DOE/RL-2000-16
Rev. 2

Remedial Design Report/Remedial Action Work Plan for the 100-NR-1 Treatment, Storage, and Disposal Units

United States
Department of Energy

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ACRONYMS

ALARA	as low as reasonably achievable
AOC	area of contamination
ARAR	applicable or relevant and appropriate requirement
AWQC	ambient water quality criteria
BARCT	best available radionuclide technology
BHI	Bechtel Hanford, Inc.
BMP	best management practice
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
CMS	corrective measures study
CVP	cleanup verification package
DAF	dilution attenuation factor
DCG	derived concentration guide
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERC	Environmental Restoration Contractor
ERDF	Environmental Restoration Disposal Facility
ESD	explanation of significant difference
HCP EIS	*Final Hanford Comprehensive Land Use Plan Environmental Impact Statement*
LDR	land disposal restriction
MCL	maximum contamination level
MTCA	*Model Toxics Control Act*
NCP	National Oil and Hazardous Substances Contingency Plan
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NPL	National Priorities List
NRC	U.S. Nuclear Regulatory Commission
OU	operable unit
PCB	polychlorinated biphenyl
PQL	practical quantitation limit
RAG	remedial action goal
RAO	remedial action objective
RCRA	*Resource Conservation and Recovery Act of 1976*
RDR/RAWP	remedial design report/remedial action work plan
RESRAD	RESidual RADioactivity dose model
RFP	request for proposal
RI/FS	remedial investigation/feasibility study
ROD	Record of Decision
RCW	*Revised Code of Washington*
SAP	sampling and analysis plan
SDWA	*Safe Drinking Water Act of 1974*
TBC	to be considered

Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TSD	treatment, storage, and disposal
UCL	upper confidence limit
UPR	unplanned release
WAC	*Washington Administrative Code*
WBS	work breakdown structure
WIDS	Waste Identification Data System

1.0 INTRODUCTION

The Hanford Site is a 1,517-km^2 (586-mi^2) Federal facility located along the Columbia River in southeastern Washington State. From 1943 until 1990, the Hanford Site produced nuclear materials for the nation's defense mission. In July 1989, the Hanford Site was listed on the National Priorities List (NPL) under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA), as amended by the *Superfund Amendments and Reauthorization Act of 1986.* The Hanford Site was divided up and listed as four NPL sites: the 100 Areas, the 200 Areas, the 300 Area, and the 1100 Area. The 100-NR-1 waste sites, which are part of the 100 Area NPL site, encompass approximately 67 km^2 (26 mi^2), bordering the southern shore of the Columbia River.

1.1 PURPOSE

The purpose of this remedial design report/remedial action work plan (RDR/RAWP) is to describe the design and implementation of the remedial actions required by the *Interim Remedial Action Record of Decision for the 100-NR-1 Operable Unit* (hereinafter referred to as the treatment, storage, and disposal [TSD]) unit Record of Decision [ROD]) (EPA 2000) and the *100-NR-1 Treatment, Storage, and Disposal Units Corrective Measures Study/Closure Plan* (DOE-RL 1998a).

1.2 SCOPE

The *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1998) specifically lists the RDR and the RAWP as two separate documents. However, this document streamlines the requirements by combining the RDR and RAWP to address both the remedial designs and remedial actions.

The 100-NR-1 Operable Unit (OU) includes liquid waste disposal sites, piping to the disposal sites, an unplanned release (UPR) site, and the facilities associated with water treatment and percolation. Included are the 116-N-1, 116-N-3, 120-N-1, and 120-N-2 TSD units, which are the subject of this report. Note that sites UPR-100-N-31 and 100-N-58 are not TSD units, but are closely associated with the 100-NR-1 TSD units and, therefore, are being addressed along with the TSD units.

Two of the TSD units, 116-N-1 (also known as 1301-N) and 116-N-3 (also known as 1325-N), and associated site UPR-100-N-31, contain radioactively contaminated soils, structures, and/or pipelines. The remedial action/closure of these waste sites represents a coordinated effort between the *Resource Conservation and Recovery Act of 1976* (RCRA) and CERCLA.

The 120-N-1 (also known as1324-NA), 120-N-2 (also known as 1324-N) TSD units, and the 100-N-58 Percolation Pond system operated as a neutralization treatment unit and did not receive radioactive contaminants. The system received corrosive wastes from the water treatment plant.

The closure of these sites will comply with RCRA. An additional 81 non-TSD waste sites are located within the 100-NR-1 OU. Remediation of these sites is addressed in a ROD for non-TSD waste sites within the 100-NR-1 OU (EPA 1999). The 81 non-TSD sites are not currently included in this RDR/RAWP, but could be added in future revisions to this document.

Remediation of the four 100-NR-1 OU TSD units is required in Chapters 16 through 19 of the *Hanford Facility Resource Conservation and Recovery Act Permit for Treatment, Storage, and Disposal of Dangerous Waste* (Ecology 1994). Remediation of the TSD units has been integrated into the 100-NR-1 OU to ensure that the remedial actions performed remain physically consistent and cost effective. Therefore, the remediation of the 116-N-1 and 116-N-3 TSD units must also meet the requirements described in the TSD ROD. (Note that remediation of the 116-N-1 and 116-N-3 TSD units and site UPR-100-N-31 is addressed in both the RCRA Permit and the TSD ROD. However, remediation [closure] of the 120-N-1 and 120-N-2 TSD units and site 100-N-58 is required only by the RCRA Permit.)

The remedial investigation/feasibility study (RI/FS) phase of the CERCLA process for the 100-NR-1 OU has been completed. The results of the remedial investigation pertinent to this RDR/RAWP are documented in the *1301-N and 1325-N Liquid Waste Disposal Facilities Limited Field Investigation Report* (DOE-RL 1996a). Additional information is presented in the *100-NR-1 Treatment, Storage, and Disposal Units Corrective Measures Study/Closure Plan* (DOE-RL 1998a) and, for 116-N-1 and 116-N-3, in the *Data Summary Report for the 116-N-1 and 116-N-3 Facility Soil Sampling to Support Remedial Design* (BHI 1999c).

1.3 WASTE SITES AND OPERABLE UNITS

The TSD ROD (EPA 2000) defines the remedial actions for TSD sites located in the 100-NR-1 OU. The closure plan presented the corrective measures study (CMS) and defines closure requirements for TSD sites that do not have contamination but nevertheless require closure (DOE-RL 1998a). Table 1-1 lists each waste site, defines the final grade, and defines the projected contaminated volume. It is possible that remedial action may also encounter waste sites adjacent to the sites listed in the TSD ROD (e.g., non-TSD waste sites that are in the vicinity of piping between the 105-N Reactor and the 116-N-1 Crib). Before any additional sites are remediated, the U.S. Department of Energy (DOE) will obtain concurrence from the appropriate regulatory agencies.

1.3.1 Waste Sites in the 100-N Area

Two OUs (i.e., 100-NR-1 and 100-NR-2) are associated with the 100-N Area at the Hanford Site. In general, the 100-NR-1 OU contains waste units associated with the liquid waste disposal facilities constructed to support N Reactor operation. The 100-NR-2 OU is the groundwater OU beneath the 100-N Area. The 100-N Area contains one reactor that operated from 1963 to 1987, four TSD units, 81 non-TSD waste sites, and numerous facilities. A pump-and-treat system in the 100-NR-2 OU is currently remediating the strontium contamination in the groundwater beneath the site. Figure 1-1 shows the locations of waste sites in the 100-N Area.

1.3.1.1 116-N-1 TSD Unit. The 116-N-1 TSD unit operated from 1963 to 1985 as the primary liquid waste disposal facility for the N Reactor. The 116-N-1 unit is composed of three distinct parts: the crib, the zig-zag trench, and the pipelines. The crib and trench received radiologically contaminated water from the 105-N Reactor basin floor drains and the 109-N floor drains. The effluent contained activation and fission products, as well as small quantities of corrosive liquids and laboratory chemicals. At times the effluent consisted of water from the primary reactor coolant system and the periphery reactor cooling system, and decontamination wastes from these systems. In 1982, pre-cast concrete panels were installed to cover the entire trench to minimize wildlife intrusion and airborne contamination. The panels were placed over the existing wooden beams and wildlife netting. The edges of the trench cover were backfilled and shotcreted. The 116-N-1 TSD unit is currently enclosed by a chain-link fence and access is controlled by a lock and key.

1.3.1.2 116-N-3 TSD Unit. The 116-N-3 TSD unit is composed of three distinct parts: the crib, the trench, and the pipelines. The crib and trench received radiologically contaminated water from the 105-N Reactor basin floor drains and the 109-N floor drains. The effluent contained activation and fission products, as well as small quantities of corrosive liquids and laboratory chemicals. At times the effluent consisted of water from the primary reactor coolant system and the periphery reactor cooling system, and decontamination wastes from these systems. The 116-N-3 Crib began operating in October 1983 as a replacement for the 116-N-1 unit, which exceeded its disposal capacity. The 116-N-3 unit received an average flow of 1,700 L/min until discharges ceased in April 1991. The unit then remained in standby mode and no longer received discharges until it was shut down in 1993. The 116-N-3 TSD unit is currently surrounded by a chain-link fence and access is controlled by lock and key.

1.3.1.3 Pipelines Associated with 116-N-1 and 116-N-3 (WIDS Designation 100-N-63). Buried pipelines associated with the 116-N-1 and 116-N-3 sites range in size from 8 to 91 cm (3.2 to 35.9 in.) in diameter, at an average depth of 3.7 m (12 ft). Because there is no process history indicating that the pipelines leaked, there is no known soil contamination associated with the pipelines. Nevertheless, it is possible that leaks have occurred but went undetected. The condition of the pipelines, internal contamination, and the extent and nature of any soil contamination that may be present will be assessed during the remedial action.

1.3.1.4 UPR-100-N-31. The UPR-100-N-31 spill occurred on July 22, 1974, while sample lines were being installed in a 15-cm (5.9-in.) steel casing through the berm on the west side of the 116-N-1 Crib. During the sample line installation, the water level in the crib was raised as a result of an emergency dump tank (1304-N) drawdown test. Due to the increased water level, effluent water containing fission and activation products flowed through the casing and was released to the soil. An area of approximately 188 m^2 (2,023 ft^2) was contaminated. After the contaminated soil was removed, clean fill material was used to restore the site. Currently the site has no postings, fences, or access restrictions because the contaminated soils have been removed and disposed.

1.3.1.5 120-N-1 Percolation Pond. The 120-N-1 Percolation Pond, the 120-N-2 Surface Impoundment, 100-N-58, and the associated pipelines comprise the disposal system for effluent from the 163-N Demineralized Water Treatment Plant. From 1977 to 1983, the 1324-NA

Percolation Pond was a large unlined basin. Liquid wastes were transferred to the north and south settling ponds where particulates were allowed to settle out. After the solids had settled out (primarily from the filter backwash effluent), the contents of the settling ponds were transferred to the percolation pond. Between 1983 and 1986, the settling ponds were closed and the percolation pond was enlarged. Effluent was treated in the percolation pond by the alternate addition of acidic cation column regeneration effluent and alkaline anion column regeneration effluent. This alternate addition of low and high pH effluent served to neutralize the effluents. The percolation pond also used the buffering capacity and calcareous nature of the soil underlying the pond to neutralize these corrosive wastes.

1.3.1.6 120-N-2 Surface Impoundment. The 120-N-2 Surface Impoundment is a double-lined pond with a leachate collection system. After treatment in the surface impoundment, neutralized wastewaters were transferred to the percolation pond by a DN300 polyvinyl chloride drain line and a DN300 polyvinyl chloride overflow line (DOE-RL 1995b). The neutralized effluent was then discharged into the soil column. The 120-N-2 Surface Impoundment was operated in conjunction with the percolation pond until November 1988, when the elementary neutralization unit was installed in the 163-N Facility. Because the surface impoundment was no longer needed for treatment of corrosive wastes, it was removed from service. The percolation pond received only neutralized effluents from November 1988, when the elementary neutralization unit became operational, until mid-year in 1991, when all effluent discharges to this system were terminated.

1.3.1.7 100-N-58, South Pond, South Settling Pond. The 100-N-58 Facility originally consisted of a north and a south pond. The ponds were constructed to reroute 163-N/183-N Water Plant wastewater discharging to the Columbia River to the ground to comply with the National Pollutant Discharge Elimination System Permit. In 1982, a plant design change was initiated to reroute the 183-N wastewater to a separate location due to continued problems with percolation. The site has been backfilled, and there is no evidence of the pond. The site is surrounded by a locked chain-link fence.

1.3.1.8 Pipelines Associated with the 120-N-1, 120-N-2, and 100-N-58 Percolation Pond System. Buried pipelines associated with the 120-N-1, 120-N-2, and 100-N-58 percolation pond system range in size from 20 to 30 cm (8 to 12 in.) in diameter, at an average depth of 3.7 m (12 ft). The buried pipelines transported corrosive wastes from the 163-N Demineralization Plant. The corrosive wastes were produced during regeneration of acidic cation columns and alkaline anion columns, which were alternately discharged through the piping. No known contamination associated with the piping exists. Several pipelines that were removed from service were likely abandoned in place. The condition of the pipelines and the extent and nature of any internal contamination that may be present will be assessed during the remedial action (see Section 3.1.2.2).

Figure 1-1. 100-N Area Waste Sites.

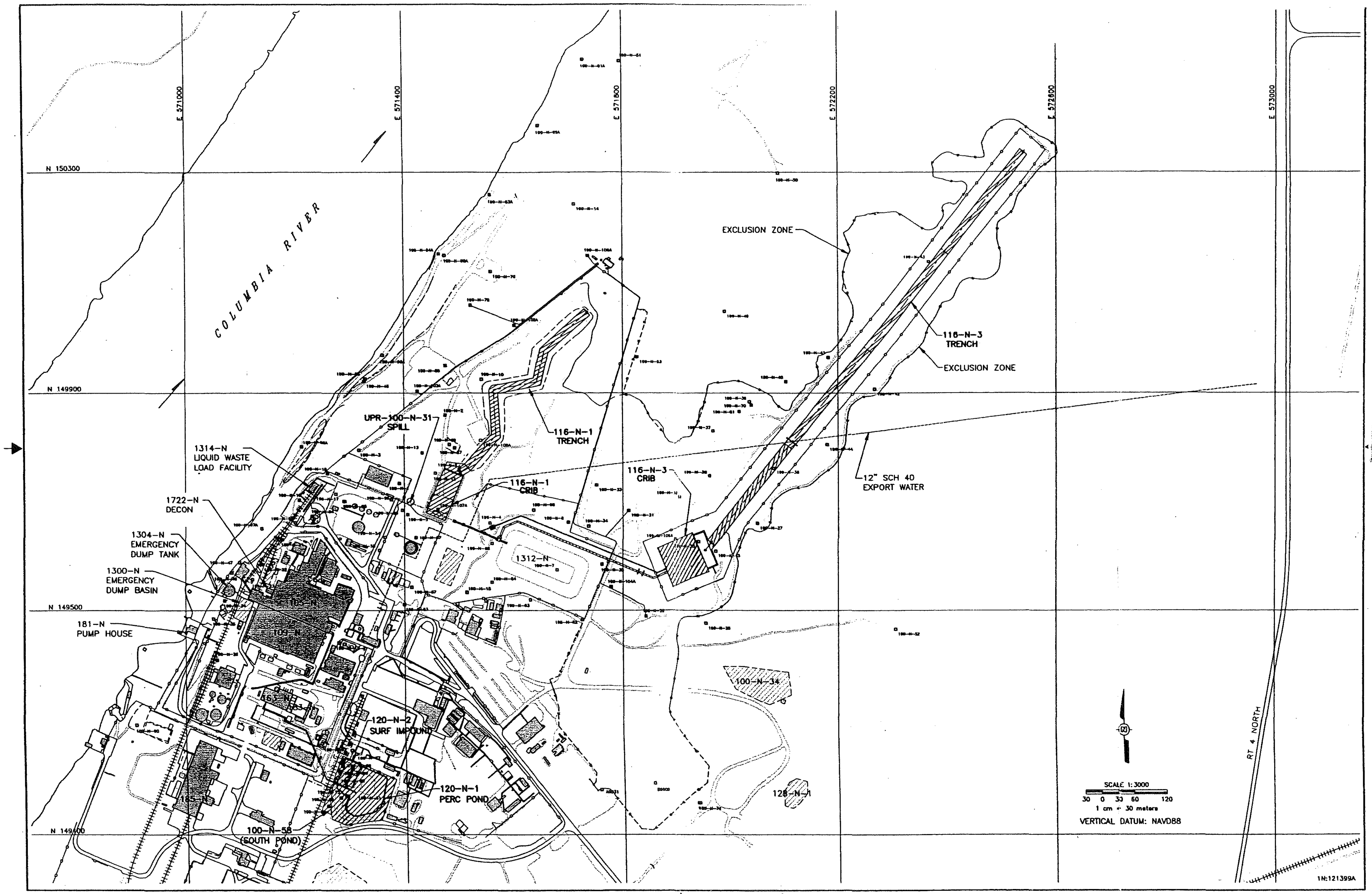

Table 1-1. Waste Sites Identified in the Interim Remedial Action Record of Decision for the 100-NR-1 Operable Unit and in Revision 5 of the Hanford Facility RCRA Permit.

