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(1) Document Number: RPP-14283	(2) Revision Number: 2	(3) Effective Date: on release	
(4) Document Type: ☐ Digital Image ☒ Hard copy ☐ PDF ☐ Video	(a) Number of pages (including the DRF) or number of digital images: 118		
(5) Release Type: ☐ New ☐ Cancel	☐ Page Change	☒ Complete Revision	
(6) Document Title: Performance Objectives for Tank Farm Closure Performance Assessments			
(7) Change/Release Description: Complete revision			
(8) Change Justification: Expanded to include standards from the Nuclear Regulatory Commission (NRC) and the Comprehensive Environmental Recovery, Compensation, and Liability Act (CERCLA).			

(9) Associated Structure, System, and Component (SSC) and Building Number:		
(a) Structure Location: NA	(c) Building Number: NA	
(b) System Designator: NA	(d) Equipment ID Number (EIN): NA	

(10) Impacted Documents:	(a) Document Type	(b) Document Number	(c) Document Revision
	NA	NA	NA

(11) Approvals:

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(b) Responsible Manager (Print/Sign): F. Anderson	Frank Anderson	Date: 09/28/05
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DOE/RL Reading Room (H)	H2-53		

Release Stamp

SEP 30 2005
DATE:
STA: 15
HANFORD RELEASE
ID: 65

(13) Clearance	(a) Cleared for Public Release	(b) Restricted Information?	(c) Restriction Type:
	☒ Yes ☐ No	☐ Yes ☒ No	

(14) Clearance Review (Print/Sign):	Date:
NANCY A. FOUAD / Nancy A. Fouad	9-30-05

A-6003-881 (05/05)

Performance Objectives for Tank Farm Closure Performance Assessments

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U.S. Department of Energy Contract DE-AC27-99RL14047

EDT/ECN: DRF
UC:
Cost Center:
Charge Code:
B&R Code:
Total Pages: 118

Key Words: Performance assessment, performence objective, tank closure

Abstract: This report documents the performance objectives (metrics, times of analyses, and times of compliance) to be used in performance assessments of Hanford Site tank farm closure.

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Nancy A. Fouad 9-30-05

Release Approval | Date | Release Stamp

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Tank Farm Contractor (TFC) **RECORD OF REVISION**	(1) Document Number RPP-14283	Page 1

(2) Title
Performance Objectives for Tank Farm Closure Performance Assessments

Change Control Record

(3) Revision	(4) Description of Change - Replace, Add, and Delete Pages	Authorized for Release	
		(5) Resp. Engr. (print/sign/date)	(6) Resp. Mgr. (print/sign/date)
1	Complete revision per ECN 721358RO	F.M. Mann 1/12/2004	F.J. Anderson 1/12/2004
2 RS	Complete revision	F.M. Mann FMann 9/28/05	F.J. Anderson Frank Anderson 09/28/05

RPP-14283
Revision 2

PERFORMANCE OBJECTIVES FOR TANK FARM CLOSURE PERFORMANCE ASSESSMENTS

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Date Published
September 2005

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Prepared for the U.S. Department of Energy
Office of River Protection

Contract # DE-AC27-99RL14047, Modification M030

Approved for Public Release; Further Dissemination Unlimited

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LIST OF TERMS

Abbreviations and Acronyms

AEA	*Atomic Energy Act of 1954*
ARAR	applicable or relevant and appropriate requirement
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CoC	contaminant of concern
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
EDE	effective dose equivalent
EPA	U.S. Environmental Protection Agency
ILCR	incremental lifetime cancer risk
ISCORS	Interagency Steering Committee on Radiation Standards
ISMS	Integrated Safety Management System
NRC	U.S. Nuclear Regulatory Commission
RCRA	*Resource Conservation and Recovery Act of 1976*
WMA	waste management area

Units

Ci/m^3	curies per cubic meter
ft	foot
gal	gallon
Gy/day	Gray/day
m	meter
m^3/s	cubic meters per second
mg/Kg	milligrams per kilogram
mg/l	milligrams per liter
mGy	milligray
mGy/day	milligray/day
mrem	millirem
mrem/yr	millirem per year
nCi/g	nanocurie per gram
$pCi\ m^{-2}\ s^{-1}$	picocuries per square meter per second
pCi/l	picocuries per liter
ppm	parts per million
µg/l	microgram per liter
$\mu g/m^3$	microgram per cubic meters

1.0 OVERVIEW

Tank Farm Closure performance assessments are studies of the long-term impacts to public health and safety as well as to the environment. They provide information to decision makers on the impacts of baseline activities and other alternatives actively under consideration. The intent is to provide sufficient information so that decision makers dealing with tank farm closure have an adequate understanding of the long-term consequences of closure decisions.

To be meaningful, results from a numeric performance assessment of the consequences of an action must be compared to the standards for such an action. That is, before one disposes of waste or closes a facility with waste, one must show that the disposal or closure action protects the public health and safety and the environment. These standards are called performance objectives.

Regulations that call for performance assessments--whether they are federal such as the U.S. Department of Energy (DOE) order on radioactive waste management (*Radioactive Waste Management* [DOE O 435.1] and its implementing guides, or those from Washington State such as the regulations implementing the "Model Toxics Control Act" (*Washington Administrative Code* [WAC] 173-340, "Model Toxics Control Act – Cleanup")--usually require that the determination of performance objectives be one of the first steps performed. These performance objectives not only set comparison levels for the numeric results, but also define the media, pathways, exposure scenarios (receptors), spatial locations, and times that the performance assessment must consider. Thus, a performance objective consists of a compliance level, place(s) of compliance, and time(s) of compliance. Whenever regulations are cited in this document, the reader is reminded that not all regulations dealing with tank farm closure are included. Rather, only those that are needed for the study of long-term impacts are included.

Performance objectives are not the levels that a regulatory agency will enforce in a permit or authorization. Those levels, often called enforcement levels, will be set in the permit or authorization. Rather, performance objectives are those levels against which the results of the numeric simulation will be compared to judge the success of the proposed cleanup or disposal actions. Additional comparison levels may be requested for information purposes, but are not officially part of the decision on the adequacy of the proposed action.

To emphasize that the performance objectives discussed in this document are not regulatory performance objectives, but rather are comparison points for performance assessments, the three components of the performance objective will be renamed in this document to assessment standard, point(s) of assessment, and time(s) of assessment. However, whenever quotations are taken from other documents (e.g., regulations) the quotation will not be changed from the more standard terminology.

According to the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989), a number of performance assessments will be required to analyze the environmental and human health impacts from waste retrieval and closure activities.

This document is based on the performance objectives in *Performance Objectives for the Hanford Immobilized Low-Activity Waste (ILAW) Performance Assessment* (Mann et al. 2002)

and *Performance Objectives for Tank Farm Closure Performance Assessments* (Mann et al. 2004). The performance objectives in this document will be used in future performance analyses for tank waste retrieval or tank closure activities. These performance analyses are summarized in Table 1-1.

Table 1-1. Important Features of Tank Farm Performance Analyses.

Category	Purpose	Significant Feature
Master performance assessment	Provides the most complete and current analyses	Provides the root document (which is maintained) on which the following analyses will be based.
Post-retrieval tank performance analysis	Determines whether additional retrieval of waste is necessary	Determines inventory of key contaminants in residual waste in tank and in any retrieval leaks. Performs numeric calculations of impacts of waste remaining (including impacts from other tanks and equipment in farm or WMA) assuming no impacts from tank fill.
Tank farm corrective measures study	Determines actions that are needed to close a tank farm or WMA	Determines impacts from various options to close tank farm or WMA. Provides worker risk information for proposed closure options.
Tank farm closure performance analysis	Determines whether closure actions as implemented have been successful	Determines impacts from closed tank farm or WMA, once all closure activities (except possibly final surface barrier) are completed.

WMA = waste management area.

The initial step in identifying performance objectives is to note the requirements that could be applied to the proposed action. If that action is the disposal of radioactive mixed waste on the Hanford Site, a variety of requirements should be considered:

- DOE requirements (Note: These are not applicable or relevant and appropriate requirements [ARAR])
- U.S. Nuclear Regulatory Commission (NRC) requirements
- U.S. Environmental Protection Agency (EPA) requirements
- Washington State requirements
- Public involvement.

Based on an analysis of these regulatory requirements, the performance assessment must evaluate risks to the following:

- General public
- Workers
- Inadvertent intruders
- Groundwater
- Surface water
- Air resources.

In addition, there are restrictions on the waste itself if it is disposed of near surface.

The performance objectives identified here are only for the long-term assessment of the public health and environmental impacts from the closure of tanks. Thus, for example, worker and public safety during the actual closure operation are not considered here. Although reviewed by others performing Hanford Site assessments, it must be emphasized that these performance objectives deal only with the tank closure activities and not with the performance objectives of other Hanford Site actions. The objectives for a set of contaminants (e.g., beta/photon emitters or non-cancerous chemicals) are summarized in Table 1-2. The objectives for specific contaminants are displayed in Tables 1-3 (groundwater), 1-4 (surface water), 1-5 (air), and 1-6 (land disposal). The values for these objectives were chosen to be the most restrictive of the applicable or relevant and applicable requirements.

Many of the objectives specify concentrations (e.g., [mg-contaminant]/[kg of soil] or [pCi-contaminant]/[liter of groundwater]). Such objectives are independent of an exposure scenario. Other objectives (e.g., all-pathways dose, incidental cancer risk) require that the exposure scenario (e.g., industrial, residential) be specified to calculate values for comparison. This document does not specify the exposure scenarios that will be used to calculate values for comparison.

As described in the remainder of the document, performance objectives have been determined for both radioactive and chemical species.

Table 1-2. Key Performance Objectives for Tank Closure.

Protection of General Public and Workers [a, b, c, d]	
All-pathways dose from only this facility (CERCLA)	15 mrem in a year [e]
All-pathways dose from only this facility (DOE/NRC)	25 mrem in a year [f]
All-pathways dose including other Hanford Site sources	100 mrem in a year [f]
Chemical carcinogens (incremental lifetime cancer risk)	1×10^{-5} [g]
Radiological carcinogen (incremental lifetime cancer risk)	10^{-4} to 10^{-5} [h]
Non-cancer-causing chemicals (hazard index)	1 [g]
Protection of an Inadvertent Intruder [a, f, i]	
Acute exposure (driller)	500 mrem
Continuous exposure (post-intrusion)	100 mrem in a year
Protection of Groundwater Resources [b, c, d, j, k]	
Alpha emitters	
Radium-226 plus radium-228	5 pCi/l
All others (excluding uranium)	15 pCi/l
Beta and photon emitters	4 mrem in a year
Uranium	0.03 mg/l
Protection of Surface Water Resources [b, l]	
Alpha emitters	
Radium-226 plus radium-228	0.3 pCi/l [m]
All others (excluding uranium)	15 pCi/l [m]
Other metrics are the same as given for the protection of groundwater	
Protection of Air Resource [a, b, f, n]	
Radon (flux through surface)	20 pCi m^{-2} s^{-1}
All other radionuclides	10 mrem in a year

[a] Doses are calculated as effective dose equivalents. Values given are in addition to any existing amounts or background.

[b] Evaluated for 1,000 years, but calculated to the time of peak or 10,000 years, whichever is longer.

[c] Groundwater use starts at the time when groundwater contaminated by Hanford Site operations occurs before the year 2000. Groundwater use is estimated to be potable.

[d] Evaluated at the point of maximal exposure, but no closer than the fenceline of the waste management area in which the tank farm belongs. Also calculated at the edge of the 200 Area Exclusion boundary and just before groundwater enters the Columbia River.

[e] Main driver is EPA 1997, *Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination*, OSWER-9200.4-18, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C

[f] DOE O 435.1, 2001, *Radioactive Waste Management*, U.S. Department of Energy, Washington, D.C.

[g] WAC 173-340, "Model Toxics Control Act – Cleanup," *Washington Administrative Code*, as amended.

[h] 40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," *Code of Federal Regulations*, as amended.

[i] Evaluated for 500 years, but calculated from 100 to 1,000 years.

[j] All concentrations are in water taken from a well.

[k] 40 CFR 141, "National Primary Drinking Water Regulations," *Code of Federal Regulations*, as amended; as applicable.

[l] Evaluated at well at the edge of the Columbia River; no mixing with the river is assumed.

[m] WAC 173-201A, "Water Quality Standards for Surface Waters of the State of Washington," *Washington Administrative Code*, as amended; as applicable.

[n] Main driver is 40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," Subparts H and Q, *Code of Federal Regulations*, as amended.

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980.*

DOE = U.S. Department of Energy.

EPA = U.S. Environmental Protection Agency.

NRC = U.S. Nuclear Regulatory Commission.

Table 1-3. Performance Standards of Specific Contaminants for Groundwater Protection.[a]

Radionuclides			
Tritium (H-3)	20,000 pCi/l	Stronium-90	8 pCi/l
Radium-226	3 pCi/l	Radium-226 and Radium-228	5 pCi/l
Uranium	30 μg/l	Beta and photon emitters	4 mrem/yr
Gross alpha (excluding radon and uranium)	15 pCi/l	Gross beta and photon	50 pCi/l
Inorganic Chemicals			
Antimony	0.006 mg/l	Arsenic	0.05 mg/l
Barium	2.0 mg/l	Beryllium	0.004 mg/l
Cadmium	0.005 mg/l	Chloride	250.0 mg/l
Chromium (total)	0.05 mg/l	Cyanide	0.2 mg/l
Fluoride	4.0 mg/l	Iron	0.3 mg/l
Mercury	0.002 mg/l	Manganese	0.05 mg/l
Nitrate (as NO_3)	10.0 mg/l	Nickel	0.1 mg/l
Nitrate + Nitrite (as NO_2)	10.0 mg/l	Nitrite (as NO_2)	1.0 mg/l
Silver	0.1 mg/l	Selenium	0.05 mg/l
Thallium	0.002 mg/l	Sulfate (as SO_4)	250.0 mg/l
		Zinc	5.0 mg/l
Organic Chemicals			
Benzene	0.005 mg/l	Bis(2-ethylhexyl)phthalate	0.006 mg/l
Carbon tetrachloride	0.005 mg/l	Chloroform	0.08 mg/l
1,4-Dichlorobenzene	0.075 mg/l	1,1-Dichloroethene	0.007 mg/l
Dichloromethane	0.005 mg/l	Ethyl benzene	0.7 mg/l
Toluene	1.0 mg/l	1,1,1-Trichloroethane	0.2 mg/l
1,1,2-Trichloroethane	0.005 mg/l	Xylenes (total)	10.0 mg/l
		Styrene	0.1 mg/l

[a] Standards are provided only for those organics most often found in tank waste (see Appendix A, Table A-1). Values are the most restrictive ones from DOE O 5400.5, 40 CFR 141, 40 CFR 264.94, WAC 173-200, WAC 173-303, WAC 246-290 (see Appendix C, Tables C-5, C-6, C-7).

40 CFR 141, "National Primary Drinking Water Regulations," *Code of Federal Regulations*, as amended.

40 CFR 264.94, "Concentration Limits," *Code of Federal Regulations*, as amended.

DOE O 5400.5, 1993, *Radiation Protection of the Public and the Environment*, U.S. Department of Energy, Washington, D.C.

WAC 173-200, "Water Quality Standards for Groundwaters of the State of Washington," *Washington Administrative Code*, as amended.

WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code*, as amended.

WAC 246-290, "Public Water Supplies," *Washington Administrative Code*, as amended.

Table 1-4. Performance Standards of Specific Chemicals for Surface Water Protection. [a]

Contaminant	Performance Standard	Contaminant	Performance Standard
Ammonia	4.0 mg/l	Arsenic	0.19 mg/l
Cadmium [b]	0.00082 mg/l	Chloride	230.0 mg/l
Copper [b]	0.0087 mg/l	Chromium (hexavalent)	0.010 mg/l
Cyanide	0.0052 mg/l	Lead [b]	0.00178 mg/l
Mercury	0.000012 mg/l	Nickel [b]	0.120 mg/l
Selenium	0.005 mg/l	Zinc [b]	0.080 mg/l

[a] Values that are the same as drinking water standards (Table 1-3) are not repeated. Values are the most restrictive ones from Table 1-3 and WAC 173-201A (see Appendix C, Table C-8).

[b] Based on Columbia River at Pasco having a mean hardness of 73 mg/l (DOE 1988).

DOE 1988. *Consultation Draft: Site Characterization Plan, Reference Repository Location, Hanford Site, Washington*, DOE/RW-0164, U.S. Department of Energy, Washington, D.C.

WAC 173-201A, "Water Quality Standards for Surface Waters of the State of Washington," *Washington Administrative Code*, as amended.

Table 1-5. Performance Standards of Specific Chemicals for Air Resources Protection. [a]

Contaminant	Limits for Average Maximum		
Sulfur oxides	0.50 ppm for 3 hours	0.14 ppm for 24 hours	0.030 ppm for 1 year
Carbon monoxide	—	35 ppm for 1 hour	9 ppm for 8 hours
Ozone	—	0.12 ppm for 1 hour	0.08 ppm for 8 hours
Nitrogen dioxide	—	—	0.053 ppm (annual)
Lead	—	—	1.5 $\mu g/m^3$ (quarterly)

[a] 40 CFR 50, "National Primary and Secondary Ambient Air Quality Standards," *Code of Federal Regulations*, as amended.

Table 1-6. Performance Standards of Specific Chemicals for Land Disposal.[a] (2 sheets)

Radionuclides			
Radionuclide	**Concentration limit**	**Radionuclide**	**Concentration limit**
C-14	8 Ci/m^3	C-14 (activated metal)	80 Ci/m^3
Ni-59 (activated metal)	220 Ci/m^3	Ni-63	700 Ci/m^3
Ni-63 (activated metal)	7000 Ci/m^3	Sr-90	7000 Ci/m^3
Nb-94 (activated metal)	0.2 Ci/m^3	Tc-99	3 Ci/m^3
I-129	0.08 Ci/m^3	Cs-137	4,600 Ci/m^3
Alpha emitters (with half-lives greater than 5 years)			100 nCi/g
Pu – 241	3500 nCi/g	Cm-242	20,000 nCi/g
Inorganic Chemicals			
Chemical	**TCLP Limit**	**Chemical**	**TCLP Limit**
Antimony	1.15 mg/l	Arsenic	5.0 mg/l
Barium	21.0 mg/l	Cadmium	0.11 mg/l
Chromium (total)	0.60 mg/l	Lead	0.75 mg/l
Mercury	0.025 mg/l	Nickel	11.0 mg/l
Selenium	1.0 mg/l	Silver	0.14 mg/l
Thallium	0.20 mg/l	Vanadium	1.6 mg/l
Zinc	4.3 mg/l	—	
Cyanide (total)	590 mg/kg	Cyanide (amenable)	30 mg/kg

Organic Chemicals		
CAS #	**Constituent**	**TCLP Limit**
56-23-5	Carbon tetrachloride	0.5 mg/l
67-56-1	Methanol	0.75 mg/l
67-66-3	Chloroform	6.0 mg/l
71-43-2	Benzene	0.5 mg/l
75-35-4	1,1-Dichloroethylene	0.7 mg/l
78-93-3	Methyl ethyl ketone	200.0 mg/l
79-01-6	Trichloroethylene	0.5 mg/l
106-46-7	1,4-Dichlorobenzene	7.5 mg/l
108-94-1	Cyclohexanone	0.75 mg/l
110-86-1	Pyridine	5.0 mg/l
127-18-4	1,1,2,2-Tetrachloroethene	0.7 mg/l

Table 1-6. Performance Standards of Specific Chemicals for Land Disposal.[a] (2 sheets)

Organic Chemicals (cont'd)		
CAS #	**Constituent**	**Concentration limit**
56-23-5	Carbon tetrachloride	6 mg/kg
67-64-1	Acetone	160 mg/kg
67-66-3	Chloroform	6 mg/kg
71-36-3	n-Butyl alcohol	2.6 mg/kg
71-43-2	Benzene	10 mg/kg
71-55-6	1,1,1-Trichloroethane	6 mg/kg
74-87-3	Chloromethane/Methyl chloride	30 mg/kg
75-09-2	Methylene chloride	30 mg/kg
75-35-4	1,1-Dichloroethylene	6 mg/kg
75-69-4	Trichlorofluoromethane	30 mg/kg
75-71-8	Dichlorodifluoromethane	7.2 mg/kg
76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	30 mg/kg
78-93-3	Methyl ethyl ketone	36 mg/kg
79-00-5	1,1,2-Trichloroethane	6 mg/kg
79-01-6	Trichloroethylene	6 mg/kg
100-41-4	Ethyl benzene	10 mg/kg
106-46-7	p-Dichlorobenzene	6 mg/kg
106-93-4	1,2-Dibromoethane/Ethylene dibromide	15 mg/kg
108-10-1	Methyl isobutyl ketone	33 mg/kg
108-88-3	Toluene	10 mg/kg
110-86-1	Pyridine	16 mg/kg
1330-20-7	Xylenes-mixed isomers (sum of o-, m-,and p-xylene concentrations)	30 mg/kg

[a] Standards are provided only for those organics most often find in tank waste (see Appendix A, Table A-1). Values are the most restrictive ones from DOE O 435.1, 10 CFR 61.55, 40 CFR 261, 40 CFR 268, WAC 173-303 (see Appendix C, Table C-10).

10 CFR 61.55, "Licensing Requirements for Land Disposal of Radioactive Waste – Waste Classification," *Code of Federal Regulations*, as amended.

40 CFR 261, "Identification and Listing of Hazardous Waste," *Code of Federal Regulations*, as amended.

40 CFR 268, "Land Disposal Restrictions," *Code of Federal Regulations*, as amended.

DOE O 435.1, 2001, *Radioactive Waste Management*, U.S. Department of Energy, Washington, D.C.

WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code*, as amended.

CAS = Chemical Abstract Service.

TCLP = Toxicity Characteristic Leaching Procedure.

2.0 BACKGROUND

This section discusses the background in regard to the single-shell tank system.

2.1 GENERAL REQUIREMENTS

Before low-level radioactive waste may be disposed of, a performance assessment must be written and then approved by DOE (DOE O 435.1). Before hazardous chemical waste can be disposed of at a newly constructed disposal unit, a performance assessment must be prepared as a component of the *Resource Conservation and Recovery Act of 1976* (RCRA) Part B Permit Application, and then approved by the Washington State Department of Ecology (Ecology) (as authorized by EPA as part of the RCRA delegation). Similarly, before a *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) contaminated site is remediated, a remedial investigation/feasibility study (including a performance assessment) must be prepared and EPA must approve the action through a record of decision. The purpose of the performance assessment is to determine whether "reasonable assurance" exists that the performance objectives of the disposal facility will be met.

DOE requirements for waste disposal (provided in Appendix B, Section B1.0), as well as the Washington State regulations implementing RCRA (provided in Appendix B, Sections B2.0 and B3.0), and CERCLA (provided in Appendix B, Section B4.0) require the protection of:

- Public health and safety
- The environment.

A first step in any performance assessment is to determine the appropriate performance objectives against which the results can be compared. Although quantitative limits are sometimes stated (e.g., the all-pathways exposure limit is 25 mrem/yr), usually there is a requirement that other associated (but usually unspecified) regulations must also be considered. Additional regulations, requirements, and guidance will need to be met for tank farm closure. That additional information is not repeated in this document.

2.2 TANK CLOSURE

As of February 2005, there are about 56 million gal of high-level waste stored in underground tanks located in the Central Plateau area of the Hanford Site (*Waste Tank Summery Report for Month Ending February 28, 2005* [Naiknimbalkar 2005]). The present plans are to retrieve these wastes, separate the wastes into streams, and then vitrify each stream. The high-level waste stream would contain relatively little volume, but it would contain the bulk of the radionuclides. The vitrified high-level waste will be stored onsite until it is shipped to a federally approved geological repository. The low-activity waste stream will contain most of the material, but relatively few radionuclides. The vitrified (or immobilized) low-activity waste is planned to be disposed of in near-surface underground trenches in the 200 East Area (which is part of Hanford's Central Plateau).

The 149 single-shell tanks are grouped into 12 tank farms (A, AX, B, BX, BY, C, S, SX, T, TX, TY, and U) that have 4 (AX) to 18 (TX) tanks. These tank farms are then grouped into seven

waste management areas (WMA) (A-AX, B-BX-BY, C, S-SX, T, TX-TY, and U) for the purpose of groundwater protection.

It is expected that some wastes will remain in the tanks because retrieving all the waste may not be technically or economically feasible. To close these tanks, DOE O 435.1 requires that performance assessments analyzing radionuclides be created and approved by DOE Headquarters in support of the Waste Incidental to Reprocessing determination, and in support of the planning of the closure of a high-level waste facility. Because the tanks are in the Part A portion of the *Dangerous Waste Portion of the RCRA Permit for the Treatment, Storage, and Disposal of Dangerous Waste* (Ecology 2001), a performance assessment is also required as part of the Hanford Site permit modification.

2.3 DESCRIPTION OF THE HANFORD SITE AND CENTRAL PLATEAU

The Hanford Site is in the southern part of central Washington State. It is bounded on the north and east by the Columbia River. The main part of the western border is the Rattlesnake Ridge, while the southern border is the Yakima River and the city of Richland.

The Central Plateau is a raised area in the central part of the site. It was created by flood deposits left from the Lake Missoula glacier floods, the last of which occurred about 10,000 years ago. The groundwater, whose top is about 200 to 350 ft below the surface, mainly flows to the east. However, because of the large amounts of liquid waste disposed to the soil (approximately 400 billion gal) (*Tank Wastes Discharged Directly to the Soil at the Hanford Site* [Waite 1991]), groundwater flow has at times been redirected to the north. With the cessation of the vast bulk of the discharge, groundwater flow is reverting to its natural course to the east.

The large discharges have contaminated the groundwater under large areas of the Central Plateau, with the groundwater plume extending to the Columbia River. The major contaminants in the plumes are tritium, iodine-129, technetium-99, uranium, nitrate, and carbon tetrachloride. The first five contaminants have multiple sources, while the last (carbon tetrachloride) comes from past discharges from the Plutonium Finishing Plant.

2.4 CONTAMINANTS (RADIOISOTOPES AND HAZARDOUS MATERIALS)

Tank waste contains both radionuclides as well as hazardous materials (as defined by RCRA regulations). Thus, both sets of contaminants of concern (CoC) must be considered. In general, the CoCs to be actually analyzed in the tank closure performance assessments and the documents created from them will be based on the result of screening analyses of the impacts. In some cases, where prior agreement with the regulatory bodies has occurred, a more limited set may be used.

Performance objectives will, in general, be established for a class of contaminants (e.g., all contaminants, chemicals only, or radionuclides only) rather than for individual CoCs. In some cases, limits for key CoCs will be listed. The radionuclides listed in this document are those that were explicitly identified in *Hanford Immobilized Low-Activity Waste Performance Assessment* (Mann et al. 2001). The dangerous chemicals listed here are those most often detected in Hanford tank waste as documented in Table B.1 of *Regulatory Data Quality*

Objectives Supporting Tank Waste Remediation System Privatization Project (Wiemers et al. 1998).

