- Scott air pack training
- Fire extinguisher training
- Noise control training
- Mask fit.

C3.3.5 Document and Records Tracking System

The RIM will develop, establish, and maintain a database in support of the RCAP. The database will provide an index of key information on all data submitted to RIM. This database will be used to assist in data retrieval and to produce index lists as required. The RCAP database will be managed by LMSI personnel.

C3.3.6 Sample and Data Tracking

The Sample Management Organization is responsible for operating a tracking database that integrates the sample and data management process. Information relating to process activities from event coordination through sample collection and analysis, receipt of data deliverables, verification and validation, data transmittal to RIM, and sample return/disposal is entered and stored in the database. The database system is a tool that can be used to provide status reports and monitor performance.

C3.3.7 Hanford Environmental Information System

The HEIS database is the primary Tri-Party Agreement resource for computerized storage, retrieval, and analysis of quality-assured technical data associated with RCAP for cleanup activities at the Hanford Site. The HEIS database provides interactive access to data sets extracted from other databases relevant to implementation of the Tri-Party Agreement (Ecology et al. 1998). The HEIS database ensures that data consistency, quality, traceability, and security are achieved through incorporation of all environmental data within a single controlled database.

The following is a list of data subjects available in the HEIS database:

- Soils (sample)
- Geologic (particle)

- Atmospheric
- Biota
- Groundwater
- Surface water
- Waste site information
- Miscellaneous materials
- Field QC
- Wells.

The HEIS data is currently available to Hanford Site users via the Hanford local area network (HLAN).

C3.3.8 Hanford Geographic Information System

The HGIS can display detailed maps for the Hanford restoration sites including data from the HEIS and WIDS databases. Such spatially-related data can be used to support analysis of waste site technical issues and restoration options. The combination of the WIDS for summary waste site information, the HEIS for sample analytical data, and the HGIS spatial displays, offers a powerful tool for many users to analyze and collectively evaluate the environmental data from the RCAP and Hanford Site-wide monitoring programs.

C3.3.9 Waste Information Data System

Pursuant to the Tri-Party Agreement, the WIDS database is the official Hanford Site source for the validated summary information and statusing of suspect waste site investigation/ classification, remediation, and closure activities. The WIDS database is accessible to Hanford Site users via the local area network.

C4.0 REFERENCES

Andrews, G. L., 1988, *The Hanford Meteorological Data Collection System and Data Base,* PNL-6509, Pacific Northwest Laboratory, Richland, Washington.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), 42 U.S.C. 9601, et seq.

DOE-RL, 1995, *Data Management Plans for Hanford Site Business Functions*, DOE/RL-94-94, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Ecology, EPA, and DOE, 1998, *Hanford Federal Facility Agreement and Consent Order,* 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

EPA, 1996, *Guidance for Data Quality Assessment, Practical Methods for Data Analysis*, EPA QA/G-9, U.S. Environmental Protection Agency, Washington, D.C.

FDH, 1997a, *Project Files Management*, HNF-PRO-232, Fluor Daniel Hanford, Incorporated, Richland, Washington.

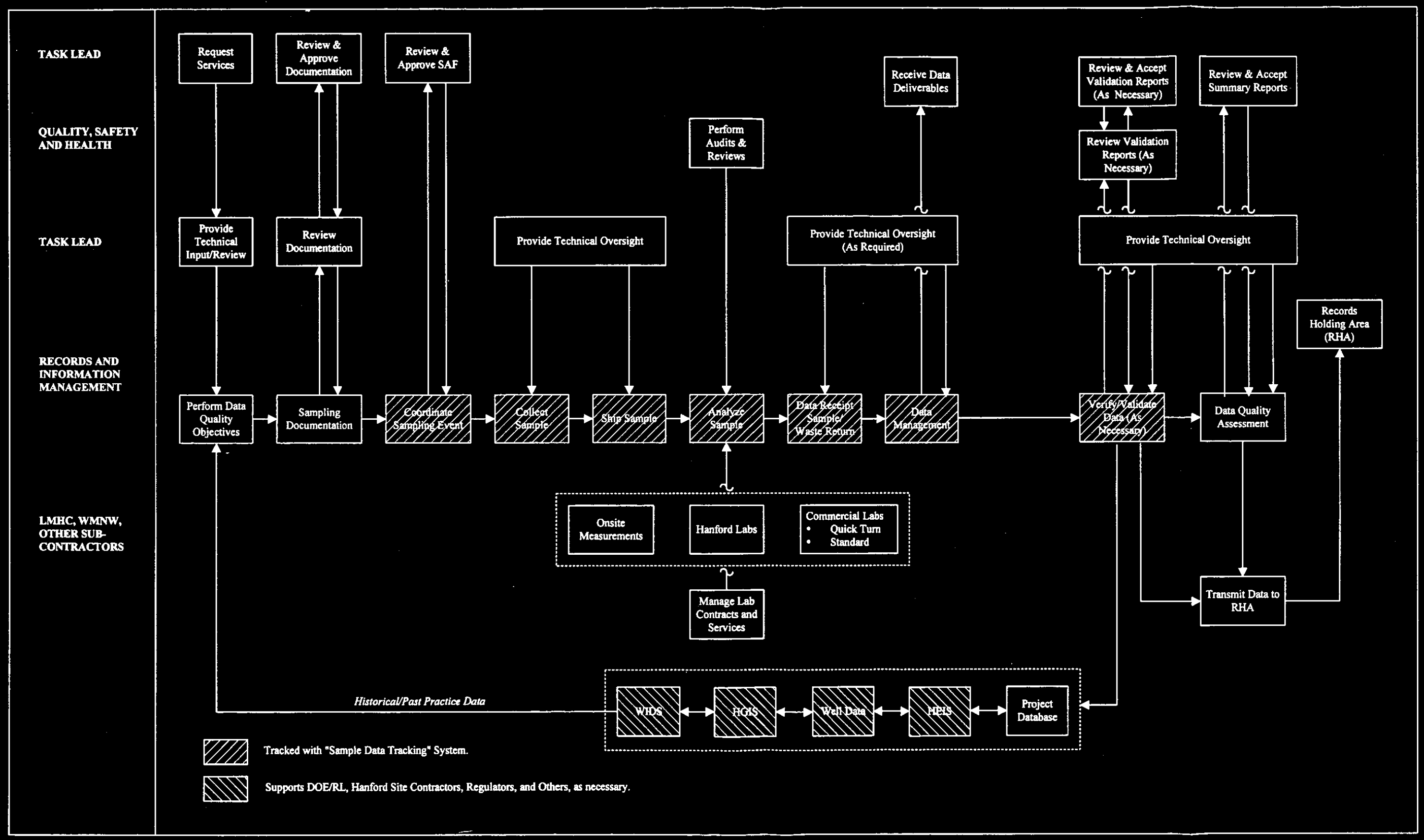
FDH, 1997b, *Records Management Program Standard*, HNF-PRO-210, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1997c, *Document Control Program Standards*, HNF-PRO-224, Fluor Daniel Hanford, Incorporated, Richland, Washington.

FDH, 1997d, *Environmental Training*, HNF-PRO-065, Fluor Daniel Hanford, Incorporated, Richland, Washington.

Resource Conservation and Recovery Act of 1976 (RCRA), 42 U.S.C. 6901, et seq.

Figure C-1. Data and Sample Management Process.



APPENDIX D

WASTE MANAGEMENT FOR THE RCRA CORRECTIVE ACTION PROGRAM

CONTENTS

D1.0 PURPOSE D-1

D2.0 OVERVIEW OF THE HANFORD SITE INVESTIGATION-DERIVED WASTE STRATEGY D-1

D3.0 COLLECTION OF INVESTIGATION-DERIVED WASTE D-2

D4.0 CHARACTERIZATION AND DESIGNATION OF INVESTIGATION-DERIVED WASTE D-3

D5.0 MANAGEMENT DETERMINATIONS FOR INVESTIGATION-DERIVED WASTE D-4
- D5.1 SOILS D-4
- D5.2 SLURRY WASTE D-5
- D5.3 GROUNDWATER D-5
- D5.4 DECONTAMINATION FLUIDS D-6
- D5.5 MISCELLANEOUS SOLID WASTE D-6

D6.0 STORAGE OF INVESTIGATION-DERIVED WASTE D-7
- D6.1 STORAGE LOCATION D-7
- D6.2 CONTAINER MANAGEMENT REQUIREMENTS D-7
- D6.3 RELEASE REPORTING D-8

D7.0 TREATMENT OF INVESTIGATION-DERIVED WASTE D-8

D8.0 DISPOSAL OF INVESTIGATION-DERIVED WASTE D-8

D9.0 REFERENCES D-9

1

ACRONYMS

CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
FDH	Flour Daniel Hanford, Incorporated
HSRCM	*Hanford Site Radiological Control Manual*
IDW	investigation-derived waste
LDR	land disposal restriction
MSW	miscellaneous solid waste
ORP	Office of River Protection
RCAP	RCRA Corrective Action Program
RCRA	*Resource Conservation and Recovery Act of 1976*
SAP	sampling and analysis plan
SST	single-shell tank
TCLP	toxicity characteristic leaching procedure
TSD	treatment, storage, and disposal
WAC	*Washington Administrative Code*
WMA	waste management area

D1.0 PURPOSE

This appendix describes the general approach and requirements for managing investigation-derived waste (IDW) generated during *Resource Conservation and Recovery Act of 1976* (RCRA) Corrective Action Program (RCAP) activities at the single-shell tank (SST) waste management areas (WMAs). The approach and requirements are based in large part on the Hanford Site-wide *Strategy for Management of Investigation-Derived Waste* (IDW strategy) (Ecology et al. 1999), that is described in Section D2.0. Additional requirements for radioactive waste will be implemented in accordance with the *Hanford Site Radiological Control Manual* (HSRCM [DOE-RL 1996]). This appendix will be the starting point for WMA-specific waste control plans that will be prepared in support of the WMA addenda. The waste control plans will identify the specific types, volumes, and disposal methods for WMA-specific IDW.

D2.0 OVERVIEW OF THE HANFORD SITE INVESTIGATION-DERIVED WASTE STRATEGY

The IDW strategy is a joint effort of the Washington State Department of Ecology (Ecology), the U.S. Environmental Protection Agency (EPA), and the U.S. Department of Energy, Richland Operations Office (Ecology et al. 1999). The strategy establishes the Hanford Site-wide approach to the management of IDW. It applies primarily to IDW generated from groundwater monitoring activities, site characterization activities, and environmental investigations of past-practice units regulated under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) and RCRA, provided that such activities or investigations have been authorized by a treatability test plan, sampling and analysis plan (SAP), Record of Decision, or similar document approved by the lead regulatory agency.

The strategy specifically excludes "any IDW generated from within the fenceline of…single-shell tanks." However, the strategy also states that the project manager for the lead regulatory agency may authorize exceptions to the requirements of the strategy on a case-by-case basis. The Ecology project manager for the RCAP has determined that an exception to the SST exclusion is appropriate if IDW generated at the SSTs otherwise meets the requirements of the IDW strategy (Ecology et al. 1999). This determination is based on the fact that the IDW generated at the SST WMAs is similar in nature and contaminant type to IDW generated at other 200 Areas waste sites included in the IDW strategy. If waste acceptance is not permitted at the Environmental Restoration Disposal Facility (ERDF), the low-level burial ground, mixed-waste burial ground, or the Waste Isolation Pilot Project site may be used for disposal of IDW. Some of the waste may require treatment before it is disposed. This master work plan and the WMA-specific waste control plans will be approved by Ecology as the lead regulatory agency and will serve as the approval documents for this IDW approach. The WMA-specific waste control plans will direct the management of IDW.

The IDW strategy defines IDW as including, but is not limited to, the following:

- Drilling mud
- Cuttings from test pit and well installation
- Materials from well maintenance, remediation, and abandonment
- Purgewater, soil, and other materials from collection of samples
- Residues (e.g., ash and spent carbon) from testing of treatment technologies
- Contaminated personal protective equipment
- Solutions (aqueous or otherwise) used to decontaminate nondisposable protective clothing and equipment.

Key provisions of the strategy include the following:

- Hanford Site IDW that meets the ERDF waste acceptance criteria (BHI 1998), applicable land disposal restrictions (LDRs), and approval authorization requirements is eligible for disposal in the ERDF. (Approval for disposal can be authorized via a treatability test plan, SAP, or similar document approved by the lead regulatory agency.)

- Project managers shall strive to minimize the generation of IDW through proper planning of activities to reduce the need for special storage or disposal requirements.

- Groundwater and free liquids contained in groundwater slurries will be managed according to the Hanford Site's *Strategy for Handling and Disposing of Purgewater at the Hanford Site, Washington* (Purgewater Agreement) (Izatt 1990).

D3.0 COLLECTION OF INVESTIGATION-DERIVED WASTE

When an IDW-generating activity is conducted within the boundaries of the WMA (or any other waste site evaluated in conjunction with a WMA), the resulting IDW may be managed at the site, or transferred to a designated central storage area. The boundaries of the WMA will be those delineated under the WMA groundwater assessment program. The boundaries of any waste sites not located inside the WMA will be identified in the WMA-specific waste control plan, based on process knowledge and environmental data for that waste site. The waste control plan will also describe the IDW collection location and method, and the final disposition as agreed to by Ecology. Waste collection will be performed pending receipt of analytical results to enable proper disposition of the waste.

Collection of soils associated with IDW test pits is not required unless directed on a case-by-case basis by Ecology. Test pit soil will normally be managed within the area of contamination and returned to the excavation site as described in Section D5.1.

When WMA characterization and investigation activities are conducted outside of the WMA or waste site boundaries, the U.S. Department of Energy Office of River Protection (ORP) and Ecology will determine the need for IDW collection. It is anticipated that IDW generated outside the WMA or waste site will not normally require collection, storage, or sampling unless process information, visual evidence, or field screening indicates the potential presence of contamination, or the project managers identify a need to do so. Slurry pits and liquid discharges to the soil outside the WMA or waste site boundary will normally be allowed, unless the area is suspected to contain contamination. If collection is required for IDW generated outside the WMA and other waste site boundaries, samples will be analyzed only for the constituents of concern identified by the project. If the analyses indicate contamination, waste stored on the soil surface from the characterization activity will be excavated to a depth that ensures all such contaminated material is removed. Contaminated waste, liquid, semi-liquid, and miscellaneous wastes from suspect areas will be managed in accordance with the requirements for IDW generated inside the WMA or waste site.

D4.0 CHARACTERIZATION AND DESIGNATION OF INVESTIGATION-DERIVED WASTE

In most cases, samples will be routinely collected as part of the investigation process. These samples will be submitted for analysis and will provide the basis for characterization. The results from these analyses, or other documentation as agreed upon by the project managers, will be used to characterize and designate IDW materials. If additional data are needed to characterize or designate IDW, samples will be collected and analyzed for the constituents of concern as identified in the associated WMA addendum or waste control plan.

Either process knowledge, waste characterization information, or both will be used in conjunction with field screening to identify those wastes that would be designated as characteristic, or listed as dangerous waste per *Washington Administrative Code* (WAC) 173-303. Regardless of any other characterization requirements, a SAP approved by Ecology is required for any IDW to be disposed of in the ERDF. The SAP must be sufficient to demonstrate compliance with the ERDF waste-acceptance criteria and, where applicable, must address all underlying hazardous constituents in IDW designated as a dangerous waste.

The SST system received wastes that were designated as dangerous waste under WAC 173-303. The 36 waste codes identified on the SST Part A permit application are also listed in Table D-1 as the basis for designation. Because the contamination at the WMAs resulted from releases from the SST system, there is a potential for IDW generated during the WMA investigations to be designated as dangerous waste. Most of the SST waste codes are based on specific toxicity characteristics of the waste leachate, or on specific state criteria. It will be necessary to determine whether the IDW also exhibits these toxicity characteristics or criteria above the thresholds for designation. Knowledge of the chemical behavior of the waste in the environment,

or waste characterization data, or both will be used to make this determination. The toxicity characteristic leaching procedure (TCLP) would normally be used to determine whether the IDW exceeds the toxicity characteristic thresholds. However, the total concentration of constituents in the IDW may be used. If the analysis of total concentrations demonstrates that individual constituents are present in concentrations that could not exceed the toxicity characteristic thresholds, the IDW in question will not be analyzed using the TCLP nor be assigned the toxicity characteristic waste code. If the total analysis cannot support this demonstration, the IDW will be analyzed using the TCLP.

Five of the SST system waste codes (F001 through F005) are listed waste codes. Listed wastes are not defined by specific contaminant concentrations, but rather by the source. If a waste (e.g., SST waste) is a listed waste, then environmental media that "contain" that waste (e.g., WMA soils near leaking SSTs) is also a listed waste, regardless of contaminant concentrations. If data collected during the WMA investigation indicate that the listed constituents are not present in the IDW above protective levels, DOE may request a "contained-in" determination from Ecology to eliminate designating the IDW under these waste codes. The contained-in determination will be made on a case-by-case basis. If a contained-in determination is not granted, the IDW must be assigned the F-list waste codes and managed appropriately.

In addition to the required chemical characterization, samples will be collected and screened for radiological constituents. Screening for radiological contamination will be performed as indicated in the WMA addenda. Waste analyses to identify radiological constituents will be performed when necessary. These actions, as well as the use of existing process knowledge, will serve to identify major risks and to protect human health and the environment during these specific types of activities.

D5.0 MANAGEMENT DETERMINATIONS FOR INVESTIGATION-DERIVED WASTE

All IDW generated during RCAP activities will be appropriately managed. The following sections describe the general management of different forms of IDW prior to disposal. The specific types and volumes of IDW expected to be generated at each WMA, and specific IDW management procedures for these activities, will be identified in the WMA-specific waste control plans.

D5.1 SOILS

Soils will be characterized as described in the appropriate waste control plan and Section D4.0 of this appendix. Process knowledge may be used to manage soils as clean material, such as when

drilling boreholes or digging test pits located outside of a WMA or other waste sites. In these cases, soil will be collected in stockpiles at the point of generation, provided that evidence does not justify otherwise. Soils may be placed back into the test pit upon completion of the activity.

Contaminated or suspect contaminated soils shall be managed to mitigate the spread of contaminants to the environment (e.g., placed on a tarp or containerized). Test pit soils may be managed within the area of contamination and returned to the excavation upon completion of sampling. Clean soils are placed on the top of the excavation. Containers of soil from activities other than test pits that contain contaminants above established release levels (described in Section D8.0), whether generated inside or outside a WMA or other waste site boundary, will be managed in accordance with the WMA-specific waste control plan and Section D6.0 of this appendix.

D5.2 SLURRY WASTE

Slurry waste includes groundwater slurries and drilling fluids, but excludes groundwater and free liquids separated from groundwater slurries. Slurry waste generated within a WMA or other waste site boundary will be containerized and sampled as described in the WMA-specific waste control plan. Containerized slurry waste will be appropriately managed at the site, or in a designated central storage area pending analytical results. Slurry waste that contains contaminants above established release criteria (described in Section D8.0) will be managed in accordance with Section D6.0 of this appendix. Slurry waste that contains contaminants below these levels will be returned to the ground at or near the point of generation.

Slurry waste generated outside a WMA or other waste site boundary may be placed in a pre-excavated, lined (porous membrane liner) slurry pit located adjacent to the drill rig if the area under investigation is not within an area requiring purgewater management as described in the Purgewater Agreement (Izatt 1990). Slurry pit locations must be located outside the exclusion zone, and will be documented in the project logbook.

D5.3 GROUNDWATER

All extracted groundwater, including purgewater and free liquids separated from groundwater slurries, will be contained or managed in accordance with the Purgewater Agreement or, alternately, in accordance with Sections D6.0 and D8.0 of this appendix. Purgewater includes all wastewater generated from a well during development, aquifer testing, routine groundwater sampling, well maintenance, well remediation, and well abandonment activities.

Before generating purgewater, an assessment will be completed to determine if the water generated must be stored at a storage facility, or can be disposed to the soil column. Depending

on the well status, as described in the Purgewater Strategy implementation list[1], purgewater will be directly discharged to the ground at the well head, diverted away from the well head via a diversion system, temporarily stored at sites, or pumped directly into trucks designed to contain purgewater, and transported to the appropriate treatment, storage, and disposal (TSD) unit. In the event that a contaminant is identified in a WMA or waste site for which there is no collection criterion established in the Purgewater Agreement, a site-specific limit will be established in the waste control plan.

D5.4 DECONTAMINATION FLUIDS

Decontamination fluids (i.e., water, or nonhazardous cleaning solutions, or both) generated from activities conducted within the boundaries of a WMA or waste site will be collected and managed in accordance with Section D6.0 of this strategy, or the Purgewater Agreement as determined by Ecology. In the event that a contaminant is identified in a WMA or waste site for which there is no collection criterion established in the Purgewater Agreement, a site-specific limit will be established in the waste control plan.

Decontamination fluids and other liquid materials generated from activities conducted outside the boundaries of a WMA or other waste site will be managed as noncontaminated, unless the area under investigation is suspect as described in Section D3.0. If not a suspect area, these wastes may be disposed to the ground at or near the point of generation. These waste disposal locations will be documented in the project logbook.

D5.5 MISCELLANEOUS SOLID WASTE

All miscellaneous solid waste (MSW) that is generated as a result of site characterization and environmental investigation efforts (e.g., rags or personal protective equipment), and that has contacted potentially contaminated materials (contact MSW), will be segregated from soils, slurries, and liquids to the extent practicable. Contact MSW will be collected upon generation and managed in accordance with Section D6.0.

Waste management determinations for contact MSW will be based on results obtained from characterization activities. Where analytical data indicate that the dangerous and radioactive constituents are below levels of concern, contact MSW will be disposed of at an appropriate facility. If analyses indicate that contaminant limits are exceeded, the contact MSW will be disposed of as IDW at the ERDF or other appropriate facility.

All MSW generated that has not contacted waste material (non-contact MSW) will be segregated from all other material generated at the unit and disposed in an appropriate facility.

---

[1] List is available from Document Information Services, Pacific Northwest National Laboratory, Richland, Washington.

D6.0 STORAGE OF INVESTIGATION-DERIVED WASTE

D6.1 STORAGE LOCATION

The IDW will be stored at the WMA, or the waste site where it was generated, or at another storage area specified in the approved waste control plan until analytical data are evaluated for proper waste designation. While in storage, the IDW will be managed in accordance with the waste control plan. Most contaminated IDW will be disposed of at the ERDF if the waste meets ERDF waste acceptance criteria (BHI 1998). However, based on field screening instrumentation or analytical data, or both, it may be determined during the waste designation process that it is appropriate to manage certain types of IDW at another approved facility rather than at the ERDF.

The IDW that cannot be treated to meet the waste acceptance criteria for the approved disposal facility will remain at the waste site or in a centralized storage area pending disposal at an appropriate facility. If, after characterization of the IDW is completed, the waste must be stored longer than 6 months, ORP will obtain concurrence from Ecology and the Hanford Field Manager on the current storage, treatment, and disposal options, and the schedule for disposition of the IDW.

D6.2 CONTAINER MANAGEMENT REQUIREMENTS

Container management of IDW will comply with applicable dangerous waste and radioactive waste storage requirements. The requirements for managing dangerous waste containers are established in the *Code of Federal Regulations* (CFR), 40 CFR 264, Subpart I; WAC 173-303-630; and WAC 173-303-160. All containers of IDW designated as dangerous waste will be managed in accordance with the requirements of these regulations. All such containers will be legibly labeled with the words "HAZARDOUS WASTE" or "DANGEROUS WASTE." The containers will also include labels that define the known major risks and dangerous waste codes. Labeling for major risks will be consistent with either the waste designation or the U.S. Department of Transportation hazard class. Descriptive labels should be used, rather than Class 9 labels, to identify major risks. All containers of radioactive waste will be labeled as appropriate to indicate the radioactive hazard. Other container requirements specified in HNF-PRO-455, *Solid Waste Management* (FDH 1997) will be applied, as well as other procedures as appropriate.