Operable Unit	Waste Site	Ground Surface[a] (m)	Estimated Contaminated Volume		
			Soil[b] (LCM)	Demolition Waste (LCM)	Piping (Linear m) Total Length,[c] Trench Length[d]
100-NR-1	116-N-1[e]	138.7[f]	34,200[f]	3,052[f]	2,450[g] 1,857[g]
	116-N-3[e]	139.1[h]	26,227[g]	4,025[g]	575[g]
	100-N-31 UPR[e]	139.1	2,000[f]	0	0
	120-N-1[i]	141.0[h]	0	0	353[g] 225[g]
	120-N-2[i]	141.0[h]	0	0	
	100-N-58[i]	141.0[h]	0	0	

[a] Final backfill elevation (from North American Vertical Datum 1988) will be considered as the ground surface, as defined in the CMS (DOE-RL 1998a) .
[b] LCM = loose cubic meters (LCY = loose cubic yards); the volume of excavated material, taking into account the additional void space or "swell" of the material. A 15% swell factor is used for soil volumes and 60% for demolition waste.
[c] Represents total length of all piping, including pipelines that are side by side.
[d] Represents total length of the pipe trench for excavation.
[e] Indicates site included in the TSD ROD (EPA 2000).
[f] 100-NR-1 TSD CMS (DOE-RL 1998a).
[g] Calculation Brief No. 0100N-CA-V0017 (BHI 1999b).
[h] 100-NR-1 design drawing numbers 0100N-DD-C0094 and 100N-DD-C0095.
[i] Indicates site included in the Hanford Facility RCRA Part B Permit.
CMS = corrective measures study
RCRA = *Resource Conservation and Recovery Act of 1976*
ROD = Record of Decision
TSD = treatment, storage, and disposal

2.0 BASIS FOR REMEDIAL ACTION

Two TSD units (i.e.,116-N-1 and 116-N-3) and the associated waste site (i.e., UPR-100-N-31) contain radioactively and chemically contaminated soils, structures, and/or pipelines. The closure of these two TSD units is a coordinated effort between RCRA closure and the CERCLA remedial action process. The selected remedy for the TSD units (and the waste site) is to remove, treat, and dispose the waste under a rural-residential scenario according to the ROD (EPA 2000) and the closure plan, pursuant to the RCRA Permit (Ecology 1994).

Soil sampling at TSD units 120-N-1 and 120-N-2 and at associated site 100-N-58 indicates that no soil contamination exists above the *Model Toxics Control Act* (MTCA) Method B values (Washington Administrative Code [WAC] 173-340); therefore, no remedial action of the soil column is required. However, there are associated pipelines, structures, and liners that may be removed and disposed in accordance with the RCRA Permit (Ecology 1994), which incorporates the closure plan (DOE-RL 1998a).

Due to the presence of groundwater contamination in the form of a radionuclide plume associated with 116-N-1 and 116-N-3, and a sulfate plume associated with 120-N-1 and 120-N-2, these sites will be closed under modified closure pursuant to the RCRA Permit and Washington State dangerous waste regulations (WAC 173-303). The Washington State Department of Ecology (Ecology) intends to retain its RCRA post-closure authority pending the completion of CERCLA groundwater remedial action.

2.1 RCRA PERMIT REQUIREMENTS

2.1.1 General Permit Requirements

The RCRA Permit has both general and site-specific requirements that must be met in order to close the TSD units. The general requirements are summarized as follows:

- Maintain a TSD unit-specific operating record
- Maintain monitoring records (i.e., quarterly inspection reports) at the TSD unit and in the project operating record
- Notify Ecology of any planned physical changes to the facilities
- Notify Ecology in advance of any changes that could result in noncompliance
- Immediately notify Ecology verbally of releases of dangerous substances or of any noncompliance that may endanger human health or the environment
- For a noncompliance event not requiring an immediate verbal notification, prepare a brief record of the release within 2 days of the incident

- Within 15 working days, prepare and submit a written report to Ecology describing any noncompliance event
- Within 15 working days, prepare a report for any incident that requires the contingency plan to be implemented
- Maintain a copy of the contingency plans
- Make changes to the contingency plan if the plan fails in an emergency or if there are changes at the unit that increase the risk of fire, explosion, or release to the environment.

2.1.2 Specific Permit Requirements

Specific permit requirements for closure of TSD units in the 100-NR-1 OU are summarized in Tables 2-1 and 2-2.

Additional site-specific permit requirements for TSD units 116-N-1 and 116-N-3 are summarized below:

- TSD training plans must identify the types of training by job category.
- TSD site-specific training provides facility workers with facility-specific knowledge relative to dangerous waste management hazards; contingency plan implementation; effective response to emergencies; communications and alarm systems; response to fire or explosion; emergency equipment; and procedures for using, inspecting, repairing, and replacing emergency and monitoring equipment.
- Field inspections for 116-N-1 and 116-N-3 institutional controls and groundwater monitoring systems shall be implemented. Inspectors are required to record any damage to the area and report any maintenance needs in the inspection logbook.
- Maintain the facility operating record by collecting all documents required by the RCRA Permit (Ecology 1994).

Groundwater monitoring and institutional controls must continue as described in the RCRA Permit (Ecology 1994), but are not part of the closure activities for soil and structures.

2.2 RECORD OF DECISION SUMMARY AND DECISION DEFINITION

2.2.1 Summary of Selected Remedy

The selected remedy specified in the TSD ROD is to remove and dispose the waste at the Environmental Restoration Disposal Facility (ERDF). The remove/dispose alternative involves the following elements:

- Remove pipelines and aboveground structures
- Excavate clean overburden material
- Excavate contaminated soils
- Treat contaminated soils (if required)
- Dispose of contaminated material at the ERDF
- Backfill with clean material, grade, and revegetate the sites.

A number of remedial action alternatives were evaluated in the CMS (DOE-RL 1998a). The alternatives evaluated include No Action, Remove/Treat/Dispose, Institutional Controls, Containment, and In Situ and Ex Situ Treatment. The Remove/Treat/Dispose and the No Action alternatives were addressed in the TSD ROD. Should future decisions restrict certain land uses, exposure scenarios and resultant alternative analyses will be reevaluated.

The objectives of the interim remedial actions authorized in the TSD ROD are to reduce potential threats to human health and the environment and to facilitate unrestricted future land use in the 100 Areas. Only the Remove/Treat/Dispose alternative is consistent with unrestricted future land use at the 116-N-1, 116-N-3, and UPR-100-N-31 waste sites.

Any material that exceeds the ERDF waste acceptance criteria (BHI 1998), which would include RCRA land disposal restrictions (LDRs) (10 CFR 62), would be stored on the Hanford Site in compliance with applicable or relevant and appropriate requirements (ARARs) until treated to meet waste acceptance criteria. Treatment will be required for LDR material unless a treatability variance or ARAR waiver is requested by DOE and approved by the regulatory agencies. Soils contaminated with chemicals at levels exceeding waste disposal acceptance criteria (if any) would be treated by solidification/stabilization or other appropriate treatment technology.

Solidification and stabilization are treatment technologies designed to reduce contaminant solubility, mobility, or toxicity through chemical or physical changes. Typical solidification and stabilization agents include cement-based materials, clays, asphalt, and resins (e.g., epoxies). Contaminated soil and/or contaminated products resulting from treatment technologies would be disposed in the same manner as materials that meet the waste acceptance criteria without treatment.

2.2.2 Remedial Action Objectives

The remedial action objectives (RAOs) set forth in the TSD ROD are narrative statements that define the extent to which the waste sites require cleanup to protect human health and the environment. The RAOs identified in the TSD ROD apply to contaminants in soils, structures, and debris. The TSD ROD specifically defines five RAOs. The RAOs cited below are excerpted from the TSD ROD (in italics).

1. *Protect human and ecological receptors from exposure to radioactive contaminants in surface and subsurface soils, structures, and debris. Exposure routes include ingestion and inhalation, as well as external radiation exposure from radionuclides. Protection will be achieved by reducing concentrations of contaminants in the upper 4.6 m (15 ft) of soil. Soils will also be removed to a depth of 1.5 m (5 ft) below the engineered structures of the 116-N-1 and 116-N-3 cribs and trenches that contain plutonium-239/240. The levels of reduction will be such that the total dose does not exceed 15 mrem/yr above Hanford Site background*[1] *for 1,000 years following remediation. The 1,000-year requirement ensures that the proposed standard accounts for decay of radionuclides to daughter products that are more highly radioactive.*

2. *Protect potential human and ecological receptors from exposure to nonradioactive contaminants present in the upper 4.6 m (15 ft) of soil and debris. Exposure routes include ingestion, inhalation, or dermal exposure. Protection will be achieved by reducing concentrations of contaminants in the upper 4.6 m (15 ft) of soil to the State of Washington MTCA Method B levels or alternates as allowed by MTCA.*

3. *Protect the unconfined groundwater system from adverse impacts by reducing concentrations of radioactive and nonradioactive chemical contaminants present in the soil column that could migrate to the groundwater. Contaminant levels will be reduced so concentrations reaching the groundwater do not exceed the State of Washington MTCA Method B levels or maximum contaminant levels (MCLs)* (see Table 2-3).

4. *Protect the Columbia River from adverse impacts so that designated beneficial uses are maintained. Protect associated potential human and ecological receptors using and living in the river from exposure to radioactive and nonradioactive chemical contaminants. Protection will be achieved by reducing concentrations of, or limiting exposure pathways to, contaminants present in the soil column that could migrate to the groundwater and eventually to the river. Contaminant levels will be reduced so that concentrations reaching the river do not exceed MTCA Method B values, MCLs promulgated under the Federal Safe Drinking Water Act, the State of Washington's drinking water standards, ambient water quality criteria (AWQC), or the State of Washington's surface water quality standards (including a* Cr^{+6} *standard of 10 ppb) (WAC 173-201A-040), whichever is most stringent.*

The first four RAOs will be achieved through the implementation of the selected remedy (remove/dispose), as outlined in the TSD ROD. The design and remedial action will incorporate the observational approach where ever possible, combining characterization and remediation steps to maximize the use of resources.

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[1] Steve Luftig and Larry Weinstock, *Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination*, OSWER No. 9200.4-18, dated August 22, 1997, U.S. Environmental Protection Agency, Washington, D.C.

5. *Prevent destruction of significant cultural resources and sensitive wildlife habitat. Minimize the disruption of cultural resources and wildlife habitat in general and prevent adverse impacts to cultural resources and threatened or endangered species.*

The fifth RAO will be achieved by completing a cultural and natural resources review prior to excavation and implementation of an exclusion area and associated fencing to prevent accidental intrusion into sensitive areas. A revegetation plan has been developed (Appendix D), and the Natural Resource Trustees and Native American Tribes will be consulted during mitigation and restoration activities.

The TSD ROD also indicates that for establishing numerical remedial action goals (RAGs) protective of human health, the RAOs will be met by using the rural-residential exposure scenario. Removal of soil and debris exceeding human health-based goals and replacement (i.e., backfilling) with clean material also will meet the objective of protection of ecological receptors. Note that the top 4.6 m (15 ft) of soil are defined from the final elevation (see Table 1-1). After RAOs have been identified, for some RAOs it is necessary to develop numerical RAGs for use in remedial design and to verify that remedial action has achieved the RAOs. The RAO framework involves the following:

- Calculating contaminant-specific concentrations in soil that correspond to the RAGs for use in remedial design

- Developing a verification methodology for use in remedial action to determine if residual concentrations in soil achieve the RAGs.

2.2.3 Remedial Action Goals

Remedial action goals are the contaminant-specific numerical cleanup criteria developed to ensure that the remedial actions to be implemented will meet the RAOs set forth in Section 2.2.2 and in the TSD ROD. The RAGs are based on ARARs, to-be-considered (TBC) information, points of compliance, and assumed land use for the remedial action identified in the TSD ROD.

- The first RAO will be achieved by meeting the requirements of 15 mrem/yr in accordance with the U.S. Environmental Protection Agency's (EPA's) standard (EPA 1997).

- The second RAO will be met by meeting the requirements of MTCA Method B levels or alternates as allowed by MTCA for nonradioactive constituents.

- The third RAO will be achieved by meeting the requirement of protection of the unconfined groundwater so levels do not exceed MTCA Method B or maximum contaminant levels (MCLs).

- The fourth RAO will be achieved by meeting the requirement of protection of the Columbia River so that contaminants remaining in the soil column that could migrate to the river do not exceed MTCA Method B values, MCLs of the Federal Safe Drinking Water Act, the State of

Washington's drinking water standards, ambient water quality criteria (AWQC), or the State of Washington's surface water quality standards (whichever is most stringent).

- The fifth RAO is subjective in nature and, as such, numeric RAGs cannot be calculated. Approval of the revegetation plan (Appendix D) and the subsequent backfilling and revegetation of the site constitute attainment of this RAO.

2.2.3.1 Remedial Action Goals for Nonradioactive Contaminants in Soil. Cleanup standards for nonradioactive contaminants in near-surface soil (to a depth of 4.6 m [15 ft] from the ground surface, defined as the grade at the time of disposal) are specified under MTCA cleanup regulations (WAC 173-340-704 through 706). MTCA Method B (WAC 173-340-705) specifies cleanup levels for groundwater, surface water, soil, and air, assuming a residential exposure scenario.[1] Cleanup levels for individual hazardous substances are established using applicable state and Federal laws and the risk equations specified in WAC 173-340-720 through 750. Cleanup levels for individual carcinogens are based on the upper bound of the estimated excess lifetime cancer risk of one in one million (1.0×10^{-6}). Cleanup levels for individual noncarcinogenic substances are set at concentrations that are anticipated to result in no acute or chronic toxic effects on human health and the environment. This level corresponds to a hazard quotient of less than one.

If a waste site involves multiple contaminants and/or multiple pathways of exposure, MTCA Method B cleanup levels for individual substances must be modified in accordance with the human health risk assessment procedures outlined in WAC 173-340-708. This modification of cleanup levels, if necessary, would take place during the verification of site cleanup following remediation. Under this method, the total excess lifetime cancer risk for a site shall not exceed one in one hundred thousand (1.0×10^{-5}), and the hazard index for substances with similar noncarcinogenic toxic effects shall not exceed one (WAC 173-340-705[4]).