Previous assessments have agreed on the important CoCs for the groundwater pathway:

- *Hanford Immobilized Low-Activity Waste Performance Assessment* (Mann et al. 2001)
- *Field Investigation Report for Waste Management Area S-SX* (Knepp 2002)
- *Composite Analysis for the Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site* (Kincaid et al. 1998)
- *Performance Assessment for the Disposal of Low-Level Waste in the 200 West Area Burial Grounds* (Wood et al. 1995)
- *Performance Assessment for the Disposal of Low-Level Waste in the 200 East Area Burial Grounds* (Wood et al. 1996).

Mann et al. (2001) found technetium-99 and iodine-129 as the main CoCs for the groundwater pathway, with chemicals being much less important. Knepp (2002) found technetium-99, nitrate, and chromium as the key CoCs. Kincaid et al. (1998) found tritium, iodine-129, and technetium-99 as the major CoCs. Wood et al. (1995, 1996) again found technetium-99 as the main CoC.)

2.5 PATHWAYS AND MEDIA

Various regulations mandate performance objectives covering various pathways and various media. DOE O 435.1 requires protection for the greatest number of contaminant pathways and is therefore used as the basis of this document.

DOE O 435.1 requires that all-pathways be investigated. In addition, the performance assessment must address impacts to groundwater, surface water, and air resources. Finally, DOE O 435.1 requires that potential impacts on an inadvertent intruder be considered when establishing contaminant concentration limits for waste packages going to disposal.

2.6 LAND USE

In 1943, the U.S. Army Corps of Engineers created the Hanford Site from small farming areas along the Columbia River to locate facilities used to produce nuclear weapon materials as part of the Manhattan Project. Since then, the major activities on the Hanford Site have been controlled by DOE and its predecessors, the U.S. Atomic Energy Commission (1945-1975), and the Energy and Research Development Administration (1975-1976). Current major programs at the Hanford Site are dedicated to waste management, environmental restoration, long-term stewardship, and research and development.

In 1992, DOE, EPA, and Ecology gathered a group of stakeholders to study potential future uses for the Hanford Site land. This Hanford Future Site Uses Working Group issued two documents based on its findings:

- *The Future for Hanford: Uses and Cleanup, Summary of the Final Report of the Hanford Future Site Uses Working Group* (HFSUWG 1992a)
- *The Future for Hanford: Uses and Cleanup, the Final Report of the Hanford Future Site Uses Working Group* (HFSUWG 1992b).

The *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE 1999) is heavily based on the work of the Hanford Future Site Uses Working Group. However, DOE land use planning extends for only 50 years instead of the 100 years forecast by the working group.

HFSUWG 1992a stated:

> "The working group identified a single cleanup scenario for the Central Plateau. This scenario assumes that future uses of the surface, subsurface and groundwater in and immediately surrounding the 200 West and 200 East Areas would be exclusive. Surrounding the exclusive area would be a temporary surface and subsurface exclusive buffer zone composed of at least the rest of the Central Plateau. As the risks from the waste management activities decrease, it is expected that the buffer zone would shrink commensurately."

64 FR 61615, "Record of Decision: Hanford Comprehensive Land-Use Plan Environmental Impact Statement" identifies near-term land uses for the Hanford Site. 64 FR 61615 prescribes the use in the 200 Areas as exclusively industrial (primarily waste management) with much of the surrounding land having the use of preservation or conservation. Recently, the Hanford Reach National Monument was established (65 FR 37253, "Establishment of the Hanford Reach National Monument") along the river corridor as well in lands at the northern and western edges of the site.

Most recently, DOE, EPA, and Ecology ("Consensus Advice #132: Exposure Scenarios Task Force on the 200 Area" [Kline et al. 2002]) put forth a risk framework that delineates the following land use scenarios:

1. The Core Zone (200 Areas including B Pond [main pond], and S Ponds) will have an Industrial Scenario for the foreseeable future.
2. The Core Zone will be remediated and closed allowing for "other uses" consistent with an industrial scenario (environmental industries) that will maintain human presence in this area, which in turn will enhance the ability to maintain the institutional knowledge of wastes left in place for the future generations. Exposure scenarios used for this zone should include a reasonable maximum exposure to a worker/day user, to possible Native American users, and to intruders.
3. DOE will follow the required regulatory processes for groundwater remediation (including public participation) to establish the points of compliance and remedial action objectives. It is anticipated that groundwater contamination under the Core Zone will

preclude beneficial use for the foreseeable future, which is at least the period of waste management and institutional controls (150 years). It is assumed that the tritium and iodine-129 plumes beyond the Control Zone boundary will exceed the drinking water standards for the period of the next 150 to 300 years (less for the tritium plume). It is expected that other groundwater contaminants will remain below, or be restored to, drinking water levels outside the Core Zone.

4. No drilling for water use or otherwise will be allowed in the Core Zone for the foreseeable future. An intruder scenario will be calculated in assessing the risk to human health and environment.
5. Waste sites outside the Core Zone but within the Central Plateau (200N, Gable Mountain Pond, B/C Crib Controlled Area) will be remediated and closed based on evaluation of multiple land use scenarios to optimize land use, institutional control cost, and long-term stewardship.
6. An industrial use scenario will set cleanup levels on the Central Plateau. Other scenarios (e.g., residential, recreational) may be used for comparison purposes to support decision making especially for:
   - The post-institutional control period (beyond 150 years)
   - Sites near the Core Zone perimeter to analyze opportunities to "shrink the site"
   - Early (precedent-setting) closure/remediation decisions.
7. This framework does not deal with the tank waste retrieval decision.

Table 2-1 summarizes this agreement.

Table 2-1. Hanford Site Land Uses. [a, b]

Time (Y)	Core Zone (approximately 200 Area)	Beyond Core Zone and Before River Corridor	National Monument and Columbia River
2000→ 2012	DOE cleanup activities	DOE cleanup activities	DOE cleanup activities
2012→ 2035	DOE cleanup activities	DOE cleanup activities	Recreational use
2035→ 2150	Restricted industrial use; no drilling, no intruders, and no groundwater use	Restricted Use, no groundwater use	Recreational use
2150→ X[c]	Industrial use; data for informational use only	Multiple land use; data for informational use only	Recreational use
X[c] →	Industrial use; other uses for informational use only	Multiple land use	Recreational use

[a] Based on the letter attachment to Kline et al. (2002).

[b] Native American exposure scenarios will be evaluated at those locations where they have been defined.

[c] X is defined as the time that the groundwater contamination falls below the limits set in 40 CFR 141 for a particular location due to contamination release before the year 2000 from Hanford Site facilities. Thus, it is likely that for locations beyond the Core Zone, X will be nearer to the present than for locations in the Core Zone. It is assumed (in the reference cited) that X is larger than 2150.

40 CFR 141, "National Primary Drinking Water Regulations," *Code of Federal Regulations*, as amended.

Kline et al. 2002, "Consensus Advice #132: Exposure Scenarios Task Force on the 200 Area," letter from K.A. Kline, Manager, U.S. Department of Energy, Richland Operations Office, D.A. Einan, Acting Hanford Project Manager, U.S. Environmental Protection Agency, Region 10, M.A. Wilson, Program Manager, Washington State Department of Ecology, Richland, Washington, to T. Martin, Chair, Hanford Advisory Board, Richland, Washington, 02-HAB-0006, dated July 11.

DOE = U.S. Department of Energy.

3.0 REGULATIONS AND OTHER PERFORMANCE ASSESSMENTS

3.1 INTRODUCTION

Because both chemicals and radionuclides are considered, a large number of federal and state regulations are potentially applicable to the determination of protection of public health, safety, and the environment The process of identifying ARARs was guided by the CERCLA process (*CERCLA Compliance with Other Laws Manual*; EPA 1989, *CERCLA Compliance with Other Laws Manual*, Part E, "Clean Air Act and Other Environmental Statues and State Requirements" [EPA 1988]). Table 3-1 lists the regulations that were reviewed and that were judged applicable or relevant and appropriate to performance assessments dealing with tank farm closure.

Chemicals and radionuclides tend to be regulated separately. Chemical waste management (including the management of the chemical components of radioactive mixed waste) is regulated by Ecology and EPA pursuant to RCRA and the "Hazardous Waste Management Act." Chemical waste activities at the Hanford Site are regulated under RCRA by virtue of Section 6001 of RCRA. EPA has delegated to Washington State much of the authority to implement the federal RCRA program. Ecology regulations (WAC 173-303, "Dangerous Waste Regulations") are consistent with, and at least as stringent as, the EPA regulations implementing RCRA.

An overarching document for chemical waste management is Ecology et al. (1989). This agreement among DOE, EPA, and Ecology provides the means for compliance at the Hanford Site for satisfying the requirements of RCRA, CERCLA, and the Washington State "Hazardous Waste Management Act." Ecology et al. (1989):

- Defines cleanup commitments and sets due dates
- Establishes responsibilities among the agencies
- Reflects the goal of achieving regulatory compliance and completing remediation activities with enforceable milestones.

DOE facilities used for the management, storage, treatment, and disposal of radioactive waste and radioactive mixed waste are planned, designed, constructed and operated under the authority of the *Atomic Energy Act of 1954* (AEA). DOE orders are issued under the authority of Section 161(i)(3) of the AEA that permits DOE to govern activities authorized by the AEA to protect health and minimize danger to life and property.

Table 3-1. List of Relevant Regulations. (2 sheets)

Regulation [a]	Comment
Federal Regulations	
"Standards for Protection Against Radiation" (10 CFR 20, particularly Subparts C, D, and K)	Establishes standards for protection against ionizing radiation resulting from activities conducted under licenses issued by the NRC.
"Licensing Requirements for Land Disposal of Radioactive Wastes" (10 CFR 61, particularly Subparts C and D)	Requirements of the NRC for the land disposal of low-level radioactive waste.
"Occupational Radiation Protection" (10 CFR 835, particularly Subpart C)	Establishes radiation protection standards, limits, and programs for protecting individuals from ionizing radiation from the conduct of DOE activities.
"National Ambient Air Quality Standards" (40 CFR 50)	Establishes air concentration standards that are protective of the public.
"National Emission Standards for Hazardous Air Pollutants" (40 CFR 61, particularly Subparts H and Q)	Establishes maximum exposure to public via air pathway.
"National Primary Drinking Water Regulations" (40 CFR 141)	Sets drinking water standards.
"National Secondary Drinking Water Standards" (40 CFR 143)	These regulations are not Federally enforceable, but are intended as guidelines for states. Washington State MTCA requires compliance with secondary standards for groundwater protection.
"Identification and Listing of Hazardous Waste" (40 CFR 261, particularly Subparts B and C)	Establishes which wastes are subject to RCRA.
"Ground Water Protection Standards" (40 CFR 264, particularly Subpart F)	Establishes groundwater protection.
"RCRA Landfills" (40 CFR 264, particularly Subpart N)	Establishes rules for landfills.
"Land Disposal Restrictions" (40 CFR 268, particularly Subpart D)	Prescribes treatment standards that must be met prior to land disposal of RCRA waste.
"Superfund, Emergency Planning, and Community Right-to-Know Programs" (40 CFR 300, particularly Subpart E)	Establishes methods and criteria for determining the appropriate extent of response by CERCLA and the *Clean Water Act of 1977.*
"PCBs Manufacturing, Processing, Distribution In Commerce, and Use Prohibitions" (40 CFR 761)	Regulates storage and disposal of PCBs.
DOE Orders and Policies	
DOE O435.1, *Radioactive Waste Management*	DOE order covering disposal of low-level waste.
DOE O 450.1, *Environmental Protection Program*	Lists executive orders, laws, and regulations which DOE actions must meet.
DOE O 5400.5, *Radiation Protection of the Public and the Environment*	Provides exposure limits for general activities and biota.
DOE P 441.1, *Department of Energy Radiological Health and Safety Policy*	Establishes basis of DOE radiological control programs.

Table 3-1. List of Relevant Regulations. (2 sheets)

Regulation [a]	Comment
Washington State Regulations	
"Water Quality Standards for Ground Waters of the State of Washington" (WAC 173-200)	Sets standards for groundwaters in Washington State.
"Water Quality Standards for Surface Waters of the State of Washington" (WAC 173-201A)	Sets standards for surface waters in Washington State.
"Dangerous Waste Regulations" (WAC 173-303)	Implements RCRA in Washington State.
"Minimal Functional Standards for Solid Waste Handling" (WAC 173-304)	Sets requirements for landfills.
"Model Toxics Control Act – Cleanup" (WAC 173-340)	Establishes the methods used to develop cleanup standards and their use in selection of a cleanup action. Primary and secondary drinking water standards and carcinogenicity (1×10^{-6} risk), are the major criteria identified in the regulation as groundwater cleanup criteria.
"General Regulations for Air Pollution Source" (WAC 173-400)	Establish technically feasible and reasonably attainable standards to control emission or air contaminants.
"Ambient Air Quality Standards and Emission Limits for Radionuclides" (WAC 173-480)	Sets emission standards into air for radionuclides in Washington State.
"Radiation Protection Standards" (WAC 246-221)	Sets radiation protection standards for Washington State.
"Radiation Protection – Air Emissions" (WAC 246-247)	Sets radioactive air emissions standards.
"Radioactive Waste – Licensing Land Disposal" (WAC 246-250)	Sets requirements for disposal of low-level radioactive wastes in Washington State.
"MCLs and MRDLs for Public Water Supplies" (WAC 246-290-310)	Defines requirements to protect consumers using public drinking water supplies.
Other	
Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination (EPA 1997) Mostly superseded by: *Radiation Risk Assessment at CERCLA* (EPA 1999b)	Provides guidance on cleanup levels at CERCLA sites.
Hanford Guidance for Radiological Cleanup (WDOH 1997)	Provide interim regulatory guidance for Hanford Site cleanup.

[a] Regulatory document reference information is provided in Section 7.0 of this document.

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980.*
DOE = U.S. Department of Energy.
EPA = U.S. Environmental Protection Agency.
MCL = maximum contaminant level.
MRDL = maximum residual disinfectant level.
MTCA = "Model Toxics Control Act."
NRC = U.S. Nuclear Regulatory Commission.
PCB = polychlorinated biphenyl.
RCRA = *Resource Conservation and Recovery Act of 1976.*

Other regulations and general environmental acts were not included in establishing performance objectives for tank farm closure performance assessments because:

- Requirements are for different environmental actions (e.g., the disposal of uranium mill tailings, transuranic, or high-level waste, which are covered by:
  - 10 CFR 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories"
  - 10 CFR 961, "Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste"
  - 40 CFR 191, "Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes"
  - 40 CFR 192, "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings"
  - 40 CFR 194, "Criteria for the Certification and Re-certification of the Waste Isolation Pilot Plant's Compliance with the 40 CFR Part 191 Disposal Regulations"
  - 40 CFR 197, "Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada")
- Requirements dealing with general environmental concerns and such concerns are thought to be adequately addressed for the long-term by regulations presented here (e.g., such requirements include:
  - *National Environmental Policy Act of 1969*
  - *National Historic Preservation Act of 1996*
  - *Archeological and Historic Preservation Act of 1996*
  - *Department of Energy Management of Cultural Resources* [DOE P 141.1)]
  - "Native American treaty rights" [Appendix A of DOE 1999]
  - 59 FR 7629, "Executive Order 12898 of February 11, 1994: Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations"
  - *Endangered Species Act of 1973*
  - Washington State Department of Fish and Wildlife, WAC 232-12, "Permanent Regulations").
- The regulations that were proposed, but that have since been withdrawn from EPA (e.g., "Radiation Site Cleanup Regulation" [proposed 40 CFR 196]; "Environmental Radiation Standards for Management and Disposal of Low-Level Waste" [proposed 40 CFR 193]). Any future developments of such proposals will be followed.

The following sections discuss how the regulations affect the various pathways and media investigated by the tank closure performance assessments. Quantitative limits from the regulations are contained in the Appendix C tables.

3.2 PROTECTION OF THE GENERAL PUBLIC

All regulations dealing with the disposal or cleanup of waste have requirements for protecting the general public. Because of regulatory history, performance objectives for the protection of the general public from radionuclides and from chemicals have taken different paths. The performance objectives for protection from radionuclides have uniformly been expressed in terms of radiation dose. For chemicals, known or suspected carcinogens are the main concern, with the performance objectives being expressed in terms of incremental lifetime cancer risk (ILCR). For non-carcinogens, the performance objectives are expressed in terms of hazard indices.

3.2.1 Radionuclides

Values of key performance objectives from various regulations and other documents for protecting the public are given in Appendix C, Table C-1.

3.2.1.1. Atomic Energy Act. Starting with the Atomic Energy Commission, rules implementing the AEA have been consistent. The philosophy was (and still is) to limit the total dose that a member of the public receives and then to limit exposures from specified actions to a fraction of this limit. Such an approach is based on international consensus and standards (i.e., publications from the International Commission on Radiological Protection, including "Recommendations of the International Commission on Radiological Protection," [ICRP 26] and "Limits for Intakes of Radionuclides by Workers" [ICRP 30]).

Over the years, as dosimetry science has progressed, how dose has been expressed has evolved from dose to critical organs to cumulative dose equivalent to the present use of effective dose equivalent (EDE). Presently, DOE (DOE O 435.1) and the NRC (10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Waste") use the same value for protecting the public from low-level waste disposal actions: 25 mrem/yr EDE.

The Defense Nuclear Facilities Safety Board ("Recommendation 94-2, Safety Standards for Low Level Waste" [DNFSB 1994]) noted that a member of the public could receive exposures from several sources at a DOE site. Guidance from DOE Headquarters (*Department of Energy Radiological Health and Safety Policy* [DOE P 441.1]) is that protection of the general public from multiple sources should be based on *Radiation Protection of the Public and the Environment* (DOE O 5400.5). This order sets a limit of 100 mrem EDE in a year from all sources. In addition, the order requires that if the dose is above 30 mrem EDE in a year, then an additional analysis is required. For the Hanford Site, this is considered to be a fence surrounding the present Hanford Site 200 Areas. Kincaid et al. (1998) shows compliance with this requirement.

3.2.1.2. Comprehensive Environmental Response, Compensation, and Liability Act. The EPA started from a different point in implementing CERCLA. Unlike the AEA, CERCLA covers both radionuclides and hazardous chemicals. Therefore, EPA developed an approach to handle both. For known or suspected carcinogens (which includes radionuclides), limits are expressed in terms of an excess upper bound lifetime cancer risk to an individual (40 CFR 300.430, "Remedial Investigation/Feasibility Study and Selection of Remedy").

In general, the EPA uses the approach of finding ARARs. The EPA "has determined that the NRC decommissioning requirements (e.g., 25, 100 mrem/yr dose limits) under 10 CFR 20, "Standards for Protection Against Radiation," Subpart E, "Radiological Criteria for License Termination," should generally not be used to establish cleanup levels under CERCLA, even when these regulations are ARARs" (*Radiation Risk Assessment At CERCLA Sites: Q & A* [EPA 1999b]; emphasis in the original). For the cases where no ARARs are present or acceptable to the EPA, "Cleanup levels not based on an ARAR should be based on the carcinogenic risk range (generally 10^{-4} to 10^{-6} ...)" (EPA 1999b). Under CERCLA, the administrator has extensive flexibility in balancing risk mitigation against other factors. The CERCLA guidance (EPA 1999b) continues "EPA generally uses 1×10^{-4} in making risk management decisions. A specific risk estimate around 10^{-4} may be considered acceptable if based on site-specific circumstances." and "In general, dose assessment used as a method to assess risk is not recommended at CERCLA sites." The *Hanford Guidance for Radiological Cleanup* (WDOH 1997) from the Washington Department of Health follows the CERCLA approach. For CERCLA remedial actions at the Hanford Site, the Tri-Parties (DOE, EPA, and Ecology) have chosen 15 mrem/yr EDE above background over a period of 1,000 years after final remediation for a maximally exposed individual to meet the CERCLA cumulative excess cancer risk range of 10^{-4} to 10^{-6}.

3.2.1.3. Summary for Radionuclides. For CERCLA sites, the performance objective for protecting the general public should be an increased ILCR of 1×10^{-4}. In its guidance for its order on radioactive waste management (*Implementation Guide for use with DOE M 435.1-1* [DOE G 435.1-1]), DOE has reaffirmed its intent to use 25 mrem/yr as the all-pathway objective, while acknowledging the EPA concern. It is recognized that the entire Hanford Site Central Plateau will be closed under CERCLA sometime in the future, but that currently individual facilities are managed under the appropriate regulation.

3.2.2 Chemicals

Although there are three sets of regulations, CERCLA, RCRA (as implemented by Washington State), and the Washington State Dangerous Waste laws and regulations that drive the protection of the general public, their goals and methods are similar. Both CERCLA (40 CFR 300.430) and Washington State (WAC 173-340-708, "Human Health Risk Assessment Procedures") (see Appendix C, Table C-2) use ILCR as the risk measure. Both use an impact measure of 1×10^{-6} increase in ILCR for single chemicals. Washington State uses a measure of 1×10^{-5} for multiple chemicals, while CERCLA uses 1×10^{-4} for multiple chemicals and radionuclides.

To handle noncarcinogenic chemicals, the hazard index is used. Contaminant concentrations are weighted by the contaminant-specific hazard index and then summed. The requirements are that the sum be less than unity. Contaminant-specific indices will be tabulated in the dosimetry data package prepared for the tank closure performance assessment activity, currently *Exposure Scenarios and Unit Dose Factors for Hanford Tank Waste Performance Assessments* (Rittmann 2004).

3.2.3 Allotment of Performance Standards

In general, the regulations provide performance standards for a given action, rather than from all sources. However, in some cases (e.g., DOE O 5400.5 and federal regulations for workers [10 CFR 835, "Occupational Radiation Protection"]), limits are given for all sources. Because standards are provided for a given action, there is no need to allocate the standards among actions.

3.2.4 Summary

Separate performance objectives are given for CERCLA and non-CERCLA sites. For CERCLA sites, the all-pathways performance objective is an increase of 1×10^{-4} in ILCR. For non-CERCLA sites, the radiological performance objective is 25 mrem/yr EDE from the action, while the carcinogenic chemical objective is 1×10^{-5} ILCR. The noncarcinogenic chemicals performance objective is a hazard index of one.

Because tanks are regulated AEA/RCRA facilities, the radiological performance objective is 25 mrem/yr EDE from the action, while the carcinogenic chemical objective is 1×10^{-5} ILCR. Also, the hazard index from noncarcinogenic chemicals must be less than one.

3.3 PROTECTION FOR WORKERS

For these performance assessments, as for others performed under DOE orders on long-term radioactive waste management for closed facilities, worker health is not explicitly addressed. Rather, the more restrictive requirements for the general public are used. Protection for workers during construction and operations will be addressed in the safety analysis report that will be prepared for the Tank Closure Program. As seen from Appendix C, Table C-1 ("Protection of General Public") and Table C-3 ("Protection of Workers"), protection of the general public is a more restrictive requirement.

3.4 PROTECTION OF THE INADVERTENT INTRUDER

Just as in protecting the general public, regulations arising from the key laws are different. In general, DOE and NRC, in the regulation of radionuclides under the AEA, have assumed that there would be a period of institutional control after disposal. For cleanup of sites, EPA also allows assumptions of periods of institutional control, such as for containment alternatives. RCRA assumes institutional control would last long enough for risk to remain unimportant.

Only sites under AEA jurisdiction have a separate protection level for inadvertent intrusion. The limits are shown in Appendix C, Table C-4. The exposure limits for protecting a hypothetical inadvertent intruder (DOE O 435.1; 10 CFR 61) are consistent, because the Class C waste disposal limits are based on 500 mrem EDE for a one-time (acute) exposure and 100 mrem/yr EDE for a continuous exposure.

3.5 PROTECTION OF GROUNDWATER RESOURCES

The protection of groundwater resources is the most complicated requirement to determine. The level of protection for groundwater is usually based on its intended use. However, predicting future groundwater use is highly subjective given the long timeframes involved in a performance assessment. The quantities being limited (decay rate and dose) differ in the various regulations. Moreover, different regulatory agencies approach the protection of groundwater resources using a variety of methods.

The guidance under DOE O 435.1 (Appendix B) is to use the Hanford Site groundwater protection management plan. However, the Hanford Site plan, *Hanford's Groundwater Management Plan: Accelerated Cleanup and Protection* (DOE-RL 2003), focuses only on short-term activities and does not address the metrics to apply for the long-term protection of groundwater.

Washington State has determined (WAC 173-200-030, "Antidegredation Policy"; WAC 173-340-720, "Ground Water Cleanup Standards") that the highest beneficial use of groundwater is as a source of drinking water. In the past, most performance assessments at the Hanford Site have generalized the requirements from 40 CFR 141, "National Primary Drinking Water Regulations" for determining if the disposal action meets the groundwater protection requirement. The scenario used is based on a public drinking water system serving at least 25 people and located at the point of assessment of the disposal facility.

Appendix C, Table C-5 provides the performance standards for drinking water standards. Table C-6 provides the performance standards for the explicit protection of groundwater. Table C-7 provides a summary of regulatory levels sorted by contaminant.

3.5.1 Radionuclides

There is agreement among the regulations about requirements for radionuclides. The notable exception is the level of contaminant concentration in WAC 173-200-040, "Criteria.". For this performance assessment, the federal standards are used. This means that the current EPA regulation governing drinking water (40 CFR 141) is used to protect groundwater. 40 CFR 141, Subpart F, "Maximum Contaminant Level Goals and Maximum Residual Disinfectant Level Goals," and 40 CFR 143, "National Secondary Drinking Water Regulations," were not used because they are stated only as goals. This follows the precedent set in *Tank Waste Remediation System, Hanford Site, Richland, Washington, Final Environmental Impact Statement* (DOE 1996b), a joint publication of Ecology and DOE, as well as earlier versions of the immobilized low-activity waste performance assessment (e.g., Mann et al. 2001).

40 CFR 141 treats radionuclides and chemicals separately. It groups beta and photon emitters into one category (having a limit of 4 mrem/yr), alpha emitters other than uranium and radon into a second category (having a limit of 15 pCi/l), and gives other contaminants individual limits (usually expressed in pCi/l or mg/l).

Washington State regulations for drinking water (WAC 246-290-310, "Maximum Contaminant Levels [MCLs] and Maximum Residual Disinfectant Levels [MRDLs]") are based on 40 CFR 141. It should be noted that radionuclides in Washington State drinking water are

regulated by the Washington State Department of Health, while water quality standards are regulated by Ecology.