If the designation of the IDW is unknown, the container must be labeled with the date of initial sampling and the words, "WASTE PENDING ANALYSIS." The following information must be maintained in the logbook for each unknown waste: the container tracking number; the date of discovery; the date samples were shipped to a testing facility; and the name, address, and phone number of the testing facility.

Waste will be stored at the WMA, waste site, or at a centralized storage area until analytical data are evaluated for proper waste designation, and subsequent disposal or transport to the appropriate disposal facility. Radiologically contaminated waste will be segregated from nonradiologically contaminated waste during storage. All containers will remain closed and sealed, except when it is necessary to add or remove waste. Routine inspections of the containers will occur to determine that they are in good condition, not leaking, and comply with the requirements of this section.

D6.3 RELEASE REPORTING

Any releases of IDW shall be reported in accordance with the requirements of WAC 173-303-145 and 40 CFR 302.

D7.0 TREATMENT OF INVESTIGATION-DERIVED WASTE

Some IDW may require treatment prior to disposal. For example, any IDW that is designated as a dangerous waste will require treatment to meet LDRs in accordance with 40 CFR 268. The most likely waste codes for designation are those codes associated with SST system waste. The treatment standard for each of those waste codes is provided in Table D-1. Several of the waste codes also specify that the waste must meet the universal treatment standards for all underlying hazardous constituents. The LDR standards only apply if the IDW is designated as a dangerous waste for that code. Examples of treatment to meet the LDRs include macroencapsulation (for IDW designated because of lead) and solidification (to eliminate free liquids in containers).

Treatment may also be required for reasons other than to meet LDRs, such as to reduce waste volumes prior to disposal. Specific treatment requirements and technologies will be identified in the WMA-specific waste control plans.

D8.0 DISPOSAL OF INVESTIGATION-DERIVED WASTE

Based on Ecology's determination (Ecology et al. 1999) to apply the IDW strategy to IDW generated as part of the RCAP, contaminated IDW that meets ERDF waste-acceptance criteria and, if applicable, the LDR standards, will be disposed of at the ERDF. The IDW that does not meet the ERDF waste acceptance criteria or the LDR standards (after treatment) will be transferred to the Hanford Central Waste Complex to be managed with other Hanford Site wastes. Depending on the concentration, activity, and nature of the waste, IDW may be disposed of at the mixed-waste burial ground, low-level waste burial ground, or at the Waste Isolation

Pilot Project site. Some of the waste may require treatment before it is disposed. Soil IDW containing hazardous and radiological constituents below dangerous waste designation limits and the Model Toxics Control Act soil cleanup standards, and that has been released from a radiological perspective, will be returned to the ground at or near the point of excavation. Liquid IDW will be managed as described in Section D5.0. Miscellaneous material that does not require disposal in the ERDF will be disposed of in an appropriate solid waste disposal facility.

D9.0 REFERENCES

40 CFR 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations*, as amended.

40 CFR 268, "Land Disposal Restrictions," *Code of Federal Regulations*, as amended.

40 CFR 302, "Designation, Reportable Quantities, and Notification," *Code of Federal Regulations*, as amended.

BHI, 1998, *Environmental Restoration Disposal Facility Waste Acceptance Criteria*, BHI-00139, Rev. 3, Bechtel Hanford, Inc., Richland, Washington.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), 42 U.S.C. 9601, et seq.

DOE-RL, 1996, *Hanford Site Radiological Control Manual* (HSRCM), DOE/RL-96-109, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Ecology, EPA, and DOE, 1999, *Strategy for Management of Investigation-Derived Waste*, dated March 17, 1999, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

FDH, 1997, *Solid Waste Management,* HNF-PRO-455, Fluor Daniel Hanford, Incorporated, Richland, Washington.

Izatt, R. D., 1990, U.S. Department of Energy, Richland Operations Office, letter to P. T. Day and T. L. Nord, MacTech Services, *Strategy for Handling and Disposing of Purgewater at the Hanford Site*, letter number 90-ERB-075, dated August 20, 1990.

Resource Conservation and Recovery Act of 1976 (RCRA), 42 U.S.C. 6901, et seq.

WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code*, as amended.

Table D-1. Land Disposal Restriction Treatment Standards for Single-Shell Tank Waste Codes. (2 Pages)

Waste Code	Basis for Regulation	Treatment Standard
D001	Ignitability	Eliminate ignitability and meet UTS
D002	Corrosivity	Eliminate corrosivity and meet UTS *or* vitrification (for corrosive radioactive high-level waste)
D003	Reactivity	Eliminate reactivity
D004	Arsenic	5.0 mg/L TCLP for arsenic and meet UTS
D005	Barium	21 mg/L TCLP for barium and meet UTS
D006	Cadmium	0.11 mg/L TCLP for cadmium and meet UTS
D007	Chromium	0.6 mg/L TCLP for chromium and meet UTS
D008	Lead	0.75 mg/L TCLP for lead and meet UTS, *or* macroencapsulation (for radioactive lead solids)
D009	Mercury	0.025 mg/L TCLP for mercury and meet UTS, *or* amalgamation (for elemental mercury contaminated with radioactive materials)
D010	Selenium	5.7 mg/L TCLP for selenium and meet UTS
D011	Silver	0.14 mg/l TCLP for silver and meet UTS
D018	Benzene	10 mg/kg benzene and meet UTS
D019	Carbon tetrachloride	6.0 mg/kg carbon tetrachloride and meet UTS
D022	Chloroform	6.0 mg/kg chloroform and meet UTS
D028	1,2-dichloroethane	6.0 mg/kg 1,2-dichlorethane and meet UTS
D029	1,1-dichloroethylene	6.0 mg/kg 1,1-dichloroethylene and meet UTS
D030	2,4-dinitrotoluene	140 mg/kg 2,4-dinitrotoluene and meet UTS
D033	Hexachlorobutadiene	5.6 mg/kg hexachlorobutadiene and meet UTS
D034	Hexachloroethane	30 mg/kg hexachloroethane and meet UTS
D035	Methyl Ethyl Ketone	36 mg/kg methyl ethyl ketone and meet UTS
D036	Nitrobenzene	14 mg/kg nitrobenzene and meet UTS
D038	Pyridine	16 mg/kg pyridine and meet UTS
D039	Tetrachloroethylene	6.0 mg/kg tetrachloroethylene and meet UTS
D040	Trichloroethylene	6.0 mg/kg trichloroethylene and meet UTS
D041	2,4,5-trichlorophenol	7.4 mg/kg 2,4,5-trichlorophenol and meet UTS
D043	Vinyl chloride	6.0 mg/kg vinyl chloride and meet UTS
WP01	Halogenated hydrocarbons >1.0% (EHW)	No land disposal of EHW (except EHW that is also radioactive waste) No free liquids No solid acid waste No organic/carbonaceous waste (>10%)
WP02	Halogenated hydrocarbons 0.01% to 1.0%	
WT01	Toxic constituent equivalent concentration ≥1.0% (EHW)	
WT02	Toxic constituent equivalent concentration ≥ 0.001% and <1.0%	

Table D-1. Land Disposal Restriction Treatment Standards for Single-Shell Tank Waste Codes. (2 Pages)

Waste Code	Basis for Regulation	Treatment Standard
F001	Spent halogenated solvents used in degreasing (several)	Acetone: 160 mg/kg Benzene: 10 mg/kg n-Butyl alcohol: 2.6 mg/kg Carbon disulfide: 4.8 mg TCLP[a] Carbon tetrachloride: 6.0 mg/kg Chlorobenzene: 6.0 mg/kg o-Cresol: 5.6 mg/kg m-Cresol: 5.6 mg/kg p-Cresol: 5.6 mg/kg Cresol – mixed isomers: 11.2 mg/kg Cyclohexanone: 0.75 mg/l TCLP[a] o-Dichlorobenzene: 6.0 mg/kg Ethyl acetate: 33 mg/kg Ethyl benzene: 10 mg/kg Ethyl ether: 160 mg/kg Isobutyl alcohol: 170 mg/kg Methanol: 0.75 mg/l TCLP[a] Methylene chloride: 30 mg/kg Methyl ethyl ketone: 36 mg/kg Methyl isobutyl ketone: 33 mg/kg Nitrobenzene: 14 mg/kg Pyridine: 16 mg/kg Tetrachloroethylene: 6.0 mg/kg Toluene: 10 mg/kg 1,1,1-trichlorethane: 6.0 mg/kg 1,1,2-trichloroethane: 6.0 mg/kg 1,1,2-trichloro-1,2,2-trifluroethane: 30 mg/kg Trichloroethylene: 6.0 mg/kg Trichloromonofluormethane: 30 mg/kg Xylenes – mixed isomers: 30 mg/kg
F002	Spent halogenated solvents (several)	
F003	Spent non-halogenated solvents (several)	
F004	Spent non-halogenated solvents (several)	
F005	Spent non-halogenated solvents (several)	

[a] This treatment standard only applies to F003 and/or F005 solvent wastes that contain any combination of carbon disulfide, cyclohexanone, and/or methanol as the only F-listed solvents.

EHW = extremely hazardous waste
TCLP = toxicity characteristic leaching procedure
UTS = universal treatment standards

1

APPENDIX E

PRELIMINARY IDENTIFICATION OF CORRECTIVE MEASURE TECHNOLOGIES

ACRONYMS

CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CMS	corrective measures study
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ICM	interim corrective measure
ITRD	Innovative Treatment Remedial Demonstration
LLW	low-level waste
RCRA	*Resource Conservation and Recovery Act of 1976*
SVOC	Semi-volatile organic compound
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TRU	transuranic
VOC	volatile organic compound
WMA	waste management area

E1.0 INTRODUCTION

Corrective measures studies (CMS) identify and evaluate alternatives to mitigate the release of waste that threatens human health and/or the environment in accordance with the *Resource Conservation and Recovery Act of 1976* (RCRA), as amended. The CMS process is outlined in *the Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1998). This appendix presents the initial screening-level results in identifying viable interim corrective measure (ICM) technologies and the applicability or limitations with respect to the waste management areas (WMAs). The results presented are not intended to constrain future technology screening or corrective measure alternative decisions. However, the technologies identified may form the basis for identifying additional information needs and for assembling corrective measure alternatives during the CMS. These initial screening-level results provide information on technologies that will allow earlier mitigation actions to be taken than if the technologies were not evaluated until later in the CMS process. The initial screening-level results also improve the efficiency of the CMS process by indicating data needs and raise worker safety concerns which can be addressed in the developmental stage of the mitigation activity.

The following sections present the preliminary technologies for soil contamination (Section E2.0) and for groundwater contamination (Section E3.0) that have previously been screened for various areas of the Hanford Site. The technologies presented in this appendix are summarized from the following documents:

- U.S. Department of Energy (DOE) preferred alternatives matrices remediation/waste processing (DOE 1997b)
- *Federal Remediation Technologies Roundtable, Remediation Technologies Screening Matrix and Reference Guide* (AEC 1997)
- *Technological Approaches to Cleanup of Radiologically Contaminated Superfund Sites* (EPA 1988)
- *Focused Feasibility Study of Engineered Barriers for Waste Management Units in the 200 Areas* (DOE-RL 1996)
- Technology transfer as provided by other DOE laboratories and contractors (not a document)
- U.S. Environmental Protection Agency (EPA) policy on the use of monitored natural attenuation (EPA 1999)
- Innovative Treatment Remedial Demonstration (ITRD) workshop held May 4 through 6, 1999 (PNNL 1999)
- *Hanford Groundwater Cleanup and Restoration Conceptual Study* (WHC 1992).

- *200 Area Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program* (DOE-RL 1999)

- Corrective measures studies and feasibility studies for various Hanford Site RCRA and *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) activities

- *Corrective Measures Study for 100-NR-1 and 100-NR-2 Operable Units* (DOE-RL 1997a)

- *Technologies for Dense Nonaqueaous Phase Liquid Source Zone Remediation* (GWRTAC 1998)

- *Hanford Site Groundwater Monitoring for Fiscal Year 1998* (Barnett et al. 1999)

- *Fiscal Year 1998 Annual Summary for the 200-UP-1, 200-ZP-1, and 100-NR-2 Pump-and-Treat Operations and Operable Units* (DOE-RL 1998)

- *Response to Tri-Party Agreement Milestone M-45-07A* (WHC 1995b)

- *Performance Evaluation Report for the Soil Vapor Extraction Operations at Carbon Tetrachloride Site, February 1992 - September 1998* (Rohay, 1999)

- *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites* (EPA 1999).

E2.0 DESCRIPTION OF PRELIMINARY TECHNOLOGIES FOR SOIL CONTAMINATION

The preliminary identification of technologies for soil contamination is presented based on the general response actions discussed in Section 4.0. Table E-1 summarizes the applicability and limitations of these technologies at the WMAs being considered.

E2.1 INSTITUTIONAL CONTROLS

For soil contamination, institutional controls include access and land-use restrictions. These controls could be considered for the shallow (e.g., <6.1 m [<20 ft]) to depth (e.g., >15 m [>50 ft]) contamination.

The advantages of these controls are listed below:

- These restrictions can be effective in protecting human health by reducing the potential for contact with contaminated media and avoiding adverse environmental, worker safety, and community safety impacts that arise from the potential release of contaminants associated with other remedial technologies (e.g., removal).

- These restrictions on real property are effective in providing a degree of human health protection by minimizing the potential for contact with the contaminated medial.

- They can be applied relatively quickly.

The disadvantages of these controls are listed below:

- This technology does not remove or destroy contaminants.
- It does limit future site use.
- For mobile contaminants, these controls do not control migration.

E2.1.1 Access Controls

Controlling access to the site requires either temporary or permanent physical restrictions to prevent or reduce exposure to site contaminants. Physical restriction examples include signage, entry control, artificial or natural barriers, and active surveillance.

E2.1.2 Land-Use Restrictions

Land-use restrictions are administrative actions implemented to prevent or reduce future human exposure to contaminants remaining onsite by restricting the use of land, including groundwater use. An example of a land-use restriction is a deed restriction that prohibits excavation or subsurface construction in a contaminated area. Restrictions can be imposed through land covenants which would be enforceable through lawsuits by the United States and, under Washington State law, the Washington State Department of Ecology.

E2.2 CONTAINMENT TECHNOLOGIES

Containment technologies use physical measures to isolate and reduce the horizontal or vertical contaminant flux. For example, capping is a containment technology in which a surface barrier is placed over the contaminated soils to control the amount of water infiltrating into the contaminated media and, therefore, reducing potential leaching of contaminants into the groundwater. The horizontal movement of subsurface contaminants is retarded by vertical barriers. Barriers are engineered to retard wind and water erosion, retard the release of organic vapors and radon, and attenuate radiation. Barriers also provide a physical barrier to limit direct human and animal interaction with contamination.

If successful, the advantages of these technologies are as follows:

- They reduce the leaching of contaminants into the groundwater.
- They apply to all contaminants.
- They can be constructed relatively quickly.

The disadvantages of these technologies are as follows:

- They do not destroy or remove contaminants, but must be used with other technologies to destroy or remove contaminants.
- Contaminants can affect the integrity of the barrier.
- The use of surface barrier concepts in general applications to tank farms would result in relatively small incremental reduction in the risk level achievable using baseline technologies (baseline technologies include traditional slucing, emptied tank stabilization, and caps).
- There is limited application of a surface barrier in the tank farms due to issues regarding acceptable dome loads.
- The use of these technologies (e.g., cryogenics) to mitigate contaminant migration in the soil column has not received much additional interest since the completion of the subsurface barrier investigation.
- Extensive safety procedures and monitoring plans may be required to ensure the protection of workers. Safety concerns (i.e., dome collapse, radiation hazards) must be balanced against the benefits of containment.

Containment technologies (e.g., surface barriers) can be considered in the tank farm areas to alternative migration of contaminants from near-surface to mid-depth (e.g., less than 15 m [15 ft]) for caps, barriers, and overhead structures. Slurry walls and grout walls can be considered from near surface to depth, depending on geology and the location of structures, to retard the flux of localized contaminants from the tanks, piping, and diversion boxes.

E2.2.1 Caps

Caps can have a range of design from a simple cover of clean soil to multiple layers designed for a variety of functions. The type of cap used depends on the nature, extent, and depth of the contamination.

Three multi-layered surface barrier designs have been specifically developed for the 200 Area categories of wastes. The barrier designs are described in the *Focused Feasibility Study of Engineered Barriers for Waste Management Units in the 200 Areas* (DOE-RL 1996). The designs include the following:

- Hanford Barrier
- Modified RCRA C Barrier
- Modified RCRA D Barrier.

E2.2.2 Overhead Structures

This technology involves the construction of a building or tent-type structure to prevent the infiltration of water into the contaminated soil area to retard potential leaching and movement of the contaminants to the groundwater.

E2.2.3 Run-On/Run-Off Control Options

Run-on/run-off controls are another way to reduce infiltration and thus limit the vertical migration of contaminants. Three process options for the control of run-on/run-off include diversion/collection, grading, and revegetation. Diversion/collection involves managing surface water by constructing dams, dikes, berms, channels, or levees. Grading involves modifying the site topography to prevent flooding, erosion, and ponding. The revegetation process involves installing vegetation cover over areas of contamination to reduce/control erosion. These technologies limit the amount of water infiltrating into the contaminated media and, therefore, reducing potential leaching of contaminates into the groundwater.

E2.2.4 Slurry Walls

Slurry walls are often used to contain groundwater, but they can be used in the vadose zone to retard the horizontal movement of moisture into an area of contamination, or to retard the flux of gases. A slurry wall is formed by vertically excavating a trench that is filled with a slurry that forms a continuous low-permeability barrier. The slurry is typically a mixture of soil, bentonite, and water.

Slurry walls are typically placed at depths of 15 m (50 ft) or more depending on geology and are generally 0.6- to 1.2-m (2- to 4-ft) thick.

E2.2.5 Grout Walls

Grout walls are formed by either injecting grout under pressure directly into the soil matrix, (permeation grouting) or in conjunction with drilling (jet grouting) at regularly spaced intervals to form a continuous low-permeability barrier. Directional drilling techniques can be used to form an angled grout wall beneath a waste site. This type of vertical barrier is limited because of difficulties in verifying that the barrier is continuous, and difficulties in drilling.

E2.2.6 Cryogenic Barrier

Cryogenic or freeze wall barriers are formed by recirculating chilled brine or other refrigerants through an array of closely spaced wells or freeze pipes. As the soil surrounding and between these wells or freeze pipes cools and freezes, the water in the voids freezes and expands. The freezing and expanding of the water effectively creates an impermeable barrier.

E2.2.7 Dynamic Compaction

Dynamic compaction is used to densify the soil, compact buried solid waste, and/or reduce the void spaces in the soil, which can reduce the hydraulic conductivity of the soil and the mobility of contaminants. This process is accomplished by dropping a heavy weight onto the ground surface. Worker exposure can be an issue with this process because the compacting process can expel contaminated particles. Dust control is required.

The technology is commonly utilized in coordination with caps. In addition, this technology would have limited application in the tank farm area because of potential tank loading during the compaction process. Because the compactive energy attenuates with depth, this process is limited to shallow applications.

E2.3 REMOVAL TECHNOLOGIES

Removal technologies include the excavation of contaminated soils or buried solid waste. The type of equipment used is based upon worker safety, desired production rates, and the potential for additional release of contaminants. The removal process starts with excavation of clean overburden, which is field surveyed and set aside for later use as backfill. The contaminated soils, solid waste, or both are excavated in lifts and surveyed for contamination. The amount of contaminated soil excavated is determined by the corrective measure performance standards.

After removal, the soil and/or debris may require ex situ treatment to meet disposal requirements or to reduce waste volume. Debris may be roughly characterized (i.e., combustible, metallic, inorganic, and radioactive) and segregated for different treatment and disposal options. Both onsite and offsite disposal options are available. Currently available disposal options for soils and soil debris include the following:

- Low-activity radioactive waste can be disposed of in the Low-Level Burial Ground, located in the 200 Areas.
- Low-level radioactive waste and/or dangerous waste can be disposed of at an appropriate disposal site. Disposal at the Environmental Restoration Disposal Facility (ERDF) would require regulatory approval.
- Dangerous waste can be disposed of offsite at an existing RCRA-approved landfill.
- Transuranic (TRU) waste can be disposed of offsite at the Waste Isolation Pilot Plant.
- Mixed wastes, dangerous waste, or both can be stored at the Central Waste Complex for eventual onsite disposal at the mixed waste disposal trenches (i.e., trenches 31 and 34), or for offsite disposal.

The advantages of these technologies are listed below:

- Removal and disposal is effective because the contaminated material is physically removed for the site.

- There are no requirements for long-term monitoring and maintenance of the site and there is greater flexibility in future land use.

- This technology is easily implemented at sites with shallow (e.g., <6.1 m [<20 ft]) contamination, using standard construction practices, and methods are available to handle most expected construction-related problems.

- Requirements for safety, monitoring, and sampling are generally well understood. Radioactive waste will require special handing protocols and may require remotely controlled equipment if radiation levels are high enough to preclude the use of standard construction equipment.

- Removal technologies do not require that the extent of contamination is precisely known before excavation. Rather, characterization can occur as the excavation proceeds, and the extent of contamination can be determined using the observational approach.

Following are several drawbacks to the implementation of removal technologies:

- Removal of contaminated material can be hazardous to workers since it requires them to handle, transport, and treat or dispose of the contaminated materials.

- Removal can result in a high degree of disturbance to existing natural and cultural resources.

- Control of fugitive dust and vapor emissions may be of particular concern at some sites.

- Extensive safety procedures and monitoring plans may be required to ensure the protection of workers and the environment. Safety and environmental concerns must be balanced against the benefits of removal.

- Technology is limited to sites with relatively shallow (e.g., <6.1 m [<20 ft]) contamination.

This technology could be considered for localized areas in the tank farms where leaks occurred from piping or diversion boxes at near-surface to mid-depth.

E2.4 IN SITU TREATMENT TECHNOLOGIES

In situ treatment technologies considered for soils were in situ electrokinetic separation, in situ bioremediation (or biodegradation), in situ solidification through injection or mixing, grout injection, deep soil mixing, vitrification, in situ soil flushing, soil vapor extraction, and monitored natural attenuation.

If successful, the general advantages of performing in situ treatment include the following:

- It minimizes the disturbance of cultural and ecological resources in the area.
- It typically reduces the toxicity and/or mobility of contaminants.
- It minimizes the impact to workers, the environment, and the community during the remedial activity because the contaminants are not removed and are not transported.
- If contaminants are destroyed, it requires no monitoring or maintenance after remediation.

The general disadvantages of performing in situ treatment include the following:

- The heterogeneous nature of the underlying geology makes it difficult to implement most in situ technologies.
- Uncertainties are associated with ensuring adequate introduction of agents and proper distribution and mixing to effect treatment.
- Uncertainties are associated with the proper placement of electrodes.
- Uncertainties are associated with evaluating the effectiveness of the process.
- Long-term monitoring and maintenance may be required if contaminants are not immobilized or destroyed.

These technologies could be considered for localized contamination from piping, the diversion boxes, or from the tanks at depth.