Cleanup levels for some contaminants may be less than natural background values or practical quantitation limits (PQLs). Where MTCA Method B cleanup levels are less than natural background concentrations, cleanup levels may be set at concentrations that are equal to the agreed-upon site or natural background concentrations (WAC 173-340-706[1][a][I]). Natural background for nonradioactive contaminants in soil was characterized for the Hanford Site (DOE-RL 1995a). Similarly, where MTCA Method B cleanup levels are less than PQLs for nonradioactive contaminants, cleanup levels will default to the PQLs (WAC 173-340-707[2]). The cleanup level for an individual nonradioactive contaminant in soil reflects the greatest value among the MTCA Method B cleanup level, the natural background concentration, and the PQL; however, in no case shall cleanup levels be greater than concentrations specified under MTCA Method C (WAC 173-340-706 [1][a]).

2.2.3.2 Remedial Action Goals for Radionuclide Contaminants in Soil. Remedial action goals for radionuclide contaminants in soil are based on the EPA standard of 15 mrem/yr

[1] MTCA Method B is based on a residential land-use scenario, including the potential for a 3.7-m (12-ft)-deep residential basement. It is assumed that deed restrictions or other institutional controls would be applied at waste sites as necessary to preclude direct exposure to residual contaminants in deep soils that might remain onsite.

(EPA 1997). This guidance would limit radiation doses from contaminated sites to 15 mrem/yr above site background levels for 1,000 years following the completion of a remedial actions. The 1,000-year requirement ensures that the decay of radionuclides to daughter products that are more radioactive are taken into account. The development of cleanup standards for the 100-NR-1 TSD sites will not be affected because the principal radionuclides of concern in the 100-NR-1 TSD sites (e.g., cobalt-60, cesium-137, strontium-90, and europium-154) do not decay to daughter products that are more radioactive.

The 15 mrem/yr standard corresponds to a lifetime increased cancer risk of 3.0×10^{-4} based on the following assumptions:

- The future land use will be residential (includes irrigation).
- Future residents are potentially exposed for 30 years.
- Potential exposure pathways are considered in assessing exposure to future residents. The exposure pathways considered are external exposure, inhalation, crop ingestion, meat ingestion, fish ingestion, and soil ingestion.
- Due to the known strontium groundwater contamination and ongoing pump-and-treat system operation, the contaminated groundwater will not be used for any purpose.

The 15 mrem/yr standard falls within the range of other radiation protection standards promulgated by the EPA (e.g., standards employed under the *Uranium Mill Tailings Radiation Control Act of 1978* and the National Emissions Standards for Hazardous Air Pollutants ([NESHAP]).

Limiting exposure levels to 15 mrem/yr above background acknowledges that background varies from site to site. Radionuclide measurement techniques must distinguish site contamination from naturally occurring radionuclides. The principal radionuclides of concern in the 100-NR-1 TSD sites (e.g., cobalt-60, cesium-137, and europium-154) are present at very low concentrations in background soils. Radionuclides that pose the largest contributions to background dose (e.g., potassium-40, uranium-238 + daughter, and thorium-232 + daughter) are generally not considered contaminants of potential concern for purposes of remedial action. Background concentrations of radionuclides in soils at the Hanford Site were published in DOE-RL (1996b).

To determine when remedial action has achieved the 15 mrem/yr cleanup level, radionuclide concentrations (pCi/g) in soil must be converted to a dose rate (mrem/yr) using a dose assessment model. The RESidual RADioactivity (RESRAD) dose model was selected as the assessment model for generating RAGs for radionuclide contaminants in soil and for verifying that concentrations remaining after remedial action achieve the 15 mrem/yr cleanup level. The RESRAD model was developed by Argonne National Laboratory (ANL 1993) to implement DOE guidelines for residual radioactive material in soil. The RESRAD model has been accepted by EPA and Ecology for performing dose assessments to support the 15 mrem/yr standard.

The use of a dose assessment model requires specification of pathways of exposure to a hypothetical receptor of radionuclides present in the soil and development of assumptions and input parameters for estimating exposures and doses to the receptor from radionuclides in the soil. Specific RESRAD input parameters used to calculate the RAGs for radionuclide contaminants in the soil are listed in Table B-1 in Appendix B.

The RESRAD model was used to calculate concentrations of individual radionuclides in soil that correspond to a dose rate of 15 mrem/yr. The single radionuclide soil concentrations correspond to a 15 mrem/yr dose. As was the case for nonradioactive contaminants in soil, the cleanup level for an individual radionuclide contaminant in soil reflects the greatest value among the single radionuclide soil concentration corresponding to a 15 mrem/yr dose, the natural background concentration, and the PQL. During the verification process, site-specific input parameters will be used in the RESRAD model to verify that residual radionuclide concentrations achieve the cleanup standard.

2.2.3.3 Remedial Action Goals for Nonradioactive Contaminants in Water – Protection of Groundwater/Columbia River. The RAGs for nonradioactive contaminants in water, protective of groundwater, are based on MCLs and MTCA Method B levels. For each nonradioactive contaminant, protection of groundwater is achieved by identifying the most restrictive contaminant-specific value from these standards as the cleanup level.

The RAGs for nonradioactive contaminants in water, protective of the Columbia River, are based on MCLs, MTCA Method B levels, AWQC, State of Washington drinking water standards, and State of Washington surface water quality standards. For each nonradioactive contaminant, protection of the Columbia River is achieved by identifying the most restrictive contaminant-specific value from these standards as the cleanup level.

2.2.3.4 Remedial Action Goals for Radionuclide Contaminants in Water – Protection of Groundwater/Columbia River. As amended in 1986, the *Safe Drinking Water Act of 1974* (SDWA) seeks to protect public water supply systems through the protection of groundwater. Any radioactive substances that may be found in water are regulated under the SDWA. The "National Primary Drinking Water Regulations" (40 *Code of Federal Regulations* [CFR] 141) specify MCLs for radionuclide contaminants in drinking water. The RAGs for radionuclide contaminants in water, protective of both surface water and groundwater, are based on achieving the MCL. Although some of the following information is not applicable to the current contaminants of concern, a complete discussion of the MCLs for radionuclides in water is presented.

The MCL for combined radium-226 and radium-228 is 5 pCi/L (40 CFR 141.15). The MCL for gross alpha activity, including radium-226 but excluding radon and uranium, is 15 pCi/L (40 CFR 141.15). The average annual concentration of beta particle and photon radioactivity from man-made radionuclides in drinking water shall not produce an annual dose equivalent to the total body or any internal organ greater than 4 mrem/yr (40 CFR 141.16). The MCLs for strontium-90 and tritium are 8 pCi/L and 20,000 pCi/L, respectively (40 CFR 141.16). In the absence of an MCL for uranium, an activity of 30 pCi/L from the *Uranium Mill Tailings Radiation Control Act of 1992* (40 CFR 192), promulgated by the EPA, is the standard for uranium. The MCL for all other man-made beta particle and photon-emitting radionuclides, except tritium and strontium-90, causing a 4-mrem/yr dose is calculated on the basis of a 2-L/day drinking water intake using the 168-hour data listed in *Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air or Water for Occupational Exposure* (NBS 1963). If two or more radionuclides are present, the sum of their annual dose shall not exceed 4 mrem/yr (40 CFR 141.16). For some radionuclides, the concentration in water calculated with this method is higher than 1/25 of the DOE-derived concentration guide (DCG) in water (1/25 of the DCG corresponds to a dose of 4 mrem/yr). In these cases, 1/25 of the DCG is adopted as the RAG for water rather than the calculated MCL value.

2.2.3.5 Remedial Action Goals for Residual Contaminants in Soil – Protection of Groundwater/Columbia River. Residual contaminants remaining in soil after remediation must be at levels so that concentrations of contaminants reaching the unconfined aquifer and, eventually, the Columbia River, by migration through the soil column do not exceed RAGs considered protective of groundwater and the Columbia River.

2.2.3.6 Groundwater Protection – Nonradioactive Contaminants. For nonradioactive contaminants, MTCA specifies that concentrations of residual contaminants are considered protective of groundwater at levels equal to or less than 100 times the groundwater cleanup levels established in accordance with WAC 173-340-720, unless it can be demonstrated that a higher soil concentration is protective of groundwater at the site (WAC 173-340-740[3][a][ii][A]). The 100 times rule is applied to nonradioactive contaminants as the first step in calculating residual soil concentrations that are protective of groundwater. If residual concentrations exceed cleanup levels calculated using the 100 times rule, site-specific modeling will be performed to provide a refinement of contaminants found to simulate actual conditions at the waste site.

2.2.3.7 Groundwater Protection – Radionuclide Contaminants. The 100 times rule is not applied to residual radionuclide contaminants. For radionuclides, groundwater protection is demonstrated through technical evaluation using RESRAD. The RESRAD model is used to demonstrate whether specific radionuclides will reach groundwater in 1,000 years (the time period specified in the EPA proposed rule for radionuclide cleanup), and, if so, what groundwater concentrations would occur. The RESRAD input parameters used in the modeling are presented in Table B-1, Appendix B. The RESRAD model is used in conjunction with a contaminant-at-depth profile to calculate values protective of groundwater.

2.2.3.8 Columbia River Protection – Nonradioactive and Radionuclide Contaminants. To achieve protection of the Columbia River, the calculation of RAGs for residual soil contamination must consider two additional contaminant transport steps beyond the migration of contaminants through the soil column and their subsequent leaching into groundwater. The additional contaminant transport steps are (1) the transportation, from beneath the waste site to near-river wells (the point of compliance), of contaminants that have leached to groundwater; and (2) the mixing of groundwater contaminant concentrations with river water within the substrate at the groundwater/river interface. The model that addresses these two steps is the dilution attenuation factor (DAF) model. This model accounts for the time required for a contaminant to travel through the groundwater underlying a site to the river, radionuclide decay during that travel time period, and a 1:1 dilution factor applied to contaminant concentrations measured in near-river wells (to account for the difference in concentration between the near-river well and the substrate at the groundwater/river interface). In evaluating contaminant transport time, the model uses a 1,000-year period (starting from the time of site closeout) and considers the effect of retardation as contaminants move from under the waste site to the river. As appropriate, dilution factors greater than 1:1 will be evaluated on a constituent-specific basis using Hanford Site data.

To be consistent, the same methodology applied to residual soil contamination to ensure protection of the groundwater was applied to ensure protection of the Columbia River. For residual nonradioactive contaminants, protection of the river is achieved by reducing concentrations remaining in soil after remediation to concentrations less than or equal to 100 times the RAG after the DAF has been applied. If residual contaminant concentrations exceed river protection cleanup levels calculated using the 100 times rule, site-specific modeling will be performed to provide a refinement on contaminants found to simulate actual conditions at the waste site.

For residual radionuclide contaminants that reach groundwater within 1,000 years, as demonstrated by RESRAD modeling, protection of the river is achieved by reducing concentrations remaining in soil after remediation to concentrations less than or equal to the value calculated by RESRAD to achieve the RAG after the DAF has been applied.

2.2.4 Application of Remedial Action Goals

The decision process for determining the extent of remediation of the waste sites will incorporate site-specific factors. The waste sites are represented by the following three general categories. The application of RAGs to meet RAOs for each site category is discussed below.

- For remediation of the top 4.6 m (15 ft) below surrounding grade or the bottom of the engineering structure, whichever is deeper, remove until contaminant levels are (1) demonstrated to be at or below MTCA Method B levels for nonradioactive chemicals and achieve 15 mrem/yr above background for radionuclides for rural-residential exposure, and (2) demonstrated to provide protection of the groundwater and the Columbia River. Contaminant levels will be reduced so concentrations reaching the groundwater or the Columbia River do not exceed MTCA Method B levels, Federal and state MCLs, or Federal and state AWQC, whichever is most restrictive.

- For sites where the engineered structure and/or contaminated soil and debris begins above 4.6 m (15 ft) and extends to below 4.6 m (15 ft), the engineered structure (at a minimum) will be remediated to achieve RAOs so that contaminant levels are demonstrated to be at or below MTCA Method B levels for nonradioactive chemicals for exposure and the 15 mrem/yr residential dose level and are at levels that provide protection of groundwater and the Columbia River. Any residual contamination present below the engineered structure and at a depth greater than 4.6 m (15 ft) shall be subject to several factors in determining the extent of remediation, including reduction in risk by decay of short-lived radionuclides (i.e., half-life less than 30.2 years), protection of human health and the environment, remediation costs, sizing of the ERDF, worker safety, presence of ecological and cultural resources, the use of institutional controls, and long-term monitoring costs. The extent of remediation also must ensure that contaminant levels remaining in the soil are at or below MCLs for protection of groundwater or AWQC for protection of the Columbia River. For radionuclides, groundwater and river protection may be demonstrated through a technical evaluation using RESRAD. The application of the criteria for the balancing factors will be made by EPA and Ecology on a site-by-site basis. A public comment period of no less than 30 days will be required prior to making any determination to invoke balancing factors.

- Remove soils to a depth of 1.5 m (5 ft) below the engineered structures of 116-N-1 and 116-N-3 Cribs and Trenches that contain plutonium-239/240.

2.2.5 Contaminant-Specific Concentrations in Soil

As discussed in Section 2.2.2, representative contaminant-specific concentrations in soil have been calculated that correspond to the RAGs described in Section 2.2.3. These contaminant-specific concentrations are used as follows:

- To identify target volumes in soil that require remediation for purposes of remedial design
- To identify minimum quantitation limits for contaminants in soil that must be achieved by analytical systems used during remedial action
- To provide lookup values for use in the field to rapidly evaluate analytical data collected during remedial action.

These contaminant-specific concentrations correspond to the RAGs but are not intended for use in verifying that remedial action is complete at a site. The concentrations represent values that individually equate to MTCA values or 15 mrem/yr dose rate. For radionuclides, the expectation is that most sites will have multiple radionuclides driving the cleanup; therefore, a cumulative dose of 15 mrem/yr would potentially result in individual radionuclide concentrations that are lower than these lookup values. The process for developing and using these contaminant-specific concentrations is presented in Figure 2-1. The verification process is further defined in Section 3.6. A summary of all representative lookup values can be found in Table 2-3.

2.2.6 Balancing Factors

The TSD ROD provides a decision framework to evaluate leaving some of the contamination in place:

> *For sites where the engineered structure and/or contaminated soil and debris begins above 4.6 m (15 ft) and extends to below 4.6 m (15 ft), the engineered structure (at a minimum) will be remediated to achieve RAOs such that contaminant levels are demonstrated to be at or below MTCA Method B levels for nonradioactive chemicals for exposure and the 15 mrem/yr residential dose level, and are at levels that provide*

> *protection of groundwater and the Columbia River. Any residual contamination present below the engineered structure and at a depth greater than 4.6 m (15 ft) shall be subject to several factors in determining the extent of remediation, including reduction in risk by decay of short-lived radionuclides (half-life less than 30.2 years), protection of human health and the environment, remediation costs, sizing of the ERDF [Environmental Restoration Disposal Facility], worker safety, presence of ecological and cultural resources, the use of institutional controls, and long-term monitoring costs. The extent of remediation also must ensure that contaminant levels remaining in the soil are at or below MCLs for protection of groundwater or AWQC for protection of the Columbia River. For radionuclides, groundwater and river protection may be demonstrated through a technical evaluation using the computer model RESRAD. The application of the criteria for the balancing factors will be made by EPA and Ecology on a site-by-site basis. A public comment period of no less than 30 days will be required prior to making any determination to invoke balancing factors." (EPA 2000)*

The balancing factors can be divided into two categories: (1) factors effecting the size of the excavation and (2) factors associated with cost. Three of the balancing factors (i.e., minimizing disturbance of cultural or ecological resources, minimizing the size of the ERDF [minimizing waste volume], and protecting worker health and safety) weigh in favor of minimizing excavation size. The other balancing factors suggest that the extent of remediation and associated costs be weighed against the reliability and cost of institutional controls. The two categories, when weighed with protection of human health and the environment, lead to the following conclusions:

- Contaminant concentrations below 4.6 m (15 ft) or below the engineered structure will be required to meet the criteria for protection of the groundwater and the Columbia River, as stated in RAO numbers 3 and 4 in Section 2.2.2. For residual contamination below 4.6 m (15 ft) or below the engineered structure shown to impact groundwater or the Columbia River, the balancing factors may be invoked.