Washington State's requirements for beta emitters are based on a screening level previously used by the EPA. These screening levels were selected because the requirements are easily verified in the field. (The current EPA regulations are based on risk limitation). The current state screening level ensures that even for beta emitters emitting high-energy gamma radiation, the dose limit will be met. However, for low-energy beta emitters, the state screening level is conservative by a factor of about 100. This high degree of conservatism exists for radionuclides (e.g., technetium-99), that are important in this performance assessment. The dose limit for beta/photon emitters is based on critical or target organ dose method.

Based on a comparison of beta and photon emitters under the national drinking water regulations (65 FR 21576, "National Primary Drinking Water Regulations: Radionuclides, Notice of Data Availability"), groundwater concentration for technetium-99 from 2 L of water consumption equates to a derived groundwater concentration of 900 pCi/l (the drinking water standard) being equivalent to the maximum contaminant level of 4 mrem/yr; EPA calculated risk is 7.28×10^{-5} for groundwater concentration of 900 pCi/l. In comparison, the 4 mrem/yr EDE equates to a derived concentration of 3,790 pCi/l being equivalent to a risk of 3.07×10^{-4} (65 FR 21576). A noticeable increase in concentration is associated with the change to an EDE. This can be shown in dose and concentration comparisons at the Hanford Site for technetium-99 (Table 3-2). This means that the concentration levels for individual beta/photon emitters range between 1.5 to 21 times higher for the dose calculated using EDE method versus the target organ dose method (*Radionuclides Notice of Data Availability Technical Support Document* [EPA 2000]).

Table 3-2. Technetium-99 Groundwater Concentration Values for Dose and Risk.

Groundwater Concentration (pCi/l)	Dose (mrem/yr)	HSRAM Residential Scenario [a] (ILCR)	HSRAM Industrial Scenario [a] (ILCR)	Risk Based on EPA FRG-13 [b] (ILCR)
900	4	3.24 E-04	1.24E-05	7.28E-05
3,790	4 EDE	1.27E-03	5.23E-05	3.07E-04

[a] Source for unit risk factors is P.D. Rittmann, 2004, *Exposure Scenarios and Unit Dose Factors for the Hanford Tank Waste Performance Assessment*, HNF-SD-WM-TI-707, Rev. 4, Fluor Government Group, Inc., Richland, Washington.

[b] EPA 1999a, *Cancer Risk Coefficients for Environmental Exposures to Radionuclides*, Federal Guidance Report No. 13, EPA 402-R-99-301, U.S. Environmental Protection Agency, Office of Radiation and Indoor Air, Washington, D.C.

EDE = effective dose equivalent.
EPA = U.S. Environmental Protection Agency.
HSRAM = Hanford Site Risk Assessment Methodology.
ILCR = incremental lifetime cancer risk.

A final question is how to apply the standards chosen. The standards can be applied at a point in the groundwater or averaged over a height corresponding to the water intake elevations of drinking water systems. Given that groundwater is being protected as a source for drinking water, the latter approach will be used. This is appropriate because estimations of future groundwater contamination are built on numeric models that have a finite cell size. A study

from Washington State University (*Evaluation of the Potential for Agricultural Development at the Hanford Site* [Evans et al. 2000]) found that the average screened length for industrial wells was 4.6 m (15 ft), for domestic wells was 6.17 m (20 ft), and for irrigation and municipal wells significantly larger. For comparisons to the performance objectives, a screen length of 4.6 m will be used, corresponding to the smallest width. These screen lengths are normally found at the bottom of the well, which Evans et al. (2000) found to be about 40 m (approximately 130 ft) deep. However, as contamination near a facility is normally near the top of the groundwater, the well screen will be assumed to start at the top of the groundwater and extend downward.

3.5.2 Chemicals

Unlike radionuclides, where the contaminants are treated usually as groups (i.e., beta/gamma emitters and alpha emitters), each chemical is treated separately. For the inorganic chemicals, there is good agreement among the regulations, as seen from Appendix C, Table C-7. Different regulations treat different organic chemicals.

For the analyses covered by this document, the most restrictive regulation will be applied. To reduce the length of the tables, only those organic chemicals listed in Appendix A, Table A-1 will be included in the list of chemicals for which performance objectives are applied. The organic chemicals listed in Table A-1 are those most often detected in Hanford tanks waste as documented in Wiemers et al. (1998).

In addition, WMA-specific risk assessments are planned under Appendix I of the Ecology et al. (1989) that are required to meet WAC 173-303-610, "Closure and Post-Closure," that include evaluation of soil concentrations that are protective of groundwater under WAC 173-340-747, "Deriving Soil Concentrations for Ground Water Protection." The purpose of this section is to establish soil concentrations that will not cause contamination of groundwater at levels that exceed the groundwater cleanup levels established under WAC 173-340-720. Soil concentrations established under WAC 173-340-747 are used to establish either Method B soil cleanup levels or Method C soil cleanup levels. Six different methods may be chosen for deriving soil concentrations that meet the requirements of WAC 173-340-747. The one that will be used is the alternative fate and transport model that requires the use of site-specific data for certain parameters.

3.5.3 Limits on Key Contaminants

The DOE Office of River Protection and Ecology have agreed that key contaminants (technetium-99, iodine-129, chromium, nitrate, and uranium) should receive additional attention in tank closure performance assessments. These contaminants are those expected to cause the largest groundwater impacts from tank farm closure. For these contaminants, the maximum contaminant levels as documented in 40 CFR 141 or the *National Interim Primary Drinking Water Regulations* (EPA 1976) will be used.

3.5.4 Allotment of Performance Standards

Unlike the standards for protecting the public, which are usually stated for a given disposal or clean-up action, the standards for groundwater protection cover all sources that cause the contamination. Especially at the Hanford Site, this is quite reasonable because many sources

may have caused a contaminant plume in groundwater. However, such a commingling of sources is difficult to sort out.

The situation is even more complicated with the agreement by the Tri-Parties (Kline et al. 2002). The agreement basically creates a new source (pre-existing Hanford conditions) that also must be considered.

Once the System Assessment Capability updates the results of Kincaid et al. (1998), then it should be possible to sort out how much of the performance standard for each contaminant can be allocated to each source (including the pre-existing sources). Until that time, the full allotment of performance standards will be applied to tank farms, as there is no basis for any other split.

3.5.5 Summary

For the protection of groundwater, 40 CFR 141 will be used, except for those chemicals where Washington State or other federal regulations are more restrictive or where agreement has been reached between the DOE Office of River Protection and Ecology.

3.6 PROTECTION OF SURFACE WATER RESOURCES

Federal (40 CFR 141) and state (WAC 173-201A, "Water Quality Standards for Surface Waters of the State of Washington"; WAC 173-340-730, "Surface Water Cleanup Standards") requirements for surface water protection are similar in scope and objectives. Both are directed at preventing degradation of surface water quality and preservation of highest priority water uses. Applicable or relevant and appropriate regulations are presented in Appendix C, Table C-8.

3.6.1 Radionuclides

Washington State regulation WAC 173-201A mandates a dose limit that is the lesser of the EPA drinking water standard and explicit limits for each radionuclide contained in the state regulation. After consultation with staff from Ecology, the EPA drinking water standard was chosen to be the performance objective for radionuclides.

3.6.2 Chemicals

Performance goals for chemicals were chosen by selecting the more restrictive of the federal and state groundwater regulations. All inorganic chemicals found in the regulations are included in Table 1-4. However, for organic chemicals, only those organic chemicals that have been detected frequently in tank waste are included in Table 1-4.

3.7 PROTECTION OF AIR RESOURCES

Appendix C, Table C-9 contains the ARARs governing air emissions. Federal air emissions limits found in 40 CFR 61, "National Emissions Standards for Hazardous Air Pollutants," Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities," and Subpart Q, "National Emission Standards for Radon

Emissions from Department of Energy Facilities," are the same as those found in *Radioactive Waste Management Manual* (DOE M 435.1-1). State standards vary, but the main Washington State Department of Health regulation uses the federal standard. Based on these standards, emissions (except radon) are limited to 10 mrem (EDE) in a year with radon emissions limited to 20 pCi/m^{2}s.

3.8 PROTECTION OF TERRESTRIAL BIOTA

Protection of biota is conducted at the Hanford Site under DOE O 5400.5 and DOE O 435.1. DOE O 5400.5 sets a dose standard of 1 rad/day for aquatic organisms. DOE O 435.1 (which replaced *General Environmental Protection Program* [DOE O 5400.1]) does not contain specific dose limits/standards for biota, but rather in requirement 4b.(1)(d) that, as part of integrating Environmental Management Systems into site Integrated Safety Management Systems, DOE elements must do the following: "protection of other natural resources including biota." Also in DOE O 5400.5), under Responsibilities section 5 (d)(14), there is a requirement to "conduct environmental monitoring, as appropriate, to support the site's ISMS, detect, characterize, and respond to releases from DOE activities; assess impacts; estimate dispersal patterns in the environment; characterize pathways of exposure to members of the public; characterize the exposures and doses to individuals, to the population; and to evaluate the potential impacts to the biota in the vicinity of the DOE activity."

These are the key requirements that drive the need for conducting biota dose screening and/or detailed evaluations. These key requirements are addressed in technical standard, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2002). DOE (2002) references the DOE requirement of 1 rad/day for aquatic organisms, and the recommended limits of 1 rad/day for terrestrial plants and 0.1 rad/day for terrestrial animals. It provides the standardized DOE approach for evaluating doses and demonstrating compliance with the DOE requirements and recommendations.

These dose rate limits were derived for reference organisms. The Interagency Steering Committee on Radiation Standards (ISCORS) technical standard uses the biota dose limits specified in DOE (2002) to demonstrate that populations of plants and animals are adequately protected from the effects of ionizing radiation:

- **Terrestrial Animals.** The absorbed dose to terrestrial animals should not exceed 0.1 rad/day (1 mGy/day) from exposure to radiation or radioactive material releases into the terrestrial environment.

- **Terrestrial Plants.** The absorbed dose to terrestrial plants should not exceed 1 rad/day (10 Gy/day) from exposure to radiation or radioactive material releases into the terrestrial environment.

For this study, the maximum measured radionuclide concentrations in the soil medium are compared with a set of biota concentration guides sum of fractions and dose calculations. The biota concentration guide dose and sum of fractions calculated in this study are specific to unit concentrations of the radio nuclide cesium-137 and represent the limiting radionuclide

concentration in a soil medium which would not result in recommended dose standards for biota to be exceeded. The methodology assumes chronic exposure and equilibrium conditions.

According to the information provided by ISCORS in the biota, dose limits specified in DOE (2002) are based on the current state of science and knowledge regarding effects of ionizing radiation on plants and animals. They should not be interpreted as a "bright line" that, if exceeded, would trigger a mandatory regulatory or remedial action. Rather, they should be interpreted and applied more as "Dose Rate Guidelines" that provide an indication that populations of plants and animals could be impacted from exposure to ionizing radiation and that further investigation and action is likely necessary (DOE 2002).

In 1992, the International Atomic Energy Agency summarized information about the effects of acute ionizing radiation on terrestrial organisms as follows:

- Reproduction (encompassing the processes from gametic formation through embryonic development) is likely to be the most limiting endpoint in terms of survival of the population.
- Lethal doses vary widely among different species, with birds, mammals, and a few tree species being the most sensitive among those considered.
- Acute doses of 10 rad (100 mGy) or less are very unlikely to produce persistent and measurable deleterious changes in populations or communities of terrestrial plants or animals.

Also in 1992, the International Atomic Energy Agency summarized information about the effects of chronic radiation on terrestrial organisms:

- Reproduction (encompassing the processes from game to genesis through embryonic development) is likely to be the most limiting endpoint in terms of population maintenance.
- Sensitivity to chronic radiation varies markedly among different taxa; certain mammals, birds, reptiles, and a few tree species appear to be the most sensitive.
- In the case of invertebrates, indirect responses to radiation-induced changes in vegetation appear more critical than direct effects.
- Irradiation at chronic dose rates of 1 rad/day (10 mGy/day) or less does not appear likely to cause observable changes in terrestrial plant populations.
- Irradiation at chronic dose rates of 0.1 rad/day (1 mGy/day) or less does not appear likely to cause observable changes in terrestrial animal populations. The assumed threshold for effects in terrestrial animals is less than that for terrestrial plants, primarily because some species of mammals and reptiles are considered to be more radiosensitive.
- Reproductive effects on long-lived species with low reproductive capacity may require further consideration.

Washington State regulatory requirements for priority contaminants that present ecological concern are presented in Table 749-2 of WAC 173-340. Relevant guidelines are presented in Table 3-3.

Table 3-3. Priority Contaminants of Ecological Concern for Sites that Qualify for the Simplified Terrestrial Ecological Evaluation Procedure.

Priority Contaminant	Soil Concentration (mg/kg)	
	Unrestricted Land Use	Industrial or Commercial Site
Chromium (total)	42	135
Lead	220	220
Mercury (inorganic)	9	9
Nickel	100	1,850
Manganese	N/A [a]	23,500

N/A = not applicable.

[a] WAC 173-340-7492(2)(c). 2001, "Contaminants Analysis," *Washington Administrative Code*, as amended.

3.9 CONCENTRATION AND RELEASE LIMITS

Besides requiring the protection of various resources, regulations under AEA and RCRA require the limiting of contaminant concentration and contaminant release rates under 40 CFR 268, "Land Disposal Restrictions." The requirements are shown in Appendix C, Table C-10.

Although NRC does not have legal authority to dispose of greater than Class C LLW at the Hanford Site, DOE does not yet have procedures to dispose of greater than Class C waste; therefore, the NRC Class C LLW limits apply at the Hanford Site.

For hazardous substances regulated under RCRA, maximum concentrations and maximum release rates are regulated. The release rates are not necessarily for the conditions that the dangerous waste will actually experience, but rather are based on a standardized test. The test, Toxicity Characteristic Leaching Procedure, is designed to mimic conditions from municipal landfills.

At present, the material properties of the residual waste are not known. It is expected that release waste tests on actual tank waste residuals will be performed.

4.0 POINTS OF ASSESSMENT

4.1 INTRODUCTION

"Points of assessment" as used in this document are not regulatory points of compliance. Although they are based on regulation, the points of assessment defined in this document are only the locations at which future impacts as estimated by performance assessments are compared against the levels set in Section 3.0. The regulatory points of compliance will be defined in regulatory documents associated with the facility (e.g., permits, records of decisions).

Another nuance is that the spatial resolution of the computer models often is quite large. The spatial resolution may be a few meters (approximately 10 ft) in the case of models dealing with the disposal facility to 375 m (approximately 0.2 mile) in the case of Hanford Site models. Therefore, even though the points of assessment may be precisely defined, as implemented in the computer models the points of assessment will cover a range of values.

The next section discusses the various options available, while the remaining sections describe the selection of points of assessment for each of the items to be protected.

4.2 OPTIONS

Although, in theory, there could be a large number of possible choices for the points of assessment, in reality there are only five:

- At the facility
- The maximum point of impact at least 100 m from the facility
- The maximum point of impact at the fenceline of the facility or beyond
- The maximum point of impact at the edge of the 200 Area Core Zone or beyond
- The maximum point of impact along the Columbia or Yakima Rivers.

The 200 Area Core Zone (Section 2.6) is a construct that has not yet been formalized. This Core Zone includes the present 200 East and 200 West Areas and the land in between them. It also includes nearby ponds (e.g., S Pond, B Ponds) created by massive discharge of dilute waste. The creation of the Core Zone recognizes the past use and impacts as well as the likely future use of this area. The following sections provide information for choosing the points of assessment for tank farm closure performance assessments.

4.3 PROTECTION OF THE GENERAL PUBLIC, WORKERS, AND GROUNDWATER

Past work (e.g., Mann et al. 2001; Knepp 2002) has shown that the most important media (by far) for the protection of the general public is groundwater. As noted in Section 3.3, long-term protection of workers is to be met by applying the same standards as protecting the public. Thus, this section will deal with groundwater points of assessment.

Whereas the points of assessment for other items are fairly straightforward, the establishment of points of assessment for protecting the general public, workers, and groundwater is complicated.

Not only do different regulations have slightly different rules, but given the complex past history of contamination at the Hanford Site, these points of assessment may be time-dependent.

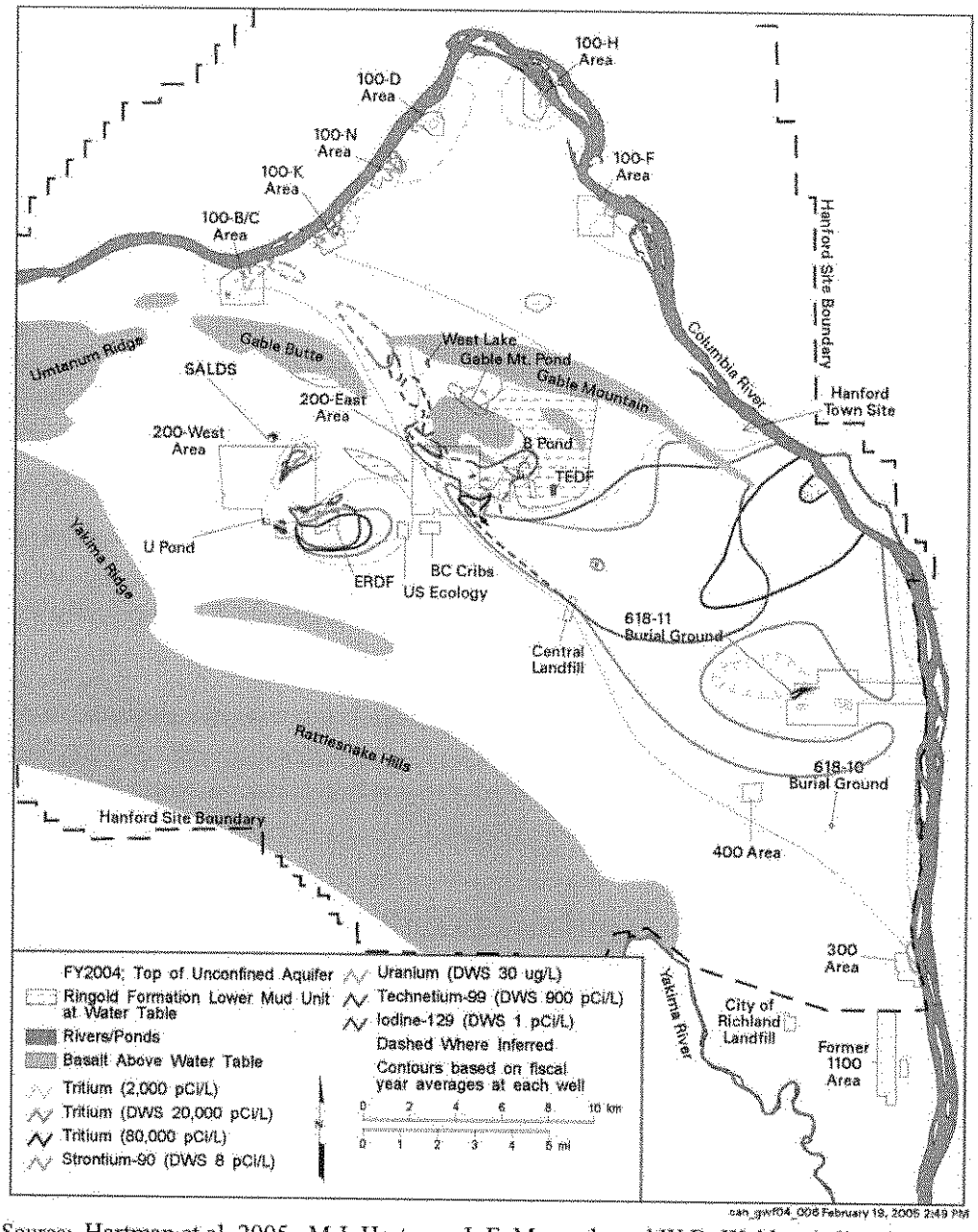
DOE, RCRA, and Washington State differ on the location of the point of compliance. RCRA (40 CFR 264 95, "Point of Compliance") states: "The point of compliance is a vertical surface located at the hydraulically downgradient limit of the WMA that extends down into the uppermost aquifer underlying the regulated units." Washington State (WAC 173-340-720(8)(a), "Point of Compliance Defined") states: "For ground water, the point of compliance is the point or points where the ground water cleanup levels established under sub-section (3), (4), (5), or (6) of this section must be attained for the site to be in compliance with cleanup standards." The AEA (DOE M 435.1-1, [IV.P92)(b)]) states: "The point of compliance shall correspond to the point of highest projected dose or concentration beyond a 100-m buffer zone surrounding the disposed waste." As noted in DOE G 435.1-1, "The "point of compliance is consistent with regulatory positions included in 40 CFR 192.32, "Standards," and 40 CFR 264.95, "Point of Compliance." The NRC regulation at 10 CFR 61.52(a)(8) states that a 'buffer zone of land must be maintained between any buried waste and the disposal site boundary ...'."

Given that fencelines are often about 100 m away from the tanks and given the relatively poor spatial resolution of the computer models, the choice between the fenceline and 100 m from the facility is usually moot. Rather, the choice that should be made is how best to model the facility and its surrounding area.

A more difficult requirement is the introduction of the future land use. Due to past actions, the groundwater underneath much of the 200 Area Core Zone and extending toward the Columbia River is currently contaminated above drinking water standards (see Figures 4-1 and 4-2, which were taken from *Hanford Site Groundwater Monitoring for Fiscal Year 2004* [Hartman et al. 2005]).

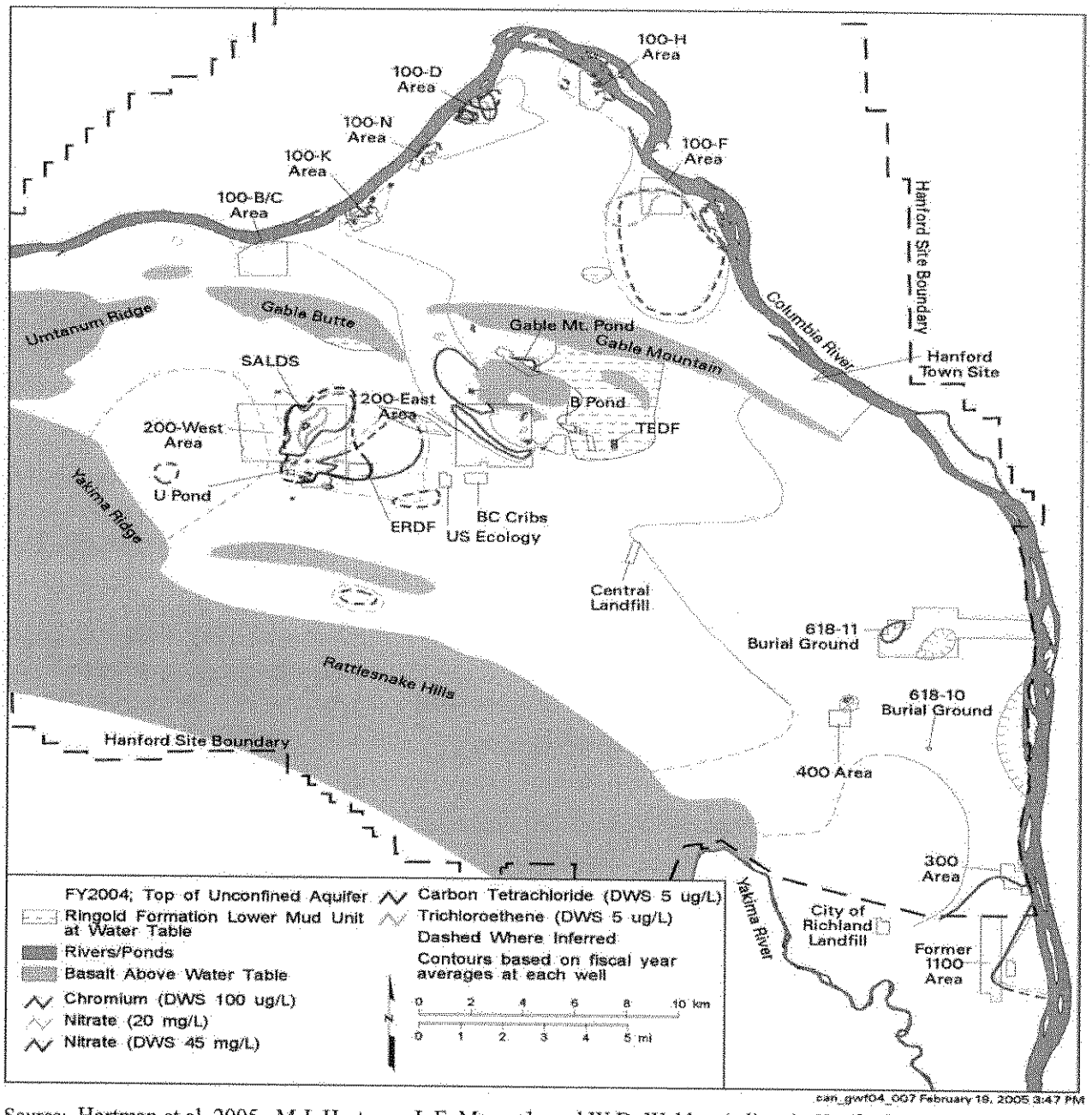
As noted in Section 2.6, the Tri-Parties have agreed that given this large area of contamination, it may be impracticable for future releases to meet standards at the waste management boundary. Rather they have adopted an approach involving time dependent points of compliance. As the groundwater is cleaned up, the point of compliance moves toward the WMA.

Figure 4-1. Location of Groundwater Concentrations of Radionuclides Above Drinking Water Standards.



Source: Hartman et al. 2005. M.J. Hartman, L.F. Morasch, and W.D. Webber (editors), *Hanford Site Groundwater Monitoring for Fiscal Year 2004*, PNNL-15070, Pacific Northwest National Laboratory, Richland, Washington.

Figure 4-2. Location of Groundwater Concentrations of Chemicals Above Drinking Water Standards.



Source: Hartman et al. 2005. M.J. Hartman, L.F. Morasch, and W.D. Webber (editors), *Hanford Site Groundwater Monitoring for Fiscal Year 2004*, PNNL-15070, Pacific Northwest National Laboratory, Richland, Washington.

Note: The MCL for nitrate as nitrogen is 10 mg/l or 45 mg/l when expressed as nitrate.

For performance assessments, such an approach is difficult to implement, as there are an infinite number of points of assessments and a similar number of times of assessment. A nearly equivalent process is to define a limited set of points of assessment with each having a separate time of assessment based on predicted Hanford Site groundwater cleanup.

The suggested points of assessment are:

- Fenceline of the facility (or 100 m downgradient of the facility)
- Edge of 200 Area Core Zone
- Just before groundwater reaches the Columbia River.

Times of assessment for each of these points are discussed in Section 5.0. These times of assessment are currently based on Kincaid et al. (1998), with updates expected from the System Assessment Capability. Such an approach allows for straightforward calculations and comparisons without biasing the comparisons.