E2.4.1 Electrokinetic Separation

Electrokinetic separation can be used for organics, inorganics, and radioactive contaminants. This technology involves applying an electrical potential across the contaminated zone by using electrodes placed in the ground. Remediation by electrokinetics is based upon the migration of water and ions in an electrical field. This technology applies the physical chemistry principles of electrophoresis and electro-osmosis to manipulate the movement of colloidal particles or macromolecules to separate and remove the particles from either the soil matrix or groundwater.

Water and ions migrate under the influence of a direct current electrical field applied to the solution. The cations collect at the cathode and the anions collect at the anode.

Following are several disadvantages of this process:

- It requires water to move ions between electrodes; therefore, application in the unsaturated soils may require water addition that could cause unwanted migration.
- Evolution of hydrogen at the cathode results from the water being electrolyzed.
- High electrical power consumption.
- The potential exists to change soil chemistry.
- Follow-up treatment would be required to remove the contaminants since the process mobilizes contaminants but does not destroy them.

E2.4.2 In Situ Biodegradation

Biodegradation is effective on organic contaminants in soils, but it is not effective on radionuclides or inorganics. Therefore, this technology would have limited application in the tank farm area.

In situ biodegradation relies on microbial transformation of organic contaminants to effect the cleanup of the soils or groundwater. Biodegradation depends upon the existence of micro-organisms that will degrade the compound(s) of interest. The micro-organisms either completely mineralize the organics into carbon dioxide and water or partially transforms organic molecules into specific intermediates. Degradation requires the presence of primary substrates, nutrients, and appropriate reduction and oxidation conditions.

Biodegradation reactions involve either oxidation or reduction of the contaminant and therefore require both an oxidizer (electron acceptor) and a reducer (electron donor). The electron donor and acceptor compounds are termed "primary substrates." Many organic compounds, including most hydrocarbons, can be used by micro-organisms as primary substrates. Oxygen is a common electron acceptor. Nitrate, sulfate, and iron can also be electron acceptors in the absence of oxygen.

Biodegradation can take place under aerobic or anaerobic conditions. The oxygen status and the redox potential of a system affect contaminant biodegradability. Therefore, in situ biodegradation design may call for aerobic or anaerobic conditions. Many organic contaminants, including nonhalogenated aromatics, polynuclear aromatics, and nonhalogenated polar and nonpolar, can be biodegraded more rapidly under aerobic conditions. Some halogenated compounds, including some halogenated aliphatics, halogenated aromatics, and polychlorinated biphenyls are more readily degraded anaerobically.

In most cases, indigenous soil bacteria can degrade target contaminants if provided with necessary nutrients, and they can be acclimated to degrade target compounds. If the native soil lacks necessary metabolic capability, microbial augmentation may be used. Commercially available cultures can be readily obtained. These cultures are selected and marketed for application towards a specific chemical or group of chemicals.

The disadvantage of in situ biodegradation in deep soil applications is the uncertainty of knowing whether the nutrients, any amendments, and biological cultures have reached the contaminants to effect degradation.

E2.4.3 Solidification

Solidification can be used for organics, inorganics, and radiological contaminants. In situ solidification is conducted through injecting or mixing solidification agents. The injection process involves drilling holes to the desired depth then injecting the solidification/stabilization agents into the soil with high-pressure pumps. The pressure gradient drives the solidification/stabilization agents into the soil pores. The radius of penetration for the solidification/stabilization agents depend upon the hydraulic conductivity and pore size of the contaminated soil, as well as the properties of the solidification/stabilization agents. Soil with large pore sizes and high hydraulic conductivity generally has higher penetrations than soils with smaller pore sizes and lower hydraulic conductivity.

A variation of the injection process is jet injection. As in injection grouting, a small-diameter hole (about 5 cm [2 in.]) is drilled to the desired depth using a downward jet of air or water. However, the solidification agent is pumped out laterally through jets located near the bottom of the drill pipe at pressures as high as 5,000 psi (rather than relying on the pressure gradient to force the solidification/stabilization agent into the soil as in the injection process). The drill pipe is rotated continuously and drawn up at a predetermined rate. The solidification/stabilization agent mixes with the soil and forms a cylindrical column of solidified soil. The diameter of the solidified column is a function of the soil composition, soil strength, jetting pressure, processing rate, rotational speed, jet-nozzle diameter, and density of the solidification/stabilization agent. After the column diameter is determined, other holes are drilled at a spacing that allows the second column to overlap and/or join in the unset material of the previous column. Continuing this pattern permits the formation of continuous subsurface walls or monoliths.

Solidification through shallow soil mixing uses a crane-mounted auger head normally 2.4 to 3.7 m (8 to 12 ft) in diameter to mix the soil and solidification agent. For those applications that require the control of fugitive dust and gases that are generated during the mixing process, the auger is enclosed in an open-bottom cylinder. This allows for a closed-system mixing of the solidifying agent and the soil.

The solidifying agent is pumped through the hollow-auger shaft as the auger is advanced through the soil and injected into the soil at the pilot bit. The solidifying agent is continuously injected as the auger penetrates through the soil. When the desired depth is reached, the auger is withdrawn from the soil while continuing to rotate and further mix the soil. The completion of one penetration leaves a column of solidified material with a diameter approximately equal to the

diameter of the auger. After completing this column, the auger is placed so the second column overlaps and joins the unset material of the previous column. This process is repeated until all of the contaminated material has been treated.

E2.4.4 Grout Injection

Grout injection for soil remediation is an adaptation of the well established technique of injecting grout into the soil matrix. This process encapsulates the contaminants. The injection process produces a monolithic block that can be left in place or excavated for disposal elsewhere. If the encapsulated contaminants are left in place, this may limit future use of the site.

E2.4.5 Deep Soil Mixing

This process uses large augers and injector-head systems to inject and mix solidifying agents into contaminated soil. The process reduces the mobility of contaminants. This process can be used to inject micro-organisms for in situ bioremediation. If the encapsulated contaminants are left in place, they may limit future use of the site.

E2.4.6 Vitrification

Vitrification can be used for organics, heavy metals, and radionuclides. In situ vitrification involves the application of an electrical current to the soil to bring it to a temperature sufficient to melt the soil. The soil is heated to temperatures of 1,400 to 2,000°C (2,552 to 3,632°F). It forms a stable, vitrified mass when cooled that chemically incorporates most inorganics including heavy metals and radionuclides, and destroys or removes all organic contaminants. The off-gases are collected using a vacuum hood and are treated. The process depths are limited to 6 m (20 ft) with existing equipment in homogeneous soils, and are generally applicable to smaller volumes of highly contaminated soil. The process can proceed from the top-down or from the bottom-up.

An advantage of this technology is that it eliminates the need for excavation, handling, transport, ex situ treatment, backfilling, and disposal of treated soils. The risk of exposure to workers and the surrounding environment is reduced. An additional advantage of this technology is that it makes a highly stable, immobilized material.

The disadvantages associated with this technology are listed below:

- It is difficult to get good soil melt below 4.6 to 6.1 m (15 to 20 ft); uncertainties exist in heterogeneous soil.
- It generally results in some land-use restrictions.
- It does not mitigate external exposure to radioactive contaminants.

E2.4.7 Soil Flushing

Soil flushing can be used for organics, inorganics, and radioactive contaminants. In situ soil flushing involves the extraction of contaminants from the soil by injecting an extractant or elute, such as water or some other suitable solvent, through the contaminated soils. The extraction fluids solubilize or elute the contaminate from the soil. The resultant solution must be recovered through extraction wells and treated at the surface by a treatment system such as an ion-exchange system. Whenever possible, the extractants are recycled. This method is potentially applicable to all types of soil contaminants.

Soil flushing is most effective in permeable soils. Contaminants are mobilized as a result of this process. Therefore, collection and removal of the extractant is critical to the success of this process and for the prevention of contamination migration. The flushing fluid may be applied to the contaminated soil by injection wells, infiltration arrays or aboveground sprays.

Soil flushing is expected to be effective on coarse sand and gravel contaminated with organic or inorganic contaminants. Removal efficiencies depend on the solvent used, the contaminant, and the soil type. The greater the depth, the greater the uncertainties that the injection process and the mixing between the soil and the flushing agent were successful when using this technology. The heterogeneous aspect of the vadose zone may make contact of the contaminant with the flushing agent difficult or impossible to achieve.

A disadvantage of soil flushing include the following:

- It may not remove all of the contaminants of concern.
- It may mobilize normally nonmobile materials, such as actinides.

E2.4.8 Soil Vapor Extraction

Soil vapor extraction is best used for volatile organic compounds (VOCs) and fuels. Therefore, this technology would have limited application in the tank farm area.

In situ soil vapor extraction is a conventional process for remediating soils contaminated with VOCs and has been identified by EPA as a presumptive remedy (EPA 1993). This process involves inducing airflow through the soil matrix with an applied vacuum that facilitates the mass transfer of adsorbed, dissolved, or free phases of the contaminant to the vapor phase. The performance of the soil vapor extraction system is a function of the volatility of the contaminants and the flow of the vapor. The volume of air that can be withdrawn through a given treatment area is a function of soil permeability, water saturation, and heterogeneity of the site. Vapors are pumped from the subsurface to the surface for treatment using vertical extraction wells or horizontal piping. In situ soil vapor extraction has been commonly used for VOC contamination at Superfund sites and has a history of effectively treating waste in place at a relatively low cost.

E2.4.9 Monitored Natural Attenuation

Monitored natural attenuation relies on natural processes to lower contaminant concentrations through physical, chemical, and/or biological processes until cleanup levels are met. These natural processes include the following:

- Biodegradation, which is effective for most organic compounds, given proper conditions
- Sorption, which can immobilize most kind of contaminants
- Oxidation-reduction reactions, which can transform contaminants into less mobile or less toxic forms
- Radioactive decay, which significantly reduces the activity of radionuclides with short half-lives (i.e., on the order of several to tens of years).

Radioactive decay is the only process to eliminate nuclear particle emissions, as no available treatment process exists to eliminate radioactivity.

Because of uncertainties in the science of natural attenuation processes, EPA considers source control and performance monitoring as fundamental components of the option. From a technical standpoint, monitored natural attenuation is readily implemented but may require significant action or commitment of resources to implement (e.g., personnel to conduct sampling and analytical work, construction activity, and loss of land use).

E2.5 EX SITU TREATMENT TECHNOLOGIES

Ex situ technologies for contaminated soils include biodegradation for organics, soil washing for inorganics and radionuclides, solidification and stabilization for all types of contaminants, thermal desorption for organics, and encapsulation for all types of contaminants. These technologies would be used in conjunction with removal technologies discussed earlier.

The general advantages of ex situ treatment include the following:

- It usually reduces toxicity, mobility, and/or volume.
- Since contaminants are removed, it requires no monitoring or maintenance at the end of remediation.
- It allows easier performance and effectiveness evaluation.
- Compared to in situ treatment, ex situ treatment provides relatively easy mixing and control of the process for addition of agents, chemicals, bacteria, and other amendments.

The general disadvantages of ex situ treatment include the following:

- It can disturb cultural and ecological resources in the area to be remediated.
- It has a greater potential impact for worker and environmental exposure to contaminants.
- Contaminants are not destroyed with soil washing, solidification and stabilization, and encapsulation.

E2.5.1 Biodegradation

Biodegradation can be used for organics, but is not effective on inorganics and radionuclides. Therefore, this technology would have limited application to any soils removed from the tank farm area.

Ex situ biodegradation is essentially the same as in situ biodegradation except the soil is excavated and placed in a system (e.g., tank) or in a pile where treatment is applied. For this technology, bacteria indigenous to the soil or cultured bacteria are used to biologically degrade organic contaminants. It is capable of treating petroleum-contaminated soils to below action levels by degrading toxic petroleum contaminants into nontoxic byproducts, thus reducing the volume of material requiring disposal. The treated soil could be used as clean backfill at the site or transported elsewhere for other uses.

Aboveground biodegradation may be accomplished by placing the excavated contaminated soil in treatment containment areas. If large quantities of volatile organics are treated in this way, an air permit may be required. Nutrients can be fed to the bacteria to promote population growth sufficient to degrade the petroleum waste in the soil.

Land farming is another biodegradation technique that mixes nutrients and other amendments while aerating the soil by tilling. This technique is used in place for shallow contaminated areas. It can also be used for deeper contamination by moving the deep soil to an aboveground area for treatment.

A bioreactor is another mechanism for biologically treating organic contaminants. The bioreactor consists of mixing vessels that blend cultured bacteria, nutrients, oxygen for aerobic conditions, and contaminated soils under controlled pH, temperature, and moisture content. Bioreactors maximize the rate that the bacteria can degrade the contaminants.

E2.5.2 Soil Washing

Soil washing uses a wash solution (e.g., water) to remove soil contaminants by dissolving or suspending the contaminants in solution or by concentrating them through particle size separation, gravity separation, and attrition scrubbing. The washing agent and soil fines are residuals that require further treatment. This process is applicable to coarse-grained soils contaminated with a wide variety of metal, radionuclide, and organic contaminants, particularly those that tend to bind to the fine soil fraction.

Advantages of this technology include the following:

- The cleaned soil can be used as clean fill.
- It reduces the volume of waste requiring disposal.

A disadvantage of this technology is that the ashwater needs to be treated to remove the contaminants that have been washed and desorbed from the soil.

E2.5.3 Solidification and Stabilization

Solidification/stabilization uses admixtures of stabilizing agents to encapsulate excavated soil and render inert various hazardous substances. This process is mainly targeted at metals, radionuclides, and other inorganics. Stabilizing agents include cement, asphalt, and polymeric materials. The EPA has identified polymer macroencapsulation as the best demonstrated available technology for radioactive lead solids and mixed waste debris. The advantage of this technology is that it can satisfy the treatment option for land disposal of restricted wastes; wastes treated in this manner could be landfilled.

Solidification/stabilization of solids can be accomplished using inorganic or organic binding agents. Inorganic solidification/stabilization agents include cement based materials, pozzolanic-based materials (e.g., silica from fly ash, kiln dust, and lime), and other materials (e.g., clay). Organic solidification/stabilization agents include thermoplastic and thermosetting materials such as asphalt, bitumen, polyolefins, epoxies, and organic polymers. Thermoplastic materials are organic polymers that are heated and mixed with the waste material in the molten state. After cooling, the waste becomes physically encapsulated by the solidified polymer. Some of the organic polymers are biodegradable.

E2.5.4 Thermal Desorption

Thermal desorption has been identified as a presumptive remedy by EPA (1993) for the removal of VOCs from soil. This technology uses relatively low-temperature heat (150° to 425° C) to volatilize organic contaminants from soil. A carrier gas or vacuum is used to collect and transport the volatilized organics to a gas treatment system. Concentrated contaminants can be removed (e.g., by carbon adsorption) from the process stream or destroyed using a secondary combustion chamber or catalytic oxidizer. Residual liquids and spent activated carbon require further treatment. With low-temperature thermal desorption, the decontaminated soil retains its physical properties and ability to support biological growth. Thermal desorption is directed toward organic removal, not organic destruction.

E2.5.5 Encapsulation

Wastes can be encapsulated by fixing individual particles in a solid matrix (as discussed in Section E2.5.3) or by enclosing a quantity of waste within an inert jacket or container. Container sizes range from less than a gallon to containers that can surround 55-gallon (or larger) drums.

If the waste are intended for land disposal, the containers must be designed for burial conditions of compaction and stress loadings, as well as biodegradation, temperature cycles, internal pressures produced by the waste, and chemical attack.

E3.0 DESCRIPTION OF TECHNOLOGIES FOR GROUNDWATER CONTAMINATION

The preliminary identification of technologies for groundwater contamination is presented based on the general response actions discussed in Section 4.0. Table E-2 summarizes the applicability and limitations of these technologies at the WMAs being considered.

E3.1 INSTITUTIONAL CONTROLS

For groundwater contamination, institutional controls include access controls and restricted water use.

The advantages of these controls include the following:

- These restrictions can be effective in protecting human health by reducing the potential for contact with contaminated media and avoiding adverse environmental, worker safety, and community safety impacts that arise from the potential release of contaminants associated with other remedial technologies (e.g., removal).
- These restrictions on real property are effective in providing a degree of human health protection by minimizing the potential for contact with the contaminated media.
- They can be applied relatively quickly.

The disadvantages of these controls include the following:

- This technology does not remove or destroy contaminants.
- It does limit future site use.
- For mobile contaminants, these controls do not control migration.

E3.1.1 Access Controls

Controlling access to the groundwater requires either temporary or permanent physical restrictions to prevent or reduce the exposure to groundwater contaminants. Possible methods of controlling access to the groundwater include signs, entry control, artificial or natural barriers, and active surveillance. Measures depend upon the specific site conditions, the proximity to the local population, and the degree of hazard associated with the groundwater contamination. This technology does not remove or destroy the contaminants and limits future site use.

E3.1.2 Groundwater-Use Restriction

Groundwater-use restrictions involve legal prohibitions on well construction and use of groundwater within a contaminated area or a specific aquifier. These restrictions are designed to limit exposure that may pose a threat to human health and to prohibit offsite groundwater extraction that could increase contaminant migration. This technology does not remove or destroy the contaminants and limits future site use.

E3.2 HYDRAULIC CONTAINMENT

This technology can be used for any mobile contaminant. Hydraulic containment is a technology that uses extraction wells that are specifically placed along a line, or surrounding an area, to control the horizontal movement of groundwater and contaminants contained within the groundwater. By placing several extraction wells in close proximity along a line and pumping the groundwater, depression zones are formed that create a barrier to the passage of groundwater by intercepting the groundwater moving through the proximity of the wells. The extracted groundwater containing the contaminants may require treatment to remove the contaminants prior to the treated water being reinjected into the plume or discharged to surface water.

The advantages of this technology include the following:

- Groundwater containing the contaminant is extracted from the subsurface (the contaminant is only removed if the extracted water is treated, see disadvantages, third bullet below).
- The technology is well known.

The disadvantages of this technology include the following:

- Failure of a system component (e.g., pump failure) may cause loss of containment.
- It is expensive for large plumes, and treatment may not be available for all contaminants (e.g., tritium).
- It needs to be used with other technologies to treat or destroy the contaminant.

E3.3 IMPERMEABLE BARRIERS

Impermeable barriers are solid walls that are placed into the subsurface to retard the movement of groundwater towards some target area (e.g., the Columbia River). Groundwater flowing toward a barrier will divert away from the barrier due to hydraulic mounding upgradient of the barrier, and the groundwater will eventually flow around the barrier. The barrier could be supplemented with extraction wells at the ends of the barrier to prevent mobile contaminants from migrating around the barrier.

Barriers or vertical cut-off walls include low-permeability or impermeable barriers constructed to capture, contain, or redirect groundwater movement and its associated contaminants. There are several methods of barrier construction. The type of barrier chosen depends on the size and shape of the required wall, the aquifier soil type, construction material availability, wall permeability requirements, and required design life.

The advantages of these technologies include the following:

- They are applicable to all contaminants.
- They can be implemented relatively quickly.

The disadvantages of these technologies include the following:

- They do no destroy or remove contaminants and need to be used in conjunction with other technologies to remove or destroy the contaminant.
- The contaminant may affect the integrity of the barrier.

E3.3.1 Slurry Walls and Soil Mixed Walls

A slurry wall (soil-bentonite and cement-bentonite slurry walls) is formed by vertically excavating a trench that is then filled with a slurry that forms a continuous low-permeability barrier. The slurry is used to shore up the trench as excavation proceeds. Soil-mixed walls are similar to the slurry wall except that the slurry replaces or is mixed with the removed soil. Augers simultaneously drill, inject slurry and mix the slurry with the soil. Jet-grouting barriers (grout curtains) use pressure injection of the grout through pipes that are inserted into the ground with drill rigs. The grout curtain method reduces the permeability of the existing soil to retard groundwater movement.

The presence of coarse-grained soils and non-uniform materials (e.g., boulders) increases the uncertainties of these methods.

E3.3.2 Sheet-Pile Barrier

This method involves the use of interlocking sheet piles. The piles are driven into the ground with either vibratory or impact pile drivers. The interlocking joints may be grouted to provide a low-permeability barrier. Rocky or dense soils make driving difficult, and excessive driving force can damage the piles. This method can be enhanced by the use of pre-excavation, pre-punching, or pre-drilling.

Sheet-pile barriers have been tested in the 100-N Area of the Hanford Site. Both methods were unsuccessful. The piling was destroyed after penetrating to a depth of 9.2 m (30 ft).

E3.3.3 Cryogenic Barrier

Cryogenic or freeze-wall barriers are formed by recirculating chilled brine or other refrigerants through an array of closely spaced wells or freeze pipes. As the soil surrounding and between the wells or freeze pipes cools and freezes, the water in the voids freezes and expands. The freezing and expanding of the water effectively creates an impermeable barrier.

Equipment failure is not as critical to this technology since the freeze-wall barrier would stay frozen for an extended period (up to 2 years) (DOE-RL 1997a).

E3.4 IN SITU TREATMENT TECHNOLOGIES

The in situ technologies considered were for two types of permeable barriers (primarily for strontium-90 and heavy metals) for in situ remediation, and a soil flushing technology for in situ remediation of radionuclides. These technologies are applicable to the primary contaminants of concern in the tank farm area.

The advantages of these technologies are as follows:

- The contaminants can be treated in place without the need for extracting a large quantity of water for treatment.
- Minimal disturbance is caused to the cultural and ecological resources in the area.

The disadvantages of these technologies are listed below:

- The heterogeneous nature of the underlying geology makes it difficult to implement (e.g., soil flushing).
- It is limited to excavation techniques for adsorption-type treatment and phosphate precipitation barrier.
- Barriers can become plugged or fully loaded and require replacement.

E3.4.1 Adsorption-Type Treatment Barrier

Permeable treatment beds/barriers are constructed by digging trenches and backfilling the trench with a mixture a soil and adsorbent(s). The bed is placed downgradient of the contaminated plume. The natural groundwater flow carries the contaminants through the bed, where the contaminant that the barrier has been designed for is adsorbed onto the bed.

The disadvantage of this technology is that the beds can become plugged or fully loaded and require replacement.

E3.4.2 Phosphate Precipitation Barrier

In this technology, phosphate compounds are used to remediate heavy metals. The phosphate minerals and compounds precipitate heavy metals (e.g., strontium-90) in the soil matrix. This technology is in the developmental stages.

E3.4.3 Soil Flushing

Soil flushing was described in the technologies for soil discussed earlier in this appendix. This technology was considered to be innovative and was considered for remediating a deep (e.g., 21.4-m [70-ft]) aquifier (DOE-RL 1997a). Using the soil flushing technology required mounding of the water table over a relatively large area.

E3.4.4 Monitored Natural Attenuation

Monitored natural attenuation relies on natural processes to lower contaminant concentrations through physical, chemical, and biological processes until cleanup levels are met. These natural process include the following:

- Biodegradation, which is effective for most organic compounds, given proper conditions
- Sorption, which can immobilize most kind of contaminants
- Oxidation-reduction reactions, which can transform contaminants into less mobile or less toxic forms
- Radioactive decay, which significantly reduces the activity of radionuclides with short half-lives (i.e., on the order of several to tens of years).

Radioactive decay is the only process that can be used to eliminate nuclear particle emissions, as no available treatment process exists to eliminate radioactivity.

Because of uncertainties in the science of natural attenuation processes, EPA considers source control and performance monitoring as fundamental components of the option. From a technical standpoint, monitored natural attenuation is readily implemented but may require significant action or commitment of resources to implement (e.g., personnel to conduct sampling and analytical work, construction activity, and loss of land use).