- Radioactive contaminants present below the 4.6-m (15-ft) level will be required to be equal to or below concentrations so the external radiation to a potential receptor (in combination with radiation exposure from other contaminant pathways) is below 15 mrem/yr.

- In the event that DOE relinquishes full control of the site, deed restrictions will be applied as necessary to prohibit excavation and drilling below the 4.6-m (15-ft) level in those cases where contaminants meet the required groundwater/river protection cleanup goals but exceed concentrations that are protective for direct exposure.

- For areas where lateral movement of contaminants, low radionuclide levels, or small quantities of disposed waste would recover marginally contaminated material to be disposed at the ERDF, or where it can be demonstrated that radionuclide concentrations will result in achieving an acceptable risk range within a reasonable period of time, the balancing factors may be invoked.

In the event that the consideration of balancing factors results in a recommendation to leave contaminated soils or debris in place at a waste site at levels that exceed the RAOs, the TSD ROD states that the Tri-Parties (i.e., DOE, EPA, and Ecology) will initiate public involvement prior to making a decision to leave contamination in place. The process will be as described for a RCRA Permit modification and/or an explanation of significant difference (ESD) in the public involvement plan (Appendix C).

Deed/lease restrictions or other institutional controls and long-term monitoring may be required to prevent human exposure to groundwater and/or contaminated soils or interference with the integrity of the cleanup action for any site. Potential deed restrictions could prohibit the drilling of any well to groundwater or any activity that would result in soil disturbance greater than 3.7 m (12 ft) below the surface. The requirement for deed/lease restrictions will be documented in the site cleanup verification package (CVP) and executed in accordance with DOE land release policy. Public comment would not be sought for deed/lease restrictions deemed necessary to prevent interference with the integrity of the cleanup action.

2.2.7 Applicable or Relevant and Appropriate Requirements

The "National Oil and Hazardous Substances Contingency Plan" (NCP) (40 CFR 300) and the TSD ROD require that the remedial actions described in this document comply with the ARARs established in the TSD ROD. The purpose of this section is to discuss how each of the ARARs identified in the TSD ROD will be met during remedial action. The discussions of ARAR compliance in this section apply to all waste sites in the TSD ROD because these waste sites are currently the only sites for which detailed remedial action plans and specifications have been prepared. Waste sites not associated with the TSD ROD (i.e., 120-N-1, 120-N-2, and 100-N-58) have ARARs established in the CMS (DOE-RL 1998a). As detailed plans and specifications are prepared for subsequent groups of sites, compliance with ARARs will be evaluated, and this section may be revised as necessary to incorporate any new activities that are subject to the ARARs.

All activities associated with the remedial action for the source area sites covered under the TSD ROD will occur onsite, as that term is defined under the NCP. As a result, the remedial actions for waste sites identified in the TSD ROD need only meet the substantive requirements of the ARARs established in the TSD ROD. The waste sites not identified in the TSD ROD are identified in the RCRA dangerous waste permit and must meet all substantive and administrative requirements of the permit.

If any requirement that would be applicable or relevant and appropriate for the selected remedial action is promulgated subsequent to the TSD ROD being signed, Ecology will review the requirement and determine whether the selected remedy is still protective in light of the new requirement. This determination will be documented in the Administrative Record.

2.2.7.1 Compliance with Applicable or Relevant and Appropriate Requirements. The selected remedy will comply with the Federal and state ARARs identified below. No waiver of any ARAR is being sought. The ARARs identified for the 100-NR-1 TSD units and their associated sites are as follows:

- *Model Toxics Control Act* (*Revised Code of Washington* [RCW] 70.105D), "MTCA Cleanup Regulation" (WAC 173-340). Establish risk-based cleanup levels that are applicable for establishing cleanup levels for metal and organic contaminants in soil, structures, and debris.

- *Safe Drinking Water Act of 1974* (40 U.S.C. 300, et seq.), "National Primary Drinking Water Regulations" (40 CFR 141). Establish MCLs for public drinking water supplies that are relevant and appropriate for establishing soil cleanup goals that are protective of groundwater.

- *Federal Water Pollution Control Act of 1977* (33 U.S.C. 1251, et seq.), "Water Quality Standards" (40 CFR 131). Establishes AWQC that are relevant and appropriate for establishing soil cleanup goals that are protective of the Columbia River.

- "Water Quality Standards for Surface Waters of the State of Washington" (WAC 173-201A). Establishes surface water quality criteria that are relevant and appropriate for establishing soil cleanup goals that are protective of the Columbia River.

- *Hazardous Waste Management Act of 1976* (RCW 70.105), "Dangerous Waste Regulations" (WAC 173-303). This RCRA-authorized state program is applicable to the identification and generation of dangerous waste (which includes all federally regulated hazardous waste under RCRA) and storage, transportation, treatment, and disposal of the wastes recovered during the interim remedial action that are designated as dangerous waste. The EPA has delegated the authority to implement RCRA to the State of Washington. As a result, the regulations promulgated by the state to implement RCRA (the dangerous waste regulations) are the primary ARARs for dangerous waste recovered during the remedial action. Activities performed to comply with the state regulations must also comply with the Federal RCRA regulations specified in the TSD ROD.

- "Closure and Post-Closure" (WAC 173-303-610[2]). RCRA closure and post-closure performance standards are applicable for the closure of the TSD units.

- "Land Disposal Restrictions" (40 CFR 268). Applicable for treatment and disposal of wastes designated as dangerous wastes.

- "RCRA Standards for Miscellaneous Treatment Units" (40 CFR 264, Subpart X). Relevant and appropriate to the construction, operation, maintenance, and closure of any miscellaneous treatment unit constructed in the 100 Areas for treatment of dangerous wastes.

- *Solid Waste Management Act* (RCW 70.95), "Minimum Functional Standards for Solid Waste Handling" (WAC 173-304). Applicable for management of solid wastes during the interim remedial action.

- *Toxic Substances Control Act* (15 U.S.C. 2601, et seq.) implemented via 40 CFR 761. Applicable to the management and disposal of remediation waste containing regulated concentrations of polychlorinated biphenyls (PCBs), including specific requirements for PCB remediation waste.

- "Requirements for Land Disposal of Radioactive Wastes" (10 CFR 62). Establishes requirements for management and disposal of radioactive waste at U.S. Nuclear Regulatory Commission (NRC)-licensed facilities that are relevant and appropriate for wastes recovered by the interim remedial action.

- *Clean Air Act* (42 U.S.C. 7401, et seq.) and "National Emissions Standards for Hazardous Air Pollutants" (40 CFR 61). Applicable to remedial activities that will result in airborne emissions of hazardous air pollutants, including prohibitions on radionuclide emissions that would result in an effective offsite dose equivalent of 10 mrem/yr and visible emissions from asbestos-handling activities.

- "Emission Limits for Radionuclides" (WAC 173-480). Applicable to remedial activities that will result in air emissions of radionuclides from specific sources, including requirements for best available radionuclide control technology (BARCT).

- *Nuclear Energy and Radiation Act* (RCW 70.98) and "Radiation Protection – Air Emissions" (WAC 246-247). Applicable to remedial activities that will result in airborne emissions of radionuclides, including prohibition on radionuclide emissions that would result in an effective offsite dose equivalent of 10 mrem/yr and requirements for monitoring, as appropriate.

- "Minimum Standards for Construction and Maintenance of Wells" (WAC 173-160). Applicable for the location, design, construction, and abandonment of water supply and resource protection wells (including monitoring wells).

- *Archeological Resources Protection Act of 1979* (16 U.S.C. 417) implemented via 43 CFR 7. Applicable when remedial activities may cause possible harm or destruction of sites in the 100-N Area having religious or cultural significance. No known archaeological or historic artifacts exist within the proposed "footprints" for the waste site excavations; however, there are culturally significant areas nearby. If any archaeological or historical artifacts are encountered during excavation, the appropriate authorities will be notified and the artifacts will be preserved. Consideration of archaeological and historic data is included in the balancing factors that will be evaluated if excavations need to be extended beyond those currently planned.

- *National Archeological and Historical Preservation Act of 1974* (26 U.S.C. 469) implemented via 36 CFR 65. Applicable when remedial activities may cause irreparable harm, loss, or destruction of significant artifacts in the 100-N Area. The *Archaeological and Historical Preservation Act* requires that remedial actions at the source area sites do not cause the loss of archaeological or historic data and that any archaeological or historic data must be preserved. There are no known archaeological or historic artifacts within the proposed footprints for the waste site excavations; however, there are culturally significant areas nearby. If any archaeological or historical artifacts are encountered during excavation, the appropriate authorities will be notified and the artifacts will be preserved. Consideration of archaeological and historic data is included in the balancing factors that will be evaluated if excavations need to be extended beyond those currently planned.

- *National Historic Preservation Act of 1966* (16 U.S.C. 470, et. seq.*)* implemented via 36 CFR 800. Applicable to remedial activities that could impact historic or potentially historic properties.

- *Endangered Species Act of 1973* (16 U.S.C. 1531, et. seq.) implemented via 50 CFR 17, 22, 200, 225, 226, 227, 402, and 424. Applicable to remedial activities that could impact threatened or endangered species or critical habitat upon which endangered or threatened species depend. The *Endangered Species Act* requires that Federal agencies consult with the Department of the Interior to ensure that actions authorized, funded, or implemented do not jeopardize the continued existence of endangered or threatened species or adversely affect their critical habitat. Because several listed and candidate endangered or threatened species have been identified in and around the Hanford Site, the remedial actions described in this document will be managed so these species existence will not be jeopardized or their habitat will not be adversely affected.

- "Habitat Buffer Zone for Bald Eagle Rules" (RCW 77.12.655) and WAC 232-12-292. Applicable if the areas of remedial activities include bald eagle habitat.

- *Hanford Reach Study Act* (Public Law 100-605*)*. Applicable to remedial activities that could result in any direct and adverse impacts to the Columbia River. Consultation with the U.S. National Park Service is required.

2.2.7.2 Other Criteria, Advisories, or Guidance to Be Considered. To-be-considered information generally consists of Federal, state, and local criteria, advisories, and proposed standards that are not legally binding (i.e., are not promulgated regulations) but that may be useful in establishing cleanup goals or remedial alternatives that are protective of human health and the environment. The TBCs identified in the TSD ROD are discussed below:

- *Environmental Restoration Disposal Facility Waste Acceptance Criteria*, BHI-00319, Rev. 3 (BHI 1998). Delineates primary requirements including regulatory requirements, specific isotopic constituents and contamination levels, the dangerous/hazardous constituents and concentrations, and the physical/chemical waste characteristics that are acceptable for disposal of wastes at the ERDF.

- *The Future for Hanford: Uses and Cleanup, the Final Report of the Hanford Future Site Uses Working Group* (December 1992). Provides stakeholder input on potential future land used of the 100 Areas.

- *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (HCP EIS) DOE/EIS-0222-F, September 1999 (DOE 1999). Provides DOE's land-use determination for the Hanford Site.

2.3 REMEDIAL DESIGN

A phased approach will be used for the remedial action design process. Waste sites will be grouped geographically to facilitate the remedial action and will be designed in a sequence to support decision documents and remedial action contracting.

2.3.1 100-NR-1 Remedial Design

The first design package includes TSD units 116-N-3, 120-N-1, and 120-N-2 and associated site 100-N-58 within the 100-NR-1 OU, as specified in the Hanford Facility RCRA Permit Modification, Revision 5 (Wilson 1999).

Remediation of these sites requires demolition of structures, soil and debris removal, segregation, storage, transportation, disposal, and backfilling. The remedial action subcontractor will be provided with waste site-specific information on the expected contaminated area and depth, reactor area-specific information, and technical specifications. The detailed design for facility layout and excavation will be provided for the remedial action subcontractor.

The technical specifications have been prepared for the types of waste sites found in the 100-NR-1 OU. Each technical specification has been prepared so that it will be appropriate for use at all similar waste sites. Each technical specification establishes quality and workmanship requirements and defines how quality is measured. Generally, each specification includes a list of Hanford Site and site-specific references; a list of codes, standards, laws, and regulations; definitions of applicable terms; and a discussion of materials, equipment, and associated testing. The list of technical specifications follows:

- Earthwork and excavated material handling
- Survey station
- Electrical materials and equipment.

During excavation, the waste site excavation is guided by radioactivity measurements. Procedures will provide a detailed discussion on the flow of data. The *Sampling and Analysis Plan for the 100-NR-1 Treatment, Storage, and Disposal Units During Remediation and Closeout* (SAP) (DOE-RL 2000) addresses data management.

2.3.2 Future Remedial Design Groups

Future remedial design tasks may include the sites identified in the *Interim Remedial Action Record of Decision for the 100-NR-1 and 100-NR-2 Operable Units* (EPA 1999) and will be defined based on an integrated schedule (e.g., DOE-RL 1998b).

Figure 2-1. Calculation of Contaminant-Specific Cleanup Levels.

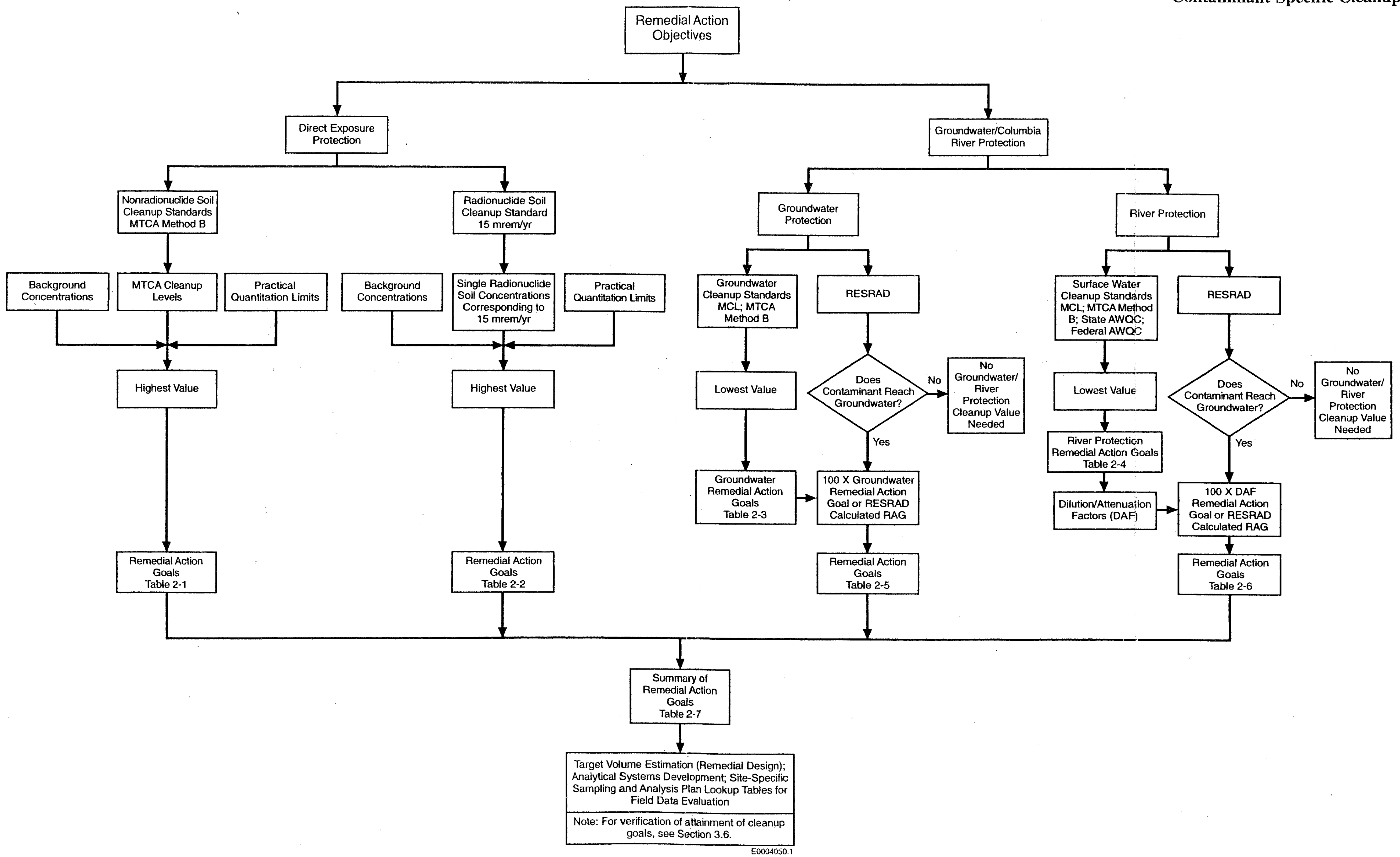

Table 2-1. Summary of Specific Permit Requirements for 116-N-1, 116-N-3, and UPR-100-N-31. (3 Pages)