For the tank closure performance assessments, the fenceline point of the WMA containing the tank(s) will be the main point of calculation. Based on previous work (Mann et al. 2001; Knepp 2002), this point is expected to have the largest impacts. However, the performance assessment analyses will be sensitive to the possibility that overlapping plumes further downgradient may yield higher concentrations. The other points (edge of 200 Area Core Zone and just before groundwater reaches the Columbia River) will be used for information only, as it is expected that the groundwater dilution will reduce the impacts.

4.4 PROTECTION OF THE INADVERTENT INTRUDER

For an inadvertent intruder to be harmed by the disposal facility, the intruder must contact the facility. Thus the point of assessment for the inadvertent intruder is the maximum point of impact at the facility itself.

4.5 PROTECTION OF SURFACE WATER RESOURCES

The only surface waters near the Hanford Site are the Columbia and Yakima Rivers. Because groundwater flows from the 200 Area to the Columbia River and not to the Yakima River, only the Columbia River will be considered. The Columbia River has an extremely large flow rate (typically 1,000 to 3,000 m^3/s [*Hanford Site Environmental Report for Calendar Year 1998* (Dirkes et al. 1999)]). However, the mixing factor for groundwater and Columbia River mixing is not well-established for regulatory purposes. Therefore, conservatively, a unit mixing factor will be used with the point of assessment being the groundwater just before it enters the Columbia River. That is, the concentration in the Columbia River will be estimated as being the concentration in the groundwater just before it enters the river.

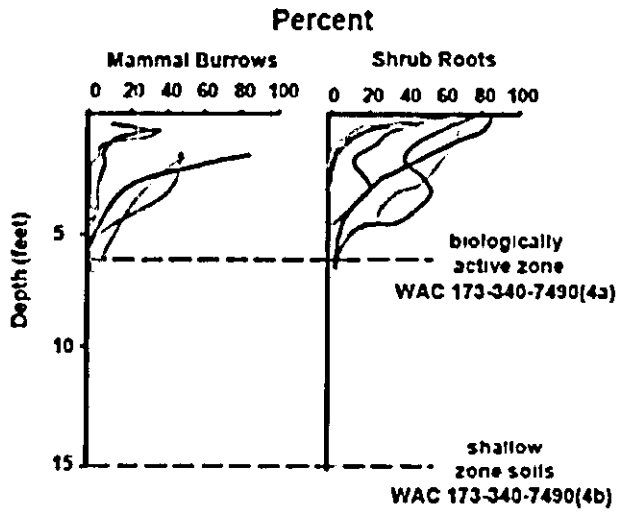
4.6 PROTECTION OF AIR RESOURCES

The point of assessment for protecting air resources is taken at the disposal facility. Either the regulations (e.g., 40 CFR 61.192, "Standard") specify a maximum flux through the surface of the facility or the regulations (e.g., 40 CFR 61.92) specify a maximum dose. Either way, the maximum impact will be at the facility.

4.7 PROTECTION OF TERRESTIAL BIOTA

The *Washington Administrative Code* defines the standard point of compliance for soil cleanup depth as extending from the ground surface to 15 ft below the ground surface (WAC 173-340-7490[4], "Point of Compliance") (Figure 4-3). This cutoff was chosen as a reasonable estimate of the soil depth that could be excavated and distributed at the soil surface as a result of site development activities, resulting in exposure by terrestrial receptors.
The *Washington Administrative Code* also allows for a conditional point of compliance as extending from the ground surface to 6 ft below the ground surface (WAC 173-340-7490[4a], "Conditional Point of Compliance") to be set at the biologically active zone.

Figure 4-3. Point of Compliance Under Washington Administrative Code.



Relevant receptors and their burrowing depths as identified in the *Central Plateau Terrestrial Ecological Sampling and Analysis Plan – Phase 1* (DOE-RL 2004) are listed in Table 4-1.

Table 4-1. Relevant Receptors and Their Burrowing Depths.

Species	Maximum Depth		Reference
Mammals			
Great Basin pocket mouse	200 cm	6.6 ft	Landeen and Mitchell 1982
Soil Biota			
Harvester ants	270 cm	8.8 ft	Fitzner et al. 1979
Plants			
Antelope bitterbrush	300 cm	9.8 ft	Klepper et al. 1985
Big sagebrush	200 cm	6.6 ft	Klepper et al. 1985
Spiny hopsage	195 cm	6.4 ft	Klepper et al. 1985
Russian thistle	172 cm	5.6 ft	Klepper et al. 1985

Fitzner et al. 1979. R.E. Fitzner, K.A. Gano, W.H. Rickard, and L.E. Rogers, 1979, *Characterization of the Hanford 300 Area Burial Grounds Task IV - Biological Transport*, PNL-2774, Pacific Northwest Laboratory, Richland, Washington.

Klepper et al. 1985. E.L. Klepper, K.A. Gano, and L.L. Caldwell, 1985, *Rooting Depth and Distributions of Deep-Rooted Plants in the 200 Area Control Zone of the Hanford Site*, PNL-5247, Pacific Northwest Laboratory, Richland, Washington.

Landeen and Mitchell 1982. D.S. Landeen and R.M. Mitchell, 1982, *Intrusion of Radioactive Waste Burial Sites by the Great Basin Pocket Mouse (Perognathus Parvus)*, RHO-SA-211, Rockwell Hanford Operations, Richland, Washington.

4.8 SUMMARY

For tank closure performance assessments, the points of assessment will be:

- At the facility for protection of the inadvertent intruder and air resources
- At the point of maximum estimated impact, but no nearer than the fenceline of the WMA downgradient from the disposal facility for the protection of the public, workers, and groundwater
- In the groundwater just before it enters the Columbia River for the protection of surface waters.

Impacts to groundwater and the public will also be generated for points at the edge of the 200 Area Core Zone and just before the groundwater enters the Columbia River for information purposes.

5.0 TIMES OF ASSESSMENT

5.1 INTRODUCTION

"Times of assessment" as used in this document are not regulatory times of compliance. Although they are based on regulation, the times of assessment defined in this document are only the time periods over which estimated future impacts are compared against levels set in Section 3.0, at points specified in Section 4.0. The regulatory times of compliance will be defined in regulatory documents authorizing the facility (e.g., permits, records of decisions).

The next section discusses the various options available, while the remaining sections describe the selection of times of assessment for each of the items to be protected.

5.2 OPTIONS

Although, in theory, there could be a large number of possible choices for the times of assessment, in reality there are only seven defined by regulatory drivers:

- From the end of institutional control to 500 years
- From the end of institutional control to 1,000 years
- From the end of institutional control to 10,000 years
- From the end of institutional control to time of maximum impact
- From the time a resource can beneficially be used to 1,000 years
- From the time a resource can beneficially be used to 10,000 years
- From the time a resource can beneficially be used to the time of maximum impact.

Different regulations have different philosophies. The same regulation (e.g., DOE M 435.1-1) may have different philosophies for different items being protected. The following text provides information for choosing the times of assessment for tank farm closure performance assessments.

It is the policy of DOE (DOE O 5400.5) that the department will not release land until all resources are protected. However, given the land use decisions outlined in Section 2.6, the separation of the end time of institutional control and the time at which resources can be beneficially used should be kept.

As noted in Section 2.6, DOE along with its regulators, EPA and Ecology, have determined that for at least the next 150 years, the 200 Area Core Zone will be under institutional control. During this time, access to the sites will be limited and controlled. Therefore, no significant impacts are expected.

In general, the times of assessment for hazardous materials are not explicitly defined in the regulations (e.g., 40 CFR 264.96, "Compliance Period"), but are rather given in the permit.

In general, DOE (DOE M 435.1-1, [IV.P](2)) uses a maximum time of 1,000 years. Calculations may extend to 10,000 years, but only as part of sensitivity and uncertainty analyses. Appendix B.1.4 of DOE (1999b) presents a more complete defense of DOE's choice of 1,000 years.

The NRC uses a longer time: 10,000 years (e.g., *Branch Technical Position on a Performance Assessment Methodology for Low-Level Radioactive Waste Disposal Facilities* [NRC 1997]). The use of 10,000 years as a time of assessment is consistent with that used in the other Hanford Site performance assessments (*Performance Assessment of Grouted Double-Shell Tank Waste Disposal at Hanford* [Kincaid et al. 1995]; Wood et al. 1995, 1996).

The use of the time having maximum exposure has not normally been used as time of assessment in performance assessments, because such a time is quite sensitive to parameters chosen for the performance assessment. However, calculations out to this time are often performed for information.

5.3 PROTECTION OF THE GENERAL PUBLIC, WORKERS, AND GROUNDWATER

For the protection of the general public, workers, and groundwater, both a beginning time and an ending time must be considered. These will be considered independently in the following text.

5.3.1 Beginning Period

Noting that exposure is primarily through the use of groundwater, the beginning time will be set as the time that beneficial use of groundwater is possible. This is consistent with the guidance given by DOE, EPA, and Ecology as noted in Section 2.6. However, since this is a relatively new policy, details have not been formalized.

A path forward for the assessment points at the 200 Area Core Zone and near the Columbia River is easily suggested. Kincaid et al. (1998) estimated groundwater impacts from 200 Area sources. Because the composite analysis was performed under AEA, neither Ecology nor EPA formally commented on the analysis nor approved the report. Kincaid et al. (1998) show that groundwater concentrations of beta/photon emitting radionuclides at the Columbia River will not fall below 40 CFR 141 limits until about 2032 (Bergeron 2002). Similarly, the analysis shows that groundwater cannot be beneficially used until approximately 2160 (Bergeron 2002) at the boundary of the 200 Area Core Zone.

Obviously, there are uncertainties with this approach. Because the composite analysis in Kincaid et al. (1998) was not designed to perform explicitly these calculations, judgment must be applied on the choice of where along the Columbia River and where along the 200 Area Core Zone to apply the criteria of beneficial use. Also, which criteria of beneficial use should be applied is uncertain. As noted in Section 3.5, there are various groundwater criteria that could be applied. Finally, the analyses for Kincaid et al. (1998) were done in 1996 and 1997, a time period predating a vast increase in vadose zone and groundwater information and understanding.

It is highly likely that the flow paths of future releases will basically follow the current groundwater steams and those predicted in the composite analysis. Although changes are to be expected (e.g., from the cessation of discharging liquids into the vadose zone and hence into groundwater), it is likely that stream path predicted by the composite analysis will predict the times that groundwater could be beneficial.

The analysis above assumed that 41 CFR 141 was the appropriate standard for beneficial use of groundwater. Washington State regulations (WAC 173-200-040; WAC 173-340-720) define the most beneficial use of groundwater that must be protected as a source of drinking water. However, rather than use 40 CFR 141, other criteria could be used (e.g., the increase in cancer deaths under 40 CFR 300.430 or WAC 173-340). The federal drinking water standards were chosen as the standards to be applied to drinking water in Section 3.6. The choice of action level and the choice of criteria to set the beginning of the assessment time should be consistent.

Although the composite analysis was issued in 1998, DOE M 435.1-1 ([IV.R.3](a)) requires that it must be maintained to reflect new information and understanding. Through the development of the System Assessment Capability and its associated data bases, a new composite analysis is expected to be issued in fiscal year 2005 or fiscal year 2006.

However, the approach of using the composite analysis cannot be applied for the point of assessment near the facility. The grid size (375 m) is too large to provide meaningful results so near the facility (approximately 100 m) and the analysis was not implemented to perform calculations so near facilities. Thus, each facility must establish its own approach.

There is significant amount of groundwater contamination presently around tank farms. The vast majority of this contamination results from planned intentional past practice liquid discharges, although some has come from unplanned tank leaks and release. It is unlikely that the groundwaters near tank farms will be of beneficial use before 2150. Therefore, this time is tentatively taken as the beginning time for the period of assessment for tank closure performance assessments. However, results will be provided starting in the year 2000.

5.3.2 Ending Period

DOE M 435.1-1 makes clear DOE's intention to use 1,000 years as the time of assessment. However, as much of the waste disposed of at the Hanford Site is derived from high-level waste, the NRC has indicated that DOE must protect the public and the environment consistent with NRC standards ("Classification of Hanford Low-Activity Tank Waste Fraction" [Paperiello 1997]). Thus, the more conservative time of assessment (10,000 years) should be used to provide information.

5.4 PROTECTION OF THE INADVERTENT INTRUDER

The time period for analyzing the inadvertent intruder is usually taken from the end of institutional control out to 500 or 1,000 years. The choice of the end time is usually not significant as the decay of key radionuclides normally overcomes the ingrowth of any other radionuclides (usually actinides) or other concentration mechanism.

The inadvertent intrusion time of assessment differs slightly between regulations. Current DOE requirements (DOE M 435.1-1) are that active institutional control shall occur for at least 100 years, but notes that longer times can be used if justified. As noted in Section 2.6, the period of control will be at least 150 years from the present to 300 years from time of closure.

A second consideration is that the NRC allows a delay in the start of the time of assessment for protecting inadvertent intruders if the waste is placed in an engineered facility that is well marked. The philosophy being that such a facility would be remembered and that the warning signs would deter intruders. For NRC Class C level waste, the 500 years is normally used because of the restrictions placed on the disposal of such waste (10 CFR 61). The Hanford Site grout performance assessment (Kincaid et al. 1995) used the 500-year assessment time based on the assumption that passive barriers and markers would be present. The performance assessments for the disposal of solid radioactive waste on the Hanford Site (Wood et al. 1995, 1996) also have used an assessment time of 500 years.

Following the precedent of the other Hanford Site performance assessments, the 500-year assessment time was used in this assessment because passive barriers and markers are planned for this proposed disposal action. Therefore, protection of an inadvertent intruder shall be considered met if the exposure limits are met at 500 years after closure. Calculations will be run from 100 years to 1,000 years after the time of disposal to obtain the doses as a function of time.

5.5 PROTECTION OF SURFACE WATER RESOURCES

The time period of assessment for surface waters is based on the discussion of protecting groundwater just before it enters the Columbia River. Therefore, the time period of assessment will be the time of site closure (2032 years) to 1,000 years. However, results will be presented out to 10,000 years.

5.6 PROTECTION OF AIR RESOURCES

Because of decay of the radionuclides, the earliest times are usually the most important. Again, based on Section 2.6, the end of institutional control (300 years) from the time of closure will be used as the start of the assessment period. The end will be taken to be 1,000 years, following DOE policy.

5.7 PROTECTION OF TERRESTRIAL BIOTA

The time period for analyzing the terrestrial biota is the same as that for the inadvertent intruder. Intrusion is the key method of exposure and cannot occur until it is feasible for humans to have access to the waste.

5.8 SUMMARY

For tank farm closure performance assessments, the times of assessment will be:

- For the protection of the general public, workers, groundwater, and air resources: 2032 to 12032
- For the protection of surface waters: 2032 to 12030
- For the protection of the inadvertent intruder and terrestrial biota: 2532 to 12032.

However, explicit calculations for the protection of the general public, workers, groundwater, and surface waters will extend to 10,000 years. Results will also be provided to show the time of peak impact for these items. Results for the inadvertent intruder will be provided starting 100 years after closure.

6.0 PUBLIC INVOLVEMENT

It is important that Hanford Site stakeholders have the opportunity to affect the performance objectives used in the tank closure performance assessments. Public comments were requested on Mann et al. (2002) on which this document is based. Only minor comments have been received.

Comments on this version of the document should be sent to:

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Because calculations for tank closure have already started, to be effective, the comments should be sent as soon as possible.

7.0 REFERENCES

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- Subpart D, "Radiation Dose Limits for Individual Members of the Public," Sections 1301 through 1302
- Subpart E, "Radiological Criteria for License Termination," Sections 1401 through 1406
- Subpart K, "Waste Disposal," Sections 2001 through 2007.

10 CFR 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories," *Code of Federal Regulations*, as amended.

10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Waste," *Code of Federal Regulations*, as amended.

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- Subpart D, "Technical Requirements for Land Disposal Facilities," Sections 50 through 59.

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40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," *Code of Federal Regulations*, as amended.

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- Subpart Q, "National Emission Standards for Radon Emissions from Department of Energy Facilities," Sections 190 through 193.

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- Subpart F, "Releases from Solid Waste Management Units," Sections 90 through 101
- Subpart N, "Landfills," Sections 300 through 317.

40 CFR 268, "Land Disposal Restrictions," *Code of Federal Regulations*, as amended.

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40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," *Code of Federal Regulations*, as amended.

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APPENDIX A

ORGANIC CHEMICALS CONSIDERED

Table A-1. Most Often Detected Organic Chemicals in Tank Waste. (2 sheets)

CAS#	Constituent	CAS#	Constituent
56-23-5	Carbon tetrachloride	108-67-8	1,3,5-Trimethylbenzene
64-17-5	Ethyl alcohol	108-87-2	Methylcyclohexane
64-18-6	Formic acid	108-88-3	Toluene
67-56-1	Methyl alcohol	108-94-1	Cyclohexanone
67-63-0	2-Propyl alcohol	109-66-0	n-Pentane
67-64-1	2-Propanone (Acetone)	109-74-0	n-Butyronitrile
67-66-3	Chloroform	109-99-9	Tetrahydrofuran
71-23-8	n-Propyl alcohol	110-43-0	2-Heptanone
71-36-3	n-Butyl alcohol	110-54-3	n-Hexane
71-43-2	Benzene	110-59-8	Pentanenitrile
71-50-1	Acetate	110-82-7	Cyclohexane
71-55-6	1,1,1-Trichloroethane	110-86-1	Pyridine
74-87-3	Chloromethane	111-13-7	2-Octanone
74-98-6	n-Propane	111-65-9	n-Octane
75-05-8	Acetonitrile	111-84-2	n-Nonane
75-07-0	Acetaldehyde	112-40-3	n-Dodecane
75-09-2	Dichloromethane (Methylene Chloride)	115-07-1	Propene
75-19-4	Cyclopropane	115-11-7	2-Methylpropene
75-35-4	1,1-Dichloroethene	117-81-7	Bis(2-ethylhexyl) phthalate
75-65-0	2-Methyl-2-propanol	123-72-8	n-Butyl aldehyde
75-69-4	Trichlorofluoromethane	124-18-5	n-Decane
75-71-8	Dichlorodifluoromethane	126-73-8	Tributyl phosphate
76-13-1	1,2,2-Trichlorotrifluoroethane	127-18-4	1,1,2,2-Tetrachloroethene
78-93-3	2-Butanone	142-82-5	n-Heptane
79-00-5	1,1,2-Trichloroethane	144-62-7	Oxalic Acid
79-01-6	1,1,2-Trichloroethylene	541-05-9	Cyclotrisiloxane, hexamethyl-
95-47-6	o-Xylene	556-67-2	Ocatamethylcyclotetrasiloxane
95-63-6	1,2,4-Trimethylbenzene	591-78-6	2-Hexanone
100-41-4	Ethyl Benzene	611-14-3	2-Ethyltoluene
100-42-5	Styrene	628-73-9	n-Hexanenitrile
104-76-7	2-Ethyl-1-hexanol	629-08-3	n-Heptanenitrile
106-35-4	3-Heptanone	629-50-5	n-Tridecane
106-46-7	1,4-Dichlorobenzene	629-59-4	n-Tetradecane
106-97-8	Butane	629-62-9	n-Pentadecane
107-12-0	Propionitrile	1066-40-6	Trimethylsilanol
107-46-0	Hexamethyldisiloxane	1120-21-4	n-Undecane
107-83-5	Pentane, 2-methyl-	1330-20-7	Xylene

Table A-1. Most Often Detected Organic Chemicals in Tank Waste. (2 sheets)

CAS#	Constituent	CAS#	Constituent
107-87-9	2-Pentanone	1825-61-2	Methoxytrimethylsilane
108-10-1	4-Methyl-2-pentanone	3622-84-2	Benzenesulfonamide, N-butyl-

Organic compounds whose vapor was detected in more than 100 independent samples from tank waste or who have been detected more than 20 times in the solid or liquid phase, as entered into the Tank Waste Information Network System (TWINS). Data taken from Table B.1 of Wiemers et al. 1998.

CAS = Chemical Abstract Service.

Wiemers et al. 1998. K.D. Wiemers, M.E. Lerchen, M. Miller, and K. Meier, 1998, *Regulatory Data Quality Objectives Supporting Tank Waste Remediation System Privatization Project*, PNNL-12040, Rev. 0, Pacific Northwest National Laboratory, Richland, Washington

APPENDIX B

KEY REGULATIONS

The regulations and guidance cited in this Appendix deal with the information needed for the creation of tank farm closure performance assessments. They are not, however, all of the regulations, requirements, or guidance needed for the closure of the tank farms or components inside those farms.

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LIST OF TERMS

Abbreviations and Acronyms

ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
HFFACO	*Hanford Federal Facility Agreement and Consent Order*
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiation Protection
IRIS	Integrated Risk Information System
LLW	low-level waste
NRC	U.S. Nuclear Regulatory Commission
NRCP	National Council on Radiation Protection
RCRA	*Resource Conservation and Recovery Act of 1976*
RCW	*Revised Code of Washington*

Units

Bq/l	becquerels per liter
$Bq/m^2/s$	becquerels per square meter per second
ft	foot
ft^3	cubic feet
m	meter
mrem	millirem
mrem/yr	millirem per year
mSv	millisieverts
pCi/l	picocuries per liter
$pCi/m^2/s$	picocuries per square meter per second

B1.0 DOE ORDER ON RADIOACTIVE WASTE MANAGEMENT

B1.1 RADIOACTIVE WASTE MANAGEMENT (DOE O 435.1)

- *Radioactive Waste Management* (DOE O 435.1), is the U.S. Department of Energy (DOE) order on radioactive waste management that is currently effective. DOE O 435.1 requires:

  (4a) "DOE radioactive waste management activities shall be systematically planned, documented, executed, and evaluated."

  (4b) "Radioactive waste shall be managed to

  (1) Protect the public from exposure to radiation from radioactive materials. Requirements for public protection are in DOE 5400.5, *Radiation Protection of the Public and the Environment* [DOE 1993].

  (2) Protect the environment. Requirements for environmental protection are in DOE 5400.1, *General Environmental Protection Program* [DOE 1990], and DOE 5400.5, *Radiation Protection of the Public and the Environment.*

  (3) Protect the work force. Requirements for radiation protection of workers are in 10 CFR Part 835, "Occupational Radiation Protection"; requirements for industry safety are in DOE O 440.1A, *Worker Protection Management for DOE Federal and Contractor Employees* [DOE 1998b].

  (4) Comply with applicable Federal, state, and local laws and regulations. These activities shall also comply with applicable Executive Orders and other DOE directives."

  (4c) "All radioactive waste shall be managed in accordance with the requirements in DOE M 435.1-1, *Radioactive Waste Management Manual*" [DOE 2001c].

B1.2 RADIOACTIVE WASTE MANAGEMENT MANUAL (DOE M 435.1-1)

- The document that implements DOE O 435.1 is *Radioactive Waste Management Manual* (DOE M 435.1-1). This manual requires (Chapter I, 1D) the following regulations and DOE directives for all DOE radioactive waste management facilities, operations, and activities.

  (1D) "**Analysis of Environmental Impacts.** Radioactive waste management facilities, operations, and activities shall meet the requirements of 10 CFR 1021, 'National Environmental Policy Act Implementing Procedures,' and DOE O 451.1A, *National Environmental Policy Act Compliance Program*" [DOE 1997].

  (1E10) "**Mixed Waste.** Radioactive waste that contains a hazardous waste component is also subject to the *Resource Conservation and Recovery Act* (RCRA) as amended." Note that hazardous waste is termed 'dangerous waste' in the Washington State requirements.

(1E13) **"Radiation Protection.** Radioactive waste management facilities, operations, and activities shall meet the requirements of 10 CFR 835, *Occupational Radiation Protection*, and DOE 5400.5, *Radiation Protection of the Public and the Environment*" [DOE 1993].

(1E18) **"Site Evaluation and Facility Design.** New radioactive waste management facilities, operations, and activities shall be sited and designed in accordance with DOE O 420.1, *Facility Safety* [DOE 2000], and DOE O 430.1A, *Life Cycle Asset Management*" [DOE 1998a].

(1E21) **"Worker Protection.** Radioactive waste management facilities, operations, and activities shall meet the requirements of DOE O 440.1A, *Worker Protection Management for DOE Federal and Contractor Employees*" [DOE 1998b].

- Section P of Chapter IV of DOE M 435.1-1 has additional requirements for low-level waste disposal facilities.

(1) **"Performance Objectives.** Low-level waste disposal facilities shall be sited, designed, operated, maintained, and closed so that reasonable assurance exists that the following performance objectives will be met for waste disposed of after September 26, 1988:

(a) Dose to representative members of the public shall not exceed 25 mrem (0.25 mSv) in a year total effective dose equivalent from all exposure pathways, excluding the dose from radon and its progeny in air.

(b) Dose to representative members of the public via the air pathway shall not exceed 10 mrem (0.10 mSv) in a year total effective dose equivalent, excluding the dose from radon and its progeny.

(c) Release of radon shall be less than an average flux of 20 pCi/m^2/s (0.74 Bq/m^2/s) at the surface of the disposal facility. Alternatively, a limit of 0.5 pCi/l (0.185 Bq/l) of air may be applied."

(2) **"Performance Assessment.** A site-specific radiological performance assessment shall be prepared and maintained for DOE low-level waste disposed of after September 26, 1988. The performance assessment shall include calculations for a 1,000 year period after closure of potential doses to representative future members of the public and potential releases from the facility to provide a reasonable expectation that the performance objectives identified in this Chapter are not exceeded as a result of operation and closure of the facility.

(a) Analyses performed to demonstrate compliance with the performance objectives in this Chapter, and to establish limits on concentrations of radionuclides for disposal based on the performance measures for inadvertent intruders in this Chapter shall be based on reasonable activities in the critical group of exposed individuals. Unless otherwise specified, the assumption of average living habits and exposure conditions in representative critical groups of individuals projected to receive the highest doses is appropriate. The likelihood of inadvertent intruder scenarios may

be considered in interpreting the results of the analyses and establishing radionuclide concentrations, if adequate justification is provided.

(b) The point of compliance shall correspond to the point of highest projected dose or concentration beyond a 100 meter buffer zone surrounding the disposed waste. A larger or smaller buffer zone may be used if adequate justification is provided.

(c) Performance assessments shall address reasonably foreseeable natural processes that might disrupt barriers against release and transport of radioactive materials.

(d) Performance assessments shall use DOE-approved dose coefficients (dose conversion factors) for internal and external exposure of reference adults.

(e) The performance assessment shall include a sensitivity/uncertainty analysis.

(f) Performance assessments shall include a demonstration that projected releases of radionuclides to the environment shall be maintained as low as reasonably achievable (ALARA).

(g) For purposes of establishing limits on radionuclides that may be disposed of near-surface, the performance assessment shall include an assessment of impacts to water resources.