E3.5 EX SITU TREATMENT TECHNOLOGIES

Aboveground treatment technologies are used to remove contaminants from the groundwater by destruction or treatment after the groundwater has been pumped to the surface. Generally, the treated water is injected back into the ground upgradient of the plume from which it was extracted. The treated water is reinjected into the plume at a point where the concentrations of contaminants in the groundwater are the same or higher than the treated water.

Ex situ treatment technologies considered were: precipitation, membrane, ion-exchange, wet air oxidation, activated carbon, and tritium treatment.
The advantage of these technologies is that the technologies can be controlled better than in situ technologies.

The disadvantage of these technologies is that they may require a significant quantity of groundwater be extracted for treatment to remove a small quantity of contaminant.

E3.5.1 Precipitation Technology

This technology is used to remove metals and radionuclides from water by precipitation. Per DOE-RL (1997a), precipitation as technology is not a stand-alone process.

E3.5.2 Membrane Technology

Membranes were considered for the treatment of radionuclides (e.g., strontium-90). The membrane adsorbs the contaminant. This technology was considered to be in the development stage.

E3.5.3 Ion-exchange Technology

In ion-exchange technology, ions are removed from the solution by adsorption on a solid medium, typically an ion-exchange resin bed or column. As the groundwater is passed through the ion-exchange resin, ionic species in the groundwater exchange with ions on the resin and are adsorbed onto the surface of the resin.

Strontium, technotium, chromium VI, and manganese are transition metals that are amenable for removal by ion exchange. Iron and manganese are typically removed by ion-exchange treatment for groundwater drinking supplies. Sulfates are usually removed by anion-exchange resins.

Ion exchange is a reversible process that allows the resin to be regenerated and reused. However, regeneration requires a large quantity of water and regeneration chemicals. This creates large volumes of spent solutions that require additional treatment for disposal.

Ion exchange normally consists of three or four ion-exchange columns configured with sequential flow to provide a polishing arrangement.

E3.5.4 Wet Air Oxidation

Wet air oxidation, a potential process for treating chlorinated hydrocarbons, is based upon a liquid-phase reaction between organics in the wastewater and compressed air. The reaction takes place in an enclosed vessel at high pressure and temperatures (typically 2,000 lb/in.^{2} and 288°C [550°F]). Since this technology is used for the treatment of organics, it may have limited application in the tank farm areas.

E3.5.5 Activated Carbon

This activated technology is a method used for removing organic hydrocarbons. The wastewater is passed over the activated carbon, where the contaminant is absorbed onto the carbon. This process could produce a mixed waste (i.e., radioactive and toxic) because of its affinity for iodine. Since this technology is mainly for the treatment of organics, it may have limited application in the tank farm areas.

E3.5.6 Tritium Treatment Technologies

Per the CMS (DOE-RL 1997a), the most successful treatment systems for tritium treatment and separation are the gaseous phase applications as used in commercial nuclear power operations. According to DOE-RL (1997a), the technologies being considered or being used for tritium are a combination of electrolysis and catalytic exchange, bithermal catalytic exchange, and membrane separation. Those technologies in the research and development stage include isotopic exchange, finely divided nickel, and chemical exchanges.

E4.0 REFERENCES

AEC, 1997, *Remediation Technology Screening Matrix and Reference Guide*, Third Edition, Federal Remediation Technologies Roundtable, prepared for the U.S. Army Environmental Center, Aberdeen Proving Ground, Maryland.

Barnett, D. B., C. J. Chou, P. E. Dresel, B. M. Gillespie, H. Hampt, D. G. Horton, V. G. Johnson, J. W. Lindberg, J. P. McDonald, R. B. Mercer, D. A. Myers, S. H. Narbutovskih, D. R. Newcomer, R. E. Petersen, R. Randall, S. P. Reidel, J. T. Rieger, V. J. Rohay, R. J. Serne, D. S. Sklarew, D. L. Stewart, L. C. Swanson, M. D. Sweeney, C. J. Thompson, P. D. Thorne, E. C. Thornton, W. D. Webber, R. L. Weiss, B. A. Williams, M. D. Williams, and S. K. Wurstner, 1999, *Hanford Site Groundwater Monitoring for Fiscal Year 1998*, PNNL-12086, Pacific Northwest National Laboratory, Richland, Washington.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), 42 U.S.C. 9601, et seq.

DOE-RL, 1996, *Focused Feasibility Study of Engineered Barrier for Waste Management Units in the 200 Areas*, DOE/RL-93-33, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1997a, *Corrective Measures Study for the 100-NR-1 and 100-NR-2 Operable Units*, DOE/RL-95-111, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE, 1997b, *DOE Preferred Alternatives Matrices Remediation/Waste Processing*, Rev. 4, published on the World Wide Web, http://www.em.doe.gov/define/r_pam.html, dated June 30, 1997, U.S. Department of Energy, Washington, D.C.

DOE-RL, 1999, *200 Area Remedial Investigation/Feasibility Study Implementation Plan -- Environmental Restoration Program*, DOE/RL-98-28, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Ecology, Ecology, and DOE, 1998, *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement), Fifth Amendment, 89-10, Washington State Department of Ecology, U.S. Environmental Protection Agency, U.S. Department of Energy, Olympia, Washington.

EPA, 1988, *Technical Approaches to Cleanup of Radiologically Contaminated Superfund Sites*, EPA/540/2-88/002, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1993, *Presumptive Remedies: Site Characterization and Technology Selection for CERCLA Sites with Volatile Organic Compounds in Soils*, OSWER Directive No. 9355.0-48FS, EPA 540-F-93-048, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1999, *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites*, OSWER Directive Number 9200.4-17P, U.S. Environmental Protection Agency, Washington, D.C.

GWRTAC, 1998, *Technologies for Dense Nonaqueous Phase Liquid Source Zone Remediation*, TE-98-02, State University of New York at Buffalo, Department of Geology, Buffalo, New York.

PNNL, 1999, *Reducing Water Infiltration Around Hanford Tanks*, Forum Proceedings, Vols. I and II, Held at Hills Conference Center, Richland, Washington, May 4-6, 1999, TechCon Program, Richland, Washington, http://web.ead.anl.gov/techcon/corproj.cfm.

Resource Conservation and Recovery Act of 1976 (RCRA), 42 U.S.C. 6901, et seq.

Rohay, V. J.,1999, *Performance Evaluation Report for the Soil Vapor Extraction Operations at Carbon Tetrachloride Site, February 1992 - September 1998*, BHI-00720, Rev. 3, Bechtel Hanford, Inc., Richland, Washington.

WHC, 1992, *Hanford Groundwater Cleanup and Restoration Conceptual Study*, WHC-EP-0458, Westinghouse Hanford Company, Richland, Washington.

1

Table E-1. Soil Technologies Applicability/Capacities/Limitations. (8 Pages)

Technology	Applicability/Capacities/Limitations
Containment Technologies	
Caps	○ Does not target specific contaminants, can be used for any contaminants ○ Can be considered for use in the tank farm areas from near-surface to mid-depth ○ Does not destroy or remove contaminants, reduces or eliminates contaminant movement caused by contaminants being leached by infiltration ○ Can be constructed relatively quickly ○ Depending on material of construction, has limited life. ○ Potential load problems in tank farms and worker safety concerns ○ Requires selection of source for capping materials and may require mitigation of capping material (supply) source location.
Overhead structures	○ Does not target specific contaminants, can be used for any contaminants ○ Can be considered for use in the tank farm areas from near-surface to mid-depth ● Does not destroy or remove contaminants, reduces or eliminates contaminant movement caused by contaminants being leached by infiltration ○ Can be constructed relatively quickly ○ Potential load problems in tank farms and worker safety concerns ○ Can be used in conjunction with removal technologies to enhance *remove effort*
Run-on/run-off control options	○ Does not target specific contaminants, can be used for any contaminants ○ Can be considered for use in the tank farm areas from near-surface to mid-depth ○ Does not destroy or remove contaminants, reduces contaminant movement caused by contaminants being leached by infiltration ○ Can be constructed relatively quickly

Table E-1. Soil Technologies Applicability/Capacities/Limitations. (8 Pages)

Technology	Applicability/Capacities/Limitations
Slurry Walls	○ Does not target specific contaminants, can be used for any contaminants ● Can be considered for use in tank farm areas to retard the flux of localized contaminants from the tanks, piping and diversion boxes from near surface to depth, depending on geology and location of structures ○ Does not destroy or remove contaminants, retards contaminants flux ○ Contaminants can degrade the slurry wall ○ If not properly "keyed" into impermeable material there could be leakage under the wall ● Use other technologies to remove and destroy contaminants ○ Typically placed at depths of 50 ft or more depending on geology and are generally 2- to 4-ft thick
Grout walls	○ Does not target specific contaminants, can be used for any contaminants ○ Can be considered for use in tank farm areas to retard the flux of localized contaminants from the tanks, piping and diversion boxes from near surface to depth, depending on geology and location of structures ○ Does not destroy or remove contaminants, retards contaminants flux ● Contaminants can affect the stability of the grout matrix ○ Moisture can affect the grout setup ○ Limitations in determining consistency, dimensions and continuity of the barrier and heterogeneous soils can cause gaps in the wall ○ In not properly "keyed" into impermeable material there could be leakage under the wall ○ Use with other technologies to remove and destroy contaminants
Cryogenic barriers	● Does not target specific contaminants, can be used for any contaminants ○ Can be considered for use in tank farm areas to retard the flux of localized contaminants from the tanks, piping and diversion boxes from near surface to depth, depending on geology and location of structures ○ Does not destroy or remove contaminants, retards contaminants flux ● Contaminants can degrade the slurry wall ○ Use with other technologies to remove and destroy contaminants

Table E-1. Soil Technologies Applicability/Capacities/Limitations. (8 Pages)

Technology	Applicability/Capacities/Limitations
Dynamic Compaction	◠ No specific target compound group ◠ This technology would have limited application in the tank farm area because of potential tank loading during the compaction process and is limited to shallow applications. ● May not reduce hydraulic conductivity low enough to adequately control contaminant migration ● Worker safety concerns because of potential dome collapse and radiation hazards ● Needs to be used with other technologies for contaminant removal or destruction
Removal Technologies	
Removal technologies	◠ Does not target specific contaminants, can be used for any contaminant ◠ Could be considered for localized areas in the tank farms where leaks occurred from piping or diversion boxes at near-surface to mid-depth ◠ Uses readily available, standard earth-moving equipment ◠ Removes contaminants, no need for long-term monitoring and maintenance of site ◠ Need to take precautions for worker exposure to contaminants ◠ Can disturb natural and cultural resources ◠ Limited to relatively shallow contamination where there are nearby facilities. Maximum depth is considered to be 50 ft for cost-effective removal (shallow) of contaminants; for deep contamination can use non-standard (e.g., shoring) in conjunction with excavation ● Soil remove can be treated to destroy contaminants or can be landfilled in approved land disposal sites.

Table E-1. Soil Technologies Applicability/Capacities/Limitations. (8 Pages)

Technology	Applicability/Capacities/Limitations
In Situ Treatment Technologies	
Electrokinetic separation	• Can be applied to sludges and solids/debris with organics, inorganics, or radioactive contaminants • Can be considered for use in the tank farm areas for localized contamination from piping or the diversion boxes or from the tanks at depth • High power consumption • Unsaturated soils may require water addition • Requires removal from electrodes and follow-up treatment of contaminants • Hydrogen is generated from the electrolysis of water
Biodegradation	• Effective on organics (generally nonhalgenated VOCs and SVOCs, petroleum hydrocarbons), but not effective on radionuclides or inorganics • Can be considered for use in the tank farm areas for localized contamination from piping or the diversion boxes or from the tanks at depth ○ Can be aerobic or anaerobic degradation ○ Allows treatment without excavation • Can be combined with soil vapor extraction or air sparging which would not be effective for the primary contaminants of concern in the tank farm area ○ Some contaminants (e.g., heavy metals, long-chain hydrocarbons, and inorganic salts) may be toxic to micro-organisms ○ Requires appropriate nutrients and oxygen for aerobic conditions ○ Uncertainty of knowing if nutrients, any amendments, and biocultures have reached contaminants in deep soil applications
Solidification	○ Can be used for organics and radiological contaminants ○ Can be considered for use in the tank farm areas for localized contamination from piping or the diversion boxes or from the tanks at depth • Contaminants are immobilized, not destroyed • High concentrations of organics can affect the stability of the grout matrix ○ Limitations in determining consistency, dimensions and continuity of the barrier and heterogeneous soils can cause gaps in the wall

Table E-1. Soil Technologies Applicability/Capacities/Limitations. (8 Pages)

Technology	Applicability/Capacities/Limitations
Grout injection	○ Used for chromium and tritium ○ Can be considered for use in the tank farm areas for localized contamination from piping or the diversion boxes or from the tanks at depth ○ Does not destroy or remove contaminants, retards contaminants flux ○ Contaminants can affect the stability of the grout matrix ○ Moisture can affect the grout setup ○ Use with other technologies to remove and destroy contaminants
Deep soil mixing	○ This technology is used for inorganics including radionuclides. Has limited effectiveness with SVOCs and on VOCs (depending on mixing agent used) ○ Can be considered for use in the tank farm areas for localized contamination from piping or the diversion boxes or from the tanks at depth ○ Does not destroy or remove contaminants, retards contaminants flux ● Use with other technologies to remove or destroy contaminants ○ Integrity of the stabilized over the long term may be affected by temperature cycles, infiltration or physical disturbances ● Limitations in determining consistency, dimensions, and continuity

Table E-1. Soil Technologies Applicability/Capacities/Limitations. (8 Pages)

Technology	Applicability/Capacities/Limitations
Vitrification	○ Can be used on organics, heavy metals, and radionuclides ○ Could be considered for use in the tank farm areas but difficult to obtain a good melt below 4.6 to 6.1 m (15 to 20 ft) ○ Process removes or destroys organics ○ Off-gas collection is required ○ Contaminants can migrate to clean areas because of soil heat ○ High power consumption ○ Metals can short out electrodes
Soil flushing	○ Can be used for VOCs, SVOCs, fuels, inorganics, and radioactive contaminants ○ Can be considered for use in the tank farm areas for localized contamination from piping or the diversion boxes or from the tanks at depth ○ Usually laboratory and field treatability studies need to be conducted to determine site-specific use ○ Low permeability soils are difficult to treat ○ Contaminants can be washed beyond capture zone ○ Heterogeneous aspects of vadose zone may make contact with flushing agent difficult or impossible ○ Need to recover all of flushing agent and flushed contaminants ○ Treatment of recovered fluids is required
Soil vapor extraction	○ Can be used for VOCs and some fuels, therefore, this technology would have limited application in tank farm areas ○ Has been used in depths from 5 to 300 ft ○ May be used with groundwater depression pumps to reduce ground water upwelling induced by the vacuum • Soil with high organic content or extremely dry has high sorption capacity for VOCs, which may reduce removal rates • Soil that has low permeability or has >50 % moisture has a reduced permeability to air, requiring higher vacuum • If off-gas treatment uses activated carbon, spent carbon requires regeneration, or disposal.

Table E-1. Soil Technologies Applicability/Capacities/Limitations. (8 Pages)

Technology	Applicability/Capacities/Limitations
Monitored natural attenuation	• Can be used for organics, inorganics including radionuclides • Destruction of contaminants may occur • Can be used with other technologies • Contaminants may migrate before they are degraded • Intermediate products may be more mobile and toxic than original contaminant • Limited future use of site until contaminant levels are reduced • May require long term monitoring and maintenance
Ex Situ Treatment Technologies	
Biodegradation	• Effective on organics (generally nonhalgenated VOCs and SVOCs, petroleum hydrocarbons), but not effective on radionuclides or inorganics and therefore would have limited application in the tank farm areas • This ex situ technology is limited to the removal techniques that can be used in the tank farm areas as discussed in this table under Removal Technologies ○ Materials handling required for soil excavation, treatment, transport, and placement at final destination ○ Some contaminants (e.g., heavy metals, long-chain hydrocarbons, and inorganic salts) may be toxic to micro-organisms ○ Addition of nutrients and oxygen (aerobic conditions) can be controlled better than in, in situ treatment. Hanford Site soil is known to lack nutrients such as nitrogen and phosphorous ○ Need odor control ○ Can require large amount of space
Soil washing	○ Can be used for SVOCs, fuels, and inorganic including radiological contaminants ○ This ex situ technology is limited to the removal techniques that can be used in the tank farm areas as discussed in this table under Removal Technologies ○ Materials handling required for soil excavation, treatment, transport, and placement at final destination ○ Can be used in combination with other technologies (i.e., bioremedation or incineration) ○ Complex contaminants make formulating washing agent difficult ○ Aqueous stream from the process will require treatment ○ No long term monitoring or maintenance of the site

Table E-1. Soil Technologies Applicability/Capacities/Limitations. (8 Pages)

Technology	Applicability/Capacities/Limitations
Solidification/stabilization	• Can be used for inorganics including radionuclides. Depending reagents used can be used for organics • This ex situ technology is limited to the removal techniques that can be used in the tank farm areas as discussed in this table under Removal Technologies • Materials handling required for soil excavation, treatment, transport, and placement at final destination • Different binding reagents are used for different contaminants • Environmental conditions may affect long term immobilization of contaminants • Could be an increase in the volume • Some contaminants may be incompatible with the process, requiring treatability studies
Thermal desorption	• Can be used for VOCs and SVOCs, therefore, its application in the tank farm area is limited • This ex situ technology is limited to the removal techniques that can be used in the tank farm areas as discussed in this table under Removal Technologies • Materials handling required for soil excavation, treatment, transport, and placement at final destination • Treatment of off-gases may be required • Spent activated carbon will required further treatment.
Encapsulation	• Can be used all waste groups • This ex situ technology is limited to the removal techniques that can be used in the tank farm areas as discussed in this table under Removal Technologies • Materials handling required for soil excavation, treatment, transport, and placement at final destination • Worker exposure may be a concern • Wastes are not destroyed • Potential for the container to lose its integrity over time due to burial conditions or compaction and stress loading, temperature cycles, internal pressures from contaminants, and chemical attack

1

Table E-2. Groundwater Technologies Applicability/Capacities/Limitations. (3 Pages)

Technology	Applicability/Capacities/Limitations
Hydraulic Containment	
Hydraulic containment	• Can be used to control the movement of or remove organics, inorganics including radionuclides (i.e., chromium, strontium-90 uranium, and techneticum-99) • Contaminants removed, but requires monitoring to demonstrate efficiency ○ Requires the use of other technologies to treat or destroy the contaminants • Can be used with barriers to remove contaminants ○ Incorrect groundwater modeling may increase mobility of the contaminant(s)
Impermeable Barriers	
Slurry walls and soil mixed walls	○ Does not target specific contaminants, can be used for any contaminants ○ Does not destroy or remove contaminants, retards contaminants flux ○ Contaminants can degrade the slurry wall • Use with other technologies to remove and destroy contaminants • High concentrations of contaminants can affect the stability of the grout matrix ○ Slurry walls are typically placed at depths of 50 ft or more and are generally 2- to 4-ft thick. • Limitations in determining consistency, dimensions and continuity of the barrier and heterogeneous soils can cause gaps or thinness in the wall • If not properly "keyed" into impermeable material there could be leakage under the wall
Sheet-pile barrier	○ Does not target specific contaminants, can be used for any contaminants ○ Does not destroy or remove contaminants, retards contaminants flux • Contaminants can degrade the sheet pile • Depth limitations usually 50 to 60 ft • Geology can cause problems (i.e., boulders or cobbles can damage sheet-pile) • Use with other technologies to remove and destroy contaminants

Table E-2. Groundwater Technologies Applicability/Capacities/Limitations. (3 Pages)

Technology	Applicability/Capacities/Limitations
Cryogenic barrier	○ Can be used for inorganics, metallic, and radioactive contaminants ○ Does not destroy or remove contaminants, retards contaminants flux ○ Use with other technologies to remove and destroy contaminants
In Situ Treatment Technologies	
Adsorption-type treatment barrier	○ Can be use for heavy metals and strontium-90. ○ Limited to excavation techniques and depths ○ Beds become plugged or fully loaded and need replacement (need to be excavated and replaced)
Phosphate precipitation barrier	○ Can be used for heavy metals (i.e., strontium-90) ○ Limited to excavation techniques and depths ○ This technology is in development stage
Soil flushing	○ Can be used for VOCs, SVOCs, fuels, inorganics, and radioactive contaminants ○ Usually laboratory and field treatability studies need to be conducted to determine site-specific use ○ Considered innovate technology for groundwater application ○ May require large volumes of flushing chemicals ○ Flushing chemicals and flushed contaminants need to be captured and treated ○ Heterogeneous aspects of saturated zone may make contact with flushing fluid agent difficult or impossible
Monitored natural attenuation	○ Can be used for organics, inorganics including radionuclides ○ Destruction of contaminants may occur ○ Can be used with other technologies ○ Contaminants may migrate before they are degraded ○ Intermediate products may be more mobile and toxic than original contaminant ○ Limited future use of site until contaminant levels are reduced ○ May require long-term monitoring and maintenance.
Ex Situ Treatment Technologies	
Precipitation technology	○ Can be used to remove metals and radionuclides from groundwater ○ May require additional treatment processes (i.e., sedimentation or filtration)

Table E-2. Groundwater Technologies Applicability/Capacities/Limitations. (3 Pages)

Technology	Applicability/Capacities/Limitations
	• Requires contaminant be removed from the subsurface for treatment to be effective ○ Multiple metals in the groundwater may result in removal difficulties ○ Further treatment may be required for discharge of treated groundwater ○ Land disposal restrictions may apply to sludges generated from this process ○ Proper disposal of waste generated from the process is required ○ Process can be costly depending on reagents that need to be added to the process
Membrane technology	○ Can be used for radionuclides (i.e., strontium-90) ○ Technology in developmental stages
Ion-exchange technology	○ Can be used for dissolved metals, radionuclides (i.e., strontium-90, technetium-99), and nitrates ○ Resins can be regenerated for reuse ○ Oil and grease may clog resins ○ Suspended solids may cause resin blinding ○ Wastewater generated during the regeneration cycle will require treatment and disposal
Wet air oxidation	○ Can be used for chlorinated organics, therefore this technology has limited application in the tank farm area ○ If catalyst is used, metals may poison the catalyst.
Activated carbon	○ Can be used for organic hydrocarbons and some inorganics; therefore, this technology may have limited application in the tank farm area ○ Can be used for either the liquid phase or vapor phase ○ Spent activated carbon requires regeneration or disposal ○ Metals can foul the carbon
Tritium treatment Technologies	• Used specifically for tritium (in the commercial nuclear power operation) ○ Most successful treatment is gaseous phase applications.

APPENDIX F

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

ACRONYMS

ARAR	applicable or relevant and appropriate requirement
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
EPA	U.S. Environmental Protection Agency
RCAP	RCRA Corrective Action Program
RCRA	*Resource Conservation and Recovery Act of 1976*
SST	single-shell tank
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
WMA	waste management area

F1.0 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

This appendix supplements the discussion provided in Section 2.0, "Regulatory Framework," and identifies and evaluates potential applicable or relevant and appropriate requirements (ARARs) for characterization and corrective action activities at the single-shell tanks (SSTs). It is intended to capture the major ARARs for all reasonably conceivable activities, but at a more generic level of detail than will occur in the future at the waste management area (WMA)-specific level. Future WMA addenda will use this information to further refine ARARs that are pertinent to the corrective action alternatives under consideration at the SSTs.