General Permit Conditions
Conduct a cultural and natural resource review prior to beginning remedial action or excavation.
Protect cultural resources.
Protect human health and the environment.
Remove and stockpile any uncontaminated overburden; use this overburden for backfilling excavation areas.
Demolish contaminated structures.
Support nearby earthen structures affected by excavation to prevent movement.
Excavation will follow ALARA and appropriate construction practices for excavation and transportation of hazardous materials.
Use dust suppressants during excavation, transportation, and disposal (as necessary).
Remediation Levels
Sites with engineered structures and/or contaminated soil and debris starting above 4.6 m (15 ft) and extending 4.6 m (15 ft) below the engineered structure (at a minimum) will be remediated to achieve RAOs: • Contamination levels demonstrated to be at or below MTCA Method B levels for nonradionuclides. • Contamination levels demonstrated to be at or below 15 mrem/yr residential dose level and provide protection of groundwater and Columbia River; use RESRAD to determine dose levels. • Contamination levels are not to exceed MTCA Method B values, Federal and state MCLs, or Federal and state AWQC (whichever is the most restrictive) for groundwater or protection of the Columbia River.
Remediation of the top 4.6 m (15 ft) below surrounding grade or bottom of engineering structure (whichever is deeper): Remove until contaminant levels are as follows: • Below MTCA Method B values for nonradionuclides and 15 mrem/yr above background for radionuclides (rural-residential scenario). • Demonstrated to be protective of groundwater and the Columbia River. Contamination levels are not to exceed MTCA Method B values, Federal and state MCLs, or Federal and state AWQC (whichever is the most restrictive).
Residual contamination present below the engineered structure, beyond 4.6 m (15 ft), shall be subject to several factors in determining remediation: • Reduction in risk of decay of short-lived radionuclides, protection of human health and the environment, remediation costs, sizing of ERDF, worker safety, ecological and cultural resources, institutional controls, and long-term monitoring costs.
Remove soils to depth of 1.5 m (5 ft) below engineered structure that contain Pu-239/240 contamination to a depth of 1.5 m (ft) below the engineered structure.
Earthen Structures
Excavate contaminated materials.
Remove buried solid waste debris.
Process material through segregation and packaging.

Table 2-1. Summary of Specific Permit Requirements for 116-N-1, 116-N-3, and UPR-100-N-31. (3 Pages)

Concrete Structures
Remove concrete weir box in the 116-N-1 Crib as contaminated waste (demolition may be necessary prior to removal).
Remove concrete cover support beams and cover panels over the 116-N-1Trench and 116-N-3 Crib in tact, if possible.
Minimize demolition activities to maintain control of airborne releases and to simplify soils excavation.
Remove demolished debris and solid waste in cribs during excavation (may include demolished concrete, wooden poles, and netting). • Dispose of with contaminated soils.
Piping Removal or Characterization As Clean
Clean Piping Systems
If piping system is determined to be clean (through process knowledge, sampling, or both), obtain Ecology's concurrence.
Piping Removal
Piping systems that have not been determined to be clean will be removed: • Remove buried pipelines. • Segment pipes either manually or remotely (depends on radiation exposure).
Contamination Controls
Drain residual fluids from piping system prior to segmentation.
Control airborne contamination during cutting and pipe-handling operations.
Post Pipe Excavation Activities
Pipe bedding soil must be surveyed to verify that contamination levels are not above MTCA Method B values, or 15 mrem/yr for radionuclides.
Soil must be excavated and disposed.
Continue groundwater monitoring.
During Remediation
Field screening methods used to measure contamination.
Limited confirmatory sampling used to correlate and validate field screening.

Table 2-1. Summary of Specific Permit Requirements for 116-N-1, 116-N-3, and UPR-100-N-31. (3 Pages)

Post-Remediation
Extensive confirmation sampling used for higher levels of quality assurance and control to support closeout of the waste site.
Treat excavated soils before disposal (as necessary) to meet RCRA LDR and ERDF waste acceptance criteria.
Excavated contaminated soils/structures/pipelines will be transported to ERDF for disposal, as appropriate.

ALARA = as low as reasonably achievable
AWQC = ambient water quality criteria
Ecology = Washington State Department of Ecology
ERDF = Environmental Restoration Disposal Facility
LDR = land disposal restriction
MCL = maximum contamination level
MTCA = *Model Toxics Control Act*
RAO = remedial action objective
RCRA = R*esource Conservation and Recovery Act of 1976*
RESRAD = RESidual RADioactivity dose model

Table 2-2. Summary of Specific Permit Requirements for 120-N-1, 120-N-3, and 100-N-58.

General Permit Conditions
Conduct a cultural and natural resource review prior to beginning remedial action or excavation.
Protect cultural resources.
Protect human health and the environment.
Remove and stockpile any uncontaminated overburden; use this overburden for backfilling excavation areas.
Demolish contaminated structures.
Support nearby earthen structures affected by excavation to prevent movement.
Removal of Structures
Earthen Basins
There will be no excavation of earthen basins.
Structure Removal
Remove Hypalon liner and leak detection systems at 120-N-2 Surface Impoundment. • Dispose of noncontaminated waste.
Remove sampling shed and perimeter fence. • Dispose of nonhazardous waste or recycle as scrap metal.
Conduct confirmatory sampling of soil after removal of liners and structures to verify that there is no contamination above the MTCA Method B values: • There are to be two samples taken from the northern portion of the units and analyzed for pH, sulfates, and metals.
Piping Removal or Characterization As Clean
Clean Piping Systems
If piping can be determined to be clean (through process knowledge, sampling, or both), obtain Ecology's concurrence to leave in place.
Piping Removal
Piping that cannot be determined to be clean will be removed: • Remove buried pipelines. • Segment pipes either manually or remotely.
Contamination Controls
Drain residual fluids from piping system prior to segmentation.
Control airborne contamination during cutting and pipe-handling operations.
Influent Pipelines
When pipelines are determined not to be clean, excavate and remove influent pipelines between 163-N and the 120-N-1 and 120-N-2 units: • If piping is determined to be clean after excavation and removal, consider suitability for recycling piping as scrap metal. • If not clean, take samples. Treatment and disposal will be based on the regulatory status.

Table 2-3. Summary of Contaminant-Specific Remedial Action Goals for Remedial Action Objectives in Soil. (2 Pages)

Remedial Action Objectives	Direct Exposure (pCi/g or mg/kg)	Protection of Groundwater (pCi/g or mg/kg)	Protection of the Columbia River (pCi/g or mg/kg)
Contaminant			
Americium-241	41.6	[a]	[a]
Cesium-137	6.1	[a]	[a]
Cobalt-60	1.4	[a]	[a]
Europium-154	3.1	[a]	[a]
Europium-155	127	[a]	[a]
Nickel-63	4,031	[a]	[a]
Plutonium-239/240	23.5	[a]	[a]
Strontium-90	3.7	[a]	[a]
Tritium (H-3)	241/400[b]	2,000[c]	5,630[c]
Thorium-228	2.2	[a]	[a]
Thorium-232	0.94	[a]	[a]
Uranium 233/234	101	2	4
Uranium 238	69	2.4	4.8
Arsenic	20[c]	[d]	[d]
Barium	5,600	[d]	[d]
Cadmium	80	[d]	[d]
Chromium (III)	80,000	1,600[a]	18.5[a,e]
Chromium (VI)	400	8	2
Lead	353	10.2[a,e]	10.2[a,e]
Mercury	24	0.33[a,e]	0.33[a,e]
Selenium	400	[c]	[c]
Silver	400	[c]	[c]

Table 2-3. Summary of Contaminant-Specific Remedial Action Goals for Remedial Action Objectives in Soil. (2 Pages)

Remedial Action Objectives	Direct Exposure (pCi/g or mg/kg)	Protection of Groundwater (pCi/g or mg/kg)	Protection of the Columbia River (pCi/g or mg/kg)
Nitrate	1.13×10^5	4,400[c]	4,400[c]
Sulfate	N/A	25,000	25,000

[a] Determination is based on RESRAD modeling (based on a conceptual model of contaminants distributed half-way to groundwater, 50/50) of activity in soil for protection of the Columbia River using a DAF of 2 to account for dilution of groundwater entering the Columbia River. Where no value is presented, the RESRAD model predicts the radionuclide contaminant will not reach groundwater within a 1,000-year time frame. It is anticipated that sampling will be required to verify that cleanup has been achieved and that contaminants left in place are not migrating.
[b] Default to the practical quantitation limit.
[c] Specified in the 100-NR-1 Treatment, Storage, and Disposal Record of Decision (EPA 2000).
[d] These metals are contaminants of concern only at the 120-N-1 and 120-N-2 sites. The corrective measures study (DOE-RL 1998a) indicates that they are contaminants of concern only for direct exposure.
[e] 100 times the preliminary remediation goal (times the DAF if for the river) is less than the Hanford Site soil background (DOE-RL 1996b). Therefore, the soil background concentration is used as the soil preliminary remediation goal.
N/A = not applicable

3.0 REMEDIAL ACTION APPROACH AND MANAGEMENT

Initiation of full-scale remedial action to accomplish the goals set forth in the TSD ROD (EPA 2000) and RCRA Permit (Ecology 1994) requires completion of numerous interdependent tasks. Key tasks are illustrated in the flowchart presented in Figure 3-1. Activities or documents requiring regulatory agency approval are appropriately designated.

3.1 REMEDIAL ACTION OPERATING SYSTEM

Remediation of 116-N-1, 116-N-3, and UPR-100-N-31, in accordance with the TSD ROD and the RCRA Permit, requires soil excavation, treatment as appropriate or required, disposal, and backfilling. Clean overburden can be segregated and stockpiled onsite for backfill purposes. For the purpose of this discussion, the system design for 116-N1, 116-N-3, and UPR-100-N-31 is divided into six subsystems: pre-excavation, excavation, material handling and transportation, soil characterization and analysis, equipment washing, and decontamination. For 120-N-1, 120-N-2, and 100-N-58, the system design is divided into pre-closure activities, equipment removal, material handling and transfer, soil characterization and analysis, and equipment washing. These subsystems merge to become the operating remediation system and are discussed in Sections 3.1.1 and 3.1.2.

3.1.1 116-N-1, 116-N-3, and UPR-100-N-31 Operating System

3.1.1.1 Pre-Excavation. Site setup involves stripping the existing organic materials and debris; establishing site utility services as required; and constructing roads, field support facilities, a decontamination facility, and survey stations (where loaded containers are surveyed for radioactive contamination). An ecological and cultural field survey will be conducted before beginning field activities to minimize impacts to ecological and cultural resources. Stripping removes surface and near-surface materials (including roots, organic materials, vegetation, cobbles, and boulders) that will be stockpiled and used later for revegetation. Hanford Site roadways are constructed of existing Site materials, except the surface course, which is imported. Field support facilities provide a changing area, lunchroom, and offices at individual sites. The changing area includes lockers, benches, and storage for both clean and contaminated personal protection equipment.

3.1.1.2 Excavation. Excavation begins when the field analytical system has obtained sufficient data to characterize the site's initial conditions (initial conditions are used for database purposes) and the excavation subcontractor receives notification to begin work. Excavation of the designated work site involves removing clean and contaminated soils and debris found within the site's boundaries and removing the perimeter fence. The soils exposed during excavation are monitored for radiological and hazardous constituents, as defined in the SAP (DOE-RL 2000).

Materials are excavated using standard equipment and construction methods for both shallow and deep excavations. Containers are relocated from the container staging area to the excavation site and are prepared with a plastic liner. Excavated materials are placed in the lined containers and, depending on the material composition, are designated for transport to the ERDF, a clean material storage area, or a soil treatment storage area.

Containers destined for the ERDF are surveyed and decontaminated (if required) prior to entering the clean work area. Survey stations provide sheltered work areas where loaded containers are covered (i.e., by folding and securing the liner over the load) and surveyed for radioactive contamination. If minor contamination is found on a container's exterior, contamination is removed at the survey stations. If a container has significant exterior contamination, it is sent to the decontamination station where it is more aggressively decontaminated. In the unlikely event that a container cannot be decontaminated with the normal equipment and techniques available at the decontamination station, an evaluation will be made of the advanced and appropriate techniques, and these techniques will be implemented.

After containers are released for transportation to the ERDF and the shipping papers have been completed, the containers are relocated to a clean container transfer area. When a transport vehicle is available, the containers are placed onto clean trailers for transport to the ERDF. The trucks and trailers used for hauling within the excavation site remain in the contaminated area and do not require decontamination. Empty containers being returned from the ERDF are loaded onto excavation site trailers for refilling.

Activities are guided during excavation from data obtained by the field analytical system working concurrently with excavation. Data are used to continually update the site characteristic database. Additional information on the field analytical system is presented in the SAP (DOE-RL 2000).

Dust control is maintained on the haul roads, at the excavation site, and at the clean soil storage area. All material transported from the excavation site is covered, contained, or has moisture content adequate for inhibiting dust without being covered or contained during transport and disposal. The moisture content of bulk-contaminated material destined for ERDF disposal is in accordance with the ERDF waste acceptance criteria (BHI 1998). Dust palliative is applied to open excavation sites when potential concerns arise about health issues or the spread of contamination.

When RAOs have been met and verified, site backfill will be authorized. Clean backfill material is obtained from clean material storage areas, approved clean rubble areas, and local borrow sites. Excavations are backfilled to agreed-upon elevations (Table 1-1).

3.1.1.3 Material Handling and Transportation. All contaminated materials, including excavated soils, debris, disposable protective clothing, air filters, and trash, whether stored or transported to the ERDF, require proper packaging, handling, and transporting. State-listed waste will require placarding before transport to the ERDF. The design of the packaging, handling, and transportation systems involves an efficient method of transporting bulk-contaminated materials from each contaminated area to a clean work area.

The proposed containers for hauling excavated materials are 20-m^3 (22-yd^3) capacity, open-top roll-off boxes, approximately 6.1 m (20 ft) long, 2.4 m (8 ft) wide, and 1.4 m (4.5 ft) high. The steel containers have 6-mm (1/4-in.)-thick floors, 5-mm (3/16-in.)-thick walls, and hinged locking rear gates. The open-top construction allows for top loading, and the top-hinged and side-hinged end gates allow the contents to be emptied by dump-bed trailers.

Haul trailers are used to transport the containers from the excavation area to the container transfer facility and to the ERDF. The containers are transported on roll-on/roll-off trailers and towed by conventional tractor units. The trailers and tractors are suitable for operating on sloped excavation access ramps and other off-road ramps and meet applicable U.S. Department of Transportation requirements. The wheel wells of the tractor tires are constructed to prevent soils from being thrown onto the trailer and its containers.