(h) For purposes of establishing limits on the concentration of radionuclides that may be disposed of near-surface, the performance assessment shall include an assessment of impacts calculated for a hypothetical person assumed to inadvertently intrude for a temporary period into the low-level waste disposal facility. For intruder analyses, institutional controls shall be assumed to be effective in deterring intrusion for at least 100 years following closure. The intruder analyses shall use performance measures for chronic and acute exposure scenarios, respectively, of 100 mrem (1 mSv) in a year and 500 mrem (5 mSv) total effective dose equivalent excluding radon in air."

B1.3 IMPLEMENTATION GUIDE FOR USE WITH DOE M 435.1-1

- DOE has also issued *Implementation Guide for use with DOE M 435.1-1* (DOE G 435.1-1) concerning how to use DOE M 435.1-1 (DOE 2001c). Section IV.P(1) provides guidance on the performance objectives.

  (1) The use of the phrase 'representative members of the public' is "to indicate that overly conservative assumptions such as age, sex, or assumed activities of persons, are not made."

  (2) The air-pathway objective (10 mrem in a year) "is for all sources on the DOE site, not just the disposal facility."

  (3) Sources of radon include the "constituent of waste at the time of disposal or produced by radioactive decay following disposal."

- "In most cases, the ground surface emanation limit for radon of 20 pCi/m^2/s should be used. However, in cases where the disposed waste radiologically resembles uranium or thorium mill tailings, the limit on air concentration may be warranted. The radon dose can also be calculated as part of the total air dose, in which case, radon does not need to be addressed separately."

- Section IV.P.(2) provides guidance on the performance assessment. "Detailed guidance on conducting performance assessments has been developed and is contained in DOE (1999a), *Format and Content Guide for U.S. Department of Energy Low-Level Disposal Facility Performance Assessments and Composite Analyses*. Guidance explicitly stated in the implementation guide includes:

  (1) The compliance time period is 1,000 years after the disposal facility has been closed. "This time was selected to encompass rates of processes likely to govern migration of radiochemical species most likely to contribute to calculated dose. Longer times of assessments are not to be used to assess compliance because of the inherent large uncertainties in extrapolating calculations over long time frames."

  (2) "Performance assessment analyses should be based on reasonable activities of the portion of the exposed population likely to receive the highest dose (i.e., the critical group). The performance assessment analyses should not be based on "worst case" assumptions. Rather, the analyses should be based on scenarios that represent reasonable actions of a typical group of individuals performing activities that are consistent with regional social customs, work, and housing practices, and expected regional environmental conditions at the time of the exposure scenario."

  (3) "The concept of a buffer zone is inherent in defining a low-level waste disposal facility. The disposal facility is comprised of a number of disposal units." "Setting the extent of the buffer zone at 100 meters is somewhat arbitrary, but 100 meters is considered to be sufficient, but not unreasonably large, for the stated purposes." "In certain cases, e.g., if the disposal facility is located adjacent to the current DOE site boundary, it may be more appropriate to use a smaller buffer zone. In other cases, e.g., where the disposal facility is located far from the DOE site boundary, and the site's land use planning does not envision relinquishing control of the site, a larger buffer zone could be considered."

  (4) Natural processes "might disrupt the intended performance of the disposal facility, but such consideration should be limited to those processes which are foreseeable." Examples of such natural processes are corrosion which "will, in time, breach most containers; environmental conditions, will, in time, consume the capacity of chemical buffers, and burrowing animals and root intrusion will eventually breach disposal facility caps." "Other processes or events, although not regularly occurring, are, nonetheless, reasonably foreseeable. Such events would include severe weather such as flooding (e.g., 100 year flood, probable maximum flood), and seismic events. Other processes, such as climate change, are considered to be too speculative for consideration in the performance assessment."

(5) Dose calculations are "for adults (i.e., Reference Man). The actual dose to a particular individual from a given exposure to radioactive material is dependent on a number of characteristics, including age and sex. However, doses are not to be predicted for specific individuals or classes of persons. Rather, the calculations are to represent potential exposures to hypothetical future members of the public."

(6) "Performance assessments should include ALARA focus on alternatives for low-level waste disposal. The alternatives considered might consider the use of different disposal unit covers, waste forms, containers, or other alternatives (e.g., concrete vaults versus earthen trenches) consistent with the situation being addressed. The rigor of the ALARA assessment and its analysis of alternatives should be commensurate with the magnitude of the risk and decisions to be made."

(7) "The hierarchy for establishing water resource protection performance measures is:

- First, the DOE LLW disposal facility must comply with any applicable State or local law, regulation, or legally applicable requirements for water resource protection.
- Second, the DOE LLW disposal facility should comply with any formal agreement applicable to water resource protection that is made with appropriate State or local officials.
- Third, if neither the above conditions apply, the site should select assumptions for use in the performance assessment based on criteria established in the site groundwater protection management program and any formal land-use plans.
- If none of the above conditions apply, the site should identify a performance measure for protection of water resources that is consistent with the use of water as a drinking water source. Examples of this type of performance measure would be the assumption of the concentration limits in 40 CFR 141 or a dose limit of 4 mrem per year above background from the ingestion of water."

(8) "Although DOE is committed to retaining control of land containing residual radioactive material, such as disposed low-level waste, it is nonetheless appropriate to consider the impacts of potential inadvertent intrusion. Intrusion can be considered either as an accident scenario which could occur during lapses of institutional control or as a hypothetical situation assumed simply to provide a basis for establishing control over the concentration of radioactive material acceptable in a near-surface disposal facility."

"Institutional control should be assumed to be effective in preventing intrusion for 100 years following disposal facility closure. Longer periods may be assumed with justification (e.g., land-use planning, passive controls)."

"Development of intruder scenarios should be based on the following assumptions:

- Intruders could carry out activities for no more than about a year before discovery.

- An intruder performs reasonable activities consistent with regional social customs and well drilling, excavation, and construction practices, and the regional environmental conditions projected for the time that intrusion is assumed to occur.
- Intrusion events involve random contact with waste.
- An intruder will take reasonable, investigative actions upon discovery of unusual materials.
- Intrusion events that contact waste should normally be assumed to be limited to drilling or simple extraction scenarios involving use of relatively unsophisticated tools and commonplace machinery.
- Doses calculated for an intruder will depend on waste disposal facility design and operating practices, and may be reduced by practices such as disposal below depths normally associated with common construction activities, use of intruder barriers or durable waste forms or containers, or distributed disposal of higher activity waste."

"The inadvertent intruder assessment should, at a minimum, include consideration of an acute construction scenario, an acute well drilling scenario, and a chronic agricultural scenario."

B1.4 TECHNICAL BASIS FOR DOE M 435.1

- Further information is given in Appendix A, "Technical Basis and Considerations for DOE M 435.1-1," of DOE (1999b). In particular, the sections on the performance objectives and performance assessment give justification for the approach taken and the values used.

  1) The requirement of an all-pathways effective dose equivalent "is consistent with established radiation protection practice that allocates a fraction of the 100 mrem/yr public dose to a particular practice or activity. It is also consistent with the regulatory practice of the NRC to require all-pathways assessments, and this is consistent with the NRC low-level waste disposal facility licensing regulations at 10 CFR 61."

  2) The requirement on groundwater protection "provides defense in depth to the all-pathways performance objective." "Guidance developed for this requirement describes a tiered structure for its application. The guidance is based on the recognition that at the current time, there are no applicable Federal regulations. Therefore, the emphasis is to be consistent with the site's groundwater protection management program. Also, the role of future use commitments between DOE and other authorities in the management of water resources may provide a sound basis for making decisions."

  3) The time period for compliance (1,000 years after closure) "was selected after consideration of the times used in other regulations (e.g., 40 CFR 191, 40 CFR 192), and recognition of the uncertainties and hypothetical nature of long-term projections." To date, DOE, NRC, and the U.S. Environmental

Protection Agency (EPA) have not specified a time of compliance for low-level waste disposal facility performance assessments. A team composed of primarily of DOE contractor performance assessment staff evaluated the options for a time of compliance. This time was consistent with the time specified on 40 CFR 191, "Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes," for high-level and transuranic waste disposal, and was considered to be conservative in that no longer times had been seriously proposed. This time or longer times had been used in DOE disposal facility performance assessments conducted up to that time. Subsequently, EPA asked agency reviewers for their opinions on the use of 10,000, 1,000, or some other time frame as the time of compliance for low-level waste disposal facility performance assessments. DOE responded that its position was that 1,000 years was an appropriate time."

4) The "point of compliance is consistent with regulatory positions included in 40 CFR 192.32 and 40 CFR 264.95. The NRC regulation at 10 CFR 61.52(a)(8) states that a 'buffer zone of land must be maintained between any buried waste and the disposal site boundary ...' In NUREG-1200, section 4.3.6 [NRC 1988] it is recommended that this buffer be at least 30 m wide. 40 CFR 192.32 permits the establishment of alternative concentration limits that are as low as reasonable and meet the standards of 40 CFR 264.94(a) at all points at a greater distance than 500 meters from the edge of the disposal area and/or outside the site boundary."

5) "The rationale for using standard adult dose conversion factors comes from the fact that in a performance assessment one is calculating a postulated dose to a hypothetical future person assumed to be engaged in a set of 'normal' activities over a period of years. Consequently, performing calculations as if real people of known age were being impacted by releases from the facility is not reasonable."

6) "In addition to calculations over the time of compliance (1000 years), performance assessments also are to present calculations of maxima relative to each of the performance objectives. The results of these calculations are part of the sensitivity and uncertainty analysis which would support a conclusion that the model is providing a reasonable projection. These longer calculations address the need to ensure that there are no unexpected significant increases shortly after the time of compliance and provide a mechanism for understanding the model performance and significance of modeling parameters. The calculation of maxima does present the possibility that there may be results that exceed the performance objectives. The significance of these results must be handled with caution and judgment. The further out in time that the maxima occurs, the less significant is the relationship to the performance objective."

"This requirement represents a DOE policy decision; it derives in part from IAEA Fundamental Principles of Radioactive Waste Management."

7) "The use of the ALARA concept in long-term assessments is a best management practice that contributes defense-in-depth to the possible exposures from a disposal facility. Application of the ALARA principle for managing current operational exposures has practical and measurable merit in that real doses are being avoided or

reduced. This concept is extended here by addressing projected releases of materials well into the future which may result in doses."

8) "The concept of protection of inadvertent intrusion is consistent with national and international practice (NRCP, ICRP, IAEA). The NRC included the protection of inadvertent intruders as one of the performance objectives in 10 CFR 61. Other international and national organizations have and continue to include the protection of inadvertent intruders as one of the elements of radiation protection."

"Since the intent of the Department is to control the use of the land where low-level waste is disposed until the land can be released, inadvertent intruder calculations provide defense-in-depth by limiting the concentration of waste that can be disposed of in the near surface. With each performance assessment evaluating and developing limits for near-surface disposal, DOE is more cost-effective in managing waste and is consistent with the philosophy of using performance based requirements."

B2.0 WASHINGTON STATE DANGEROUS WASTE REGULATIONS

B2.1 INTRODUCTION

- WAC 173-303, "Dangerous Waste Regulations," "implements chapter 70.105 RCW, the Hazardous Waste Management Act of 1976 as amended, and implements in part chapters 70.105A, 70.105D, and 15.54 RCW, and subtitle C of Public Law 94-580, the Resource Conservation and Recovery Act, ..." (Section 010). Section 10 also states "The purposes of this regulation are to ... (4) establish the siting, design, operation, closure, post-closure, financial, and monitoring requirements for dangerous and extremely hazardous waste transfer, treatment, storage, and disposal facilities; ...; (6) establish and administer a program for permitting dangerous and extremely dangerous waste management facilities; ..."

- Dangerous and extremely hazardous wastes are defined in Sections 70 through 100 of the regulation. In general, Hanford tank wastes are considered dangerous or extremely hazardous wastes. As noted in Section 70(2)(a), "once a material has been determined to be a dangerous waste, then any solid waste generated from the recycling, treatment, storage, or disposal of that dangerous waste is a dangerous waste unless and until ..." a specific action agreed to by the state has occurred.

- Although Section 160 does not apply to Hanford tanks – the section applies to containers, which are portable devices – it gives insight into the definition of empty. By section 160(2), "A container or inner liner is "empty" when: (a) All wastes in it have been taken out that can be removed using practices commonly employed to remove materials from that type of container or inner liner (e.g., pouring, pumping, aspirating, etc.) and, no more than one inch of waste remains at the bottom of the container or inner, or ... if the container's total capacity is greater than one hundred ten gallons, the volume of waste remaining in the container or inner liner is no more than 0.3 percent of the container's total capacity." For 100-series tanks, which have a diameter of 75 ft, the tank would be empty if the tank had less than 367 ft^3. For 200-series tanks, which have a diameter of 20 ft, the corresponding volume is 27 ft^3. The *Hanford Federal Facility Agreement and Consent Order* (HFFACO) [Ecology et al. 1989]requirements for maximum volume after retrieval (see Milestone M-45-00) are 360 ft^3 for 100-series tanks and a volume of 30 ft^3 for 200-series tanks, unless the Appendix H process of the HFFACO is implemented on the tank.

B2.2 CLOSURE AND POSTCLOSURE

- Sub-section (2) of WAC 173-303-610, "Closure and Post-Closure," requires as a closure performance standard that "the owner or operator must close the facility in a manner that:

  (a) (i) Minimizes the need for further maintenance;

  (ii) Controls, minimizes, or eliminates 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 to the ground, surface water, ground water, or the atmosphere; and

(iii) returns the land to the appearance and use of surrounding land areas to the degree possible given the nature of the previous dangerous waste activity.

(b) Where the closure requirements of this sections, or of ...[various WAC 173-303 sections] or 40 CFR 264.1102 (incorporated by reference at WAC 173-303-695) call for the removal or decontamination of dangerous wastes, wastes residuals, or equipment, bases, liners, soils, or other materials containing or contaminated with dangerous wastes or waste residue, then such removal or decontamination must assure that the levels of dangerous waste or dangerous waste constituents or residuals do not exceed:

(i) For soils, ground water, surface, and air, the numeric cleanup levels calculated using residual residential exposure assumptions according to the Model Toxic Control Act Regulations, Chapter 173-340 WAC as now or hereafter amended. Primarily, these will be numeric cleanups calculated according to MTCA Method B, although MTCA Method A may be used as appropriate, see WAC 173-340-700 through 173-340-760, excluding WAC 173-340-745; and

(ii) For all structures, equipment, bases, and liners, etc., clean closure standards will be set by the department on a case-by-case basis in accordance with the closure performance standards of WAC 173-303-610(2)(a)(ii) and in a manner that minimizes or eliminates post-closure escape of dangerous waste constituents."

- Section 610(3) provides the requirements of the closure plan. Section 610(4) provides schedule requirements. Section 610(5) provides general requirements for the disposal or decontamination of equipment, structures, and soils, while (6) deals with the certificate of closure. Section 610(7)(a) states post-closure care "must continue for thirty years" after closure. Section 610(7)(b) allows the Washington State Department of Ecology (Ecology) to shorten or lengthen that time.

- Section 640(4) provides requirements for containment and detection of releases from tanks. Section 640 (8)(a) requires "At closure of a tank system, the owner or operator must remove or decontaminate all waste residues, contaminated containment system components (liners, etc.), contaminated soils, and structures and equipment contaminated with waste, and manage them as dangerous waste, unless WAC 173-303-070(2)(a) applies. The closure plan, closure activities, cost estimates for closure, and financial responsibility for tank systems must meet all requirements specified in WAC 173-303-610 and WAC-173-303-620." Section 640(8)(b) goes on to state: "If the owner or operator demonstrates that not all contaminated soils can be practically removed or decontaminated as required in (a) of this sub-section, then the owner or operator must close the tank system and perform post-closure care in accordance with the closure and post-closure care requirements that apply to landfills (see WAC 173-303-665(6)). In addition, for purposes of closure, post-closure, and financial responsibility, such a tank system is then considered to be a landfill, and the owner or operator must meet all of the

requirements for landfills specified in WAC 173-303-610 and 173-303-620." Section 640(8)(c) requires compliance with 640(8)(a) and (b) for tanks that do not have secondary containment.

- Section 645 governs the releases from regulated facilities unless exempt according to WAC 173-303-2(a). Sub-section 3 describes the groundwater protection standard in general terms. Sub-section 4 authorizes Ecology to specify the contaminants of concern in the permit. Sub-section 5 provides concentration limits. The sub-section states: "The concentration of a dangerous constituent (i) must not exceed the background level of that constituent in the ground water at the time that limit is specified in the permit; or (ii) for any of the constituents listed in Table 1 of this sub-section, must not exceed the respective value given in that table if the background level of the constituent is below the value given in Table 1; or (iii) must not exceed an alternate limit established by the department under (b) of this sub-section." Table 1 is reproduced as Table C-6. Sub-section (b) states: "The Department will establish an alternate concentration limit for a dangerous constituent if it finds that the constituent will not pose a substantial present or potential hazard to human health or the environment as long as the alternate concentration limit is not exceeded."

- Sub-section (6) defines the point of compliance with "The department will specify in the facility permit the point of compliance at which the ground water protection standard of sub-section (3) of this section, applies and at which monitoring must be conducted. The point of compliance is a vertical surface located at the hydraulically downgradient limit of the waste management area that extends down into the uppermost aquifer underlying the regulated units. Alternatively, the point of compliance may be any closer points identified by the department at the time the permit is issued, considering the risks of the facility, the wastes and constituents managed there, the potential for waste constituents to have already migrated past the alternate compliance point, and the potential threats to the ground and surface waters. Sub-section (7) defines the time of compliance as "the compliance period during which the ground water protection of sub-section (3) of this section applies." Sub-sections (8) through (11) provide general groundwater monitoring requirements. In particular, sub-section (11) describes the requirements for a corrective action program. Section 646 furthers describes "corrective actions."

B2.3 AIR EMISSIONS

WAC 173-303-692, "Air Emission Standards for Tanks, Surface Impoundments, and Containers," applies the requirements of 40 CFR 264, Subpart CC, "Air Emission Standards for Tanks, Surface Impoundments, and Containers."

B2.4 HANFORD SITE REQUIREMENTS

WAC 173-303, Section 700, (Requirements for the Washington State extremely hazardous waste management at Hanford) sets no performance objectives, but rather deals with administrative matters.

B3.0 MODEL TOXICS CONTROL ACT

- WAC 173-340 is "promulgated under the Model Toxic Controls Act [RCW 70.105D]. It establishes administrative processes and standards to identify, investigate, and clean up facilities where hazardous substances have come to be located. ... This chapter is primarily intended to address releases of hazardous substances caused by past activities although its provisions may be applied to potential and ongoing releases of hazardous substances from current activities (Section 100) ... If hazardous substances remain at a facility after actions have been completed under other applicable laws or regulations, this chapter may be applied to protect human health or the environment" (Section 110). Relevant hazardous substances are defined or designated under 70.105 RCW or Section 101 (14) of the federal cleanup law, 42 U.S.C., Sec. 9601 (14) [CERCLA] and includes radioactive isotopes and hazardous chemicals."

- Under Part VII, "Cleanup Standards," cleanup standards are defined as ARARs under CERCLA actions.

- Part VII of WAC 173-340 establishes cleanup standards that "consist of the following: 1) cleanup levels for hazardous substances present at the site, 2) the location where these cleanup levels must be met (point of compliance), and 3) other regulatory requirements that apply to the site because of the type of action and / or location of the site (applicable state and federal laws)." "The cleanup level is the concentration of a hazardous substance in soil, water, air, or sediment that is determined to be protective of human health and the environment under specific exposure conditions."

- Three methods are defined under this section for establishing cleanup levels. Method A "may be used to establish cleanup levels at sites that have few hazardous substances and that meet one of the following criteria:

  a) Sites undergoing a routine cleanup action as defined in WAC 173-340-200, or

  b) Sites where numerical standards are available for all indicator hazardous substances in the media for which the Method A cleanup level is being used."

- This method provides a tabular list of concentrations for the different media (groundwater, soil, surface water, and air).

- Method B (Universal Method) "applies to all media at all sites." Under Method B, "cleanup levels shall be at least as stringent as all of the following:

  a) Concentrations of individual hazardous substances established under applicable state and federal laws,

  b) Concentrations that are estimated to result in no adverse effects on the protection and propagation of aquatic life, and no significant adverse effects of terrestrial ecological receptors using the procedures specified in WAC 173-340-7490 through 173-340-7494,

c) For hazardous substances for which sufficiently protective health-based criteria or standards have not been established under applicable state and federal laws, those concentrations which protect human health as determined by the following methods:

1) Concentrations that are estimated to result in no acute or chronic toxic effects on human health as determined using hazard quotient of 1 and the procedures specified in WAC 173-340-720 through 173-340-760

2) For known or suspected carcinogens, concentrations for which the upper bound on the estimated excess cancer risk is less than or equal to one in one million as determined the procedures specified in WAC 173-340-720 through 173-340-760

3) Concentrations that eliminate or minimize the potential for food chain contamination as necessary to protect human health."

- Method C (Conditional Method) cleanup levels represent concentrations that are protective of human health and the environment for specified site uses and conditions. Each medium must be evaluated separately using the criteria applicable to that medium. Under Method C, cleanup levels for individual hazardous substances are established using applicable state and federal laws and the risk factor equations and other requirements specified in this Chapter. Under Method B, "cleanup levels shall be at least as stringent as all of the following:

a) Concentrations of individual hazardous substances established under applicable state and federal laws,

b) Concentrations that are estimated to result in no adverse effects on the protection and propagation of aquatic life, and no significant adverse effects of terrestrial ecological receptors using the procedures specified in WAC 173-340-7490 through 173-340-7494,

c) For hazardous substances for which sufficiently protective health-based criteria or standards have not been established under applicable state and federal laws, those concentrations which protect human health as determined by the following methods:

1) Concentrations that are estimated to result in no significant adverse acute or chronic toxic effects on human health as estimated using a hazard quotient of 1 and the procedures specified in WAC 173-340-720 through 173-340-760

2) For known or suspected carcinogens, concentrations for which the upper bound on the estimated excess cancer risk is less than or equal to one in one hundred thousand as determined using the procedures specified in WAC 173-340-720 through 173-340-760

3) Concentrations that eliminate or minimize the potential for food chain contamination as necessary to protect human health."

- The department may establish more stringent cleanup levels "when based on site specific evaluation the department determines such levels are necessary to protect human health and the environment. ... Concentrations of individual hazardous substances ..., including those based on applicable state and federal laws, shall be adjusted downward to

take into account exposure to multiple hazardous substances and/or exposures resulting from more than one pathway of exposure. These adjustments need to be made only if, without these adjustments, the hazard index would exceed one (1) or the total excess cancer risk would exceed one in one hundred thousand (1×10^{-5})."

- Section 708 "defines the risk assessment framework that shall be used to establish cleanup levels and remediation levels using a quantitative risk assessment ... Cleanup and remediation levels shall be based on estimates of current and future resource uses and reasonable maximum exposures expected to occur under both current and potential future site use conditions. ... WAC 1733-340-720 through 173-340-760 define the reasonable maximum exposures for groundwater, surface water, soil and air. ... Land uses other than residential and industrial shall not be used a basis for a reasonable maximum exposure scenario for the purposes of establishing a cleanup level. Estimated doses of individual hazardous substances resulting from more than one pathway of exposure are assumed to be additive."

- Section 708 prescribes reference doses, carcinogenic potency factors, bioconcentration factors and exposure parameters to be used in human health risk assessments. "For the purposes of establishing cleanup level and remediation levels, a reference dose/reference concentration established by the U.S. Environmental Protection Agency and available through the IRIS data base shall be used" (if available). Other EPA databases are referenced if the IRIS database does not include the hazardous substance. "For the purposes of establishing cleanup levels and remediation levels for hazardous substances, ...a carcinogenic potency factor established by the U.S. Environmental Protection Agency and available through IRIS shall be used." Other EPA databases are referenced if the IRIS database does not include the hazardous substance. "For the purposes of establishing cleanup levels and remediation levels for a hazardous substance under WAC 173-340-730 (Surface water cleanup standards) a bioconcentration factor established by the U.S. EPA and used to establish the ambient water quality criterion for that substance under section 304 of the *Clean Water Act* shall be used." "... the department has defined in WAC 173-340-720 through 173-340-760 the default values for exposure parameters to be used when establishing cleanup levels and remediation levels ..." Exceptions for these default values are explicitly defined in WAC 173-340-708 and 173-340-720 through 173-340-760. "Probabilistic risk assessment methods may be used only under this chapter on an informational basis for evaluating alternative remedies. Such methods shall not be used to replace cleanup standards and remediation levels derived using deterministic methods."

- Cleanup standards are established under WAC 173-340-720 through 173-340-760 for groundwater, surface water, unrestricted land use soil, industrial properties soil, air, and sediment cleanup. The procedures for determining cleanup levels are described for Methods A, B, and C. Points of compliance are established for the groundwater and surface water standards. Method B and Method C equations for estimating both carcinogenic and noncarcinogenetic limits on allowable concentrations are also provided for selected media.

- The Code also requires terrestrial ecological evaluations. "WAC 173-340-7490 through 173-340-7494 define the goals and procedures the department will use for:
  a) Determining whether a release of hazardous substances to the soil may pose a threat to the terrestrial environment;
  b) Characterizing existing or potential threats to terrestrial plants or animals exposed to hazardous substances in soil; and,
  c) Establishing site-specific cleanup standards to the protection of terrestrial plants and animals."
- No further ecological evaluation is required if the site meets any of the following criteria (WAC 173-340-7491): 1) "all soil contaminated with hazardous substances is or will be located below the point of compliance ... (an institutional control is not required if the contamination is at least fifteen feet below ground surface)," 2) "all soil contaminated with hazardous substances is or will be covered by buildings, paved roads, pavement, or other physical barriers that will prevent plants or wildlife from being exposed to the soil contaminations ...," 3) "where site conditions are related or connected to undeveloped land in the following manner: ..." such that there is limited undeveloped land, or the contamination includes specific hazardous substances, or 4) "the concentrations of hazardous substances do not exceed background levels as defined in WAC 173-340-709."

B4.0 COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT

(Text of Subchapter 1, section 9621, Cleanup Standards)

(a):

The President shall select appropriate remedial actions determined to be necessary to be carried out under section 9604 of this title or secured under section 9606 of this title which are in accordance with this section and, to the extent practicable, the national contingency plan, and which provide for cost-effective response."

(d)(1):

Remedial actions selected under this section or otherwise required or agreed to by the President under this chapter shall attain a degree of cleanup of hazardous substances, pollutants, and contaminants released into the environment and of control of further release at a minimum which assures protection of human health and the environment. Such remedial actions shall be relevant and appropriate under the circumstances presented by the release or threatened release of such substance, pollutant, or contaminant.