In accordance with Section 121(d) of the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA), remedial actions undertaken at the Hanford Site must comply with ARARs. Section 7.5 of the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1990) specifies that ARARs, as appropriate, will also apply to *Resource Conservation and Recovery Act of 1976* (RCRA) correction action activities. Thus, the requirement to identify and comply with ARARs applies to the SST RCRA Corrective Action Program (RCAP). Section 7.5 of the Tri-Party Agreement also provides a list of key state statutes and regulations from which ARARs must be developed. The Tri-Party Agreement refers to the "CERCLA Compliance with Other Laws Manual" (EPA 1988, 1989) for Federal statutes, regulations, and "to-be-considered" criteria. This manual, the Tri-Party Agreement, and the DOE orders and regulations were considered in developing the potential ARARs for the RCAP. The ARARs will be evaluated in a Corrective Measures Study and final ARARs for interim corrective measures, if required, will be documented via an approved Permit modification.

As discussed in Section 2.3 of the master work plan, potential ARARs are classified into chemical-specific, location-specific, and action-specific categories. To-be-considered information, although not legally binding, is considered in some circumstances along with ARARs to determine the corrective action necessary for protection of human health and the environment. The EPA may waive ARARs and select a corrective action that does not attain the same level of cleanup as identified by the ARARs in certain situations.

Potential Federal and state ARARs are presented in Tables F-1 and F-2, respectively. Detailed evaluation and possible modification to these potential ARARs will occur during the corrective measures study.

F2.0 REFERENCES

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), 42 U.S.C. 9601, et seq.

Ecology, EPA, and DOE, 1990, *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement), 2 vols., as amended (89-10 Rev. 5, December 1998), Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

EPA, 1988, *CERCLA Compliance with Other Laws Manual, Interim Final,* EPA/540/G-89/006, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, D.C.

EPA, 1989, *CERCLA Compliance with Other Laws Manual: Part II, Clean Air Act and Other Environmental Statutes and State Requirements,* EPA/540/G-89/009, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, D.C.

Resource Conservation and Recovery Act of 1976 (RCRA), 42 U.S.C. 6901, et seq.

Table F-1. Identification of Potential Federal ARARs and TBCs for the RCRA Corrective Action Program. (6 pages)

ARAR Citation	Applicable, Relevant and Appropriate, or To Be Considered	Requirement	Rationale for Use
CHEMICAL-SPECIFIC			
Safe Drinking Water Act of 1974, 42 USC 300, et seq.			
National Primary Drinking Water Regulations, 40 CFR 141	ARAR	Establishes maximum contaminant levels (MCLs) and maximum contaminant level goals (MCLGs) that are drinking water criteria designed to protect human health from the potential adverse effects of contaminants in drinking water.	Potential media cleanup standards for groundwater protection. Groundwater in the 200 Areas is not currently used for drinking water, but it meets the technical criteria of a potential drinking water source and could be used in the future if the site is released from institutional controls. In addition, groundwater in the 200 Areas is hydraulically connected to groundwater that is used for drinking water and to the Columbia River.
National Secondary Drinking Water Standards, 40 CFR 143	ARAR	Establishes secondary drinking water standards for use in establishing cleanup levels.	Potential media cleanup standards for groundwater protection. Federal secondary standards are not enforceable standards and are not typically ARARs; however, the State of Washington Model Toxics Control Act requires that these standards be considered in establishing cleanup levels protective of groundwater.
Clean Water Act of 1977, 33 USC 1251, as amended			
Designation of Hazardous Substances, 40 CFR 116	ARAR	Designates hazardous substances in Tables 116.4A and 116.4B of the regulation. These are included in the CERCLA list of hazardous substances.	Hazardous substances are present in the SST WMAs. The requirements for reporting are applicable to new releases that occur during the interim corrective action.
Atomic Energy Act of 1954, as amended, 42 USC 2011, et seq.			
Environmental Radiation Protection Standards for Nuclear Power Operations, 40 CFR 190	ARAR	Specifies protective levels for normal operations of the uranium fuel cycle. The standard requires dose equivalents to the public from facility operations not to exceed 25 mrem/yr to whole body, 75 mrem/yr to thyroid, or 25 mrem/yr to any other organ.	These standards are not applicable because the RCAP will not involve operation of a uranium fuel cycle. However, they are relevant and appropriate because they address the acceptable dose to the public and may thus serve as media cleanup standards.
Environmental Radiation Protection Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Waste, 40 CFR 191	ARAR	Establishes protective levels for management, storage, and disposal of spent nuclear fuel, high-level waste, and transuranic wastes at disposal facilities operated by the DOE. Subpart A establishes public dose limits that are not to exceed 25 mrem/yr to whole body and 75 mrem/yr any critical organ for management and storage of spent nuclear fuel, high-level waste, and transuranic waste at facilities that will dispose of such waste.	These standards are not applicable because the RCAP will not involve operation of a disposal facility (although wastes may be generated and transferred to an approved disposal facility). However, the standards are potentially relevant and appropriate because they address acceptable dose to the public and may thus serve as media cleanup standards.

Table F-1. Identification of Potential Federal ARARs and TBCs for the RCRA Corrective Action Program. (6 pages)

ARAR Citation	Applicable, Relevant and Appropriate, or To Be Considered	Requirement	Rationale for Use
Nuclear Regulatory Standards for Protection Against Radiation, 10 CFR 20	ARAR	Establishes standards for protection of the public against radiation arising from the use of regulated materials. Limits external and internal exposure from releases to levels that do not exceed 100 mrem/yr, or 2 mrem/hr from external exposure in unrestricted areas. Also establishes criteria for closing NRC-licensed sites, including a soil remediation standard of 25 mrem/yr.	These standards are not applicable because the Hanford Site is not a NRC-licensed facility. However, they are relevant and appropriate because they establish standards for protection of the public against radiation arising from the use of regulated materials and soil cleanup standards that may serve as media cleanup standards.
DOE Order 5400.5, Radiation Protection of the Public and the Environment, and 10 CFR 834 (Proposed Rule)	To be considered	Establishes standards for DOE operations with respect to protection of the public and the environment against undue risk to radiation. Limits the annual effective dose equivalent to 100 mrem from all exposure pathways, except under specified circumstances and the annual effective dose equivalent from drinking water supplies operated by DOE to 4 mrem. Where residual radioactive materials remain, the proposed rule states that various disposal modes should address impacts beyond the 1,000-year time period and identifies derived concentration guide (DCG) reference values.	Pertinent for establishing appropriate media cleanup levels because the RCAP addresses radiological contaminants. The DCG reference values should be used for estimating potential dose and determining compliance with the requirements of the proposed rule.
EPA Memorandum, "Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination," OSWER No. 9200.4-18	To be considered	Provides guidance on radioactive cleanup levels at CERCLA sites. States that soil remediation standard established by the NRC in 10 CFR 20 (25 mrem/yr) is generally not sufficient to meet CERCLA requirements but that a cleanup level of 15 mrem/yr is consistent with the CERCLA acceptable risk range of 10^{-4} to 10^{-6}.	This cleanup level identified in this memorandum, although a TBC, is considered by EPA to be more protective than NRC standards and will be considered in setting media cleanup standards for the RCAP.
Resource Conservation and Recovery Act, 42 USC 6901, et seq.			
Ground Water Protection Standards, 40 CFR 264.92	ARAR	Identifies three groundwater protection levels: background, MCLs, and ACLs. MCLs are set at the same levels as SDWA MCLs, and where no SDWA MCL has been set or on a case-by-case basis, health-based ACLs may be established that are protective of human health and environment.	Groundwater restoration goals established by this section are relevant and appropriate to the establishment of media cleanup standards.
Corrective Action for Solid Waste Management Units, 40 CFR 264, Subpart S (proposed)	To be considered	Identifies chemical-specific soil cleanup levels that are protective of groundwater. Proposed standards are based on ensuring groundwater protected to MCLs where available.	Groundwater restoration goals established by this section should be considered in establishing soil media cleanup standards protective of groundwater. Because this is a proposed rule, it is to be considered at this time.
Land Disposal Restrictions, 40 CFR 268	ARAR	Establishes numerical criteria that must be met to allow land disposal of hazardous/dangerous wastes.	Some waste generated as part of the RCAP is likely to be designated as a dangerous waste and will be subject to the LDR standards prior to disposal.

Table F-1. Identification of Potential Federal ARARs and TBCs for the RCRA Corrective Action Program. (6 pages)

ARAR Citation	Applicable, Relevant and Appropriate, or To Be Considered	Requirement	Rationale for Use
Uranium Mill Tailings Radiation Control Act of 1978, 42 USC 2022			
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings, 40 CFR 192	ARAR	Subpart B sets groundwater protection requirements for concentrations of radium-226, radium-228, and gross alpha particle activity at EPA-established levels for drinking water, 5 pCi/L for radium-226 and radium-228 and 15 pCi/L for gross alpha activity excluding radon and uranium. Concentration limits for radium-226 in soils for land cleanup actions are set at 5 pCi/g averaged over the upper 15 cm (6 in.) and 15 pCi/g averaged over any 15-cm- (6-in.) thick layer more than 15 cm (6 in.) from the surface. The level of gamma radiation in any occupiable building is not to exceed 20 microroentgens/hr above background.	Requirements of this act are relevant and appropriate in setting media cleanup standards for the RCAP because radium-226 is a SST contaminant. The standard is not applicable because the SSTs are not milling sites for uranium or thorium.
Toxic Substances Control Act (TSCA), 15 USC 2601 et seq.			
Regulation of PCBs, 40 CFR 761	ARAR	These requirements identify soil remediation standards for sites contaminated with PCBs where the original source contained PCBs at concentrations greater than 50 ppm.	These requirements are applicable in setting PCB media cleanup standards for the RCAP if it is determined that the waste in the SSTs or any waste generated as part of the RCAP is TSCA-regulated.
LOCATION-SPECIFIC			
National Historic Preservation Act of 1966, 16 USC 470	ARAR	This act requires that historically significant properties be protected. The act requires that agencies undertaking projects must evaluate impacts to properties listed on or eligible for inclusion on the National Register of Historic Places. The National Register of Historic Places is a list of sites, buildings, or other resources identified as significant to United States history. An eligibility determination provides a site the same level of protection as a site listed on the National Register of Historic Places.	None of the SSTs have been determined to be eligible for the National Register. However, this law is applicable if buildings/structures that are eligible for the National Register will be affected by RCAP activities.
Archeological and Historic Preservation Act, 16 USC 469a	ARAR	This act requires that actions conducted at the site must not cause the loss of any archeological and historic data. This act mandates preservation of the data and does not require protection of the actual facility. Where a site is determined to be eligible for the National Register and mitigation is unavailable, artifacts and data will be recovered and preserved prior to commencement of the action.	Archeological and historic sites have been identified within the 200 Areas, and therefore these requirements are applicable to actions that might disturb these sites. However, since the area around the SST WMAs has been highly disturbed in the past, it is unlikely that any cultural resources will be affected by RCAP activities.
American Indian Religious Freedom Act of 1978, 42 USC 1996	ARAR	Provides for access by Native Americans to religious sites and development of migration measures if actions will deny such access. Requires agency to consult with traditional religious leaders regarding activities that might affect religious sites.	The Act is applicable where RCAP activities threaten Native American religious sites. However, there are no known religious sites in the area where the RCAP activities would occur.

Table F-1. Identification of Potential Federal ARARs and TBCs for the RCRA Corrective Action Program. (6 pages)

ARAR Citation	Applicable, Relevant and Appropriate, or To Be Considered	Requirement	Rationale for Use
Native American Graves Protection and Repatriation Act of 1990, 25 USC 3001-3013 Public Law 101-601 (1993)	ARAR	Requires action by the Federal agency when Native American human remains and associated funerary objects are inadvertently discovered during excavation. Requires work stoppage, protection of items and notification to appropriate Indian tribes.	The Act is applicable if Native American human remains or burial objects are discovered where RCAP activities are being conducted, however, the area around the SST WMAs has been highly disturbed in the past and it is unlikely that human remains or objects would be found.
Endangered Species Act of 1973, 16 USC 1531, et seq.	ARAR	This act prohibits Federal agencies from jeopardizing threatened or endangered species or adversely modifying habitats essential to their survival. If waste site remediation is within sensitive habitat or buffer zones surrounding threatened or endangered species, mitigation measures must be taken to protect this resource.	The Endangered Species Act of 1973 is applicable if threatened or endangered species are identified in areas where RCAP activities will occur. Their presence could dictate the approach to the corrective actions that may be necessary.
ACTION-SPECIFIC			
Resource Conservation and Recovery Act, as amended, 42 USC 6901			
Guidelines for Land Disposal of Solid Waste, 40 CFR 241	ARAR	Establishes requirements for handling and disposal of solid waste. Included in these requirements are design and closure/post-closure standards for cover systems.	These requirements are applicable if solid waste is generated during the RCAP.
Land Disposal Restrictions, 40 CFR 268	ARAR	These requirements prohibit the placement of restricted RCRA hazardous wastes in land-based units such as landfills, surface impoundments, and waste piles until treated to standards considered protective for disposal. Specific treatment standards are included in the requirements.	These requirements are applicable because restricted waste (dangerous waste) is likely to be generated during the RCAP.
Federal Water Pollution Control Act as amended by the Clean Water Act of 1988, 33 USC 1251			
NPDES Criteria and Standards, 40 CFR 125.104	ARAR	These standards require that a best management practices program be developed in accordance with good engineering practices.	These standards are applicable if the RCAP activities include wastewater discharge. It also applies to storm water runoff associated with industrial activities.
Clean Air Act of 1977, as amended 42 USC 7401, et seq.			
National Ambient Air Quality Standards, 40 CFR 50	ARAR	Requirements of these regulations are applicable to airborne releases of criteria pollutants specified under the statute. Specific release limits for particulates are set at 50 $\mu g/m^3$ annually or 150 $\mu g/m^3$ per 24-hour period.	Applicable to airborne releases of criteria pollutants that may be generated during RCAP activities.
Ambient Air Quality Monitoring, 40 CFR 58	ARAR	This regulation presents the criteria and requirements for ambient air quality monitoring and reporting for local air pollution control agencies and operators of new sources of air pollutants.	Not applicable to SST WMA because the RCAP activities do not meet the regulatory definition of a new source. However, these requirements may be considered relevant and appropriate to RCAP activities that have the potential to emit air contaminants.

Table F-1. Identification of Potential Federal ARARs and TBCs for the RCRA Corrective Action Program. (6 pages)

ARAR Citation	Applicable, Relevant and Appropriate, or To Be Considered	Requirement	Rationale for Use
Standards of Performance for New Stationary Sources, 40 CFR 60	ARAR	These requirements provide standards for new stationary sources or modifications of existing sources.	The RCAP may include modification of existing stationary sources for which these requirements would be applicable.
National Emission Standards for Hazardous Air Pollutants (NESHAP), 40 CFR 61	ARAR	Establishes emission standards for hazardous air pollutants including radionuclides, other than radon, and asbestos. Subpart H sets radioactive emission limits from the entire facility to ambient air that are not to cause any member of the public to receive an effective dose equivalent of 10 mrem/yr. The definition of facility includes all buildings, structures, and operations at one contiguous site.	These requirements are applicable because of the potential to release radioactive contaminants to the air during RCAP activities.
Atomic Energy Act of 1954, as amended, 42 USC 2011, et seq.			
Licensing Requirements for the Land Disposal of Radioactive Waste, 10 CFR 61	ARAR	Requires that NRC-licensed disposal systems be designed to limit the annual dose equivalent beyond the facility boundary below 25 mrem to the whole body, 75 mrem to the thyroid, or 25 mrem to any other organ are relevant and appropriate to remedial actions that include land disposal or release radioactive effluent. Inadvertent intruder requirements for land disposal units are also contained in this regulation.	The regulation is not applicable because Hanford is not a NRC-licensed facility and waste is not being received from other persons. However, it is relevant and appropriate if radioactive waste will be left in place following the RCAP. Requirements to protect inadvertent intruders may also be relevant and appropriate to actions implemented at the site.
Environmental Radiation Protection Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level, and Transuranic Radioactive Wastes, 40 CFR 191	ARAR	These requirements state that radionuclide release to the environment for a period of 10,000 years after disposal shall have a likelihood of less than one chance in ten of exceeding the level specified in Appendix A, Table 1 of the regulation, or a likelihood of less than one in 1,000 chance of exceeding 10 times the limit specified in Appendix A, Table 1.	These requirements are not directly applicable because the RCAP does not involve operation of a disposal facility. However, transuranic wastes may be generated during the RCAP and will require offsite disposal in accordance with this regulation.
Department of Energy Occupational Radiation Protection, 10 CFR 835	ARAR	These requirements set occupational dose limits for adults. Total effective dose equivalent must not exceed 5 rem/yr.	Standards for occupational dose limits are applicable to the RCAP because workers are likely to be exposed to radiation.
Radioactive Waste Management, DOE Order 5820.2A and DOE Order 435.1	To be considered	These guidelines establish radioactive waste management requirements. DOE Order 5820.2A sets performance objectives to limit the annual effective dose equivalent beyond the facility boundary to 25 mrem. Disposal methods selected must be sufficient to limit the annual effective dose equivalent to 100 mrem for continuous exposure or 500 mrem for acute exposures when active institutional controls are removed.	Although these standards are not promulgated regulations, they must be considered because compliance with DOE orders is required at the Hanford Site. The materials are pertinent because radiological waste is likely to be generated by RCAP activities. DOE Order 435.1 became effective July 9, 1999, however, it is not yet contractually binding. DOE Order 5820.2A will likely be replaced with DOE Order 435.1 in the near future.

Table F-1. Identification of Potential Federal ARARs and TBCs for the RCRA Corrective Action Program. (6 pages)

ARAR Citation	Applicable, Relevant and Appropriate, or To Be Considered	Requirement	Rationale for Use
Hazardous Materials Transportation Act, 49 USC 1801, et seq.			
Hazardous Materials Regulation, 49 CFR 171	ARAR	These requirements state that no person may offer to accept hazardous material for transportation in commerce unless the material is properly classed, described, packaged, marked, labeled, and in condition for shipment.	These requirements are applicable to hazardous material generated during the RCAP that would be sent offsite for disposal.
Hazardous Materials Tables, Hazardous Materials Communications Requirements, and Emergency Response Information Requirements, 49 CFR 172	ARAR	Tables are used to identify requirements for labeling, packaging, and transportation based on categories of waste types. Small quantities of radioactive wastes are not subject to the requirements of the standard if activity levels are below limits established in paragraph 173.421, 173.422, or 173.424. Specific performance requirements are established for packages used for shipping and transport of hazardous materials.	These requirements are applicable if hazardous waste is generated during the RCAP and is transported offsite. In the event of a discharge of hazardous waste during transportation from the SST WMA to the disposal facility, this section is applicable.
Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations	ARAR	Requires agencies to identify and address disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations. The agencies must ensure that such programs, policies, and activities do not have the effect of excluding persons (including populations) from participation in, denying persons (including populations) the benefits of, or subjecting persons (including populations) to discrimination under, such programs, policies, and activities because of their race, color, or national origin.	Applicable to RCAP activities (including significant employment opportunities) that may have a disproportionately high and adverse impact on minority or low-income populations.
DOE 1996b, "Guidance for a Composite Analysis of the Impact of Interacting Source Terms on the Radiological Protection of the Public from Department of Energy Low-Level Waste Disposal Facilities"	To be considered	The Composite Analysis provides an estimate of the cumulative radiological impacts from active and planned low-level radioactive waste disposal actions and other potentially interacting radioactive waste disposal sources that will remain following Hanford Site closure.	This TBC guidance from DOE is pertinent to the SST WMA RCAP if radiological contaminants will be left in place.

ACL = alternate concentration level
ALARA = as low as reasonably achievable
CAMU = corrective action management unit
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act*
CFR = *Code of Federal Regulations*
DCG = derived concentration guide
DOE = U.S. Department of Energy
EPA = U.S. Environmental Protection Agency
HCRL = Hanford Cultural Resources Laboratory
MCL = maximum contaminant level
NESHAP = National Emission Standards for Hazardous Air Pollutants
NCP = National Oil and Hazardous Substance Contingency Plan
NEPA = *National Environmental Policy Act*
NPDES = National Pollutant Discharge Elimination System
NRC = U.S. Nuclear Regulatory Commission
PCB = polychlorinated biphenyl
RCAP = RCRA Corrective Action Program
RCRA = *Resource Conservation and Recovery Act*
SDWA = *Safe Drinking Water Act*
SST = single-shell tank
TBC = to be considered
TSCA = *Toxic Substances Control Act*
WMA = waste management area

Table F-2. Identification of Potential State ARARs and TBCs for the RCRA Corrective Action Program. (7 pages)

ARAR Citation	Applicable, Relevant and Appropriate, To Be Considered	Requirement	Rationale for Use
CHEMICAL-SPECIFIC			
Hazardous Waste Clean Up/Model Toxics Control Act, Ch. 70.105D RCW			
Model Toxics Control Act, WAC 173-340	ARAR	This act identifies the methods used to develop cleanup standards and their use in selection of a cleanup action. Cleanup levels are based on protection of human health and the environment, the location of the site, and other regulations that apply to the site. The standard specifies cleanup goals that implement the strictest Federal or state cleanup criteria. In addition, MTCA uses three basic methods for establishing cleanup levels; these methods may be used to identify cleanup standards for groundwater, surface water, soils, and protection of air quality.	The MTCA methods for establishing cleanup levels are relevant and appropriate to establishing media cleanup standards for nonradioactive contaminants addressed during the RCAP.
Dangerous Waste Regulations, Ch. 70.105 RCW			
Dangerous Waste Regulations, WAC 173-303			
Designation of Waste, WAC 173-303-070 through 110	ARAR	Establishes numerical criteria for determining if solid waste requires management as dangerous waste.	The requirements of this section are applicable because dangerous waste might be generated during characterization and corrective actions associated with the RCAP.
Releases from Regulated Units, WAC 173-303-645	ARAR	Establishes action levels for releases to groundwater from dangerous waste final status regulated units.	The standard is applicable because, although the SSTs are tank systems (not regulated units), the Tri-Party Agreement requires that the SSTs be monitored in accordance with –645. The action levels serve as the trigger for this RCAP.
Water Pollution Control/Water Resource Act of 1971, Ch. 90.48 RCW/Ch. 90.54 RCW			
Surface Water Quality Standards, WAC 173-201A	ARAR	These standards set water quality standards at levels protective of aquatic life.	Groundwater below the SST WMAs migrates and discharges to the Columbia River; therefore, surface water quality criteria established under this chapter must be taken under consideration when developing media cleanup standards for soil and groundwater associated with the RCAP.