Dump-bed haul trailers are used to transport containers and to deposit excavated materials at the clean material storage area and (if required) at the LDR material storage area. The dump-bed haul trailers have hydraulic dumping capabilities that make them suitable for handling the containers, as all of the dumping and operational controls for the trailers are located inside the motive tractor cab. Handling of both loaded and empty containers will be roll-on and roll-off; however, the containers are also equipped with bottom-lift forklift pockets.

In the interest of as low as reasonably achievable (ALARA) concerns and worker safety, oversize and/or overweight loads may be required for shipment of materials to the ERDF. These shipments will follow Hanford Site requirements for permitting and notification.

Containers are transported over existing Hanford Site roadways to the ERDF. Empty containers returning from the ERDF are removed from the clean tractor-trailers at the container transfer area and placed onto tractor-trailers for refilling. A queue, maintained near the end of the container transfer area, provides temporary storage for full and/or empty containers if a backlog of containers develops or is required. The queue helps to maintain a continuous flow of materials through the transportation system by allowing excavation to continue for a limited time if the trucks running to the ERDF are not operating, or it allows ERDF trucks to continue to run for a limited time if the excavators are not operating.

3.1.1.4 Soil and Debris Characterization and Analysis. Soil and debris characterization and analysis are based on the observational approach. This approach relies on recorded information from historical process operations, including liquid effluent discharges and information from limited field investigations on the nature and extent of existing contamination, combined with a "characterize-and-remediate-in-one-step" methodology. The latter methodology consists of site excavation and field screening. Remediation proceeds until it can be demonstrated, through a combination of field screening and verification sampling, that cleanup goals have been achieved.

During excavation, soils are monitored for radiological and, as necessary, chemical constituents; however, for the following reasons, gamma-emitting radiological constituents are used as the primary indicator contaminants to guide excavation:

- Data indicate, in general, that when gamma-emitting radionuclide concentrations are less than cleanup criteria, concentrations of nonradiological constituents are also less than cleanup criteria.

- Gamma-emitting radionuclide contaminants are readily detected with field instruments at levels specified for cleanup, whereas alpha- and beta-emitting radionuclides and chemical constituents are not readily detected.

Upon initial completion of excavation at each waste site, cleanup verification sampling and analysis will be performed to confirm attainment of cleanup criteria for all contaminants of concern. If analytical results indicate that cleanup criteria have not been achieved, then excavation will resume using appropriate analyses as guidance.

Each shipment of soil/debris transported to the ERDF is referenced to a waste profile that is representative of the material found at the site. The waste profile is in effect until the characteristics of the excavation site have changed significantly. A large increase in radioactivity levels for any of the expected constituents, or the detection of previously unknown contaminants, would trigger the issuance of an updated waste profile. If the waste profile, as indicated by field screening, approaches the ERDF waste acceptance criteria, a sampling event will be initiated.

3.1.1.5 Equipment Washing. Cleaning and washing of equipment that has not been in a contaminated area is considered equipment washing. Equipment washing will follow normal waste minimization best management practices (BMP). Collection of equipment washwater is not necessary.

3.1.1.6 Decontamination. Decontamination to support excavation activities is provided primarily by two methods: (1) wet methods using pressure washers and steam cleaners, and (2) dry methods using wiping and high-efficiency particulate air filtered vacuum cleaners.

If equipment has been used in a contaminated area and if after using dry decontamination methods the equipment can be released from radiological controls, then wet decontamination is not needed.

If equipment has been used in a contaminated area and if after using dry decontamination methods the equipment cannot be released from radiological controls, then wet decontamination methods will be used. All decontamination water will initially be collected at a decontamination pad. This will continue until a portion of the 116-N-3 Trench or Crib containing significant levels of contamination has been excavated. The decontamination water will be sampled for the waste site contaminants of concern. The sample results will be evaluated, and if results are greater than 10 times the groundwater MCL the water will be disposed of at an appropriate facility (e.g., absorbed and sent to the ERDF or sent to the Effluent Treatment Facility). If the results are less than 10 times the groundwater MCLs, then the water may be used for dust suppression in an area that will be excavated. Decontamination water will continue to be collected, and another sample of decontamination water will be collected. Results from the second sample will be evaluated, and if results are less than 10 times the groundwater MCLs, then the water may be used for dust suppression in a area that will be excavated. If both of the decontamination samples show contaminants of concern less than 10 times the groundwater MCLs, further collection of decontamination water is not required. Instead, the following BMP for the wet decontamination of heavy equipment and vehicles working directly in contaminated areas will be followed:

- General BMP. Applies to equipment decontamination activities within a waste site.
  - Conduct decontamination within the waste site to prevent the spread of contaminants.
  - Minimize the amount of water used to clean equipment.
  - Use raw or potable water only.
  - Do not add soaps, detergents, or other cleaning agents to washwater.
  - Pressure washing will normally use cold water (hot water may be used to avoid icing).
  - Steam cleaning may be used only after other decontamination methods prove to be ineffective.
  - Decontamination practices will be documented in the daily log (e.g., radiological control survey report or subcontract technical representative daily report).
  - Personnel responsible for equipment decontamination will be trained to this BMP.
- Ongoing Remediation Site BMP. Applies to equipment being decontaminated within sites that have ongoing remediation.
  - Equipment decontamination will be located in areas with ongoing waste removal.
  - Spent decontamination water and associated contamination will be kept within the area of contamination.
  - Pre- and post-washing/decontamination contaminant surveys are not required.
  - The project may choose to collect decontamination water for reuse in the excavation or to be sent for treatment.

- Completed Remediation Site BMP. Applies to equipment being decontaminated within sites that have achieved preliminary remediation goals.
  - At the completion of excavation activities at a site, the project may choose to transport the equipment to a nearby site that is being remediated (by excavation) to perform equipment decontamination (as described above).
  - Equipment decontamination to be performed at the site will be physically located within the remediated site.
  - Pre- and post-surveys will be performed on the decontamination area to assess and remediate (if required) areas affected by the activity.
  - When the decontamination is set up in an area of a site that has apparently attained the preliminary remediation goals, sampling of the area will be performed in accordance with the SAP (DOE-RL 2000).
  - The project may choose to perform other methods of equipment washing and/or decontamination for a completed site (e.g., wrap the equipment for transfer to a decontamination pad, provide for a temporary facility at the site to collect decontamination water, or fix the contamination to the equipment).

3.1.2 120-N-1, 120-N-2, and 100-N-58 Operating System

Closure activities for sites 120-N-1, 120-N-2, and 100-N-58 include the elements below.

3.1.2.1 Pre-Closure Activities. Pre-closure preparations involve establishing site utility services as required and constructing roads and field support facilities. An ecological and cultural field survey will be conducted before beginning field activities to minimize impacts to ecological and cultural resources. Hanford Site roadways are constructed of existing site materials, except the surface course, which is imported. Field support facilities provide a changing area, lunchroom, and offices at individual sites. The changing area includes lockers, benches, and storage for both clean and contaminated personal protection equipment.

3.1.2.2 Equipment Removal. Soil excavation will not occur at sites 120-N-1, 120-N-2, and 100-N-58. Equipment removal involves removing the Hypalon liner and leak detection systems at site 120-N-2 using conventional excavation equipment. In addition, the sampling shed and perimeter fence will be removed. The demolished components will be disposed as uncontaminated waste at an onsite demolition debris disposal facility.

No contamination is known to exist for underground piping located between the 163-N Demineralization Plant and the 120-N-1 and 120-N-2 sites. However, the condition of the piping and the extent and nature of any internal contamination that may be present will be assessed through sampling that is planned to be conducted during closure activities. If it is determined through process knowledge, sampling, or both, that the piping meets clean closure standards and can be left in place, the determination will be submitted to Ecology for concurrence. Where piping cannot be determined to be clean, the piping will be excavated and disposed at the ERDF. The excavated piping would be segmented for removal manually or with excavation equipment. Excavation of contaminated piping, if present, will follow the operating system description described in Section 3.1.1.

When RAOs have been met and verified, site backfill will be authorized. Clean backfill material will be obtained from clean material storage areas, approved clean rubble areas, and local borrow sites. The sites are backfilled to agreed-upon elevations (Table 1-1).

3.1.2.3 Material Handling and Transportation. All uncontaminated materials removed from the 120-N-1, 120-N-2, and 100-N-58 sites will be loaded onto trucks for transport to an onsite demolition landfill. Dust control is maintained on haul roads at the site. All material being transported from the excavation site is covered, contained, or has moisture content adequate for inhibiting dust without being covered or contained during transport and disposal. Trucks traveling to and from the demolition landfill will travel over existing Hanford Site roadways. If piping is determined to be contaminated, these materials (including excavated soils, debris, disposable protective clothing, and trash) will be transported to the ERDF as described in Section 3.1.1.3.

3.1.2.4 Characterization and Analysis. Soil sampling and analysis after equipment removal will be conducted as described in the SAP (DOE-RL 2000). Two samples will be collected from the northern part of 120-N-2 unit and analyzed for metals, pH, and sulfate. The arithmetic mean of these two samples will be compared to MTCA Method B-based cleanup values to verify compliance with cleanup. The results of sampling of equipment removed (e.g., liner and piping) will be used to designate this waste stream, as described in Section 4.0.

3.1.2.5 Equipment Washing. Cleaning and washing of equipment that has not been in a contaminated area are considered equipment washing. Equipment washing will follow normal waste minimization BMPs described in Section 3.1.1.6. Collection of equipment washwater is not necessary.

3.2 PROJECT SCHEDULE AND COST

Project schedules are developed in accordance with Bechtel Hanford, Inc. (BHI) procedure ERC-PC-01, *Baseline and Funds Management System,* at several different levels consistent with the project work breakdown structure (WBS). The schedule for remedial action is illustrated in Figure 3-2. The WBS-based schedules promote complete and consistent compliance with DOE Order 4700.1, *Project Management System,* and cost and schedule control systems criteria. Large-scale (i.e., multi-year) projects encompassing multiple smaller projects (i.e., each waste site remediation can be considered a single project, while the entire project is to remediate all waste sites) are generally planned and scheduled using a phased approach. Near-term (i.e., less than 1 year) work is usually planned and scheduled at a detail activity level using logic ties to establish and maintain a true critical path schedule. Logic-driven, critical-path schedules (commonly referred to as the critical-path method) are used to manage and control the daily progress of the work and provide early warning of problem areas. Forecast planning and scheduling (i.e., 1 to 2 years) can be performed at the task-package level, and long-range planning and scheduling (i.e., greater than 2 years) is performed at the work package or cost account levels.

3.2.1 Remediation Scheduling

Post-TSD ROD planning and scheduling for remediation projects follows a distinct pattern consistent with the work package level of the WBS. Planning elements at this level include, but are not limited to or bound by, remedial design, procurement, remedial actions, and site closures.

3.2.1.1 Remedial Design. Remedial design includes all design work, project plans, project procedures, remediation cost estimating, drawings, and specifications required to procure a remediation subcontractor to perform the remediation. Project plans will define the data-gathering requirements to ensure worker health and safety and to eventually prove that the waste sites meet remediation goals and standards. Project procedures will define how to obtain data and control site activities. Planning documentation is discussed further in Section 3.4. The scope of work, design drawings, and specifications will provide the necessary tools to procure a subcontractor.

3.2.1.2 Procurement. Procurement includes soliciting qualified subcontractors, preparing request for proposals (RFPs), awarding the subcontract, coordinating submittal, negotiating change orders, and receiving and controlling subcontractor request for payments. The RFP documents are prepared as part of the remedial design. Procurement must assemble the RFPs and contract documents.

3.2.1.3 Remedial Actions. Remedial action includes implementing the remedial design and project plans. The implementation will include, but is not limited to, subcontractor oversight, excavation, material handling, analytical system operations, worker health and safety, radiological controls, data gathering, and overall daily conduct of operations. Subcontractor oversight occurs through administration of subcontract documents. Project specifications and procedures define how to perform excavation, material handling, analytical system operation, data gathering, and the overall daily conduct of operations. Worker health and safety and radiological control requirements are included in site health and safety plans and permits.

3.2.1.4 Site Verification and Closeout. Site verification and closeout include, but are not limited to, sampling and analysis, data evaluation, data interpretation, preparation of documentation (e.g., RCRA certification of closure and CVPs [see Section 3.7]) and updating the Hanford Site Waste Identification Data System (WIDS).

3.2.2 100-NR-1 TSD Sites Interim Remedial Action Schedule

A long-range schedule for all TSD ROD and RCRA Permit waste sites as developed from the RCRA Permit is provided in Figure 3-2. The long-range schedule is based on factors defined by the Tri-Parties. This schedule may be revised to include additional waste sites in the 100-NR-1 OU. If the schedule is revised, a Permit modification is required (see Section 3.5).

If waste sites are added, upon regulatory agency review and approval, the schedule will be updated and the additional waste sites will be integrated into the remedial action.

3.2.3 Project Cost

Table 3-1 presents current cost estimates for the remedial actions specified in the TSD ROD. Note that the cost estimates in Table 3-1 differ from those presented in the TSD ROD; this is the result of recent revisions to the cost estimating models to reflect a better understanding of the scope and level of effort required for remediation in the 100-NR-1 TSD sites.

3.3 PROJECT TEAM

The term project team, in the strictest sense, refers to all individuals working to accomplish a particular project. According to this definition, there are numerous members of the project team. For the purpose of this discussion, the project team will be limited to the Environmental Restoration Contractor (ERC), DOE, EPA, and Ecology.

3.3.1 Regulatory Agencies

The regulatory agency responsible for the RCRA remediation activities at the 100-NR-1 TSD sites of the Hanford Site is Ecology. The lead regulatory agency is Ecology. The lead regulatory agency may request support from the nonlead agency, if necessary. The lead regulatory agency is responsible for overseeing the activities to ensure that all applicable regulatory requirements are met.

3.3.2 U.S. Department of Energy

The DOE is the government agency responsible for the remedial actions throughout the 100-NR-1 TSD sites and throughout the Hanford Site. The DOE has assigned project managers to each major area and task involved with remediation activities.

The DOE project manager is responsible for the management of their assigned activities, including scope, budget, schedule, quality, personnel, communication, risk/safety, contracts, and regulatory interface.

3.3.3 Environmental Restoration Contractor

Bechtel Hanford, Inc., along with their pre-selected subcontractors (i.e., CH2M Hill Hanford, Inc., and Thermo Hanford, Inc.), comprise the ERC Project Team. Under the direction of the manager of remedial action projects, project managers are assigned consistent with the project management assignments of DOE to promote a single point-of-contact management philosophy. Each ERC project manager must develop, maintain, and oversee individual project teams. The project team will include all required disciplines to accomplish remedial actions in a safe, efficient, and compliant manner.

3.4 PLANNING DOCUMENTATION

Planning documentation to implement remedial actions includes the preparation of a set of field documents required to guide the work being performed. Examples include the environmental control plan, emergency preparedness plan, and radiological work permits. Documents are prepared by project staff and are reviewed by ERC functional groups. Some documentation requires review and concurrence of DOE and the regulatory agencies.

3.4.1 Field Procedures

Existing ERC field procedures and associated documentation provide guidance to ERC site workers during field work execution. The procedures and associated documentation (e.g., radiological work permit) define the scope, operations, and progression of field work; personnel control requirements; radiological posting requirements; and analytical system guidance. The procedures and associated documentation also provide guidance if unexpected conditions arise.