(d)(2)(A):

With respect to any hazardous substance, pollutant or contaminant that will remain onsite, if -

(i) any standard, requirement, criteria, or limitation under any Federal environmental law, including, but not limited to, the *Toxic Substances Control Act* (15 U.S.C. 2601 et seq.), the *Safe Drinking Water Act* (42 U.S.C. 300f et seq.), the *Clean Air Act* (42 U.S.C. 7401 et seq.), the *Clean Water Act* (33 U.S.C. 1251 et seq.), the *Marine Protection, Research and Sanctuaries Act* (16 U.S.C. 1431 et seq., 1447 et seq., 33 U.S.C. 1401 et seq., 2801 et seq.), or the *Solid Waste Disposal Act* (42 U.S.C. 6901 et seq.); or

(ii) any promulgated standard, requirement, criteria, or limitation under a State environmental or facility siting law that is more stringent than any Federal standard, requirement, criteria, or limitation, including each such State standard, requirement, criteria, or limitation contained in a program approved, authorized or delegated by the Administrator under a statute cited in subparagraph (A), and that has been identified to the President by the State in a timely manner,

is legally applicable to the hazardous substance or pollutant or contaminant concerned or is relevant and appropriate under the circumstances of the release or threatened release of such hazardous substance or pollutant or contaminant, the remedial action selected under section 9604 of this title or secured under section 9606 of this title shall require, at the completion of the remedial action, a level or standard of control for such hazardous substance or pollutant or contaminant which at least attains such legally applicable or relevant and appropriate standard, requirement, criteria, or limitation. Such remedial action shall require a level or standard of control which at least attains Maximum Contaminant Level Goals established under the *Safe Drinking Water Act* (42 U.S.C. 300f et seq.) and water quality criteria established under section 304 or 303 of the *Clean Water Act* (33 U.S.C. 1314, 1313), where such goals or criteria are relevant and appropriate under the circumstances of the release or threatened release.

B5.0 REFERENCES

10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Waste," *Code of Federal Regulations*, as amended.

- Subpart D, "Technical Requirements for Land Disposal Facilities," Sections 50 through 59.

10 CFR 835, "Occupational Radiation Protection," *Code of Federal Regulations*, as amended.

10 CFR 1021, "National Environmental Policy Act Implementing Procedures," *Code of Federal Regulations*, as amended.

40 CFR 141, "National Primary Drinking Water Regulations," *Code of Federal Regulations*, as amended.

40 CFR 191, "Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes," *Code of Federal Regulations*, as amended.

40 CFR 192, "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings," *Code of Federal Regulations*, as amended.

- Subpart D, "Standards for Management of Uranium Byproduct Materials Pursuant to Section 84 of the Atomic Energy Act of 1954, as Amended," Sections 30 through 34.

40 CFR 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations*, as amended.

- Subpart F, "Releases from Solid Waste Management Units," Sections 90 through 101
- Subpart CC, "Air Emission Standards for Tanks, Surface Impoundments, and Containers," Sections 1080 through 1091
- Subpart DD, "Containment Buildings," Sections 1100 through 1110.

Clean Air Act, 42 USC 7401 et seq. Online at http://www4.law.cornell.edu/uscode/42/7401.html.

Clean Water Act of 1977, Public Law 95-217, 91 Stat. 1566 and Public Law 96-148, et seq. *Clean Water Act of 1977*, 33 USC 1251, et seq. Online at http://www4.law.cornell.edu/uscode/33/ch26.html.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, Public Law 96-150, 94 Stat. 2767, Title 26, 42 USC 9601 et seq. *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 USC 9601 et seq. Online at http://www4.law.cornell.edu/uscode/42/ch103.html.

DOE 1999a. *Format and Content Guide for U.S. Department of Energy Low-Level Disposal Facility Performance Assessments and Composite Analyses*, U.S. Department of Energy, Washington, D.C.

DOE G 435.1-1, 1999b, *Implementation Guide for use with DOE M 435.1-1*, U.S. Department of Energy, Washington, D.C. Online at http://ww.directives.doe.gov.

DOE M 435.1-1, 2001c, *Radioactive Waste Management Manual*, U.S. Department of Energy, Washington, D.C. Online at http://ww.directives.doe.gov.

DOE O 420.1, 2000. *Facility Safety*, U.S. Department of Energy, Washington, D.C. Online at http://ww.directives.doe.gov.

DOE O 430.1A, 1998a. *Life Cycle Asset Management*, U.S. Department of Energy, Washington, D.C. Online at http://ww.directives.doe.gov.

DOE O 435.1, 2001b. *Radioactive Waste Management*, U.S. Department of Energy, Washington, D.C. Online at http://ww.directives.doe.gov.

DOE O 440.1A, 1998b. *Worker Protection Management for DOE Federal and Contractor Employees*, U.S. Department of Energy, Washington, D.C. Online at http://ww.directives.doe.gov.

DOE O 451.1A, 1997. *National Environmental Policy Act Compliance Program*, U.S. Department of Energy, Washington, D.C., June 5. Online at http://ww.directives.doe.gov.

DOE O 451.1B, 2001a. *National Environmental Policy Act Compliance Program*, U.S. Department of Energy, Washington, D.C. Online at http://ww.directives.doe.gov.

DOE O 5400.1, 1990. *General Environmental Protection Program*, Change 1, U.S. Department of Energy, Washington, D.C. Online at http://ww.directives.doe.gov.

DOE O 5400.5, 1993. *Radiation Protection of the Public and the Environment*, U.S. Department of Energy, Washington, D.C. DOE, 1993, *Radiation Protection of the Public and the Environment*, DOE Order 5400.5 Change 2, U.S. Department of Energy, Washington, D.C. Online at http://www.directives.doe.gov.

Ecology et al. 1989. Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order*, as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington. Online at http://www.hanford.gov/tpa/tpahome.htm.

Marine Protection, Research, and Sanctuaries Act, 16 USC 1431 et seq. Online at http://www4.law.cornell.edu/uscode/html/uscode/16/ch32.html.

NRC 1988. Standard Review Plan for the Review of a License Application for a Low-Level Radioactive Waste Disposal Facility, NUREG-1200, Rev. 1, U.S. Nuclear Regulatory Commission, Washington, D.C.

RCW 15.54, "Fertilizers, Minerals, and Limes," *Revised Code of Washington*, as amended.

RCW 70.105, "Hazardous Waste Management," *Revised Code of Washington*, as amended.

RCW 70.105A, "Hazardous Waste Fees," *Revised Code of Washington*, as amended.

RCW 70.105D, "Hazardous Waste Cleanup – Model Toxics Control Act," *Revised Code of Washington*, as amended.

Resource Conservation and Recovery Act of 1976, 42 USC 6901 et seq. Online at http://www4.law.cornell.edu/uscode/html/uscode/42/ch82.html.

Safe Drinking Water Act, 42 USC 300f et seq. Online at http://www4.law.cornell.edu/uscode/42/ch6AschXII.html.

Solid Waste Disposal Act, 42 USC 6901 et seq. Online at http://www4.law.cornell.edu/uscode/html/uscode/42/ch82.html.

Toxic Substances Control Act (TSCA), 15 USC 2601 et seq. Online at http://www4.law.cornell.edu/uscode/15/ch53.html.

WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code*, as amended.

- "Designation of Dangerous Waste," Section 070
- "Closure and Post-Closure," Section 610
- "Financial Requirements," Section 620
- "Landfills," Section 665
- "Air Emission Standards for Tanks, Surface Impoundments, and Containers," Section 692
- "Containment Buildings," Section 695.

WAC 173-340, "Model Toxics Control Act – Cleanup," *Washington Administrative Code*, as amended.

- "Definitions," Section 200.
- "Cleanup Standards," Part VII, Sections 700-760.

APPENDIX C

SUPPORTING TABLES

Values from Washington State Regulations are NOT reported when the state values are adopted by reference from the federal values. This reduces redundancy as the values from regulations are already stated.

These tables contain numeric values obtained from regulations and orders that impact the creation of performance assessments. The tables do not contain all numeric values (e.g., soil cleanup values determined, at least partially from performance assessments) that will be used in tank farm closure.

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Table C-1. Numeric Requirements for Protecting the Public from Radioactive Materials. (2 sheets)

DOE Order on Radioactive Waste Management DOE M 435.1-1 (DOE 2001)	
All-pathways (<1,000 years)	25 mrem/yr

DOE Order for Radiation Protection of the Public and the Environment DOE Order 5400.5(II)(1)(a) (DOE 1993)	
All-pathways (from all DOE facilities at the site)	100 mrem/yr

Federal Standards for Protection Against Radiation 10 CFR 20.1301	
All-pathways from action	100 mrem/yr
All-pathways from action	2 mrem/hr

Federal Licensing Requirements for the Land Disposal of Radioactive Waste 10 CFR 61.41	
All-pathways (whole body)	25 mrem/yr
All-pathways (thyroid)	75 mrem/yr
All-pathways (other organs)	25 mrem/yr

Washington State Radioactive Waste Licensing for Land Disposal WAC 246-250-170	
All-pathways (whole body)	25 mrem/yr
All-pathways (thyroid)	75 mrem/yr
All-pathways (other organs)	25 mrem/yr

Federal Standard for DOE Workers 10 CFR 835.208	
All-pathways-all sources (controlled area)	100 mrem/yr

Table C-1. Numeric Requirements for Protecting the Public from Radioactive Materials. (2 sheets)

CERCLA Guidance for Radiation Protection of the Public CERCLA,EPA 1999, WDOH 1997	
All-pathways	15 mrem/yr
Incremental lifetime cancer risk	10^{-4}

10 CFR 20.1301, "Dose Limits for Individual Members of the Public," *Code of Federal Regulations*, as amended.

10 CFR 61.41, "Protection of the General Population from Releases of Radioactivity," *Code of Federal Regulations*, as amended.

10 CFR 835.208, "Limits for Members of the Public Entering a Controlled Area," *Code of Federal Regulations*, as amended.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, Public Law 96-150, 94 Stat. 2767, Title 26, 42 USC 9601 et seq. Online at http://www4.law.cornell.edu/uscode/42/ch103.html.

DOE M 435.1-1, 2001. *Radioactive Waste Management Manual*, U.S. Department of Energy, Washington, D.C. Online at http://www.directives.doe.gov. [Chapter II, "Requirements for Radiation Protection of the Public and the Environment," Paragraph 1, "Public Dose Limits," Item a, "DOE Public Dose Limit—All Exposure Modes, All Sources of DOE Radiation"].

EPA 1999b. *Radiation Risk Assessment at CERCLA Sites: Q & A*, U.S. Environmental Protection Agency, Office of Emergency and Medical Response and Office of Solid Waste and Emergency Response, Washington, D.C.

WAC 246-250-170, "Protection of the General Population from Releases of Radioactivity," *Washington Administrative Code*, as amended.

WDOH 1997. *Hanford Guidance for Radiological Cleanup*, WDOH/320-015, Rev. 1, Interim Regulatory Guidance, Washington State Department of Health, Olympia, Washington.

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980.*
DOE = U.S. Department of Energy.

Table C-2. Numeric Requirements for Protecting the Public from Hazardous Chemicals.

CERCLA Standard for Risk 40 CFR 300.430(e)(2)(i)(A)(2)	
Carcinogens (excess lifetime cancer risk) (single material)	10^{-6}
Carcinogens (excess lifetime cancer risk) (multiple materials)	10^{-4}

Washington State Model Toxics Control Act WAC 173-340(720-760)	
Carcinogens (excess lifetime cancer risk) (single chemical)	10^{-6}
Carcinogens (excess lifetime cancer risk) (multiple chemicals)	10^{-5}
Hazard index (noncarcinogen)	1.0

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980.*

40 CFR 300.430, "Remedial Investigation/Feasibility Study and Selection of Remedy," Section (e), "Feasibility Study," Item (2)(i)(A)(2), *Code of Federal Regulations*, as amended.

WAC 173-340, "Model Toxics Control Act – Cleanup," Part VII, "Cleanup Standards," Sections 720-760, *Washington Administrative Code*, as amended.

Table C-3. Numeric Requirements of Relevant Worker Protection Regulations.

Federal Standard for DOE Workers 10 CFR 835, Subpart C	
All-pathways (effective dose equivalent)	5,000 mrem/yr
Sum of deep dose equivalent for external exposures and the committed dose equivalent to any organ or tissue other than the lens of the eye	50,000 mrem
Lens of the eye (dose equivalent)	15,000 mrem
Shallow dose equivalent to the skin or any extremity	50,000 mrem
Embryo/fetus	500 mrem
Minor	500 mrem/yr
Air Dose	5,000 mrem/yr

Federal Standards for Protection Against Radiation 10 CFR 20, Subpart C	
All-pathways (effective dose equivalent)	5,000 mrem/yr
Sum of deep dose equivalent for external exposures and the committed dose equivalent to any organ or tissue other than the lens of the eye	50,000 mrem
Lens of the eye (dose equivalent)	15,000 mrem
Shallow dose equivalent to the skin or any extremity	50,000 mrem
Minor (10% of above)	500 mrem/yr
Embryo/fetus	500 mrem
Air dose	5,000 mrem/yr
Uranium intake to body	10 mg/week

Washington State Radiation Protection Standards WAC 246-221-010	
All-pathways	5,000 mrem/yr
Sum of deep dose equivalent for external exposures and the committed dose equivalent to any organ or tissue other than the lens of the eye	50,000 mrem
Lens of the eye (annual limit)	15,000 mrem
Shallow dose equivalent to the skin or any extremity (annual limit)	50,000 mrem
Uranium intake to body	10 mg/week

DOE = U.S. Department of Energy.

10 CFR 20, "Standards for Protection Against Radiation," Subpart C, "Occupational Dose Limits," Sections 1201 through 1208, *Code of Federal Regulations*, as amended.

10 CFR 835, "Occupational Radiation Protection," Subpart C, "Standards for Internal and External Exposure," Sections 201 through 209, *Code of Federal Regulations*, as amended.

WAC 246-221-010, "Occupational Dose Limits for Adults," *Washington Administrative Code*, as amended.

Table C-4. Numeric Requirements for Protecting an Inadvertent Intruder.

DOE Order on Radioactive Waste Management DOE M 435.1-1 (DOE 2001)	
Intruder (> 100 years or larger)	100 mrem/yr (continuous)
Intruder (> 100 years or larger)	500 mrem (single event)

Federal Licensing Requirements for the Land Disposal of Radioactive Waste 10 CFR 61.41	
Only Class C LLW disposal	See Table C-10

10 CFR 61.41, "Protection of the General Population from Releases of Radioactivity," *Code of Federal Regulations*, as amended.

DOE M 435.1-1, 2001. *Radioactive Waste Management Manual*, U.S. Department of Energy, Washington, D.C. Online at http://www.directives.doe.gov.

DOE = U.S. Department of Energy.

LLW = low-level waste.

Table C-5. Numeric Requirements of Relevant Drinking Water Regulations. (4 sheets)

DOE Order for Radiation Protection of the Public and the Environment DOE Order 5400.5 (II)(d) (DOE 1993)	
Radionuclides	4 mrem/year
Ra-226 plus Radium-228	5×10^{-9} µCi/ml (= 5 pCi/l)
Alpha emitters (but not Rn nor U)	1.5×10^{-8} µCi/ml (= 15 pCi/l)

National Primary Drinking Water Regulations 40 CFR 141.XX		
40 CFR 141.11		
Arsenic		0.05 mg/l
40 CFR 141.66 (Effective 12/8/2003)		
Ra-226+Ra-228		5 pCi/l
Alpha activity (except Rn and U)		15 pCi/l
Beta and photon activity (2 L/d)		4 mrem/yr
H-3		20,000 pCi/l
Sr-90		8 pCi/l
Uranium		30 µg/l
40 CFR 141.61		
CAS #	**Constituent**	**Limit**
50-32-8	Benzo[a]pyrene	0.0002 mg/l
56-23-5	Carbon tetrachloride [a]	0.005 mg/l
57-74-9	Chlordane	0.002 mg/l
71-43-2	Benzene [a]	0.005 mg/l
71-55-6	1,1,1-Trichloroethane [a]	0.2 mg/l
72-20-8	Endrin	0.002 mg/l
72-43-5	Methoxychlor	0.04 mg/l
75-01-4	Vinyl chloride	0.002 mg/l
75-35-4	1,1-Dichloroethylene [a]	0.007 mg/l
75-09-2	Dichloromethane (Methylene Chloride) [a]	0.005 mg/l
75-99-0	Dalapon	0.2 mg/l
76-44-8	Heptachlor	0.0004 mg/l
77-47-4	Hexachlorocyclopentadiene	0.05 mg/l
78-87-5	1,2-Dichloropropane	0.005 mg/l
79-00-5	1,1,2-Trichloroethane [a]	0.005 mg/l
79-01-6	Trichloroethylene [a]	0.005 mg/l
85-00-7	Diquat	0.02 mg/l
87-86-5	Pentachlorophenol	0.001 mg/l
88-85-7	Dinoseb	0.007 mg/l

Table C-5. Numeric Requirements of Relevant Drinking Water Regulations. (4 sheets)

National Primary Drinking Water Regulations 40 CFR 141.XX (Cont'd)		
40 CFR 141.61 (Cont'd)		
CAS #	**Constituent**	**Limit**
90-50-1	σ-Dichlorobenzene	0.06 mg/l
93-72-1	2,4,5-TP	0.05 mg/l
94-75-7	2,4-D	0.07 mg/l
95-47-6	o-Xylene [a]	0.7 mg/l
96-12-8	Dibromochloropane	0.00002 mg/l
100-41-4	Ethyl benzene [a]	0.7 mg/l
100-42-5	Styrene	0.1 mg/l
103-23-1	Di(2-ethylhexyl) adipate	0.4 mg/l
106-46-7	para Dichlorobenzene [a]	0.075 mg/l
106-93-4	Ethylene dibromide [a]	0.00005 mg/l
107-06-2	1,2 Dichloroethane	0.005 mg/l
108-74-1	Hexachlorbenzene	0.001 mg/l
108-88-3	Toluene [a]	1.0 mg/l
108-90-7	Monochlorobenzene	0.1 mg/l
116-06-3	Aldicarb	0.003 mg/l
117-81-7	Di(2-ethylhexyl) phthalate [a]	0.006 mg/l
120-82-1	1,2,4-Trichloro-benzene	0.07 mg/l
122-34-9	Simazine	0.004 mg/l
127-18-4	1,1,2,2-Tetrachloroethene	0.005 mg/l
145-73-3	Endothall	0.1 mg/l
156-59-2	Cis-1,2-Dichloroethylene	0.07 mg/l
156-60-5	Trans-1,2-Dichloroethylene	0.1 mg/l
1024-57-3	Heptachlor epoxide	0.0002 mg/l
1071-53-6	Glyphosate	0.7 mg/l
1330-20-7	Xylenes (total) [a]	10.0 mg/l
1336-36-3	Polychlorinated biphenyls	0.0005 mg/l
1563-66-2	Carbofuran	0.04 mg/l
1646-87-3	Aldicarb sulfoxide	0.004 mg/l
1656-87-4	Aldicarb sulfone	0.002 mg/l
1746-01-6	2,3,7,8-TCDD (Dioxin)	3×10^{-8} mg/l
1912-24-9	Atrazine	0.003 mg/l
1918-02-1	Picloram	0.5 mg/l
8001-35-2	Toxaphene	0.003 mg/l
15972-60-8	Alachlor	0.002 mg/l
23235-22-0	Oxamyl (Vydate)	0.2 mg/l

Table C-5. Numeric Requirements of Relevant Drinking Water Regulations. (4 sheets)

National Primary Drinking Water Regulations 40 CFR 141.XX (Cont'd)			
40 CFR 141.62			
Antimony	0.006 mg/l	Barium	2.0 mg/l
Beryllium	0.004 mg/l	Cadmium	0.005 mg/l
Chromium (total)	0.1 mg/l	Cyanide	0.2 mg/l
Fluoride	4.0 mg/l	Mercury	0.002 mg/l
Nitrate (as N)	10.0 mg/l	Nitrite (as N)	1.0 mg/l
Nitrate + Nitrite (as N)	10.0 mg/l	Selenium	0.05 mg/l
Thallium	0.002 mg/l	—	—

National Secondary Drinking Water Regulations 40 CFR 143.3			
Aluminum	0.05 to 0.2 mg/l	Chloride	250.0 mg/l
Copper	1.0 mg/l	Fluoride	2.0 mg/l
Iron	0.3 mg/l	Manganese	0.05 mg/l
Silver	0.1 mg/l	Sulfate	250.0 mg/l
Zinc	5.0 mg/l	—	—

CERCLA Standard for Risk 40 CFR 300.430(e)(2)(i)(B)			
Maximum contaminant level goals greater than zero shall be attained			
Washington State Public Water Supplies Regulation WAC 246-290-310(3)			
Antimony	0.006 mg/l	Arsenic	0.05 mg/l
Barium	2.0 mg/l	Beryllium	0.004 mg/l
Cadmium	0.005 mg/l	Chloride	250.0 mg/l
Chromium	0.1 mg/l	Cyanide	0.2 mg/l
Fluoride	2.0 mg/l	Iron	0.3 mg/l
Manganese	0.05 mg/l	Mercury	0.002 mg/l
Nickel	0.1 mg/l	Nitrate (as N)	10.0 mg/l
Nitrite (as N)	1.0 mg/l	Selenium	0.05 mg/l
Silver	0.1 mg/l	Sulfate	250.0 mg/l
Thalium	0.002 mg/l	Zinc	5.0 mg/l

Table C-5. Numeric Requirements of Relevant Drinking Water Regulations. (4 sheets)

[a] Organic compounds whose vapor was detected in more than 100 independent samples from tank waste or who have been detected more than 20 times in the solid or liquid phase, as entered into the TWINS database. Data taken from Table B.1 of Wiemers, K.D., M.E. Lerchen, M. Miller, and K. Meier, 1998, *Regulatory Data Quality Objectives Supporting Tank Waste Remediation System Privatization Project*, PNNL-12040, Rev. 0, Pacific Northwest National Laboratory, Richland, Washington, October.

40 CFR 141, "National Primary Drinking Water Regulations," *Code of Federal Regulations*, as amended.

40 CFR 141, Subpart F, "Maximum Contaminant Level Goals and Maximum Residual Disinfectant Level Goals," Sections 51 through 55," *Code of Federal Regulations*, as amended.

40 CFR 141.11, "Maximum Contaminant Levels for Inorganic Chemicals," *Code of Federal Regulations*, as amended.

40 CFR 141.61, "Maximum Contaminant Levels for Organic Contaminants," *Code of Federal Regulations*, as amended.

40 CFR 141.62, "Maximum Contaminant Levels for Inorganic Contaminants," *Code of Federal Regulations*, as amended.

40 CFR 141.66, "Maximum Contaminant Levels for Radionuclides," *Code of Federal Regulations*, as amended.

40 CFR 143.3, "Secondary Maximum Contaminant Levels," *Code of Federal Regulations*, as amended.

40 CFR 300.430, "Remedial Investigation/Feasibility Study and Selection of Remedy," Section (e), "Feasibility Study," Item (2)(i)(B), *Code of Federal Regulations*, as amended.

DOE Order 5400.5, 1993, *Radiation Protection of the Public and the Environment*, U.S. Department of Energy, Washington, D.C. [Chapter II, "Requirements for Radiation Protection of the Public and the Environment," 1(d)]

WAC 246-290-310, "Maximum Contaminant Levels (MCLs) and Maximum Residual Disinfectant Levels (MRDLs)," Section 3, "Inorganic Chemical and Physical," *Washington Administrative Code*, as amended.

CAS = Chemical Abstract Service.
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980.*
DOE = U.S. Department of Energy.
TWINS = Tank Waste Information Network System.