Table F-2. Identification of Potential State ARARs and TBCs for the RCRA Corrective Action Program. (7 pages)

ARAR Citation	Applicable, Relevant and Appropriate, To Be Considered	Requirement	Rationale for Use
Department of Health Standards for Public Water Supplies, WAC 246-290	ARAR	The rule established under WAC 246-290 defines the regulatory requirements necessary to protect consumers using public drinking water supplies. The rules are intended to conform with the Federal SDWA, as amended. WAC 246-290-310 establishes MCLs that define the water quality requirements for public water supplies. WAC 246-290-310 establishes both primary and secondary MCLs and identifies that enforcement of the primary standards is the Department of Health's first priority.	The requirements of WAC 246-290-310 are relevant and appropriate to the SST WMA RCAP because groundwater is technically classified as a potential future source of drinking water.
State Radiation Protection Requirements, Ch. 70.98 RCW			
Radiation Protection Standards, WAC 246-221	ARAR	Establishes radiation protection requirements for the state. Establishes annual average concentration limits for radioactive releases in gaseous and liquid effluent released to unrestricted areas. Sets occupational and public dose limits. that individual members of the	This regulation is not applicable because it does not apply to Federal agencies under the Atomic Energy Act (AEA). However, it is considered relevant and appropriate because it establishes standards for acceptable levels of exposure to radiation and may support development of media cleanup standards.
Radiation Protection at Uranium and Thorium Milling Operations, WAC 246-252	ARAR	Radium-226 concentrations are required to be less than 5 pCi/g averaged over the upper 15 cm and not more than 15 pCi/g averaged over any 15-cm interval deeper than 15 cm from the surface. Groundwater protection standards established for gross alpha excluding radon and uranium are set at 15 pCi/L, and for combined radium-226 and radium-228 not to exceed 5 pCi/L.	This regulation is not applicable because the RCAP does not involve uranium or thorium milling operations; however, the regulation is relevant and appropriate because it contains specific soil cleanup limits for radium-226 and radium-228 and groundwater protection limits.
LOCATION-SPECIFIC			
Department of Game Procedures, WAC 232-012	ARAR	This standard defines the requirements that the Department of Game must take to protect endangered or threatened wildlife.	These requirements may be applicable if endangered or threatened wildlife are identified in the 200 Areas during wildlife surveys. The requirements of this chapter will be reevaluated should protected wildlife species be identified within the 200 Areas.
National Area Preserves, RCW 79.70			
Washington Natural Heritage Program	To be considered	The Washington State Natural Heritage Program serves as an advisory council to the Washington State Department of Natural Resources, Fish and Wildlife, the Parks and Recreation Commission, and other state agencies managing state-owned land or natural resources. The list of state endangered, threatened, and sensitive plants developed by the program, along with program-recommended levels of protection, are to be used to assist resource managers in determining which species of concern occur in their areas and	The requirements of the Natural Heritage Program are TBC guidance for the RCAP. However, no state-listed threatened or endangered plant species have been identified in the 200 Areas and at present, there are no state-owned lands or natural resources in the 200 Areas.

Table F-2. Identification of Potential State ARARs and TBCs for the RCRA Corrective Action Program. (7 pages)

ARAR Citation	Applicable, Relevant and Appropriate, To Be Considered	Requirement	Rationale for Use
		recommend protection. The designations provided to plants by the Washington State Natural Heritage Program are advisory and do not specify a regulatory level of protection.	
ACTION-SPECIFIC			
Hazardous Waste Cleanup-Model Toxics Control Act, Ch. 70.105D RCW			
Model Toxics Control Act Cleanup Regulations, WAC 173-340	ARAR	Establishes a process for cleanup of contaminated sites in the state. Specifies that all cleanup actions be protective of human health, comply with all applicable state and Federal regulations, and provide for compliance monitoring.	These requirements are relevant and appropriate to nonradioactive contaminants because the RCAP involves cleanup of waste sites.
Hazardous Waste Management Act, 70.105 RCW			
Dangerous Waste Regulations, WAC 173-303	ARAR	Establishes the requirements for generation, storage, treatment, and disposal of dangerous waste.	These requirements are applicable because dangerous waste is likely to be generated during the RCAP. All sections of this chapter may be applicable. Key sections are highlighted below.
Land Disposal Restrictions, WAC 173-303-140	ARAR	Identifies dangerous wastes that are restricted from land disposal, describes requirements for state-only restricted wastes, and defines the circumstances under which a prohibited waste may be disposed.	Applicable to the disposal of dangerous waste generated during SST WMA characterization and corrective actions.
Spills and Discharges into the Environment, WAC 173-303-145	ARAR	Sets forth the requirements that apply when any dangerous waste or hazardous substance is intentionally or accidentally spilled or discharged into the environment such that human health and the environment are threatened, regardless of the quantity of dangerous waste or hazardous substance.	Applicable should dangerous waste or hazardous substances be spilled or discharged into the environment.
Requirements for Generators of Dangerous Waste, WAC 173-303-170 through 230	ARAR	Specifies requirements for specific levels of training, emergency preparedness, and record keeping.	Applicable to actions performed at the site if dangerous waste is generated. Generation of dangerous waste through RCAP activities is expected.
General Requirements for Dangerous Waste Management Facilities, WAC 173-303-280 through 395	ARAR	General requirements include siting standards and procedures for permitting, training, emergency preparedness, security, inspections, contingency planning, waste analysis, and management of containers.	Applicable to RCAP activities that include treatment, storage, or disposal of designated dangerous waste.

Table F-2. Identification of Potential State ARARs and TBCs for the RCRA Corrective Action Program. (7 pages)

ARAR Citation	Applicable, Relevant and Appropriate, To Be Considered	Requirement	Rationale for Use
Treatment, Storage, and Disposal Facility Requirements, WAC 173-303-600 through 695	ARAR	Specifies closure and postclosure standards (which require compliance with MTCA cleanup levels), groundwater monitoring requirements, corrective action management unit/temporary unit requirements, air emission standards for process vents and equipment leaks, and specific unit requirements for: containers, tanks, surface impoundments, land treatment units, waste piles, landfills, incinerators, drip pads, miscellaneous units, and containment buildings.	Applicable to facilities that receive dangerous waste generated from RCAP activities.
Solid Waste Management, Recovery, and Recycling Act, Ch. 70.95 RCW			
Minimum Functional Standards for Solid Waste Handling, WAC 173-304	ARAR	Establishes requirements to be met for the management of solid waste. Solid waste controlled by this Act includes garbage, industrial waste, construction waste, and ashes. Requirements for containerized storage, collection, transportation, treatment, and disposal of solid waste are included.	These regulations are applicable to onsite management and disposal of solid waste that may be generated during RCAP characterization or corrective action activities.
Water Well Construction, Ch. 18.104 RCW			
Minimum Standards for Construction and Maintenance of Water Wells, WAC 173-160	ARAR	Establishes minimum standards for design, construction, capping, and sealing of all wells; sets additional requirements, including disinfection of equipment, decommissioning of wells, and quality of drilling water.	These requirements are applicable to the RCAP if actions will include construction of wells that will be used for groundwater extraction, monitoring, or injection of treated groundwater or wastes.
Rules and Regulations Governing the Licensing of Well Contractors and Operators, WAC 173-162	ARAR	Establishes procedures for the examination, licensing and continuing education, and regulation of well contractors and operators.	This regulation is applicable to the RCAP if groundwater wells will be installed.
Water Pollution Control/Water Resources Act, Ch. 90.48 RCW/Ch. 90.54 RCW			
Protection of Upper Aquifer Zones, WAC 173-154	ARAR	Directs Ecology to provide for protection of upper aquifers and upper aquifer zones to avoid depletions, excessive water level declines, or reductions in water quality.	This regulation is not applicable to the RCAP because it establishes the policy and program for Ecology. However, the regulation is considered relevant and appropriate since protection of the aquifer from adverse impacts caused by waste management units is a primary goal.

Table F-2. Identification of Potential State ARARs and TBCs for the RCRA Corrective Action Program. (7 pages)

ARAR Citation	Applicable, Relevant and Appropriate, To Be Considered	Requirement	Rationale for Use
State Waste Discharge Program, WAC 173-216	ARAR	Implements a permit system applicable to industrial and commercial operations that discharge to the groundwater, surface waters, or municipal sewerage systems. Specific discharges prohibited under the program are identified. The intent of the law is to maintain the highest possible standards, and the law requires the use of all known available and reasonable methods to prevent and control the discharge of wastes into the waters of the state.	Requirements of this program are applicable to RCAP activities that include discharges to the ground (e.g., if groundwater extraction and treatment systems are employed).
Underground Injection Control Program, WAC 173-218	ARAR	Sets requirements for injection of effluents through wells that may endanger the groundwater of the state.	This regulation is applicable as the RCAP may involve the use of sampling or monitoring wells.
Washington Clean Air Act, Ch. 70.94 RCW and Ch. 43.21A RCW			
General Regulations for Air Pollution, WAC 173-400	ARAR	Requires that all sources of air contaminants meet emission standards for visible, particulate, fugitive, odors, and hazardous air emissions. This section requires that all emission units use reasonably available control technology, which may be determined for some source categories to be more stringent than the emission limitations listed in this chapter. The regulation requires that source testing and monitoring be performed. A new source would include any process or source that may increase emissions or ambient air concentration of any contaminant for which Federal or state ambient or emission standards have been established.	Requirements of this standard are applicable to RCAP activities that could result in the emission of hazardous air pollutants. Substantive standards established for the control and prevention of air pollution under this regulation are applicable to corrective actions that may be proposed at a site.
Air Operating Permit Program, WAC 173-401	ARAR	Establishes the Washington State air operating permit program consistent with the requirements of Title V of the Clean Air Act. A sitewide permit is required for the Hanford Site which addresses both radioactive and non-radioactive airborne emissions for all emission units that are above threshold limits. The permit establishes emission limits and conditions of operation restrictions for major sources.	The Air Operating Permit Program requirements are applicable because the Hanford Site is considered a major source. Therefore, any activities on the Hanford Site that cause a potential to emit are subject to the permit requirements. It is expected that the RCAP will involve activities causing a potential to emit.

Table F-2. Identification of Potential State ARARs and TBCs for the RCRA Corrective Action Program. (7 pages)

ARAR Citation	Applicable, Relevant and Appropriate, To Be Considered	Requirement	Rationale for Use
Controls for New Sources of Air Pollution, WAC 173-460	ARAR	Requires that new sources of air emissions provide emission estimates for toxic air contaminants listed in the regulation. The standard requires that emissions be quantified and used in risk modeling to evaluate ambient impacts and establish acceptable source impact levels. The standard establishes three major requirements for new sources of air pollutants: use of best available control technology, quantification of toxic emissions, and demonstration that human health is protected.	The standard is relevant and appropriate to RCAP activities because nonradioactive contaminants of concern are identified in the regulation as toxic air contaminants.
Ambient Air Quality Standards for Particulate Matter, WAC 173-470	ARAR	Sets maximum acceptable levels for particulate matter in the ambient air at 150 $\mu g/m^3$ over a 24-hour period, or 60 $\mu g/m^3$ annual geometric mean. It also sets the 24-hour ambient air concentration standard for particles less than 10 µm in diameter (PM_{10}), which are set at 105 $\mu g/m^3$ and 50 $\mu g/m^3$ geometric mean. The section defines standards for particle fallout not to exceed 10 g/m^2 per month in an industrial area or 5 g/m^2 per month in residential or commercial areas. Alternate levels for areas where natural dust levels exceed 3.5 g/m^2 per month are set at 6.5 g/m^2 per month, plus background levels for industrial areas, and 1.5 g/m^2 per month plus background in residential and commercial areas.	These requirements are applicable to RCAP activities that may emit particulate matter to the air.
Ambient Air Quality Standards and Emission Limits for Radionuclides, WAC 173-480	ARAR	Establishes that the most stringent Federal or state ambient air quality standard for radionuclides be enforced. The WAC 173-480 standard defines the maximum allowable level for radionuclides in the ambient air, which shall not cause a maximum accumulated dose equivalent of 25 mrem/yr to the whole body or 75 mrem/yr to any critical organ. However, ambient air standards under 40 CFR 61 Subparts H and I are not to exceed amounts that result in an effective dose equivalent of 10 mrem/yr to any member of the public. Emission standards for new and modified emission units shall utilize best available radionuclide control technology.	Requirements of this standard are relevant and appropriate to RCAP activities performed at the site that may emit radionuclides to the air.

Table F-2. Identification of Potential State ARARs and TBCs for the RCRA Corrective Action Program. (7 pages)

ARAR Citation	Applicable, Relevant and Appropriate, To Be Considered	Requirement	Rationale for Use
Emission Standards and Controls for Sources Emitting Volatile Organic Compounds (VOCs), WAC 173-490	ARAR	Establishes technically feasible and attainable standards for sources emitting VOCs.	This regulation is probably not applicable to RCAP activities because the source of potential VOC emissions generated by corrective actions most likely does not meet the definition of emission sources specified under WAC 173-490-03. However, this regulation may be considered relevant and appropriate if RCAP activities have the potential to emit VOCs into the air.
Radiation Protection - Air Emissions, WAC 246-247	ARAR	Establishes air emission limits for airborne radionuclide emissions as defined in WAC 173-480 and 40 CFR 61 Subparts H and I. The ambient air standards under WAC 173-480 require that the most stringent standard be enforced. Ambient air standards under 40 CFR 61, Subparts H and I, are not to exceed amounts that result in an effective dose equivalent of 10 mrem/yr to any member of the public. The ambient standard in WAC 173-480 specifies that emission of radionuclides to the air must not cause a dose equivalent of 25 mrem/yr to the whole body or 75 mrem/yr to any critical organ. These standards specify emission monitoring requirements and the application of best available radionuclide control technology (BARCT) requirements.	This regulation is applicable because there is a potential to emit radioactive airborne emissions through RCAP activities, which would need to be controlled using BARCT and monitored.
State Radiation Protection Requirements, Ch. 70.98 RCW			
Radioactive Waste-Licensing Land Disposal, WAC 246-250	ARAR	Establishes the procedures, criteria, and conditions for licensing of low-level radioactive waste land disposal facilities. This section presents specific levels of radiation protection and technical requirements for land disposal of radioactive waste.	These requirements are considered relevant and appropriate if the RCAP activities allow radioactive waste to remain on site.

BARCT = best available radionuclide control technology
CFR = *Code of Federal Regulations*
Ecology = Washington State Department of Ecology
MCL = maximum contaminant level
MTCA = *Model Toxics Control Act*
RCAP = RCRA Corrective Action Program
RCRA = *Resource Conservation and Recovery Act*
RCW = *Revised Code of Washington*
SEPA = *State Environmental Policy Act*
SDWA = *Safe Drinking Water Act*
SST = single-shell tank
TBC = to be considered
TSD = treatment, storage, and disposal
VOC = volatile organic compound
WAC = *Washington Administrative Code*
WMA = waste management area

APPENDIX G

DATA QUALITY OBJECTIVE TEMPLATES

DATA QUALITY OBJECTIVES CHECKLIST

The following pages contain the data quality objectives (DQO) checklist (pages G-1 through G-6) and workbook (pages G-7 through G-25).

PROJECT TITLE:

I	ASPECT: Project Scope	RESPONSIBLE PERSON:
ISSUES: Identify the questions and problems to be resolved through the DQO process. What is the focus of the project? What is/is not important for the resolution of the concerns that are the subject of this DQO?		
I(a)	COMPONENT: Project Assumptions	SOURCE:
SUMMARY:		

I(b)	COMPONENT: Project Goals	SOURCE:
SUMMARY:		

I(c)	COMPONENT: Principal Study Questions	SOURCE:
SUMMARY:		

I(d)	COMPONENT: Decision Statements	SOURCE:
SUMMARY:		

II	ASPECT: Site Knowledge	RESPONSIBLE PERSON:
ISSUES: Describe the processes/activities that took place at the site(s) under consideration. Which processes/activities are significant for the decisions required for this DQO?		
II(a)	COMPONENT: Process/Activity Description	SOURCE:
SUMMARY:		

II(b)	COMPONENT: Process History	SOURCE:
SUMMARY:		

II(c)	COMPONENT: Process Feed Materials	SOURCE:
SUMMARY:		

II(d)	COMPONENT: Process Data	SOURCE:
SUMMARY:		

II(e)	COMPONENT: Process Output Stream(s)	SOURCE:
SUMMARY:		

II(f)	COMPONENT: Site Maps, Diagrams, Drawings	SOURCE:
SUMMARY:		

II(g)	COMPONENT: Site Visits	SOURCE:
SUMMARY:		

II(h)	COMPONENT: Other	SOURCE:
SUMMARY:		

III	ASPECT: Historical Analytical Data	RESPONSIBLE PERSON:
ISSUES: What analytical data are available for the contaminants of concern at the site under consideration? Is the existing data suitable for decision making?		
III(a)	COMPONENT: Soils	SOURCE:
SUMMARY:		

III(b)	COMPONENT: Sediment/Debris	SOURCE:
SUMMARY:		

III(c)	COMPONENT: Air	SOURCE:
SUMMARY:		

III(d)	COMPONENT: Groundwater	SOURCE:
SUMMARY:		

III(e)	COMPONENT: Surface Water	SOURCE:
SUMMARY:		

III(f)	COMPONENT: Waste Materials	SOURCE:
SUMMARY:		

III(g)	COMPONENT: Radiological Data	SOURCE:
SUMMARY:		

III(h)	COMPONENT: Other	SOURCE:
SUMMARY:		

IV	ASPECT: Regulatory Drivers	RESPONSIBLE PERSON:
ISSUES: What regulations or other agreements establish the requirements for the project? Are there enforceable milestones, deadlines, or permit conditions that are relevant?		
IV(a)	COMPONENT: Key Agencies	SOURCE:
SUMMARY:		

IV(b)	COMPONENT: RCRA	SOURCE:
SUMMARY:		

IV(c)	COMPONENT: CERCLA	SOURCE:
SUMMARY:		

IV(d)	COMPONENT: CAA	SOURCE:
SUMMARY:		

IV(e)	COMPONENT: NPDES	SOURCE:
SUMMARY:		

IV(f)	COMPONENT: SDWA	SOURCE:
SUMMARY:		

IV(g)	COMPONENT: TSCA	SOURCE:
SUMMARY:		

IV(h)	COMPONENT: NEPA	SOURCE:
SUMMARY:		

IV(i)	COMPONENT: SEPA	SOURCE:
SUMMARY:		

IV(j)	COMPONENT: Compliance Order/Consent Agreement	SOURCE:
SUMMARY:		

IV(k)	COMPONENT: Waste Acceptance Criteria	SOURCE:
SUMMARY:		

IV(l)	COMPONENT: Milestones/Schedule	SOURCE:
SUMMARY:		

IV(m)	COMPONENT: Other	SOURCE:
SUMMARY:		

V	ASPECT: Operational Concerns	RESPONSIBLE PERSON:
ISSUES: Does the site present special considerations that affect data collection activities?		
V(a)	COMPONENT: Health and Safety	SOURCE:
SUMMARY:		

V(b)	COMPONENT: Cultural and Biological	SOURCE:
SUMMARY:		

V(c)	COMPONENT: Nuclear Criticality	SOURCE:
SUMMARY:		

V(d)	COMPONENT: Access/Equipment Limitations	SOURCE:
SUMMARY:		

V(e)	COMPONENT: Other	SOURCE:
SUMMARY:		

VI	ASPECT: COPCs	RESPONSIBLE PERSON:
ISSUES: Based on available information, what are the contaminants of potential concern (COPCs)? How were these derived? Are there regulatory limits (e.g., risk-based criteria or ARARs) associated with these COPCs? What are the appropriate sampling/analytical methods for evaluating their presence and concentrations?		
VI(a)	COMPONENT: Draft List of COPCs	SOURCE:
SUMMARY:		

VI(b)	COMPONENT: Regulatory Limits/Basis	SOURCE:
SUMMARY:		

VI(c)	COMPONENT: *Sampling Method(s)*	SOURCE:
SUMMARY:		

VI(d)	COMPONENT: Analytical Methods/Detection Limits	SOURCE:
SUMMARY:		

VII	ASPECT: Risk Scenarios/Exposure Pathways	RESPONSIBLE PERSON:
ISSUES: Evaluating potential exposures provides a primary basis for data collection. Are there existing studies that evaluate risk scenarios and/or exposure pathways? Are there fate/transport models and data available?		
VII(a)	COMPONENT: Conceptual Models	SOURCE:
SUMMARY:		

VII(b)	COMPONENT: Risk Assessment	SOURCE:
SUMMARY:		

VII(c)	COMPONENT: Fate and Transport	SOURCE:
SUMMARY:		

DATA QUALITY OBJECTIVES WORKBOOK

1.0 STEP 1 – STATE THE PROBLEM

The purpose of this DQO process is to support decision making activities as they pertain to the RCAP activities addressing *[Note: Add the name of the facility and/or facility]*. The objective of DQO Step 1 is to use the information gathered from the DQO scoping process, along with other relevant information to clearly and concisely state the problem to be resolved. The free-form text sections included in this step are intended to define the project objectives and assumptions, present the project issues, summarize the facility background information, and provide a concise statement of the problem. The tables provided in this section are designed to document the personnel involved in the DQO process, identify the contaminants of concern, and summarize the key information needed to support the writing of the problem statement.

1.1 PROJECT OBJECTIVES

NOTE ON COMPLETION OF SECTION 1.1:

Clearly state the project objectives as they pertain to activities. Begin discussing the project objectives on a large scale, then focus the discussion on the facility-specific objectives.

1.2 PROJECT ASSUMPTIONS

NOTE ON COMPLETION OF SECTION 1.2:

Clearly state all of the project-specific assumptions that have been made based on DQO Team discussions and interviews with the regulators.

1.3 PROJECT ISSUES

1.3.1 Global Issues

NOTE ON COMPLETION OF SECTION 1.3.1:

Present the date when the global issues meeting was held, and note the organizations that were represented at the meeting. List each of the global issues that were discussed and the resolutions that were agreed upon.

1.3.2 Project-Specific Technical Issues and Resolutions

NOTE ON COMPLETION OF SECTION 1.3.2:

Identify all project-specific technical issues that were identified during the DQO Workshop and follow-up meetings. Discuss how each of these issues was resolved.

1.4 EXISTING REFERENCES

Table 1-1 presents a list of all of the references that were reviewed as part of the scoping process along with a summary of the pertinent information contained within each reference. These references were the primary source for the background information presented in Section 1.5.

Table 1-1. Existing References.

Reference	Summary

1.5 FACILITY BACKGROUND INFORMATION

NOTE ON COMPLETION OF SECTION 1.5:

In this section, provide background information about the facility under investigation. This information will be used to support the development of the problem statement. This section should address the following key areas:

- Facility description
- Process history
- Specific areas within the facility to be investigated
- Summary of all recorded spills and releases
- Current housekeeping practices
- Summary of historical analytical data

1.6 DQO TEAM MEMBERS AND KEY DECISION MAKERS

Individual members of the DQO Team were carefully selected to participate in the seven-step DQO process based on their technical background to provide expertise in all of the technical areas needed to

meet the project objectives. The key decision makers included representatives from the U.S. Department of Energy (DOE), Washington State Department of Ecology (Ecology), and U.S. Environmental Protection Agency (EPA) Region 10. The role of the key decision makers was to make final decisions related to the sampling design.

Tables 1-2 and 1-3 identify each of the individual members of the DQO Team and the key decision makers. In addition, these tables identify the organization that each DQO Team member or key decision maker represents, along with their technical area of expertise and telephone number.

Table 1-2. DQO Team Members.

Name	Organization	Area of Expertise	Telephone Number

Table 1-3. DQO Key Decision Makers.

Name	Organization	Area of Expertise	Telephone Number

1.7 CONTAMINANTS OF CONCERN

A list of the contaminants of concern (COCs) for the WMA under investigation was generated by initially listing all of the contaminants of potential concern (COPCs) based on historical process operations. Certain COPCs are identified for exclusion because they have a short half-life, are not regulated, pose no risk, are non-toxic, or if process knowledge/analytical data confirms that insignificant releases have occurred.

1.7.1 Total List of WMA COPCs and COPC Exclusion Rationale

Table 1-4 identifies all of the COPCs expected for the WMA under investigation and the rationale for excluding certain COPCs from the WMA characterization effort.

Table 1-4. COPC List and Rationale for COPC Exclusions.

CAS #	COPC	Rationale for Exclusion

1.7.2 Final List of COCs

Table 1-5 presents the final list of COCs to be carried through the remainder of the DQO process.

Table 1-5. Final List of COCs.