3.4.2 Sampling and Analysis Plan

The SAP (DOE-RL 2000) will provide guidance to field samplers during the field work specific to a remediation site or group of sites. Sampling will be performed to meet five objectives: excavation guidance, waste profile verification, worker health and safety, site cleanup verification, and overburden soil and backfill material verification. The SAP will also include a quality assurance project plan. The quality assurance project plan defines the chain of custody and analysis strategy to control the quality and reliability of the analytical data. The field analytical team must perform all sampling and analysis efforts in strict compliance with the SAP. The SAP is prepared by project staff and is reviewed by the ERC functional organization. The SAP will be provided to DOE and regulatory agencies for review and approval.

Protocols for managing analytical data developed to support remedial action are specified in the SAP (DOE-RL 2000). The data management process starts with using the project's past-practice data as input to the data quality objective process and tracks the remedial action project sample data flow through collection, analysis, verification/validation, and storage in Hanford Site data management databases. Both the past-practice and remedial action project data are managed under documented configuration control procedures. Procedures are in place for the integrated sample data management processes.

3.4.3 Health and Safety Plan

Health and safety plans are prepared in conjunction with the activity hazards' classification. These plans provide guidance to the site superintendent and all personnel on the site for health and safety concerns specific to the remediation site and action. The project-specific health and safety plan is prepared by the project health and safety officer and is reviewed by all project staff. The site superintendent must comply with the health and safety plan at all times. All project field staff must understand the health and safety plan. All unescorted site visitors are required to read and sign the health and safety plan before entering the construction area.

Escorted visitors are briefed on health and safety concerns and must be escorted by the site superintendent (or designee) at all times when in the construction area. The health and safety plan is prepared and revised in accordance with 29 CFR 1926.65.

3.4.4 Mitigation Action Plan

The mitigation action plan (DOE-RL 1996c) provides guidance to design and field staff to ensure that natural and cultural resources are protected during field activities. The plan covers avoidance and minimization steps in mitigation. Consideration is also given to the desires and perspectives of local Native American Tribes and Nations for cultural resources concerns. Natural resource issues are coordinated with the Natural Resource Trustees, as required by CERCLA. The mitigation action plan was developed by DOE in coordination with the Trustees.

3.5 CHANGE MANAGEMENT

This section describes TSD ROD-related remedial action change management and the RCRA permit modification process. The change management process for nuclear safety documents is addressed in BHI-specific procedures (BHI-DE-01, *Design Engineering Procedures*, EDPI 4.40-01, "Management of Change").

3.5.1 Remedial Action Change Management

Three types of changes in the 100-NR-1 TSD sites remedial actions are possible that affect compliance with the requirements in the TSD ROD (EPA 2000): (1) a nonsignificant or minor change, (2) a significant change to a component of the remedy, and (3) fundamental changes to the overall remedy.

A nonsignificant or minor change falls within the normal scope of changes occurring during the remedial design and remedial action processes. These minor changes should be documented in the appropriate post-decision project file. Nonsignificant changes shall not impact the requirement of the TSD ROD or the functional requirements. Examples of nonsignificant changes include, but are not limited to, the following:

- The addition of waste sites that are adjacent to and within the area required for remediation of sites addressed in the TSD ROD or subsequent TSD ROD amendment
- The modifications to the remedial action schedule that do not impact agreed-upon milestones
- The granting of a treatability variance if it is technically impractical to meet the LDR treatment standard.

It may be determined that a significant change to the selected remedy, as described in the TSD ROD, is necessary. Significant changes are defined as changes that significantly modify the scope, performance, or component cost for the remedy, as presented in the TSD ROD. All significant changes will be addressed in an ESD. Examples of significant changes will include, but are not limited to, the following:

- A 50% or greater increase in the total cost of site remediation addressed in the TSD ROD
- A delay in the scheduled completion of a remedial action or objective
- The addition of waste sites for remediation in a manner that is consistent with the scope and role of action as described in the TSD ROD.

A fundamental change is a change that does not meet the requirements set forth in the TSD ROD or that incorporates remedial activities not defined in the scope of the TSD ROD. In few cases are there fundamental changes to a TSD ROD. Should the situation arise, the TSD ROD must be amended. Examples of significant changes that fundamentally alter the remedy occur as follows:

- Waste remains in place above cleanup objectives (e.g., due to the presence of cultural resources)
- A final land use is defined that is not compatible with the TSD ROD
- Stabilization of waste remaining in place in the 100-NR-1 TSD sites rather than excavating and disposing the soil at the ERDF.

The project manager is responsible for tracking all changes and obtaining appropriate reviews by ERC staff. The project manager will discuss the change with DOE, and DOE will then discuss the type of change that is necessary with EPA and Ecology. The lead regulatory agency's responsibility is to determine the significance of the change. Appropriate documentation will follow based upon the type of change.

3.5.2 RCRA Permit Change Process

The RCRA closure plans will be amended whenever changes in closure activities or post-closure requirements occur and prior to certification of closure and post-closure, respectively, and would constitute a Class 1, 2, or 3 modification to the Permit (WAC 173-303-830). Examples of events that may require a Permit modification include a schedule change for remedial actions, invoking balancing factors that would result in waste being left in place, or a change in the selected remedy.

3.6 ATTAINMENT OF REMEDIAL ACTION OBJECTIVES

This section describes the approach for verifying attainment of cleanup of soils in accordance with the RAOs identified in the TSD ROD and presents the supporting calculations. Section 3.1.2 and the CMS describe closure attainment for the 120-N-1, 120-N-2 and 100-N-58 sites (which are not listed in the TSD ROD). The general approach for verifying attainment of RAOs is presented in Figure 3-3 and involves the following steps:

1. Identify the unit(s) within a site for cleanup verification.

2. Calculate the summary statistics for the identified unit(s).

3. Identify the appropriate site-specific RAGs to be applied to the unit(s).

4. Evaluate the summary statistics for the identified unit(s) against the decision rules for achieving the appropriate RAGs.

Details regarding verification sampling and analysis may be found in the SAP (DOE-RL 2000).

3.6.1 Identify the Unit(s) Within a Site for Cleanup Verification

In this step, the site is divided into units for purposes of collecting verification samples. Summary statistics (e.g., arithmetic mean and 95% upper confidence limit [UCL]) are calculated for verification samples from a particular unit. Verification sampling and analysis data will be evaluated against the decision rules (see Section 3.6.4) on a unit-by-unit basis. Generally, a site will be divided into the following units: (1) stockpiled “clean” soil that will be returned to the excavation, (2) soil from the bottom of the excavation when excavation is from 0 to 4.6 m (0 to 15 ft) below ground surface, and (3) soil from the bottom of the excavation when excavation is greater than 4.6 m (15 ft) below ground surface. Additional units may be defined as needed for large sites or other specific needs. These units will be identified in site-specific instructions and documented in an engineering calculation brief prepared for confirmation sampling. Details regarding verification sampling and analysis can be found in the SAP (DOE-RL 2000).

3.6.2 Calculate the Summary Statistics for the Identified Unit(s)

The summary statistics needed for each unit are arithmetic mean, standard deviation, single-sided 95% UCL, and the total number of samples collected from the unit. The number of samples with concentrations exceeding the MTCA cleanup level and two times the MTCA cleanup level must also be determined from the sampling and analytical data. The 95% UCL for the mean will be calculated for each contaminant of concern, with adjustments for censored data in accordance with Ecology’s *Statistical Guidance for Ecology Site Managers* (Ecology 1992) and *Statistical Guidance for Ecology Site Managers, Supplement S-6* (Ecology 1993). For nonradionuclides, the 95% UCL will be compared to the MTCA Method B limit in addition to the comparison of the raw data to twice the MTCA Method B limit and the proportion of raw data exceeding that MTCA Method B limit. The 95% UCL for each of the contaminants of concern will be used as the basis for RESRAD modeling, as necessary.

Examination of the distribution of data sets will be in accordance with the guidelines presented in Ecology's *Statistical Guidance for Ecology Site Managers* (Ecology 1992) and *Statistical Guidance for Ecology Site Managers, Supplement S-6* (Ecology 1993), and will typically be performed using the MTCAStat Excel™ module.

3.6.3 Identify the Appropriate Remedial Action Goals to be Applied to the Unit(s)

The RAGs that apply to a site must be identified to verify that remedial action has attained the RAOs. Site-specific RAGs may vary from those presented in Tables 2-8 and 2-9 (which are based on a conceptual model of contaminants distributed half-way to groundwater, 50/50) and will be determined based on site-specific conditions (e.g., size, depth to groundwater). A review of Section 2.2.3 provides the information necessary to identify the appropriate RAGs. One or more of these goals may apply to any particular unit. Compound-specific RAGs within groups of compounds (e.g., hydrocarbon, pesticide, volatile organic analyte, and semivolatile organic analyte compounds) will be calculated as needed for site verification.

3.6.4 Evaluate the Summary Statistics Against the Decision Rules for Achieving the Appropriate Remedial Action Goals

For the RAGs identified in the previous step, decision rules are defined that will be used to test verification sampling and analysis data. These decision rules follow:

- MTCA standards are achieved under the following conditions (WAC 173-340-740[7][e]):
  - The 95% UCL on the arithmetic mean from verification samples collected is less than the cleanup standard for each contaminant of concern.
  - No single sample concentration is greater than two times the cleanup standard.
  - Less than 10% of the sample concentrations exceed the cleanup standard.
- Radionuclide soil cleanup standards are achieved under the following conditions:
  - The dose calculated from the 95% UCL on the arithmetic mean for the sum of all radioactive contaminants of concern from verification samples collected from the sides of the excavation and from soil 0 to 4.6 m (0 to 15 ft) below grade is less than 15 mrem/yr. The dose is calculated assuming exposure through inhalation, soil ingestion, crop ingestion, meat and milk ingestion, aquatic foods ingestion, and external gamma exposure pathways using residential exposure assumptions (specific assumptions for dose calculations are presented in Appendix B). Figure 3-4 illustrates this conceptual model.
  - The dose calculated from the 95% UCL on the arithmetic mean for the sum of all radioactive contaminants of concern from verification samples collected from soil from

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the bottom of the excavation is less than 15 mrem/yr. See Figure 3-4 for a depiction of this conceptual model.

- For nonradioactive contaminants, cleanup of soils for groundwater protection will have been achieved when the 95% UCL on the arithmetic mean concentration in soil of each contaminant of concern is less than 100 times the groundwater RAG.

- For radionuclide contaminants, cleanup of soils for groundwater protection will have been achieved when the 95% UCL on the arithmetic mean concentration in soil of each contaminant of concern is less than the value, as calculated by RESRAD, which meets the groundwater RAG.

- For nonradioactive contaminants, cleanup of soils for protection of the Columbia River will have been achieved when the 95% UCL on the arithmetic mean concentration in soil of each contaminant of concern is less than 100 times the RAG after the DAF has been applied.

- For radionuclide contaminants, cleanup of soils for protection of the Columbia River will have been achieved when the 95% UCL on the arithmetic mean concentration in soil of each contaminant of concern is less than the value, as calculated by RESRAD, which meets the RAG after the DAF has been applied.

3.6.5 Verify the Attainment of the Radionuclide Soil Cleanup Standard

Determining when a remedial action has achieved the cleanup level (i.e., 15 mrem/yr) involves converting radionuclide concentrations (in pCi/g) in soil into dose rates (in mrem/yr) using a dose assessment model. Use of a model requires an exposure scenario that specifies (1) a hypothetical receptor, (2) pathways of exposure from radionuclides in soil to the receptor, and (3) assumptions and parameters for estimating exposures and doses to the receptor from radionuclides in soil.

Unrestricted future use in the 100-NR-1 TSD sites is represented by an individual resident in a rural-residential setting. The resident is assumed to consume crops raised in a backyard garden, meat and milk from locally raised livestock, and meat from game animals and fish, and to live in a residence with a basement 3.7 m (12 ft) below grade. The following exposure pathways are considered when estimating doses from radionuclides in soil: inhalation; soil ingestion; ingestion of crops, meat, fish, and milk; and external gamma exposure. External gamma exposure is assumed to be the only exposure pathway from contaminants at the bottom of the excavation and is assumed to occur only when an individual is in the basement. (Wastes left in place at depths greater than 4.6 m [15 ft] and that are protective of groundwater and the Columbia River will have institutional controls applied [e.g., deed restrictions for well drilling and deep excavation].) This individual is conservatively assumed to spend 80% of his/her lifetime at the site. Therefore, doses are calculated separately in fill soil from 0 to 4.6 m (0 to 15 ft) below grade and for residual contaminants at the bottom of the excavation. These doses are then summed to obtain the total dose associated with radionuclides in soil. A list of the assumptions and model parameters used in RESRAD is presented in Appendix B.

3.6.6 Verify the Attainment of the MTCA Cleanup Standards

Verifying the attainment of MTCA Method B cleanup standards involves comparing the appropriate summary statistics with the RAGs. The decision rules for MTCA standards presented in Section 3.6.4 are also used for this verification.

3.6.7 Verify the Attainment of the Contaminant Concentrations in Soil for Protection of the Groundwater

Verifying the attainment of groundwater RAGs involves two steps. For nonradioactive contaminants, the 100 times rule will be used to determine contaminant-specific concentrations in soil protective of groundwater. This step involves comparing the appropriate summary statistics to the contaminant-specific concentrations in soil that meet the groundwater RAGs. If the RAG is not attained by these methods, the RESRAD model will be used with site-specific input parameters to determine if contaminants reach groundwater. For radionuclide contaminants, the RESRAD model will be used to determine compliance with groundwater RAGS.

3.6.8 Verify the Attainment of the Contaminant Concentrations in Soil for Protection of the Columbia River

Similar to the steps presented in Section 3.6.7, verifying the attainment of RAGs protective of the Columbia River involves two steps. For nonradioactive contaminants, the 100 times rule times the DAF will be used to determine contaminant-specific concentrations in soil protective of groundwater. This step involves comparing the appropriate summary statistics to the contaminant-specific concentrations in soil that meet the river protection RAGs. If the RAG is not attained by these methods, then the RESRAD model will be used with site-specific input parameters to determine if contaminates reach the Columbia River. For radionuclide contaminants, the RESRAD model will be used to determine compliance with river protection RAGS.

3.7 RCRA CLOSURE OF THE TREATMENT, STORAGE, AND DISPOSAL SITES

Because the TSD sites are managed as a RCRA TSD unit, they must be closed in accordance with the RCRA regulation. As part of the RCRA Part B permitting process, a closure plan (DOE-RL 1998a) was prepared that governs the process by which the trenches will be closed. Closure of the trenches requires that a certification of closure be prepared and submitted to Ecology within 60 days of completing the remedial actions at the site. The certification of closure will be prepared and submitted to Ecology by an independent Washington State registered professional engineer.

In support of the site closures, a CVP or other closeout documentation will be prepared for the 116-N-1 and 116-N-3 sites. The closeout documentation will document the level of detail needed for closeout of these waste sites.

Because the 120-N-1, 120-N-2, and 100-N-58 sites are not contaminated, they likely do not require the level of detail commonly provided in a CVP. Closeout documentation will be prepared for these sites commensurate with the need of the sites. All closeout documentation will support the eventual delisting of the OU from the NPL.

Subsequent to remedial action, each waste site will be reclassified in the WIDS database in accordance with the Tri-Party Agreement Handbook Management Procedure MP-14 (DOE-RL 1998c). Regulator approval will be documented on a MP-14 site reclassification form.

3.8 SITE RELEASE

The DOE will continue to manage the land in the 100-NR-1 OU as long as necessary to support remedial actions. The time frame depends on many different parameters and is documented in the HCP EIS (DOE 1999). The final selected land use for the 100 Areas (documented in the HCP EIS and subsequent TSD ROD) are recreation, conservation, and preservation.

Access to the property will be controlled in the near term by periodic patrols by Hanford Site personnel (as long as the Site is under DOE jurisdiction). The property may also be controlled through deed restrictions if DOE sells or leases the property to others.