Table C-6. Numeric Requirements of Relevant Groundwater Regulations. (4 sheets)

Federal Land Disposal Restrictions Regulations 40 CFR 264.94			
Arsenic	0.05 mg/l	Barium	1.0 mg/l
Cadmium	0.01 mg/l	Chromium	0.05 mg/l
Lead	0.05 mg/l	Mercury	0.002 mg/l
Selenium	0.01 mg/l	Silver	0.05 mg/l
Endrin	0.0002 mg/l	Lindane	0.004 mg/l
Methoxyclor	0.1 mg/l	Toxaphene	0.005 mg/l
2,4-D	0.1 mg/l	2,4,5-TP Silvex	0.01 mg/l

Water Quality Standards for the Groundwaters of the State of Washington WAC 173-200-040			
Alpha emitters			15 pCi/l
Beta emitters			50 pCi/l
H-3			20,000 pCi/l
Sr-90			8 pCi/l
Ra 226 plus Ra-228			5 pCi/l
Ra 226			3 pCi/l
Chemical			
Arsenic	0.00005 mg/l	Barium	1 mg/l
Cadmium	0.01 mg/l	Chloride	250.0 mg/l
Chromium	0.05 mg/l	Copper	1.0 mg/l
Fluoride	4.0 mg/l	Iron	0.30 mg/l
Lead	0.05 mg/l	Manganese	0.05 mg/l
Mercury	0.002 mg/l	Selenium	0.01 mg/l
Silver	0.05 mg/l	Zinc	5.0 mg/l
Sulfate (SO4)	250.0 mg/l	Nitrate (as N)	10.0 mg/l
2-4 D			0.10 mg/l
2,4,5-TP Silvex			0.01 mg/l
Acrylamide			0.00002 mg/l
Acrylonitrile			0.00007 mg/l
Aldrin			0.000005 mg/l
Aniline			0.014 mg/l
Aramite			0.003 mg/l
Azobenzene			0.0007 mg/l
Benzene [a]			0.001 mg/l
Benzidine			0.0000004 mg/l
Benzo(a)pyrene			0.000008 mg/l
Benzotrichloride			0.000007 mg/l
Benzyl chloride			0.0005 mg/l
Bis(chloroethyl)ether			0.00007 mg/l

Table C-6. Numeric Requirements of Relevant Groundwater Regulations. (4 sheets)

Water Quality Standards for the Groundwaters of the State of Washington WAC 173-200-040	
Bis(chloromethyl)ether	0.0000004 mg/l
Bis(2-ethylhexyl)phthalate [a]	0.006 mg/l
Bromodichloromethane	0.0003 mg/l
Bromoform	0.005 mg/l
Carbazole	0.005 mg/l
Carbon tetrachloride [a]	0.0003 mg/l
Chlordane	0.00006 mg/l
Chlorodibromomethane	0.0005 mg/l
Chloroform [a]	0.007 mg/l
4 Chloro-2-methyl aniline	0.0001 mg/l
4 Chloro-2-methyl analine hydrochloride	0.0002 mg/l
o-Chloronitrobenzene	0.003 mg/l
p-Chloronitrobenzene	0.005 mg/l
Chlorthalonil	0.030 mg/l
Diallate	0.001 mg/l
DDT (includes DDE and DDD)	0.0003 mg/l
1,2 Dibromomethane	0.000001 mg/l
1,4-Dichlorobenzene [a]	0.004 mg/l
3,3' Dichlorobenzidine	0.0002 mg/l
1,1 Dichloroethane [a]	0.001 mg/l
1,2 Dichloroethane (ethylene chloride)	0.0005 mg/l
1,2 Dichloropropane	0.0006 mg/l
1,3 Dichloropropene	0.0002 mg/l
Dichlorvos	0.0003 mg/l
Dieldrin	0.000005 mg/l
3,3' Dimethoxybenzidine	0.006 mg/l
3,3 Dimethylbenzidine	0.000007 mg/l
1,2 Dimethylhydrazine	0.060 mg/l
2,4 Dinitrotoluene	0.0001 mg/l
2,6 Dinitrotoluene	0.0001 mg/l
1,4 Dioxane	0.007 mg/l
1,2 Diphenylhydrazine	0.00009 mg/l
Direct Black 38	0.000009 mg/l
Direct Blue 6	0.000009 mg/l
Direct Brown 95	0.000009 mg/l
Endrin	0.0002 mg/l
Epichlorohydrin	0.008 mg/l

Table C-6. Numeric Requirements of Relevant Groundwater Regulations. (4 sheets)

Water Quality Standards for the Groundwaters of the State of Washington WAC 173-200-040 (Cont'd)	
Ethyl acrylate	0.002 mg/l
Ethylene dibromide	0.000001 mg/l
Ethylene thiourea	0.002 mg/l
Folpet	0.020 mg/l
Furazolidone	0.00002 mg/l
Furium	0.000002 mg/l
Furmecyclox	0.003 mg/l
Heptachlor	0.00002 mg/l
Heptachlor Epoxide	0.000009 mg/l
Hexachlorobenzene	0.00005 mg/l
Hexachlorocyclohexane (alpha)	0.000001 mg/l
Hexachlorocyclohexane (technical)	0.00005 mg/l
Hexachlorodibenzo-p-dioxin, mix	0.00000001 mg/l
Hydrazine/Hydrazine sulfate	0.00003 mg/l
Lindane	0.00006 mg/l
2 Methoxy-5-nitroaniline	0.002 mg/l
2 Methylaniline	0.0002 mg/l
2 Methylaniline hydrochloride	0.0005 mg/l
4,4' Methylene bis(N,N'-dimethyl) aniline	0.002 mg/l
Methoxychlor	0.1 mg/l
Methylene chloride (dichloromethane) [a]	0.005 mg/l
Mirex	0.00005 mg/l
Nitrofurazone	0.00006 mg/l
N-Nitrosodiethanolamine	0.00003 mg/l
N-Nitrosodiethylamine	0.0000005 mg/l
N-Nitrosodimethylamine	0.000002 mg/l
N-Nitrosodiphenylamine	0.017 mg/l
N-Nitroso-di-n-propylamine	0.00001 mg/l
N-Nitrosopyrrolidine	0.00004 mg/l
N-Nitroso-di-n-butylamine	0.00002 mg/l
N-Nitroso-N-methylethylamine	0.000004 mg/l
PAH	0.00001 mg/l
PBBs	0.00001 mg/l
PCBs	0.00001 mg/l
o-Phenylenediamine	0.000005 mg/l
Propylene oxide	0.00001 mg/l
2,3,7,8-Tetrachlorodibenzo-p-dioxin	0.0000000006 mg/l

Table C-6. Numeric Requirements of Relevant Groundwater Regulations. (4 sheets)

Water Quality Standards for the Groundwaters of the State of Washington WAC 173-200-040 (Cont'd)	
Tetrachloroethylene (perchloroethylene)	0.0008 mg/l
p,a,a,a-Tetrachlorotoluene	0.000004 mg/l
2,4 Toluenediamine	0.000002 mg/l
o-Toluidine	0.0002 mg/l
Toxaphene	0.00008 mg/l
Trichloroethylene [a]	0.003 mg/l
2,4,6-Trichlorophenol	0.004 mg/l
Trimethyl phosphate	0.002 mg/l
Vinyl chloride	0.00002 mg/l

Washington State Model Toxics Control Act WAC 173-340-730	
Exposure to multiple hazardous substances / more than one pathway	
Total excess cancer risk (carcinogen)	1×10^{-5}
Hazard index (noncarcinogen)	1

Washington State Dangerous Waste Regulations WAC 173-303-645			
Arsenic	0.05 mg/l	Barium	1 mg/l
Cadmium	0.01 mg/l	Chromium	0.05 mg/l
Lead	0.05 mg/l	Mercury	0.002 mg/l
Selenium	0.01 mg/l	Silver	0.05 mg/l
Endrin		0.0002 mg/l	
Methoxychlor		0.1 mg/l	
2-4 D		0.10 mg/l	
2,4,5-TP Silvex		0.01 mg/l	
Lindane		0.004 mg/l	
Toxaphene		0.005 mg/l	

[a] Organic compounds whose vapor was detected in more than 100 independent samples from tank waste or who have been detected more than 20 times in the solid or liquid phase, as entered into the TWINS database. Data taken from Table B.1 of Wiemers et al. 1998.

40 CFR 264.94, "Concentration Limits," *Code of Federal Regulations*, as amended.

WAC 173-200-040, "Criteria," *Washington Administrative Code*, as amended.

WAC 173-340-730, "Surface Water Cleanup Standards," *Washington Administrative Code*, as amended.

WAC 173-303-645, "Releases from Regulated Units," *Washington Administrative Code*, as amended.

Wiemers et al. 1998. K.D. Wiemers, M.E. Lerchen, M. Miller, and K. Meier, 1998, *Regulatory Data Quality Objectives Supporting Tank Waste Remediation System Privatization Project*, PNNL-12040, Rev. 0, Pacific Northwest National Laboratory, Richland, Washington.

TWINS = Tank Waste Information Network System.

Table C-7. Summary of Numeric Requirements of Relevant Drinking Water and Groundwater Regulations. (7 sheets)

Radionuclides	DOE 1993	40 CFR 141.66 (before 12/03)		WAC-173-200-040	
Beta and photon activity	4 mrem/yr	4 mrem/yr		50 pCi/l	
Alpha emitters (but not Ra and U)	15 pCi/l	15 pCi/l		15 pCi/l	
H-3		20,000 pCi/l		20,000 pCi/l	
Sr-90		8 pCi/l		8 pCi/l	
Ra-226				3 pCi/l	
Ra-226 and Ra-228	5 pCi/l	5 pCi/l		5 pCi/l	
Chemicals	**40 CFR 141**	**WAC 246-290-310**	**40 CFR 264.94**	**WAC 173-200-040**	**WAC 173-303-645**
Antimony	0.006 mg/l	0.006 mg/l			
Arsenic	0.01 mg/l	0.05 mg/l	0.05 mg/l	0.00005 mg/l	0.05 mg/l
Barium	2.0 mg/l	2.0 mg/l	1.0 mg/l	1.0 mg/l	1.0 mg/l
Beryllium	0.004 mg/l	0.004 mg/l			
Cadmium	0.005 mg/l	0.005 mg/l	0.01 mg/l	0.01 mg/l	0.01 mg/l
Chloride		250.0 mg/l		250.0 mg/l	
Chromium	0.1 mg/l	0.1 mg/l	0.05 mg/l	0.05 mg/l	0.05 mg/l
Copper				1.0 mg/l	
Cyanide	0.2 mg/l	0.2 mg/l			
Fluoride	4.0 mg/l	2.0 mg/l		4.0 mg/l	
Iron		0.3 mg/l		0.30 mg/l	
Lead			0.05 mg/l	0.05 mg/l	0.05 mg/l
Manganese		0.05 mg/l		0.05 mg/l	
Mercury	0.002 mg/l	0.002 mg/l	0.002 mg/l	0.002 mg/l	0.002 mg/l
Nickel		0.1 mg/l			
Nitrate (as N)	10.0 mg/l	10.0 mg/l		10.0 mg/l	
Nitrite (as N)	1.0 mg/l	1.0 mg/l			
Nitrate + Nitrite (as N)	10.0 mg/l				
Selenium	0.05 mg/l	0.05 mg/l	0.01 mg/l	0.01 mg/l	0.01 mg/l
Silver		0.1 mg/l	0.05 mg/l	0.05 mg/l	0.05 mg/l
Sulfate (as SO_4)		250.0 mg/l		250.0 mg/l	

Table C-7. Summary of Numeric Requirements of Relevant Drinking Water and Groundwater Regulations. (7 sheets)

Chemicals	40 CFR 141	WAC 246-290-310	40 CFR 264.94	WAC 173-200-040	WAC 173-303-645
Thalium	0.002 mg/l	0.002 mg/l			
Zinc		5.0 mg/l		5.0 mg/l	
2-4 D	0.07 mg/l		0.1 mg/l	0.10 mg/l	0.10 mg/l
2,3,7,8-TCDD (Dioxin)	3×10^{-8} mg/l				
2,4,5-TP Silvex	0.05 mg/l		0.01 mg/l	0.01 mg/l	0.01 mg/l
Acrylamide				0.00002 mg/l	
Acrylonitrile				0.00007 mg/l	
Alachlor	0.002 mg/l				
Aldicarb	0.003 mg/l				
Aldicarb sulfoxide	0.004 mg/l				
Aldicarb sulfone	0.002 mg/l				
Aldrin				0.000005 mg/l	
Atrazine	0.003 mg/l				
Aniline				0.014 mg/l	
Aramite				0.003 mg/l	
Azobenzene				0.0007 mg/l	
Benzene [a]				0.001 mg/l	
Benzidine				0.0000004 mg/l	
Benzo(a)pyrene	0.002 mg/l			0.000008 mg/l	
Benzotrichloride				0.000007 mg/l	
Benzyl chloride				0.0005 mg/l	
Bis(chloroethyl)ether				0.00007 mg/l	
Bis(chloromethyl)ether				0.0000004 mg/l	
Bis(2-ethylhexyl)phthalate [a]				0.006 mg/l	
Bromodichloromethane				0.0003 mg/l	
Bromoform				0.005 mg/l	
Carbazole				0.005 mg/l	
Carbofuran	0.04 mg/l				

Table C-7. Summary of Numeric Requirements of Relevant Drinking Water and Groundwater Regulations. (7 sheets)

Chemicals	40 CFR 141	WAC 246-290-310	40 CFR 264.94	WAC 173-200-040	WAC 173-303-645
Carbon tetrachloride [a]	0.005 mg/l			0.0003 mg/l	
Chlordane	0.002 mg/l			0.00006 mg/l	
Chlorodibromomethane				0.0005 mg/l	
Chloroform [a]				0.007 mg/l	
4 Chloro-2-methyl aniline				0.0001 mg/l	
4 Chloro-2-methyl analine hydrochloride				0.0002 mg/l	
o-Chloronitrobenzene				0.003 mg/l	
p-Chloronitrobenzene				0.005 mg/l	
Chlorthalonil				0.030 mg/l	
Dalapon	0.2 mg/l				
Diallate				0.001 mg/l	
DDT (includes DDE and DDD)				0.0003 mg/l	
Dibromochloropane	0.00002 mg/l				
1,2 Dibromomethane				0.000001 mg/l	
Para-Dichlorobenzene	0.075 mg/l				
σ-Dichlorobenzene	0.06 mg/l				
1,4-Dichlorobenzene [a]				0.004 mg/l	
3,3' Dichlorobenzidine				0.0002 mg/l	
1,1 Dichloroethane	0.007 mg/l			0.001 mg/l	
1,2 Dichloroethane (ethylene chloride)	0.005 mg/l			0.0005 mg/l	
Cis-1,2-Dichloroethylene [a]	0.07 mg/l				
Trans-1,2-Dichloroethylene [a]	0.1 mg/l				
Dichloromethane [a]	0.005 mg/l				
1,2 Dichloropropane	0.005 mg/l			0.0006 mg/l	
1,3 Dichloropropene				0.0002 mg/l	

Table C-7. Summary of Numeric Requirements of Relevant Drinking Water and Groundwater Regulations. (7 sheets)

Chemicals	40 CFR 141	WAC 246-290-310	40 CFR 264.94	WAC 173-200-040	WAC 173-303-645
Dichlorvos				0.0003 mg/l	
Dieldrin				0.000005 mg/l	
3,3' Dimethoxybenzidine				0.006 mg/l	
3,3 Dimethylbenzidine				0.000007 mg/l	
1,2 Dimethylhydrazine				0.060 mg/l	
2,4 Dinitrotoluene				0.0001 mg/l	
2,6 Dinitrotoluene				0.0001 mg/l	
Dinoseb	0.007 mg/l				
1,4 Dioxane				0.007 mg/l	
1,2 Diphenylhydrazine				0.00009 mg/l	
Diquat	0.02 mg/l				
Direct Black 38				0.000009 mg/l	
Direct Blue 6				0.000009 mg/l	
Direct Brown 95				0.000009 mg/l	
Di(2-ethylhexyl) adiapite	0.4 mg/l				
Di(2-ethylhexyl) phthalate	0.006 mg/l				
Endothall	0.1 mg/l				
Endrin	0.002 mg/l		0.0002 mg/l	0.0002 mg/l	0.0002 mg/l
Epichlorohydrin				0.008 mg/l	
Ethyl acrylate				0.002 mg/l	
Ethyl benzene [a]	0.7 mg/l				
Ethylene dibromide	0.00005 mg/l			0.000001 mg/l	
Ethylene thiourea				0.002 mg/l	
Folpet				0.020 mg/l	
Furazolidone				0.00002 mg/l	

Table C-7. Summary of Numeric Requirements of Relevant Drinking Water and Groundwater Regulations. (7 sheets)

Chemicals	40 CFR 141	WAC 246-290-310	40 CFR 264.94	WAC 173-200-040	WAC 173-303-645
Furium				0.000002 mg/l	
Furmecyclox				0.003 mg/l	
Glyphosate	0.7 mg/l				
Heptachlor	0.0004 mg/l			0.00002 mg/l	
Heptachlor Epoxide	0.0002 mg/l			0.000009 mg/l	
Hexachlorobenzene	0.001 mg/l			0.00005 mg/l	
Hexachlorocyclohexane (alpha)	0.05 mg/l			0.000001 mg/l	
Hexachlorocyclohexane (technical)				0.00005 mg/l	
Hexachlorodibenzo-p-dioxin, mix				0.00000001 mg/l	
Hydrazine/Hydrazine sulfate				0.00003 mg/l	
Lindane			0.004 mg/l	0.00006 mg/l	0.004 mg/l
2 Methoxy-5-nitroaniline				0.002 mg/l	
2 Methylaniline				0.0002 mg/l	
2 Methylaniline hydrochloride				0.0005 mg/l	
4,4' Methylene bis (N,N'-dimethyl) aniline				0.002 mg/l	
Methoxychlor	0.04 mg/l		0.1 mg/l	0.1 mg/l	0.1 mg/l
Methylene chloride (dichloromethane)				0.005 mg/l	
Mirex				0.00005 mg/l	
Monochlorobenzene	0.1 mg/l				
Nitrofurazone				0.00006 mg/l	
N-Nitrosodiethanolamine				0.00003 mg/l	
N-Nitrosodiethylamine				0.0000005 mg/l	
N-Nitrosodimethylamine				0.000002 mg/l	
N-Nitrosodiphenylamine				0.017 mg/l	

Table C-7. Summary of Numeric Requirements of Relevant Drinking Water and Groundwater Regulations. (7 sheets)

Chemicals	40 CFR 141	WAC 246-290-310	40 CFR 264.94	WAC 173-200-040	WAC 173-303-645
N-Nitroso-di-n-propylamine				0.00001 mg/l	
N-Nitrosopyrrolidine				0.00004 mg/l	
N-Nitroso-di-n-butylamine				0.00002 mg/l	
N-Nitroso-N-methylethylamine				0.000004 mg/l	
Oxamyl (Vydate)	0.2 mg/l				
PAH				0.00001 mg/l	
PBBs				0.00001 mg/l	
PCBs	0.0005 mg/l			0.00001 mg/l	
Pentachlorophenol	0.001 mg/l				
o-Phenylenediamine				0.000005 mg/l	
Picloram	0.5 mg/l				
Propylene oxide				0.00001 mg/l	
Simazine	0.004 mg/l				
Styrene	0.1 mg/l				
2,3,7,8-Tetrachlorodibenzo-p-dioxin				0.0000000006 mg/l	
Tetrachloroethylene (perchloroethylene)	0.005 mg/l			0.0008 mg/l	
p,a,a,a-Tetrachlorotoluene				0.000004 mg/l	
2,4 Toluenediamine				0.000002 mg/l	
Toluene [a]	1.0 mg/l				
o-Toluidine				0.0002 mg/l	
Toxaphene	0.003 mg/l		0.005 mg/l	0.00008 mg/l	0.005 mg/l
1,2,4-Trichloro-benzene	0.07 mg/l				
Trichloroethylene	0.005 mg/l			0.003 mg/l	
1,1,1-Trichloroethane [a]	0.2 mg/l				
1,1,2-Trichloroethane [a]	0.005 mg/l				

Table C-7. Summary of Numeric Requirements of Relevant Drinking Water and Groundwater Regulations. (7 sheets)

Chemicals	40 CFR 141	WAC 246-290-310	40 CFR 264.94	WAC 173-200-040	WAC 173-303-645
2,4,6-Trichlorophenol				0.004 mg/l	
Trihalomethanes	0.10 mg/l				
Trimethyl phosphate				0.002 mg/l	
Vinyl chloride	0.002 mg/l			0.00002 mg/l	
Xylenes (total) [a]	10.0 mg/l				
o-Xylene [a]	0.7 mg/l				

A blank entry in the cell means that the corresponding regulation does not cover the indicated contaminant.

[a] Organic compounds whose vapor was detected in more than 100 independent samples from tank waste or who have been detected more than 20 times in the solid or liquid phase, as entered into the TWINS database. Data taken from Table B.1 of Wiemers et al. 1998.

40 CFR 141, "National Primary Drinking Water Regulations," *Code of Federal Regulations*, as amended.

40 CFR 264.94, "Concentration Limits," *Code of Federal Regulations*, as amended.

DOE Order 5400.5, 1993, *Radiation Protection of the Public and the Environment*, U.S. Department of Energy, Washington, D.C.

WAC 173-200-040, "Criteria," *Washington Administrative Code*, as amended.

WAC 173-303-645, "Releases from Regulated Units," *Washington Administrative Code*, as amended.

WAC 246-290-310, "Maximum Contaminant Levels (MCLs) and Maximum Residual Disinfectant Levels (MRDLs)," *Washington Administrative Code*, as amended.

Wiemers et al. 1998. K.D. Wiemers, M.E. Lerchen, M. Miller, and K. Meier, 1998, *Regulatory Data Quality Objectives Supporting Tank Waste Remediation System Privatization Project*, PNNL-12040, Rev. 0, Pacific Northwest National Laboratory, Richland, Washington.

TWINS = Tank Waste Information Network System.

Table C-8. Numeric Requirements of Relevant Surface Water Regulations.

Water Quality Standards for Surface Waters of the State of Washington – Toxic Substances WAC 173-201A-240			
Ammonia	4.0 mg/l	Arsenic	0.19 mg/l
Cadmium *	0.00082 mg/l	Chloride	230.0 mg/l
Copper *	0.0087 mg/l	Chromium	0.011 mg/
Cyanide	0.0052 mg/l	Lead *	0.00178 mg/l
Mercury	0.000012 mg/l	Nickel *	0.120 mg/l
Selenium	0.005 mg/l	Zinc *	0.080 mg/l

Water Quality Standards for Surface Waters of the State of Washington – Radioactive Substances WAC 173-201A-250			
Radionuclides	0.08 of WAC 246-221-290 Or EPA drinking water standards (40 CFR 141, see Table C-5 above)		
H-3	80000.0 pCi/l	Se-79	640.0 pCi/l
Sr-90	40.0 pCi/l	Zr-93	3200.0 pCi/l
Nb-93m	16000.0 pCi/l	Tc-99	4800.0 pCi/l
Sn-126	320.0 pCi/l	I-129	16.0 pCi/l
Cs-137	80.0 pCi/l	Ra-226	4.8 pCi/l
Ra-228	4.8 pCi/l	Th-232	2.4 pCi/l
Pa-231	0.48 pCi/l	U–233	24.0 pCi/l
U–234	24.0 pCi/l	U–235	24.0 pCi/l
U–236	24.0 pCi/l	U–238	24.0 pCi/l
Np-237	1.6 pCi/l	Pu-239	1.6 pCi/l
Pu-240	1.6 pCi/l	Am-241	1.6 pCi/l
Am-243	1.6 pCi/l	—	

Washington State Model Toxics Control Act WAC 173-340-730	
Exposure to multiple hazardous substances / more than one pathway	
Total excess cancer risk (carcinogen)	1×10^{-5}
Hazard index (noncarcinogen)	1.0

For drinking water standards, see Table C-5.

40 CFR 141, "National Primary Drinking Water Regulations," *Code of Federal Regulations*, as amended.

WAC 173-201A-240, "Toxic Substances," *Washington Administrative Code*, as amended.

WAC 173-201A-250, "Radioactive Substances," *Washington Administrative Code*, as amended.

WAC 173-340-730, "Surface Water Cleanup Standards," *Washington Administrative Code*, as amended.

WAC 246-221-290, "Appendix A – Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure; Effluent concentrations; Concentrations for Release to Sanitary Sewerage," *Washington Administrative Code*, as amended.

EPA = U.S. Environmental Protection Agency.

Table C-9. Numeric Requirements of Relevant Air Regulations. (2 sheets)

DOE Order on Radioactive Waste Management DOE O 435.1 (DOE 2001)	
Air emissions (except radon)	10 mrem/year
Air emissions (radon)	20 pCi/m^{2}s

DOE Order on Radiation Protection of the Public and the Environment DOE Order 5400.5(II)(b) (DOE 1993)	
Air emissions	10 mrem/year

National Primary and Secondary Ambient Air Quality Standards 40 CFR 50			
	Limits for Average Maximum		
Sulfur oxides	0.50 ppm for 3 hours	0.14 ppm for 24 hours	0.030 ppm for 1 year
Carbon Monoxide		35 ppm for 1 hour	9 ppm for 8 hours
Ozone		0.12 ppm for 1 hour	0.08 ppm for 8 hours
Nitrogen Dioxide			0.053 ppm (annual)
Lead			1.5 µg/m3 (quarterly)

National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities Standards 40 CFR 61.92	
Air emission (except radon)	10 mrem/year

National Emission Standards for Radon Emissions from Department of Energy Facilities Standards 40 CFR 61.192	
Air emissions (radon)	20 pCi/m^{2}s

Washington State General Regulations for Air Pollution Sources WAC 173-480-40	
Sulfur dioxide	1 ppm

Washington State "Ambient Air Quality Standards for Radionuclides" WAC 173-480-40	
Air emissions (except radon) (whole body)	25 mrem/yr
Air emissions (except radon) (critical organ)	75 mrem/yr
Washington State Radiation Protection for Air Emissions WAC 246-247-040	
References WAC 173-480 and 40 CFR 61	

Table C-9. Numeric Requirements of Relevant Air Regulations. (2 sheets)

Washington State Model Toxics Control Act WAC 173-340-750	
Exposure to multiple hazardous substances / more than one pathway	
Total excess cancer risk (carcinogen)	1×10^{-5}
Hazard index (noncarcinogen)	1.0

Based on Columbia River at Pasco having a mean hardness of 73 mg/l (DOE, 1988, *Site Characterization Plan*, DOE/RW-0164, Consultation Draft, Volume 2, Page 3.4-16, U.S. Department of Energy, Washington, D.C., January).

40 CFR 50, "National Primary and Secondary Ambient Air Quality Standards," *Code of Federal Regulations*, as amended.

40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," *Code of Federal Regulations*, as amended.

40 CFR 61.92, "Standard," *Code of Federal Regulations*, as amended.

40 CFR 61.192, "Standard," *Code of Federal Regulations*, as amended.

DOE Order 5400.5, 1993, *Radiation Protection of the Public and the Environment*, U.S. Department of Energy, Washington, D.C. [Section II, "Requirements for Radiation Protection of the Public and the Environment," (II)(b)]

DOE O 435.1, 2001, *Radioactive Waste Management*, U.S. Department of Energy, Washington, D.C.

WAC 173-340-750, "Cleanup Standards to Protect Air Quality," *Washington Administrative Code*, as amended.

WAC 173-480, "Utilities and Transportation Commission," *Washington Administrative Code*, as amended.

WAC 173-480-40, "Passenger Charter Carriers," *Washington Administrative Code*, as amended.

WAC 246-247-040, "General Standards," *Washington Administrative Code*, as amended.

DOE = U.S. Department of Energy.