CAS #	COC

1.8 CURRENT AND POTENTIAL FUTURE LAND USE

The current and potential future uses for the land in the immediate vicinity of the facility under investigation are summarized in Table 1-6. This information is needed later in the DQO process to support the evaluation of decision error consequences.

Table 1-6. Current and Potential Future Land Use.

Current Land Use	Potential Future Land Use

1.9 PRELIMINARY CLEANUP LEVELS

The hypothetical media cleanup levels for each COC are presented in Table 1-7. The levels presented are hypothetical because of uncertainty regarding WMA point-of-compliance boundaries (i.e., WMA boundary, 200 Area boundary, 200 Area buffer zone boundary, and Columbia River) and closure options (i.e., clean closure, modified closure, or landfill closure). The hypothetical media cleanup levels presented are based on regulatory thresholds (i.e., MTCA B) and/or risk and will be used only to establish contaminant detection limits.

Table 1-7. List of Hypothetical Media Cleanup Levels.

CAS #	COC	Hypothetical Media Cleanup Level	Regulatory/Risk Basis

1.10 CONCEPTUAL MODEL

Table 1-10 presents a tabular depiction of the conceptual model which identifies the release mechanisms, migration pathways, and potential receptors for each of the COCs.

Table 1-8. Tabular Depiction of the Conceptual Model.

CAS #	COC	Release Mechanism	Migration Pathways	Potential Receptors

1.11 STATEMENT OF THE PROBLEM

NOTE ON COMPLETION OF SECTION 1.12:

Combine the relevant background information into a concise statement of the problem to be resolved.

2.0 STEP 2 -- IDENTIFY THE DECISION

In Step 2 the principal study questions (PSQs) that need to be resolved to address the problem identified in DQO Step 1 are documented. In addition, the alternative actions that would result from resolving the PSQs are identified. The PSQs and alternative actions are then combined into decision statements (DSs) that express a choice among alternative actions.

Table 2-1. Summary of DQO Step 2 Information.

Principal Study Question #1 -	
PSQ-AA#	**Alternative Action**
Decision Statement #1 -	
Principal Study Question #2 -	
PSQ-AA#	**Alternative Action**
Decision Statement #2 -	
Principal Study Question #3 -	
PSQ-AA#	**Alternative Action**
Decision Statement #3 -	

3.0 STEP 3 -- IDENTIFY INPUTS TO THE DECISION

In Step 3 the data/information needed to resolve the DSs is documented. In addition, analytical performance requirements (e.g., practical quantitation limits [PQLs], precision, and accuracy) are defined for the data. If it is determined that the data/information need to resolve the DSs do not already exist, new data/information must be derived through computational, field survey, sampling, and/or analytical methods.

3.1 SOURCE REFERENCE INFORMATION

Table 3-1 identifies if the required information to resolve each of the DSs already exists. For existing information , source references are provided, along with a qualitative assessment of the adequacy of the information to resolve the DSs.

Table 3-1. Required Information and Reference Sources.

DS#		Required Data	Does Data Exist? (Y/N)	Source Reference	Sufficient Quality (Y/N)	Additional Information Required? (Y/N)

3.2 COMPUTATIONAL AND SURVEY/ANALYTICAL METHODS

Table 3-2 identifies the DSs where existing information does not exist or is of insufficient quality to resolve the DSs. Table 3-2 also documents computational (including computer codes or models)and surveying/sampling methods that could be used to obtained the required information.

Table 3-2. Information Required to Resolve the Decision Statements.

DS#		Required Information	Computational Methods	Survey/Analytical Methods

Table 3-3 presents details for the computational methods identified in Table 3-2.

Table 3-3. List of Potential Computational Methods.

DS#	Computational Method	Source/Author	Application to Study

Table 3-4 documents the survey/analytical methods that may be used to provide the required information needed to resolve the DSs. The possible limitations associated with each method and cost estimates are also provided.

Table 3-4. Potentially Appropriate Survey/Analytical Methods.

DS#		Survey/ Analytical Method	Possible Limitations	Estimated Cost

3.3 ANALYTICAL PERFORMANCE REQUIREMENTS

Table 3-5 defines the analytical performance requirements to resolve the DSs identified in Table 3-4.

Table 3-5. Analytical Performance Requirements.

DS#	COC	Survey/ Analytical Method	Hypothetical Media Cleanup Level	PQL	Precision Req't	Accuracy Req't

4.0 STEP 4 -- DEFINE THE BOUNDARIES OF THE STUDY

In Step 4 the DQO Team will identify the geographic (spatial) and temporal boundaries of the WMA under investigation, as well as practical constraints (hindrances or obstacles) for the sampling design.

4.1 POPULATION OF INTEREST

Clearly define the attributes of the "populations of interest" that apply for each DS. The attributes could relate to media (e.g., soil or groundwater) or to project waste streams (e.g., tools, pipes, and construction debris).

Table 4-1. Characteristics that Define the Populations of Interest.

DS #	Population of Interest

4.2 GEOGRAPHIC AREA

Table 4-2 identifies the geographic areas that apply to each DS. Documenting the geographic boundaries of the study area ensures that the investigation does not expand beyond the original scope of the project.

Table 4-2. Geographic Area Under Investigation.

DS#	Geographic Area Under Investigation

4.3 ZONES WITH HOMOGENEOUS CHARACTERISTICS

Table 4-3 documents the zones within the WMA that have relatively homogeneous characteristics. These zones were identified by using existing information to segregate the elements of the population into subsets that exhibit relatively homogeneous characteristics, such as types of contaminants. Dividing the facility into separate zones reduces the overall complexity of the problem by breaking the facility into more manageable pieces.

Table 4-3. Zones With Homogeneous Characteristics.

DS#		Population of Interest	Zone	Homogeneous Characteristic Logic

4.4 SPATIAL AND TEMPORAL BOUNDARIES

Table 4-4 documents the spatial scale and any temporal boundaries that may apply to each DS. The spatial scale for decision making defines decision units, which are typically areas or volumes for which remediation or regulatory compliance decisions may apply. The temporal boundary defines the time period over which DSs apply (e.g., days, months, seasons, or years).

Table 4-4. Spatial Scale and Temporal Boundaries for Decision Making.

DS#	Spatial Scale	Temporal Boundary

4.5 PRACTICAL CHARACTERIZATION CONSTRAINTS

Table 4-5 documents any practical constraints that may affect data/information collection(e.g., physical barriers, difficult sample matrices, high radiation areas).

Table 4-5. Practical Constraints on Data/Information Collection.

5.0 STEP 5 – DEVELOP A DECISION RULE

In Step 5 the information provided in Steps 1 through 4 is combined with statistical parameters (e.g., mean, median, upper confidence limit, or percentile) and a hypothetical media cleanup levels to describe actions that may be taken based on the information collected. The statistical parameters specify the characteristics/attributes the decision-makers want to know about the population, while the hypothetical media cleanup levels are potential threshold values that could provide criteria for selecting interim cleanup measures (ICMs).

5.1 STATISTICAL PARAMETER OF INTEREST

For each COC, Table 5-1 identifies statistical parameters of interest and hypothetical media cleanup levels.

Table 5-1. Statistical Parameter of Interest.

DS#	COC	Statistical Parameter of Interest	Hypothetical Media Cleanup Levels

5.2 SCALE FOR DECISION MAKING

The scale for decision making is derived by combining the spatial scale and temporal boundariesfrom Table 4-4 into one statement for each DS.

Table 5-2. Scale for Decision Making.

DS#	Scale for Decision Making

5.3 DECISION RULES

Table 5-3 combines the statistical parameters of interest, the scale for decision-making, hypothetical media cleanup levels, and alternative ICMs into IF…THEN… statements or "decision rules" (DRs). Each DS has one or more DRs associated with it.

1

Table 5-3. Decision Rules.

DS#	DR#	Decision Rule

6.0 STEP 6 -- SPECIFY TOLERABLE LIMITS ON DECISION ERRORS

Analytical information can only estimate the true condition of a WMA, so decisions based on analytical information could potentially be in error (decision error). For this reason, the primary objective of Step 6 is to define tolerable limits on the probability of making a decision error.

6.1 CONCENTRATION RANGES

Table 6-1 defines statistical parameter concentration ranges for each COC based on historical analytical data.

Table 6-1. Statistical parameter of interest Concentration Ranges.

Media	COC	Statistical parameter of interest	Range	
			Lower Limit	Upper Limit

6.2 NULL HYPOTHESIS

Table 6-2 identifies the null hypothesis that applies to the WMA under investigation. The null hypothesis refers to the baseline condition of the WMA, which is defined using historical data and process knowledge.

Table 6-2. Defining the Null Hypothesis.

Null Hypothesis Statement	Indicate Selection
Facility material is assumed to be contaminated until it is shown to be clean.	
Facility material is assumed to be clean until it is shown to be contaminated.	

6.3 CONSEQUENCES OF DECISION ERROR

Table 6-3 documents the decision errors that are possible for each DS and the potential consequences (e.g., environment, budget, and schedule) associated with the errors.

Table 6-3. Consequences of Decision Error.

Decision Statement #___:		
	True Condition of WMA Decision Units	
Decision Based on Data	**Achieves Preliminary Corrective Measure Performance Standards**	**Does Not Achieve Preliminary Corrective Measure Performance Standards**
Achieves Preliminary Corrective Measure Performance Standards	**CORRECT DECISION** Project may proceed as planned	**INCORRECT DECISION** **(Decision Error)** **(Health Risk Consequences)** Consequences: Environmental impact: Budget impact: Schedule impact: Severity:
Does Not Achieve Preliminary Corrective Measure Performance Standards	**INCORRECT DECISION** **(Decision Error)** **(Increased Cost Consequences)** Consequences: Environmental impact: Budget impact: Schedule impact: Severity:	**CORRECT DECISION** Project may proceed as planned

Of the decision errors identified in Table 6-3, the more severe consequence occurs when the information suggests that the **Preliminary Corrective Measure Performance Standards are achieved,** when in reality, the ***Preliminary Corrective Measure Performance Standards are not achieved.*** The consequence of this decision error is a potential increase in human health or environmental risk.

6.4 SAMPLING DESIGN

Based on the decision error consequences, a statistical or non-statistical sampling design decision for each DS is documented in Table 6-4. For decision statements that require multiple sampling phases, Table 6-4 presents the sampling design that applies to each phase.

Table 6-4. Selected Sampling Design.

DS#	Severity of Decision Error	Sampling Phase	Sampling Design (Statistical or Non-Statistical)	Justification

For DSs that require a statistical sampling approach, it is necessary to define a range of parameter values around the preliminary corrective measure performance standards where the consequences of decision error are relatively minor. This "gray region" is bounded by the performance standards and by the parameter value where the consequences of decision error begin to be significant. It is also necessary to establish tolerable decision error limits to points above and below the gray region. The two types of decision error either mistakenly conclude that the performance standards are achieved when they actually have not been achieved, or the performance standards are not achieved, when they actually have been achieved.

6.5 TOLERABLE DECISION ERROR

For DSs requiring a statistical sampling approach, Table 6-5 documents the gray region and tolerable limits on decision errors for each COC.

Table 6-5. Tolerable Decision Errors.

DS#	COC	Statistical parameter of interest	Statistical parameter of interest Range	Performance Standards	Gray Region	Tolerable Decision Error	
						Mistakenly Concluding Performance Standards Achieved	Mistakenly Concluding Performance Standards Not Achieved

7.0 STEP 7 -- OPTIMIZE THE DESIGN

In Step 7 alternative characterization designs are documented that meet the data quality requirements specified in Steps 1 through 6. The most resource-effective design that satisfies the data quality requirements can then be selected.

7.1 NON-STATISTICAL SAMPLING

Tables 7-1 through 7-3 are for DSs that can be resolved using non-statistical approaches. The tables document the rationale for selecting non-statistical designs, identify alternative screening/sampling approaches, select the preferred screening/sampling approach, and present the final data collection design.

Table 7-1 identifies the screening technologies considered to resolve each DS, the optional methods of implementing each technology, and the limitations associated with each screening technology.

Table 7-1. Summary of Screening Alternatives.

DS#	Media	Screening Technology	Implementation Design	Limitations	Relative Cost

7.1.1 Sampling Method Alternatives

Table 7-2 identifies the media that need to be sampled to resolve each DS and alternative methods for collecting the samples. This table presents alternative implementation designs for each sampling method and identifies any limitations that may be associated with each sampling method and/or design.

Table 7-2. Summary of Sampling Method Alternatives.

DS#	Media	Sampling Method	Implementation Design	Limitations	Relative Cost

7.1.2 Implementation Design

Table 7-3 presents the selected screening and sampling methods for resolving each DS, a summary of how the selected methods will be integrated into the final design, and the rationale for the selected methods and design.

Table 7-3. Selected Implementation Design.

DS#	Selected Screening Technology	Selected Sampling Method	Implementation Design	Rationale

7.2 STATISTICAL SAMPLING

Tables 7-4 through 7-8 are for DSs requiring statistical approaches. For each DS, these tables document the selected method for testing the null hypothesis, present the formula for calculating the potential number of samples needed, identify the total number of samples to be collected, estimate the cost for various Type I (α) and Type II (β) error tolerances, present the results from a trade-off analysis, and summarize of the selected statistical sampling design.

7.2.1 Statistical Testing of Null Hypothesis

Table 7-4 documents the suggested method for testing the null hypothesis for each DS and presents the formula used to calculate the potential number of samples needed.

Table 7-4. Statistical Methods for Testing the Null Hypothesis.

DS#	Null Hypothesis	Statistical Method for Testing Null Hypothesis	Assumptions Made in Selecting Statistical Method	Formula for Calculating Number of Samples

7.2.2 Number of Samples

Table 7-5 documents the potential number of samples required for each DS using varying Type I (α) and Type II (β) error tolerances. The potential number of samples is calculated using the statistical method identified in Table 7-4.

Table 7-5. Potential Number of Samples Required to Resolve Each Decision Statement.

DS #1	Formula		
	β=	β=	β=
α =			
α =			
α =			
DS #2	**Formula**		
	β=	β=	β=
α =			
α =			
α =			

7.2.3 Sampling Cost

Table 7-6 documents the estimated cost for resolving each DS using the varying Type I (α) and Type II (β) error tolerances used in Table 7-5. The estimates reflect the cost for sampling and analysis.

Table 7-6. Estimated Cost for Resolving Each Decision Statement.

DS #1	Formula		
	β=	β=	β=
α =			
α =			
α =			
DS #2	**Formula**		
	β=	β=	β=
α =			
α =			
α =			

7.2.4 Trade-Off Analysis

The results from the trade-off analysis are documented in Table 7-7. A trade-off analysis is performed to identify the optimal number of samples for a given budget. It is important to consider trade-offs so contingency project plans can be developed.

Table 7-7. Results of Trade-Off Analysis.

7.2.5 Final Statistical Sampling Design

The results from the trade-off analysis are evaluated for each DS. If required, one or more outputs to Steps 1 through 6 could be modified to tailor the design to most efficiently meet all of the DQO constraints. For each DS, Table 7-8 presents a summary of the final statistical sampling design and the total number of samples to be collected.

Table 7-8. Final Statistical Sampling Design.

DS#	Statistical Sampling Design	Number of Samples

1

APPENDIX H

ANNOTATED OUTLINES

H1.0 ANNOTATED OUTLINES

The purpose of this appendix is to provide guidance on the requirements, considerations, and content of future *Resource Conservation and Recovery Act of 1976* (RCRA) corrective action program (RCAP) documents in order to ensure consistency and adequacy. These future documents include the following:

- Waste management area addendum
- Waste management area field investigation report
- Phase 1 RCRA facility investigation (RFI) report
- Phase 1 Corrective measures study

An annotation of each document is provided in the following sections. The requirements associated with the various documents are listed in Table H-1.

H2.0 WASTE MANAGEMENT AREA ADDENDUM

H2.1 INTRODUCTION

The purpose of the waste management area (WMA) addendum is to provide the WMA-specific details and field activities, building upon the information outlined in the master work plan. The scope will include details for specific characterization activities (e.g., borehole or test pit designs, and sample locations) as defined in WMA-specific data quality objective (DQO) sessions. A discussion will also be included to address integration efforts as outlined in Section 7.3 of this master work plan and the agreements and commitments for subsequent assessment activities.

H2.2 BACKGROUND AND SETTING

The background and setting for the Hanford Site and the 200 Areas will be referenced to Section 3.0 of the master work plan. A detailed description of the WMA will be provided, including location, geologic, hydrogeologic, and subsurface conditions or other information that is WMA-specific and pertinent. Section 3.0 of the master work plan and other reports such as DOE/RL-98-28 (Appendix H) or *Aggregate Area Management Study Reports* (e.g., DOE/RL-91-60) will be referenced for a description of 200 Area processes that generated tank waste. Additional information on WMA-specific waste generation, transfer, storage, and disposal processes will be presented.

H2.3 INITIAL EVALUATION

Section 3.0 of the master work plan will be referenced for the initial list of contaminants of potential concern (COPCs). A review of WMA-specific known and suspected contamination, including estimated waste volumes, will be presented. This will include a compilation and discussion of available monitoring information, including groundwater data where available. Section 4.0 of the master work plan will be referenced for the conceptual exposure model. The model will be refined, as appropriate, to incorporate WMA-specific elements. The refined conceptual exposure model coupled with the initial list of COPCs from the master work plan will be used to develop the WMA-specific list of COPC. As appropriate, the corrective measure performance standards and associated hypothetical media cleanup standards will be updated based on the revised COPC list and updated land use decisions.

H2.4 WORK PLAN APPROACH AND RATIONALE

Results of the WMA-specific DQO process will be presented in order to discuss data uses, needs, quality, and quantity for the investigations to be conducted. Section 6.0 of the master work plan will be referenced for characterization tools and limitations. These

will be used to develop a general approach to the WMA-specific investigation and characterization activities, with reference to the sampling and analysis plan in the appendices for more details. A process will be defined for the management and communication of field deviations.

H2.5 FACILITY INVESTIGATION PROCESS

A WMA-specific discussion of the work breakdown structure, project management organization, and approach will be presented. Section 7.0 of the master work plan will be referenced for general project management. This will be followed by a description of field activities that cover all areas of characterization, including field procedures and protocols, laboratory analyses, data evaluation tasks, waste management, etc. A discussion of treatability testing needs will be included if enough information is available. However, this may need to be addressed in the field investigation report or the RFI report after data evaluations have been completed.

H2.6 PROJECT SCHEDULE

A detailed schedule for all of the tasks to be completed for the WMA will be presented. The schedule may include field activities, data evaluation, document submittal, and potential milestones. Activities will be planned using the work breakdown structure and project milestones defined in Section 7.0 of the master work plan.

H2.7 REFERENCES

H2.8 APPENDICES

Appendices to the WMA addenda may include the following:

- DQO summary report
- Subsurface conditions report
- Refined applicable or relevant and appropriate requirements (ARARs), only as required
- Sampling and analysis plan
- Site-specific health and safety plan

H3.0 WASTE MANAGEMENT AREA FIELD INVESTIGATION REPORT

H3.1 INTRODUCTION

The purpose of this report is to summarize the WMA-specific field investigation activities, compile the results of the investigation, and perform a preliminary evaluation of the data. The scope will include describing the investigative approach, presenting the investigation results and associated conclusions, summarizing the results of the risk evaluation, and recommending further WMA-specific activities as appropriate (e.g., interim measures [IMs], or accelerated corrective measures study [CMS]).

H3.2 INVESTIGATIVE APPROACH

The specific activities performed as part of the field investigation including characterization locations and techniques and analytical methods will be described. Any deviations from the WMA addendum will be noted, along with the basis for, and communication of, the deviation.

H3.3 INVESTIGATION RESULTS AND CONCLUSIONS

The results of the field investigation will be presented. Data complied will include field screening data, geophysical data (e.g., borehole logs), and laboratory analytical results. Conditions encountered in the field that could influence data interpretation or the evaluation of corrective measures will be noted. The data will be summarized in tabular form. Conclusions and trends that can be drawn from the data will be discussed.

H3.4 SUMMARY AND CONCLUSIONS OF THE RISK EVALUATION

The results of the evaluation of potential risk to a hypothetical human receptor will be presented. At a minimum, the potential risk will be evaluated for a receptor located at the WMA boundary using the risk evaluation approach described in Section 4.0 of the master work plan (e.g., qualitative evaluation). The results will be tied to the DQO decisions.

H3.5 RECOMMENDATIONS

Recommendations will be provided based on the conclusions of the risk evaluation. If the potential risk to human health and the environment is significant, IMs may be identified. Alternately, an accelerated CMS may be recommended.

H3.6 REFERENCES

H4.0 PHASE 1 RCRA FACILITY INVESTIGATION REPORT

H4.1 INTRODUCTION

The purpose of the RFI report will be to consolidate and evaluate the results of investigations at all of the WMAs. The scope will include summarizing the key results of WMA-specific investigations, identifying similarities and differences between the WMAs, presenting the results of the risk evaluations, and recommending future activities for the RCAP.

Typical facility investigation topics such as the investigative approach and WMA-specific results and conclusions will be referenced to the field investigation reports. The focus of this report will be to address cumulative risks (i.e., WMAs and other potential sources to the anticipated receptor) and a more quantitative risk evaluation, as necessary, based on the initial evaluation in the WMA-specific field investigation reports.

H4.2 SUMMARY AND CONCLUSIONS OF THE RISK EVALUATION

The results of the evaluation of potential risk to a hypothetical human receptor will be presented on a cumulative basis. The WMA-specific results will be reevaluated only as new inputs to the models are made.

Cumulative risk evaluations will be performed using the data collected from the WMAs. Hypothetical risk to a potential receptor will be calculated at the four potential receptor locations identified in Section 4.0 of the master work plan.

H4.3 RECOMMENDATIONS

Recommendations will be provided based on the conclusions of the risk evaluation. If the potential risk to human health and the environment is significant, IMs may be identified or a CMS may be recommended.

H4.4 REFERENCES

H5.0 PHASE 1 CORRECTIVE MEASURES STUDY REPORT

H5.1 INTRODUCTION

The purpose of the CMS will be presented as the development and evaluation of interim corrective measure (ICM) alternatives leading to a recommendation of a preferred ICM(s). The scope will include developing ICM alternatives for those WMAs identified in the RFI report as presenting a sufficient risk to warrant further action, evaluating those alternatives against specific criteria, and using the evaluation as the basis for identifying the preferred ICM(s).

H5.2 DESCRIPTION OF CURRENT CONDITIONS

A brief summary discussion of the key conclusions from the RFI and any new information that has been discovered since the RFI report shall be included. This discussion should concentrate on those issues that could significantly affect the evaluation and selection of the ICMs.

H5.3 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND MEDIA CLEANUP STANDARDS

The development of potential ARARs presented in the master work plan will be referenced. This list will be screened as appropriate based on information gathered during the RFI and the corrective measure alternatives that will be evaluated. Proposed media cleanup goals will be presented. The standards will derive from the corrective measure performance standards presented in the master work plan and refined throughout the process.

H5.4 IDENTIFICATION, SCREENING, AND DEVELOPMENT OF CORRECTIVE MEASURE ALTERNATIVES

The development of general response actions and the initial identification and screening of corrective measure technologies presented in the master work plan will be referenced. The technologies that survived screening in the master work plan will be further screened as appropriate based on information gathered during the RFI and the results of the risk evaluation. Not all technologies will be appropriate to carry forward (e.g., if organic contaminants are not determined to be significant risk drivers, technologies that only address organic contaminants would be eliminated.) If new technologies have been developed since the master work plan, they will be considered for inclusion. The technologies will be assembled into one or more alternatives targeted at mitigating the significant risks identified in the RFI report.