Table C-10. Numeric Requirements of Relevant Regulations for Concentrations in Waste. (10 sheets)

Licensing Requirements for the Land Disposal of Radioactive Waste 10 CFR 61.55 (Class C)			
C-14	8.0 Ci/m^3	C-14 (activated metal)	80.0 Ci/m^3
Ni-59 (activated metal)	220.0 Ci/m^3	Ni-63	700.0 Ci/m^3
Ni-63 (activated metal)	7000 Ci/m^3	Sr-90	7000.0 Ci/m^3
Nb-94 (activated metal)	0.2 Ci/m^3	Tc-99	3.0 Ci/m^3
I-129	0.08 Ci/m^3	Cs-137	4600.0 Ci/m^3
Alpha emitters (with half-lives greater than 5 years)			100 nCi/g
Pu-241	3500 nCi/g	Cm-242	20000 nCi/g

Toxicity Characteristics – TCLP Limits 40 CFR 261.24			
Arsenic	5 mg/l	Barium	100 mg/l
Cadmium	1 mg/l	Chromium	5 mg/l
Lead	5 mg/l	Mercury	0.2 mg/l
Selenium	1mg/l	Silver	5 mg/l
CAS #	Constituent		
56-23-5	Carbon tetrachloride [a]		0.5 mg/l
57-74-9	Chlordane		0.03 mg/l
58-89-9	Lindane		0.4 mg/l
67-66-3	Chloroform [a]		6.0 mg/l
67-72-1	Hexachloroethane		3.0 mg/l
71-43-2	Benzene [a]		0.5 mg/l
72-20-4	Endrin		0.02 mg/l
72-43-5	Methoxychlor		10.0 mg/l
75-01-4	Vinyl chloride		0.2 mg/l
75-35-4	1,1-Dichloroethylene [a]		0.7 mg/l
76-04-8	Heptachlor		0.008 mg/l
78-93-3	Methyl ethyl ketone [a]		200.0 mg/l
79-01-6	Trichloroethylene [a]		0.5 mg/l
87-68-3	Hexachlorobutadiene		0.5 mg/l
87-86-5	Pentachlorophenol		100.0 mg/l
88-06-2	2,4,6-Trichlorophenol		2.0 mg/l
93-72-1	2,4,5-TP (Silvex)		1.0 mg/l
94-75-7	2,4-D		10.0 mg/l
95-48-7	o-Cresol		200.0 mg/l
95-95-4	2,4,5-Trichlorophenol		400.0 mg/l
98-95-3	Nitrobenzene		2.0 mg/l

Table C-10. Numeric Requirements of Relevant Regulations for Concentrations in Waste. (10 sheets)

Toxicity Characteristics – TCLP Limits 40 CFR 261.24 (Cont'd)		
CAS #	Constituent	
106-44-5	p-Cresol	200.0 mg/l
106-46-7	1,4-Dichlorobenzene [a]	7.5 mg/l
107-06-2	1,2-Dichloroethane	0.5 mg/l
108-39-4	m-Cresol	200.0 mg/l
108-90-7	Chlorobenzene	100 mg/l
110-86-1	Pyridine [a]	5.0 mg/l
118-74-1	Hexachlorobenzene	0.13 mg/l
121-14-2	2,4-Dinitrotoluene	0.13 mg/l
127-18-4	1,1,2,2-Tetrachloroethene [a]	0.7 mg/l
8001-35-2	Toxaphene	0.5 mg/l

RCRA Treatment Standards 40 CFR 268.40	
Establishes treatment standards	
Standards bounded by 40 CFR 268.48	

RCRA Universal Treatment Standards 40 CFR 268.48	
	TCLP Result Limits
Antimony	1.15 mg/l
Arsenic	5.0 mg/l
Barium	21.0 mg/l
Beryllium	1.22 mg/l
Cadmium	0.11 mg/l
Chromium (total)	0.60 mg/l
Lead	0.75 mg/l
Mercury	0.025 mg/l
Nickel	11.0 mg/l
Selenium	5.7 mg/l
Silver	0.14 mg/l
Thallium	0.20 mg/l
Vanadium	1.6 mg/l
Zinc	4.3 mg/l
Cyanide (total)	590 mg/kg
Cyanide (amenable)	30 mg/kg

Table C-10. Numeric Requirements of Relevant Regulations for Concentrations in Waste. (10 sheets)

RCRA (Universal Treatment Standards 40 CFR 268.48 (Cont'd)		
CAS #	**Constituent**	**TCLP Result Limits**
67-56-1	Methanol [a]	0.75 mg/l
75-15-0	Carbon disulfide	4.8 mg/l
108-94-1	Cyclohexanone [a]	0.75 mg/l
CAS #	**Constituent**	**Concentration Limit**
50-29-3	p,p'-DDT	0.087 mg/kg
50-32-8	Benzo(a)pyrene	3.4 mg/kg
51-28-5	2,4-Dinitrophenol	160 mg/kg
52-85-7	Famphur	15 mg/kg
53-19-0	o,p'-DDD	0.087 mg/kg
53-70-3	Dibenz(a,h)anthracene	8.2 mg/kg
53-96-3	2-Acetylaminofluorene	140 mg/kg
55-18-5	N-Nitrosodiethylamine	28 mg/kg
56-23-5	Carbon tetrachloride [a]	6 mg/kg
56-38-2	Parathion	4.6 mg/kg
56-49-5	3-Methylcholanthrene	15 mg/kg
56-55-3	Benz(a)anthracene	3.4 mg/kg
57-47-6	Physostigmine	1.4 mg/kg
57-64-7	Physostigmine salicylate	1.4 mg/kg
57-74-9	Chlordane (alpha and gamma isomers)	0.26 mg/kg
58-89-9	gamma-BHC	0.066 mg/kg
58-90-2	2,3,4,6-Tetrachlorophenol	7.4 mg/kg
59-50-7	p-Chloro-m-cresol	14 mg/kg
59-89-2	N-Nitrosomorpholine	2.3 mg/kg
60-29-7	Ethyl ether	160 mg/kg
60-57-1	Dieldrin	0.13 mg/kg
62-44-2	Phenacetin	16 mg/kg
62-53-3	Aniline	14 mg/kg
62-75-9	N-Nitrosodimethylamine	2.3 mg/kg
63-25-2	Carbaryl	0.14 mg/kg
64-00-6	m-Cumenyl methylcarbamate	1.4 mg/kg
67-64-1	Acetone [a]	160 mg/kg
67-66-3	Chloroform [a]	6 mg/kg
67-72-1	Hexachloroethane	30 mg/kg
71-36-3	n-Butyl alcohol [a]	2.6 mg/kg
71-43-2	Benzene [a]	10 mg/kg

Table C-10. Numeric Requirements of Relevant Regulations for Concentrations in Waste. (10 sheets)

RCRA Universal Treatment Standards 40 CFR 268.48 (Cont'd)		
CAS #	Constituent	Concentration Limit
71-55-6	1,1,1-Trichloroethane [a]	6 mg/kg
72-20-8	Endrin	0.13 mg/kg
72-43-5	Methoxychlor	0.18 mg/kg
72-54-8	p,p'-DDD	0.087 mg/kg
72-55-9	p,p'-DDE	0.087 mg/kg
74-83-9	Bromomethane/Methylbromide	15 mg/kg
74-87-3	Chloromethane/Methyl chloride [a]	30 mg/kg
74-88-4	Iodomethane	65 mg/kg
74-95-3	Dibromomethane	15 mg/kg
75-00-3	Chloroethane	6 mg/kg
75-01-4	Vinyl chloride	6 mg/kg
75-09-2	Methylene chloride [a]	30 mg/kg
75-25-2	Tribromomethane/Bromoform	15 mg/kg
75-27-4	Bromodichloromethane	15 mg/kg
75-34-3	1,1-Dichloroethane	6 mg/kg
75-35-4	1,1-Dichloroethylene [a]	6 mg/kg
75-69-4	Trichlorofluoromethane [a]	30 mg/kg
75-71-8	Dichlorodifluoromethane [a]	7.2 mg/kg
76-01-7	Pentachloroethane	6 mg/kg
76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane [a]	30 mg/kg
76-44-8	Heptachlor	0.066 mg/kg
77-47-4	Hexachlorocyclopentadiene	2.4 mg/kg
78-83-1	Isobutyl alcohol	170 mg/kg
78-87-5	1,2-Dichloropropane	18 mg/kg
78-93-3	Methyl ethyl ketone [a]	36 mg/kg
79-00-5	1,1,2-Trichloroethane [a]	6 mg/kg
79-01-6	Trichloroethylene [a]	6 mg/kg
79-06-1	Acrylamide	23 mg/kg
79-34-5	1,1,2,2-Tetrachloroethane	6 mg/kg
80-62-6	Methyl methacrylate	160 mg/kg
82-68-8	Pentachloronitrobenzene	4.8 mg/kg
83-32-9	Acenaphthene	3.4 mg/kg
84-66-2	Diethyl phthalate	28 mg/kg
84-74-2	Di-n-butyl phthalate	28 mg/kg
85-01-8	Phenanthrene	5.6 mg/kg

Table C-10. Numeric Requirements of Relevant Regulations for Concentrations in Waste. (10 sheets)

RCRA Universal Treatment Standards 40 CFR 268.48 (Cont'd)		
CAS #	Constituent	Concentration Limit
85-44-9	Phthalic anhydride	28 mg/kg
85-68-7	Butyl benzyl phthalate	28 mg/kg
86-30-6	Diphenylnitrosamine	13 mg/kg
86-73-7	Fluorene	3.4 mg/kg
87-65-0	2,6-Dichlorophenol	14 mg/kg
87-68-3	Hexachlorobutadiene	5.6 mg/kg
87-86-5	Pentachlorophenol	7.4 mg/kg
88-06-2	2,4,6-Trichlorophenol	7.4 mg/kg
88-74-4	o-Nitroaniline	14 mg/kg
88-75-5	o-Nitrophenol	13 mg/kg
88-85-7	2-sec-Butyl-4,6-dinitrophenol/ Dinosebdinitrophenol/Dinoseb	2.5 mg/kg
91-20-3	Naphthalene	5.6 mg/kg
91-58-7	2-Chloronaphthalene	5.6 mg/kg
91-80-5	Methapyrilene	1.5 mg/kg
93-72-1	Silvex/2,4,5-TP	7.9 mg/kg
93-76-5	2,4,5-Trichlorophenoxy acetic acid/2,4,5-T	7.9 mg/kg
94-59-7	Safrole	22 mg/kg
94-75-7	2,4-Dichlorophenoxyacetic acid/2,4-D	10 mg/kg
95-48-7	o-Cresol	5.6 mg/kg
95-50-1	o-Dichlorobenzene	6 mg/kg
95-57-8	2-Chloropchenol	5.7 mg/kg
95-94-3	1,2,4,5-Tetrachlorobenzene	14 mg/kg
95-95-4	2,4,5-Trichlorophenol	7.4 mg/kg
96-12-8	1,2-Dibromo-3-chloropropane	15 mg/kg
96-18-4	1,2,3-Trichloropropane	30 mg/kg
96-86-2	Acetophenone	9.7 mg/kg
97-63-2	Ethyl methacrylate	160 mg/kg
98-87-3	Benzal chloride	6 mg/kg
98-95-3	Nitrobenzene	14 mg/kg
99-55-8	5-Nitro-o-toluidine	28 mg/kg
100-01-6	p-Nitroaniline	28 mg/kg
100-02-7	p-Nitrophenol	29 mg/kg
100-21-0	Phthalic acid	28 mg/kg
100-25-4	1,4-Dinitrobenzene	2.3 mg/kg
100-41-4	Ethyl benzene [a]	10 mg/kg

Table C-10. Numeric Requirements of Relevant Regulations for Concentrations in Waste. (10 sheets)

RCRA Universal Treatment Standards 40 CFR 268.48 (Cont'd)		
CAS #	**Constituent**	**Concentration limit**
100-75-4	N-Nitrosopiperidine	35 mg/kg
101-14-4	4,4-Methylene bis(2-chloroaniline)	30 mg/kg
101-27-9	Barban	1.4 mg/kg
101-55-3	4-Bromophenyl phenyl ether	15 mg/kg
105-67-9	2,4-Dimethylphenol	14 mg/kg
106-44-5	p-Cresol	5.6 mg/kg
106-46-7	p-Dichlorobenzene [a]	6 mg/kg
106-47-8	p-Chloroaniline	16 mg/kg
106-93-4	1,2-Dibromoethane/Ethylene dibromide [a]	15 mg/kg
107-05-1	3-Chloropropylene	30 mg/kg
107-06-2	1,2-Dichloroethane	6 mg/kg
107-12-0	Ethyl cyanide/Propanenitrile [a]	360 mg/kg
107-13-1	Acrylonitrile	84 mg/kg
108-10-1	Methyl isobutyl ketone [a]	33 mg/kg
108-39-4	m-Cresol	5.6 mg/kg
108-88-3	Toluene [a]	10 mg/kg
108-90-7	Chlorobenzene	6 mg/kg
108-95-2	Phenol	6.2 mg/kg
110-86-1	Pyridine [(a)]	16 mg/kg
111-44-4	bis(2-Chloroethyl)ether	6 mg/kg
111-91-1	bis(2-Chloroethoxy)methane	7.2 mg/kg
114-26-1	Propoxur	1.4 mg/kg
117-84-0	Di-n-octyl phthalate	28 mg/kg
118-74-1	Hexachlorobenzene	10 mg/kg
120-12-7	Anthracene	3.4 mg/kg
120-58-1	Isosafrole	2.6 mg/kg
120-82-1	1,2,4-Trichlorobenzene	19 mg/kg
120-83-2	2,4-Dichlorophenol	14 mg/kg
121-14-2	2,4-Dinitrotoluene	140 mg/kg
121-44-8	Triethylamine	1.5 mg/kg
122-39-4	Diphenylamine	13 mg/kg
122-42-9	Propham	1.4 mg/kg
123-91-1	1,4-Dioxane	170 mg/kg
124-48-1	Chlorodibromomethane	15 mg/kg
126-72-7	tris-(2,3-Dibromopropyl) phosphate	0.1 mg/kg

Table C-10. Numeric Requirements of Relevant Regulations for Concentrations in Waste. (10 sheets)

RCRA Universal Treatment Standards 40 CFR 268.48 (Cont'd)		
CAS #	**Constituent**	**Concentration Limit**
126-98-7	Methacrylonitrle	84 mg/kg
126-99-8	2-Chloro-1,3-butadiene	0.28 mg/kg
127-18-4	Tetrachloroethylene [a]	6 mg/kg
129-00-0	Pyrene	8.2 mg/kg
131-11-3	Dimethyl phthalate	28 mg/kg
141-78-6	Ethyl acetate	33 mg/kg
143-50-0	Kepone	0.13 mg/kg
156-60-5	trans-1,2-Dichloroethylene	30 mg/kg
191-24-2	Benzo(g,h,i)perylene	1.8 mg/kg
193-39-5	Indeno(1,2,3-c,d) pyrene	3.4 mg/kg
205-99-2	Benzo(b)fluoranthene	6.8 mg/kg
206-44-0	Fluoranthene	3.4 mg/kg
207-08-9	Benzo(k)fluoranthene	6.8 mg/kg
208-96-8	Acenaphthylene	3.4 mg/kg
218-01-9	Chrysene	3.4 mg/kg
298-00-0	Methyl parathion	4 mg/kg
298-02-2	Phorate	4.6 mg/kg
298-04-4	Disulfoton	6.2 mg/kg
309-00-2	Aldrin	0.066 mg/kg
315-18-4	Mexacarbate	1.4 mg/kg
319-84-6	alpha-BHC	0.066 mg/kg
319-85-7	beta-BHC	0.066 mg/kg
319-86-8	delta-BHC	0.066 mg/kg
465-73-6	Isodrin	0.066 mg/kg
534-52-1	4,6-Dinitro-o-cresol	160 mg/kg
541-73-1	m-Dichlorobenzene	6 mg/kg
606-20-2	2,6-Dinitrotoluene	28 mg/kg
608-93-5	Pentachlorobenzene	10 mg/kg
621-64-7	Di-n-propylnitrosamine	14 mg/kg
630-20-6	1,1,1,2-Tetrachloroethane	6 mg/kg
759-94-4	EPTC	1.4 mg/kg
789-02-6	o,p'-DDT	0.087 mg/kg
924-16-3	N-Nitroso-di-n-butylamine	17 mg/kg
930-55-2	N-Nitrosopyrrolidine	35 mg/kg
959-98-8	Endosulfan I	0.066 mg/kg

Table C-10. Numeric Requirements of Relevant Regulations for Concentrations in Waste. (10 sheets)

RCRA Universal Treatment Standards 40 CFR 268.48 (Cont'd)		
CAS #	**Constituent**	**Concentration Limit**
1024-57-3	Heptachlor epoxide	0.066 mg/kg
1031-07-8	Endosulfan sulfate	0.13 mg/kg
1114-71-2	Pebulate	1.4 mg/kg
1129-41-5	Metolcarb	1.4 mg/kg
1330-20-7	Xylenes-mixed isomers (sum of o-, m-,and p-xylene concentrations) [a]	30 mg/kg
1336-36-3	Total PCBs (sum of all PCB isomers, or all Aroclors)	10 mg/kg
1563-38-8	Carbofuran phenol	1.4 mg/kg
1563-66-2	Carbofuran	0.14 mg/kg
1646-88-4	Aldicarb sulfone	0.28 mg/kg
1929-77-7	Vernolate	1.4 mg/kg
2008-41-5	Butylate	1.4 mg/kg
2032-65-7	Methiocarb	1.4 mg/kg
2212-67-1	Molinate	1.4 mg/kg
2303-17-5	Triallate	1.4 mg/kg
2631-37-0	Promecarb	1.4 mg/kg
3268-87-9	1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin(OCDD)	0.005 mg/kg
3424-82-6	o,p'-DDE	0.087 mg/kg
7421-93-4	Endrin aldehyde	0.13 mg/kg
8001-35-2	Toxaphene	2.6 mg/kg
10061-01-5	cis-1,3-Dichloropropylene	18 mg/kg
10061-02-6	trans-1,3-Dichloropropylene	18 mg/kg
10595-95-6	N-Nitrosomethylethylamine	2.3 mg/kg
10605-21-7	Carbenzadim	1.4 mg/kg
621-64-7	Di-n-propylnitrosamine	14 mg/kg
630-20-6	1,1,1,2-Tetrachloroethane	6 mg/kg
16752-77-5	Methomyl	0.14 mg/kg
17804-35-2	Benomyl	1.4 mg/kg
22781-23-3	Bendiocarb	1.4 mg/kg
23135-22-0	Oxamyl	0.28 mg/kg
23422-53-9	Formetanate hydrochloride	1.4 mg/kg
23564-05-8	Thiophanate-methyl	1.4 mg/kg
23950-58-5	Pronamide	1.5 mg/kg
33213-65-9	Endosulfan II	0.13 mg/kg
35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin(1,2,3,4,6,7, 8-HpCDD)	0.0025 mg/kg
39001-02-0	1,2,3,4,6,7,8,9-Octachlorodibenzofluran (OCDF)	0.005 mg/kg

Table C-10. Numeric Requirements of Relevant Regulations for Concentrations in Waste. (10 sheets)

RCRA Universal Treatment Standards 40 CFR 268.48 (Cont'd)		
CAS #	**Constituent**	**Concentration Limit**
39638-32-9	bis(2-Chloroisopropyl) ether	7.2 mg/kg
52888-80-9	Prosulfocarb	1.4 mg/kg
55285-14-8	Carbosulfan	1.4 mg/kg
55673-89-7	1,2,3,4,6,7,8-Heptachlorodibenzofluran (1,2,3,4,7,8,9-HpCDF)	0.0025 mg/kg
59669-26-0	Thiodicarb	1.4 mg/kg
67562-39-5	1,2,3,4,6,7,8-Heptachlorodibenzofluran (1,2,3,4,6,7,8-HpCDF)	0.0025 mg/kg
NA	Dithiocarbamates (total)	28 mg/kg
NA	HxCDDs (All Hexachlorodibenzo-p-dioxins)	0.001 mg/kg
NA	HxCDFs (All Hexachlorodibenzofurans)	0.001 mg/kg
NA	PeCDDs (All Pentachlorodibenzo-p-dioxins)	0.001 mg/kg
NA	PeCDFs (All Pentachlorodibenzofurans)	0.001 mg/kg
NA	TCDDs (All Tetrachlorodibenzo-p-dioxins)	0.001 mg/kg
NA	TCDFs (All Tetrachlorodibenzofurans)	0.001 mg/kg

Washington State Dangerous Waste Regulations – TCLP Result Limits WAC 173-303-090			
Arsenic	5 mg/l	Barium	100 mg/l
Cadmium	1 mg/l	Chromium	5 mg/l
Lead	5 mg/l	Mercury	0.2 mg/l
Selenium	1 mg/l	Silver	5 mg/l
CAS #	**Constituent [a]**		**TCLP Result Limit**
56-23-5	Carbon tetrachloride [a]		0.5 mg/l
57-74-9	Chlordane		0.03 mg/l
58-89-9	Lindane		0.4 mg/l
67-66-3	Chloroform [a]		6 mg/l
67-72-1	Hexachloroethane		3 mg/l
71-43-2	Benzene [a]		0.5 mg/l
72-20-8	Endrin		0.02 mg/l
72-43-5	Methoxychlor		10 mg/l
75-01-4	Vinyl chloride		0.2 mg/l
75-35-4	1,1-Dichloroethylene [a]		0.7 mg/l
76-44-8	Heptachlor (and its epoxide)		0.008 mg/l
78-93-3	Methyl ethyl ketone [a]		200 mg/l
79-01-6	Trichloroethylene [a]		0.5 mg/l
87-68-3	Hexachlorobutadiene		0.5 mg/l

Table C-10. Numeric Requirements of Relevant Regulations for Concentrations in Waste. (10 sheets)

Washington State Dangerous Waste Regulations – TCLP Result Limits WAC 173-303-090 (Cont'd)		
CAS #	**Constituent** [a]	**TCLP Result Limit**
87-86-5	Pentachlorophenol	100 mg/l
88-06-2	2,4,6-Trichlorophenol	2 mg/l
93-72-1	2,4,5-TP (Silvex)	1 mg/l
94-75-7	2,4-D	10 mg/l
95-48-7	o-Cresol	200 mg/l
95-95-4	2,4,5-Trichlorophenol	400 mg/l
98-95-3	Nitrobenzene	2 mg/l
106-44-5	p-Cresol	200 mg/l
106-46-7	1,4-Dichlorobenzene [a]	7.5 mg/l
107-06-2	1,2-Dichloroethane	0.5 mg/l
108-39-4	m-Cresol	200 mg/l
108-90-7	Chlorobenzene	100 mg/l
110-86-1	Pyridine [a]	5 mg/l
118-74-1	Hexachlorobenzene	0.13 mg/l
121-14-2	2,4-Dinitrotoluene	0.13 mg/l
127-18-4	Tetrachloroethylene [a]	0.7 mg/l
8001-35-2	Toxaphene	0.5 mg/l
NA	Sum of m-, o-, and p- Cresol	200 mg/l

[a] Organic compounds whose vapor was detected in more than 100 independent samples from tank waste or who have been detected more than 20 times in the solid or liquid phase, as entered into the TWINS database. Data taken from Table B.1 of Wiemers et al. 1998.

10 CFR 61.55, "Waste Classification," *Code of Federal Regulations*, as amended.

40 CFR 261.24, "Toxicity Characteristic," *Code of Federal Regulations*, as amended.

40 CFR 268.40, "Applicability of Treatment Standards," *Code of Federal Regulations*, as amended.

40 CFR 268.48, "Universal Treatment Standards," *Code of Federal Regulations*, as amended.

Resource Conservation and Recovery Act of 1976, 42 USC 6901 et seq. Online at http://www4.law.cornell.edu/uscode/html/uscode/42/ch82.html.

WAC 173-303-090, "Dangerous Waste Characteristics," *Washington Administrative Code*, as amended.

Wiemers et al. 1998. K.D. Wiemers, M.E. Lerchen, M. Miller, and K. Meier, 1998, *Regulatory Data Quality Objectives Supporting Tank Waste Remediation System Privatization Project*, PNNL-12040, Rev. 0, Pacific Northwest National Laboratory, Richland, Washington.

CAS = Chemical Abstract Service.
RCRA = *Resource Conservation and Recover Act of 1976.*
TCLP = Toxicity Characteristic Leaching Procedure.
TWINS = Tank Waste Information Network System.

Table C-11. Numeric Requirements for Terrestrial Ecological Evaluation Procedure. (2 sheets)

Table 749-2 Priority Contaminants of Ecological Concern for Sites that Qualify for the Simplified Terrestrial Ecological Evaluation Procedure. [a]		
Priority Contaminant	Soil Concentration (mg/kg)	
	Unrestricted land use [b]	Industrial or commercial site
Metals [c]		
Antimony	See note d	See note d
Arsenic III	20 mg/kg	20 mg/kg
Arsenic V	95 mg/kg	260 mg/kg
Barium	1,250 mg/kg	1,320 mg/kg
Beryllium	25 mg/kg	See note d
Cadmium	25 mg/kg	36 mg/kg
Chromium (total)	42 mg/kg	135 mg/kg
Cobalt	See note d	See note d
Copper	100 mg/kg	550 mg/kg
Lead	220 mg/kg	220 mg/kg
Magnesium	See note d	See note d
Manganese	See note d	23,500 mg/kg
Mercury, inorganic	9 mg/kg	9 mg/kg
Mercury, organic	0.7 mg/kg	0.7 mg/kg
Molybdenum	See note d	71 mg/kg
Nickel	100 mg/kg	1,850 mg/kg
Selenium	0.8 mg/kg	0.8 mg/kg
Silver	See note d	See note d
Tin	275 mg/kg	See note d
Vanadium	26 mg/kg	See note d
Zinc	270 mg/kg	570 mg/kg
Pesticides		
Aldicarb/aldicarb sulfone (total)	See note d	See note d
Aldrin	0.17 mg/kg	0.17 mg/kg
Benzene hexachloride (including lindane)	10 mg/kg	10 mg/kg
Carbofuran	See note d	See note d
Chlordane	1 mg/kg	7 mg/kg
Chlorpyrifos/chlorpyrifos-methyl (total)	See note d	See note d
DDT/DDD/DDE (total)	1 mg/kg	1 mg/kg
Dieldrin	0.17 mg/kg	0.17 mg/kg
Endosulfan	See note d	See note d

Table C-11. Numeric Requirements for Terrestrial Ecological Evaluation Procedure. (2 sheets)

Table 749-2 Priority Contaminants of Ecological Concern for Sites that Qualify for the Simplified Terrestrial Ecological Evaluation Procedure.[a]		
	Soil Concentration (mg/kg)	
Pesticides (Cont'd)		
Endrin	0.4 mg/kg	0.4 mg/kg
Heptachlor/heptachlor epoxide (total)	0.6 mg/kg	0.6 mg/kg
Hexachlorobenzene	31 mg/kg	31 mg/kg
Parathion/methyl parathion (total)	See note d	See note d
Pentachlorophenol	11 mg/kg	11 mg/kg
Toxaphene	See note d	See note d
Other Chlorinated Organics		
Chlorinated dibenzofurans (total)	3E-06 mg/kg	3E-06 mg/kg
Dioxins (total)	5E-06 mg/kg	5E-06 mg/kg
Hexachlorophene	See note d	See note d
PCB mixtures (total)	2 mg/kg	2 mg/kg
Pentachlorobenzene	168 mg/kg	See note d
Other Nonchlorinated Organics		
Acenaphthene	See note d	See note d
Benzo(a)pyrene	30 mg/kg	300 mg/kg
Bis (2-ethylhexyl) phthalate	See note d	See note d
Di-n-butyl phthalate	200 mg/kg	See note d
Petroleum		
Gasoline Range Organics	200 mg/kg	12,000 mg/kg except that the concentration shall not exceed residual saturation at the soil surface.
Diesel Range Organics	460 mg/kg	15,000 mg/kg except that the concentration shall not exceed residual saturation at the soil surface.

[a] Caution on misusing these chemical concentration numbers. These values have been developed for use at sites where a site-specific terrestrial ecological evaluation is not required. They are not intended to be protective of terrestrial ecological receptors at every site. Exceedances of the values in this table do not necessarily trigger requirements for cleanup action under this chapter. The table is not intended for purposes such as evaluating sludges or wastes.

This list does not imply that sampling must be conducted for each of these chemicals at every site. Sampling should be conducted for those chemicals that might be present based on available information, such as current and past uses of chemicals at the site.

[b] Applies to any site that does not meet the definition of industrial or commercial.

[c] For arsenic, use the valence state most likely to be appropriate for site conditions, unless laboratory information is available. Where soil conditions alternate between saturated, anaerobic and unsaturated, aerobic states, resulting in the alternating presence of arsenic III and arsenic V, the arsenic III concentrations shall apply.

[d] Safe concentration has not yet been established. See WAC 173-340-7492 (2)(c), "Contaminants Analysis," *Washington Administrative Code*, as amended.