H5.5 EVALUATION OF INTERIM CORRECTIVE MEASURES

For each alternative that warrants a more detailed evaluation, including those situations when only one feasible alternative is identified, the alternative(s) will be evaluated against the following criteria:

- Protection of human health and the environment (i.e., defined as the corrective measure performance standards)
- Attainment of media cleanup standards (including any proposed alternate concentration limits [ACLs])
- Source control (reduction or elimination, to the extent practicable, of future releases)
- Compliance with ARARs (including waste management standards)
- Long-term effectiveness and permanence, and degree of certainty that the alternative will be successful
- Reduction in the toxicity, mobility, or volume through treatment
- Short-term effectiveness (risks to public health, workers, and the environment and the time required to achieve protection)
- Ease and difficulty of implementation
- Cost (capital and operation and maintenance)
- State acceptance
- Community acceptance
- *National Environmental Policy Act of 1969* (NEPA) requirements, as appropriate.

H5.6 INTERIM CORRECTIVE MEASURE ALTERNATIVE RECOMMENDATION

A recommendation of the preferred ICM(s) will be provided for consideration by the Washington Department of Ecology. The recommendation should include a description and supporting rationale for the proposed ICM(s), consistent with the previous sections.

H5.7 REFERENCES

Figure H-1. Comprehensive List of RCAP Requirements and Considerations. (5 pages)

Requirement or Consideration	Reference (1)	WMA Addendum	WMA Field Investigation Report	Phase 1 RFI	Phase 1 CMS
The evaluation of data under the Phase 1 RCAP will be driven by the need to define risks associated with past releases and to define what measures should be implemented to address those releases. Evaluation of data to support retrieval- and closure-related decisions will be performed by the retrieval and closure projects, respectively, and is not within the scope of the Phase 1 RCAP as defined in the draft Change Control Form. However, because some of the data evaluation activities needed to support retrieval and closure decisions are very similar to those needed to answer corrective action decisions, the RCAP project teams will seek opportunities to leverage their data evaluation activities.	1.2.2	*		*	
The characterization results and lessons-learned from previous activities will be incorporated into the planning process.	1.1.2	*			
Within the framework established by the Groundwater/Vadose Zone Integration Project, the RPP Vadose Zone Project Manager will be responsible to ensure RCAP-specific interfaces are managed aggressively to support both SST and site-wide objectives.	1.1.4.2	*	*	*	*
As part of the DQO process, the WMA project teams will evaluate what is known about each WMA, to develop specific decision statements and to design characterization programs to address the information gaps.	1.2.1				
The WMA-specific DQO process must identify all relevant sites associated with and adjacent to the tank farms.	1.2.2	*			
Corrective measures will be evaluated against standard criteria identified in Section 2.0.	2.1.2.2 & 2.2.3				*

Figure H-1. Comprehensive List of RCAP Requirements and Considerations. (5 pages)

Requirement or Consideration	Reference (1)	WMA Addendum	WMA Field Investigation Report	Phase 1 RFI	Phase 1 CMS
Each WMA addendum will provide a detailed description of the associated SST farms, a summary of available data, the contaminant of potential concern refinement, the characterization sampling and analysis plan, the schedule for conducting the work, and a refinement of the potential corrective measure technologies as appropriate.	2.2.1	*			
The DQO process will form the basis for the WMA addendum, including establishing the number, type, and location of samples, specific analytical requirements (e.g., methods, detection limits).	2.2.1 & A3	*			
The general purpose of the Phase 1 RCRA Facility Investigation will be to characterize the nature, extent, rate and direction of movement, and concentration of releases from SSTs; determine the potential need for IMs and ICMs; and aid in the selection and implementation of those measures.	2.2.2			*	
The purpose of the field investigation report will be to summarize data from the WMA investigation and evaluate the data to the extent necessary to determine the need for immediate action at the WMA. At a minimum, the data will be evaluated to determine the potential risk associated with hypothetical exposure to soil and groundwater at the WMA boundary as described in Section 4.0.	2.2.2		*		
The RFI report will include descriptions of human and ecological receptors; analyses of current concentrations and extrapolations of future contamination for several hypothetical receptor exposure scenarios; and preliminary treatability studies.	2.2.2			*	
A summary of logging efforts applicable to SSTs shall be included in WMA addenda.	3.1.8	*			
The tables provided in Section 3 will serve as the basis for WMA-specific DQO. Specifically, the exclusion criteria discussed should be considered for radionuclides.	3.1.9	*			
The hydrogeologic setting in the WMA addenda will focus on the WMA-specific setting.	3.2.3	*			

Figure H-1. Comprehensive List of RCAP Requirements and Considerations. (5 pages)

Requirement or Consideration	Reference (1)	WMA Addendum	WMA Field Investigation Report	Phase 1 RFI	Phase 1 CMS
Consultations with representatives of the Native American communities with ancestral ties to the Hanford Site will be required before ground disturbances can occur to ensure that traditional cultural resources are adequately identified and protected.	3.3.5	*	*	*	*
The WMA-specific conceptual model will be presented in WMA addenda and will describe at a minimum the worst-case scenario in the WMA. The model will include those items required in Section 3.5.	3.5	*			
Points of compliance and exposure scenarios will need to be specified before the CMS can be completed.	4.1.4				*
Integrating WMA risk evaluations with other Hanford Site programs (e.g., system assessment capabilities, environmental restoration projects) is an important RCAP requirement.	4.1.5	*	*	*	*
Risk assessment during a WMA characterization and corrective measure would utilize the methodology described in Section 4.1.5.2.	4.1.5.2	*	*	*	*
A sensitivity analyses of key risk drivers and other pertinent parameters (e.g., temporal risk variations and contaminant fate and transport analyses) is required.	4.1.5.2				*
The initial process of identifying corrective measure alternatives consists of the defining corrective measure performance standards, identifying general response actions, identifying and screening technologies and process associated with the general response actions, and assembling viable alternatives.	4.2				*
Project Teams will use the initial decision framework as a starting point for each WMA-specific DQO process. During the DQO process, the team will update, refine, and complete the framework based on the best regulatory and programmatic information available at the time.	5.1.2	*			

Figure H-1. Comprehensive List of RCAP Requirements and Considerations. (5 pages)

Requirement or Consideration	Reference (1)	WMA Addendum	WMA Field Investigation Report	Phase 1 RFI	Phase 1 CMS
The first step in the DQO process for each WMA will be to develop a "problem statement." The RFI/CMS workshop team developed a general problem statement that reflects essential issues that may be used by the WMA project teams when initiating the DQO process. It is expected that each WMA project team will develop a problem statement that reflects the general statement below, but which is specific to the WMA under consideration	5.2	*			
The decision makers have agreed to evaluate risks using several exposure scenarios that are likely to bound the eventual outcome.	5.3.2	*	*	*	
If data collection activities require prioritization, the process and results will be documented in the DQO summary report as part of the WMA RFI planning process.	5.6	*			
The DQO process will form the basis for the WMA addendum.					
In order to ensure that data utilized in the development of the WMA-specific addendum is both sound and adequate, a data evaluation and preliminary subsurface conditions effort will be undertaken.	6.1.1	*			
The EPA seven-step DQO process and several associated activities and workshops will be implemented to support the preparation of each WMA addendum.	6.2	*			
Characterization must consider proven methods and potentially applicable innovative technologies.	6.3	*			
The characterization activities require primary facility safety basis documentation for safe operation.	6.3	*			
The quality assurance project plan establishes the quality requirements for the environmental data collection and sampling and analyses.	A1.0	*	*	*	

Figure H-1. Comprehensive List of RCAP Requirements and Considerations. (5 pages)

Requirement or Consideration	Reference (1)	WMA Addendum	WMA Field Investigation Report	Phase 1 RFI	Phase 1 CMS
Technical procedures applicable to quality assurance will be identified in the WMA addenda and address the requirements specified in the quality assurance project plan. The general requirements identified in Appendix A shall be supplemented by WMA-specific requirements developed through the data quality objective (DQO) process and documented in each addendum. By following and referencing the guidelines in this appendix, site-specific sampling documents should not require individual QAPjPs.	A1.0	*			
The results of the DQO process shall be reflected within the document structure of WMA addenda as a summary table of data quality requirements.	A2.4	*			
Appropriate site-specific safety documents (e.g., job hazard analysis) will be prepared in accordance with the general health and safety plan.	B1.0	*			
Data quantities for the investigative activities will be estimated in each WMA addenda.	C2.3	*			
WMA-specific waste control plans will be developed based on the plan provided in Appendix D.	D1.0	*			
The boundaries of any waste sites not located inside the WMA will be identified in the WMA-specific waste control plan based on process knowledge and environmental data for that waste site.	D3.0	*			
Investigation-derived waste will be managed in accordance with Appendix D.	D5.0	*			

1) References are assumed to be sections in this master work plan unless otherwise noted.

1

APPENDIX I

PRELIMINARY IDENTIFICATION OF RETRIEVAL AND CLOSURE TECHNOLOGIES

ACRONYMS

DOE	U.S. Department of Energy
DQO	data quality objective
Ecology	Washington State Department of Ecology
HEPA	high-efficiency particulate air
HTI	Hanford Tank Initiative
LVDG	low volume density gradient
MTCA	*Model Toxics Control Act*
RCAP	RCRA corrective action program
RCRA	*Resource Conservation and Recovery Act of 1976*
SST	single-shell tank
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
WAC	*Washington Administrative Code*
WMA	waste management area

1

I1.0 INTRODUCTION

Although retrieval of waste and closure of the single-shell tanks (SSTs) is outside the scope of the Phase 1 *Resource Conservation and Recovery Act of 1976* (RCRA) corrective action program (RCAP), the U.S. Department of Energy (DOE) and the Washington State Department of Ecology (Ecology) agreed that during the data quality objective (DQO) process and preparation of the waste management area (WMA) addenda, every effort will be made to identify the environmental data and information needs to support retrieval and closure. A preliminary list of decisions related to retrieval and closure that may be supported by environmental data is provided in Figures 5-3 and 5-4. Decisions on technology selection are required for both retrieval and closure, and this appendix briefly describes technologies under consideration for each. The descriptions are general and do not address all the options that have been discussed for the SSTs. Additional discussions on retrieval and closure technologies and the various engineering studies performed in support of the Hanford Tank Initiative (HTI) program are provided in the *Retrieval Performance Evaluation Methodology for the AX Tank Farm* (DOE-RL 1999).

I2.0 WASTE RETRIEVAL TECHNOLOGY

A comparison of the available retrieval technologies has been performed to determine which technologies or combinations of technologies would most likely be used to achieve the interim *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1998) retrieval goal of no more than 10 m^3 (360 ft^3) of residual waste (Kreig 1998). As discussed in DOE-RL (1999), past-practice sluicing and a vehicle-based retrieval system were identified as technologies that would be used to retrieve waste from the AX tanks. Past-practice sluicing is the baseline SST waste retrieval technology and is the technology that will be used to remove the majority of the high-heat waste from tank 241-C-106. The technology involves mobilizing tank "salt cakes" with high-pressure water sprays and retrieving the resultant fluid with submersible pumps. The vehicle-based retrieval system is intended for "heel" retrieval. This system is under development and consists of a self-propelled vehicle that is lowered into the tank through a riser and retrieves waste using a confined sluicing attachment. The vehicle-based system is assumed to include tools capable of cleaning the tank sides and bottom and the internal and external surfaces of the in-tank equipment. Eventual testing of this system will provide an indication of the limits of technology (i.e., with respect to minimizing residual wastes).

Additional technologies under consideration are the low volume density gradient (LVDG) technology and dry retrieval technologies. The LVDG technology exploits the fact that as much as 60% of the salt cake in some tanks may be soluble. The technology involves sprinkling water on the salt cake and allowing sufficient time for dissolution, after which the brine is retrieved and treated. Dry retrieval technologies would involve different approaches to "excavating" the salt cake and removing it from the tanks. Neither the LVDG nor dry removal technologies have been demonstrated yet in the Hanford Site SSTs.

I3.0 CLOSURE TECHNOLOGIES

As presently envisioned, closure of the SSTs will follow one of three paths: (1) clean closure, (2) modified closure, or (3) closure as a landfill. The criteria for each is defined in Section 3.3 of the SST closure work plan (DOE-RL 1996). Generally speaking, it is assumed that clean closure will require either the removal or decontamination of all dangerous waste, waste residues and equipment, bases, liners, soil/subsoils, or other material contaminated with dangerous waste or dangerous waste residual. In turn, the removal and/or decontamination standards are typically assumed to be specified as *Model Toxics Control Act* (MTCA) (Washington Administrative Code [WAC] 173-340) Method B levels of contamination. By comparison, the requirements for modified closure will employ the industrial cleanup standards defined in MTCA Method C. Closure as a landfill will follow the closure requirements specified for all landfills.

Although it is premature to define a path forward for closure, it can be assumed that the bounds are defined by either complete removal of contaminated material and media or the in situ stabilization of all material and media. As part of the HTI, several engineering studies (see Table I-1) were completed that evaluated the technologies that could be used to accomplish various end states. These engineering studies were used as a basis for the development of 15 waste retrieval and disposal options that have been evaluated and compared in DOE-RL (1999). The AX tank farm (four tanks) served as a pilot for these analytical studies. The following paragraphs briefly summarize this information.

I3.1 TANK STABILIZATION

Following waste retrieval, the tanks would be stabilized to prevent subsidence and provide a structurally sound base for the surface barrier. Grout would be mixed in a portable batch plant set up near the various tank farms. Grout pipes would be installed in each tank through riser penetrations to distribute the grout within the tank. Grout would be pumped into the tanks through existing tank risers in a series of lifts; the thickness of the lifts would depend on final grout formulation. No new risers would be constructed for grout stabilization of the tanks. The conceptual approach to stabilizing the tanks with grout is taken from DOE-RL (1996). Tank stabilization with grout is a technology that has been used at the U.S. Department of Energy's (DOE's) Savannah River Site for tank closure (WHC 1996).

The fill material for the tanks is assumed to be similar to the cold-cap grout formulation developed by the U.S. Army Corps of Engineers for the Hanford Grout Disposal Program. This formulation exhibits a relatively low heat of hydration, is free flowing and self-leveling, and is designed to involve little or no free water during curing.
In-tank hardware would not impede stabilizing the tanks with grout. For in-tank hardware that would not be filled during main grout pours (e.g., airlift circulators), existing riser penetrations would be used to inject grout directly into the hardware during ancillary equipment stabilization activities.

A skid-mounted exhauster with a high-efficiency particulate air (HEPA) filtration system would be installed during the grout filling operation to reduce the potential release of radiological particulates that could be displaced during the grout fill operation. The HEPA filtration system would be similar to those currently used in the tank farms.

In addition to grout fill, three other options were evaluated that could be used to fill and stabilize tanks (WHC 1996). These included; (1) the use of crushed aggregate, (2) grouted crushed aggregate, and (3) concrete. The study evaluated the cost, operator health risk (occupational exposure), and technical feasibility. Although no recommendation was provided, from a health perspective, stabilizing the tanks using either grout or cement was calculated to be the preferred alternative.

I3.2 ANCILLARY EQUIPMENT STABILIZATION

Stabilization of the ancillary equipment would include demolishing and removing all surface buildings and equipment that would interfere with constructing the surface barrier, and stabilizing the subsurface equipment with grout to prevent long-term subsidence. As discussed in DOE-RL (1999), the requirements for and conceptualization of processes and technologies that will be used to stabilize ancillary equipment requires additional study. The following information and data is derived from a conceptual study prepared in support of the HTI (Skelly 1998a).

Conventional construction equipment would be used to demolish noncontaminated facilities and structures. Hydraulic excavators with shielded cabs would be used to demolish contaminated facilities and equipment in order to reduce worker doses.

Grouting the subsurface equipment would be accomplished by gaining access to the equipment and injecting the grout mixture. In areas where access from the surface is not available, and for piping runs that are too long to grout from a single point, excavating the cover soil would be required to gain access. Concepts developed for excavation in the tank farms would use the L9000 Dirt Guzzler®, or an equivalent piece of equipment, to expedite excavation. Dirt Guzzlers remove soil using a vacuum and are currently used at the Hanford Site to expedite hand excavation. The tasks that would be completed in grouting the ancillary equipment include the following:

- Abandon wells and drill replacement wells. Wells would be abandoned by perforating the well casings and filling the wells with grout. This procedure conforms to the requirements for abandoning resource protection wells in *Washington Administrative Code* (WAC) 173-160. Perforating the casings and injecting grout into the well would eliminate the preferential flow paths for water and contaminants inside and around the outside of the well. Replacement groundwater wells would be constructed outside the tank farm, as appropriate, to replace the groundwater wells in the tank farm that would be abandoned.

- Fill contaminated piping and encasements with grout.

- Fill leak detection pits with grout.

- Fill pits and boxes with grout.

- Fill risers with grout.

- Excavate the cover soil above the tank domes to gain access to the airlift circulator supports. Perforate the internal air line to allow grout to flow into the annulus of the airlift circulator. Fill each of the airlift circulators with grout.

Most sluice lines and waste transfer lines terminate at jumper nozzles in pits. Jumper pits are below-grade concrete boxes with multiple incoming and outgoing transfer lines that were used to route waste transfers. The pits are covered with concrete cover blocks to provide a means for access and shielding. Because the nozzles are existing and accessible, they would be employed to do as much of the grouting as possible. The engineering study included fabricating jumpers, removing cover blocks at the appropriate pits, pouring approximately 0.3 m (1 ft) of grout onto the floor of the pit to reduce worker exposures, making connections to existing piping, and then pumping grout into the line to the perimeter of the closure area or to the stall distance limit for the pipe size involved. Because of the nature of the tasks that would be required to grout ancillary equipment, many of the operations were assumed to require direct worker contact with equipment to establish grout injection points. If the stall distance is less than the total length to be grouted, then supplemental pipe penetrations would have to be made along the length of the pipe. Supplemental pipe penetrations would be made by excavating the soil to expose the pipe at the appropriate location and installing a tapping sleeve and a riser extension to make the new grout injection point.

I3.3 REMEDIATION OF CONTAMINATED SOIL

As part of the HTI, an engineering study was performed to evaluate the various corrective measures that could be used to remediate the contaminated soil that exists in the AX tank farm. Soil excavation, stabilization, and disposal through soil grouting (in situ stabilization) were the primary technologies investigated (FDH 1999). Several techniques were evaluated to support the excavation process. These included driving sheet piles for shallow excavations and the use of caisson construction and clamshells for deep excavations. The technology used for stabilization was grout injection through an array of grout pipes drilled into the soil. Cost estimates are provided for the various alternatives that were evaluated.

I3.4 REMOVAL OF TANKS

The technologies and estimated costs associated with removing the four tanks in the AX tank farm have been documented (SESC 1997a). The concept for removing tanks was to excavate and rubblize the structures. However, this action must be performed in a very carefully controlled environment due to worker health risk and safety considerations. In addition, the size and volume of the tanks requires the use of extremely large equipment and the expenditure of

large amounts of energy. It is noted that the engineering study that assesses removal of four tanks from the AX tank farm does not include all activities or processes associated with the removal of the tanks. The reader is referred to DOE-RL (1999) for a more comprehensive discussion and evaluation of the activities to remove tanks.

I4.0 REFERENCES

COGEMA, 1999, *AX Tank Farm Process Impacts Study*, HNF-4098, Rev. 0., COGEMA Engineering Corporation, Richland, Washington.

DOE-RL, 1993, *Focused Feasibility Study for Engineered Barriers for Waste Management Units in the 200 Areas*, DOE/RL-93-33, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1996, *Single-Shell Tank Closure Work Plan*, DOE/RL-89-16, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1999, *Retrieval Performance Evaluation Methodology for the AX Tank Farm*, DOE/RL-98-72, April 1999, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Ecology, EPA, and DOE, 1998, *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement), Fifth Amendment, 89-10, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

FDH, 1999, *AX Tank Farm Soil Remediation Study*, HNF-3913, Rev. 0, Fluor Daniel Hanford, Incorporated, Richland, Washington.

Kreig, 1998, *AX Tank Retrieval Alternatives Cost Estimates*, HNF-2693, Rev. 1, Numatec Hanford Company, Richland, Washington.

NHC, 1997, *AX Tank Farm Waste Inventory Study for the Hanford Tanks Initiative Project*, HNF-SD-HTI-TI-001, Rev. 0, Numatec Hanford Company, Richland, Washington.

Norman, 1999, *Hanford Tank Initiative Engineering Study Refinements Report*, HNF-4195, Rev. 0, Parsons Infrastructure and Technology Group, Inc., Richland, Washington.

Resource Conservation and Recovery Act of 1976 (RCRA), 42 U.S.C. 6901, et seq.

SESC, 1997a, *Tank Removal Engineering Study I*, SESC-EN-RPT-003, Rev. 0, SGN Eurisys Services Corporation, Richland, Washington.

SESC, 1997b, "Hanford Tanks Initiative – AX Tank Farm Soil Remediation; Retrieval Performance Evaluation Criteria," letter, D. Ramsower to D. Becker, CCN SESC-97-547, SGN Eurisys Services Corporation, Richland, Washington, September 1997.

Skelly, 1998a, *AX Tank Farm Ancillary Equipment Study*, HNF-3441, Rev. 0, COGEMA Engineering Corporation, Richland, Washington.

Skelly, 1998b, *AX Tank Farm Tank Removal Study*, HNF-3378, Rev. 0, COGEMA Engineering Corporation, Richland, Washington.

WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells, *Washington Administrative Code*, as amended.

WAC 173-340, "Model Toxics Control Act-Cleanup," Washington Administrative Code, as amended.

WHC, 1996, *Engineering Study of Tank-Fill Alternatives for Closure of Single-Shell Tanks,* WHC-SD-WM-ES-399, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Table I-1. Summary of Engineering Studies and Technical Reports Used for Retrieval Performance Evaluation.[a]

Data	Document Number	Strategies Supported
Inventory (tank residuals, past leaks, retrieval leakage)	HNF-SD-HTI-TI-001 (NHC 1997)	All strategies
Ancillary equipment inventory and remediation	HNF-3441 (Skelly 1998a)	All strategies
Tank removal with no retrieval leakage	HNF-3378 (Skelly 1998b)	Baseline Retrieval/ Unrestricted Land Use with no retrieval leakage
Tank fill (stabilization)	WHC-SD-WM-ES-399, Rev. 0 and 0A (WHC 1996)	Baseline Retrieval/Restricted Land Use closure strategies
Surface barriers	DOE/RL-93-33 (DOE-RL 1993)	Strategies with an enhanced RCRA Subtitle C barrier, Hanford barrier, or temporary barrier
Soil remediation of past leaks with no retrieval leakage	SESC-97-547 (SESC 1997b)	Baseline Retrieval/ Unrestricted Land Use with no retrieval leakage
Tank removal with retrieval leakage	HNF-4195 (Norman 1999)	Baseline Retrieval/ Unrestricted Land Use with retrieval leakage
Soil remediation following retrieval leakage	HNF-4195 (Norman 1999)	Baseline Retrieval/ Unrestricted Land Use
Preprocessing high-activity soil and debris removed during tank removal	HNF-4098 (COGEMA 1999)	Baseline Retrieval/ Unrestricted Land Use

[a] Reference: Modified from Table 3.2.1 (DOE-RL 1999)

1

Distribution Page

Central Files	B1-07
DPC	A3-94
DOE Reading Rm.	H2-53
Hanford Tech. Lib.	P8-55
Johnson, Joanne	H0-22 (3)