Where deed restrictions or other institutional controls are used in accordance with this RDR/RAWP and the TSD ROD, DOE will not allow any activities that would interfere with the remedial action prior to EPA and Ecology approval. Additionally, DOE will take necessary measures (e.g., filing the deed restrictions in appropriate county offices) to ensure the continuation of these restrictions prior to any transfer or lease of the property. A copy of a notification of any restrictions will be given to any prospective purchaser/transferee before any transfer or lease by DOE. The DOE will provide EPA and Ecology with written verification that these restrictions have been put in place.

Figure 3-1. Remedial Action Process Overview.

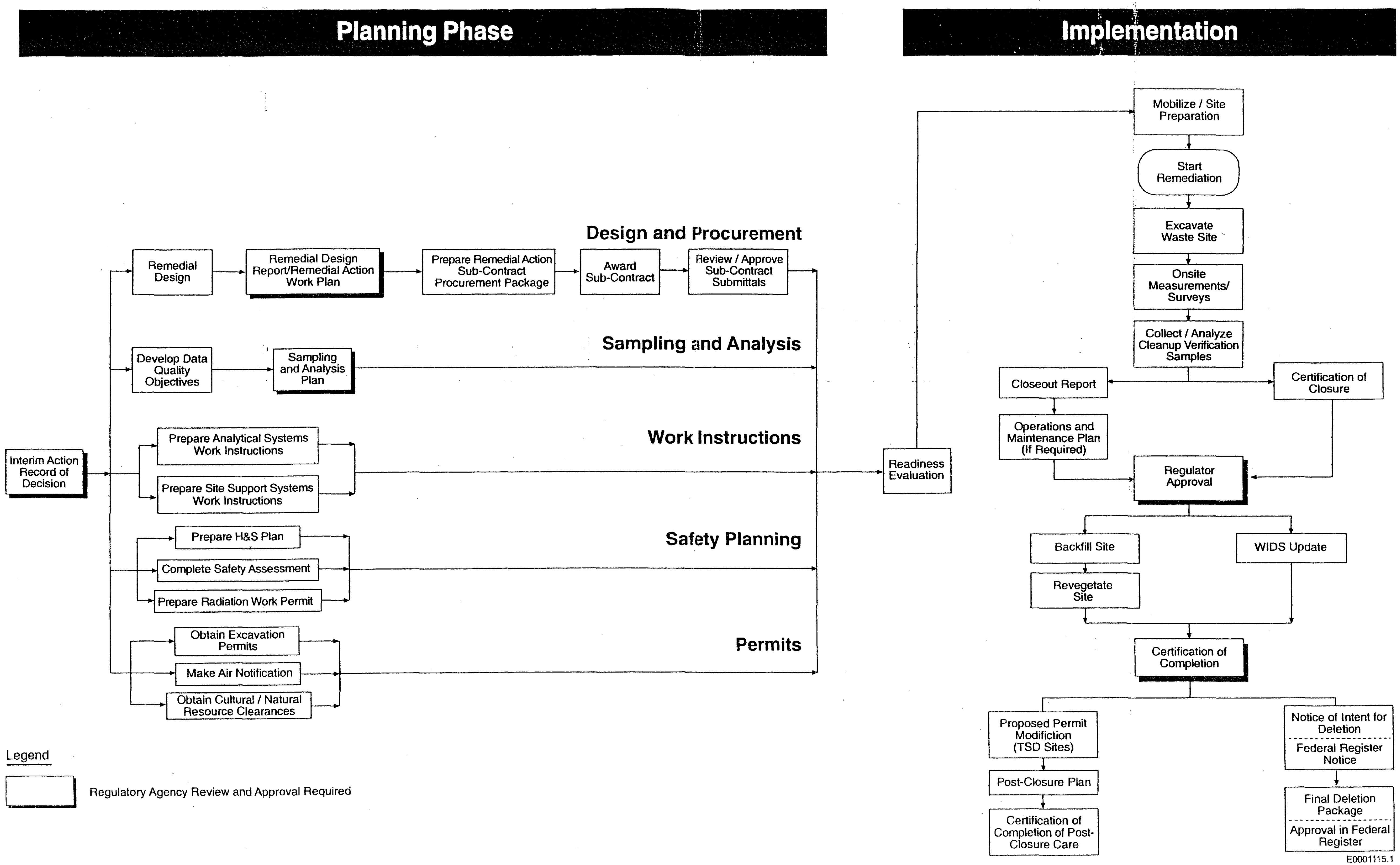
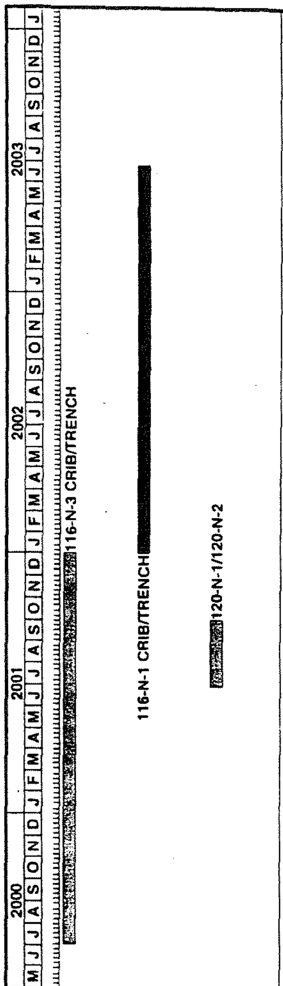


Figure 3-2. Remedial Action Schedule.

Activity ID	Activity Description	Orig Dur	Early Start	Early Finish
1030	116-N-3 CRIB/TRENCH	377*	03JUL00*	02JAN02
1031	116-N-1 CRIB/TRENCH	380	02JAN02*	25JUN03
1032	120-N-1/120-N-2	64	02JUL01*	01OCT01



Project Start 01OCT99
Project Finish 25JUN03
Data Date 01OCT99
Run Date 29MAR00
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Early Bar
Progress Bar
Critical Activity

RAWP

100-N RDR/RAWP SCHEDULE

Sheet 1 of 1

Figure 3-3. Verification of Soil Cleanup.

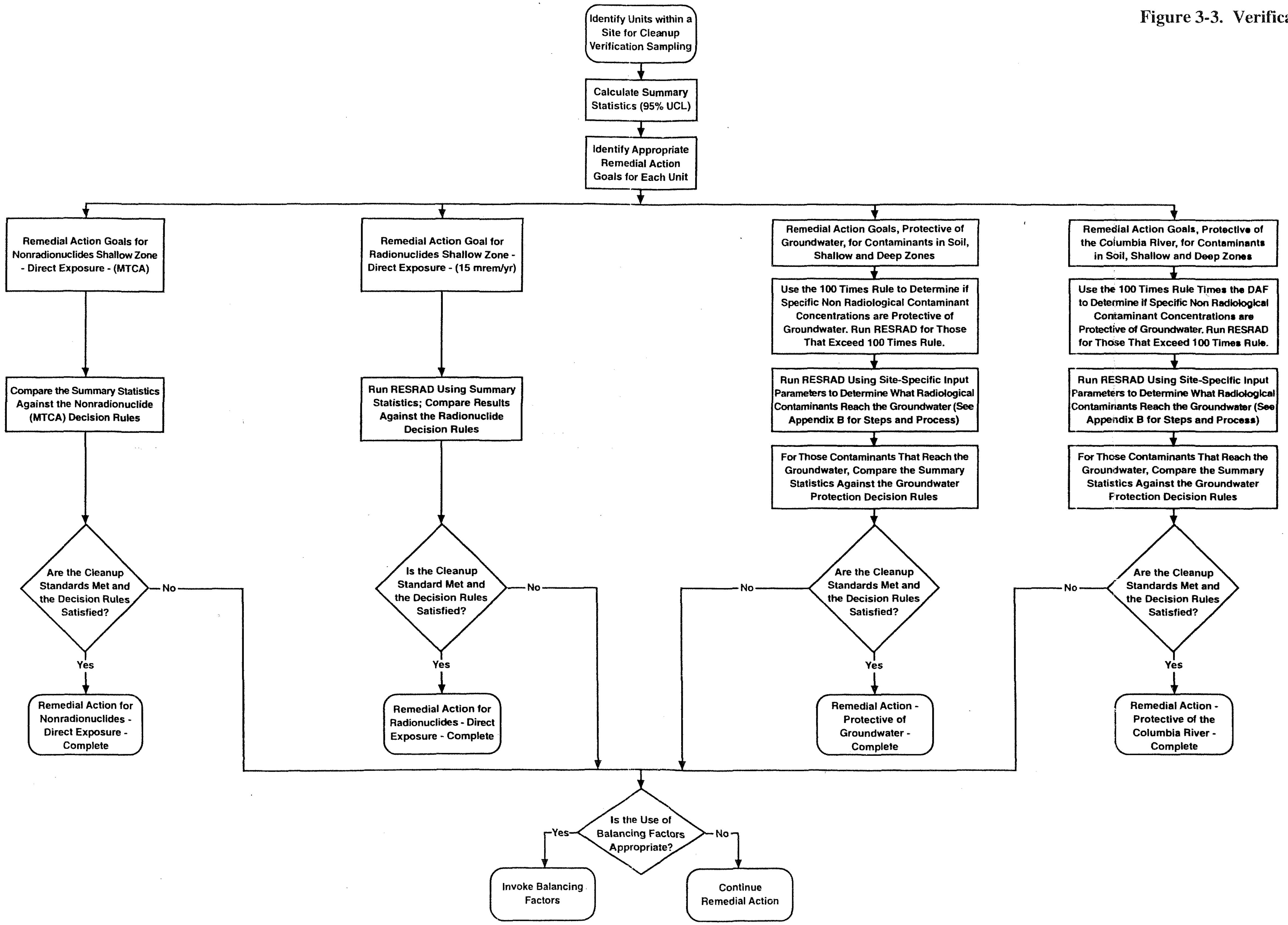

Figure 3-4. Human Exposure Scenario.

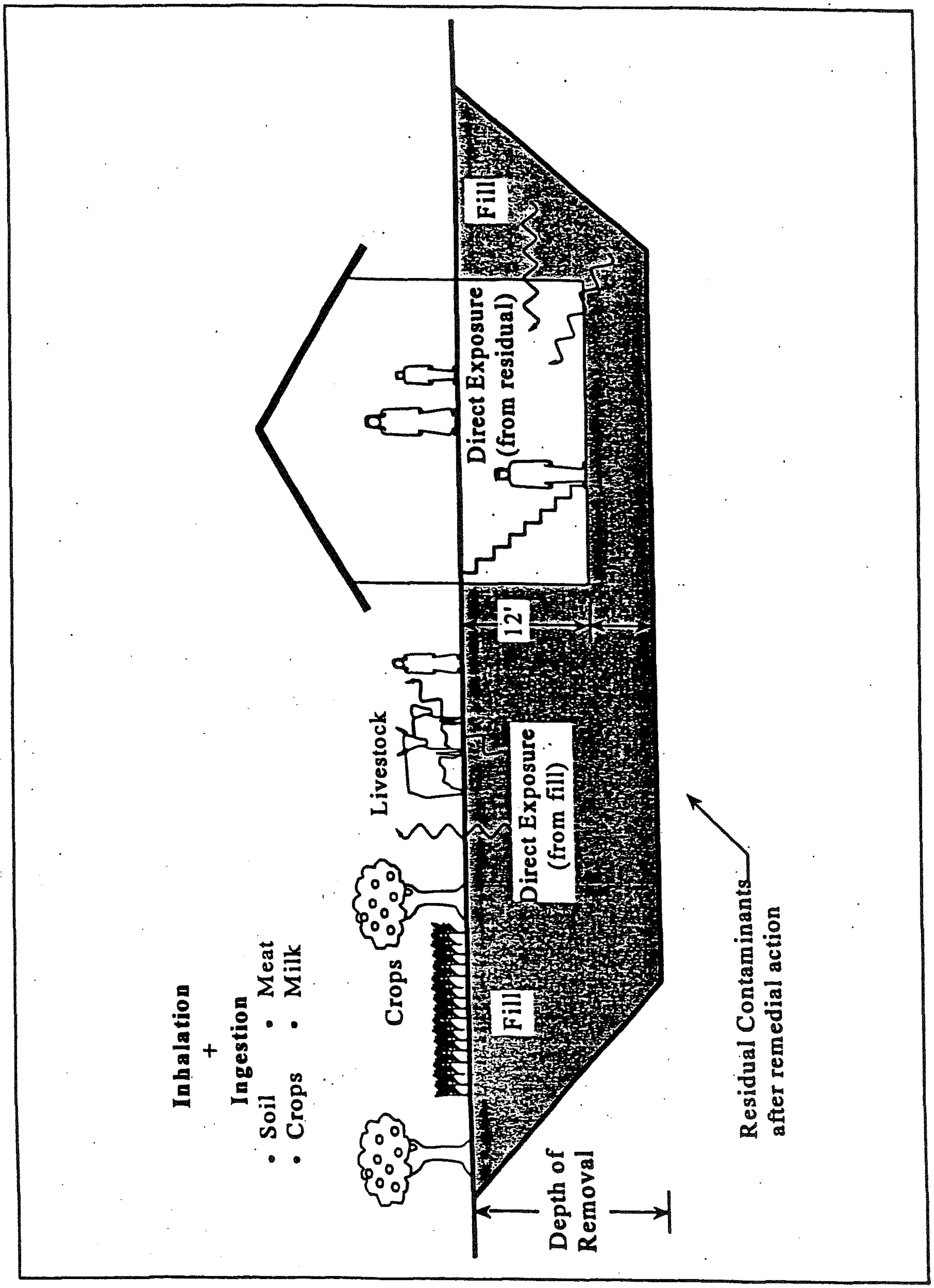

Table 3-1. Cost Estimate Summary for 116-N-1 and 116-N-3 for the Remove/Dispose Alternative Under a Rural-Residential Exposure Scenario.

Item Description	Estimated Cost
Remove concrete panels and beams	$479,819
Demolish and remove high-dose concrete	$113,846
Demolish and remove low-level waste concrete	$25,693
Excavate 116-N-1 Crib	$344,639
Excavate 116-N-1 Trench	$307,364
Excavate 116-N-1 Crib	$230,985
Excavate 116-N-1 Trench	$196,654
Excavate clean overburden -- 116-N-1 Crib and Trench	$36,388
Excavate clean overburden -- 116-N-1 Crib and Trench	$26,792
Backfill	$1,037,209
Site restoration	$36,350
Support functions	$684,918
Mobilization/demobilization	$367,535
Subtotal	$3,888,192
ERDF disposal	$3,775,475
ERC support	$2,320,371
Pipeline removal	$1,967,804
Subtotal	$11,951,842
Engineering/design	$2,570,000
Subtotal	$14,521,842
Direct distributables	$2,679,280
Subtotal	$17,201,121
General and administrative	$629,561
Subtotal	$17,830,682
Contingency (34%)	$4,063,626
TOTAL	$21,894,309

Source: *100-NR-1 Treatment, Storage, and Disposal Units Engineering Study*, BHI-01092, Rev. 1 (BHI 1999a).
ERC = Environmental Restoration Contractor
ERDF = Environmental Restoration Disposal Facility

4.0 WASTE MANAGEMENT

Waste management activities will be performed in accordance with waste management ARARs identified in Section 2.2.7. The requirements specified by the ARARs and other applicable guidance will be addressed in a site-specific waste management instruction prepared in accordance with BHI-FS-03, *Field Support Waste Management Requirement*s, Instruction W-006, "Site Specific Waste Management Instructions." The site-specific waste management instruction will address waste storage, transportation, packaging, handling, and labeling as they specifically apply to waste streams.

In conducting the removal action, various waste steams will be encountered. Each waste stream will require specific processing and disposal. The waste streams anticipated include the following:

- Solid waste
- Low-level radioactive waste (includes soil, concrete, debris, and decommissioning waste from wells in the 100-NR-1 OU)
- Mixed waste (i.e., waste that is both low-level radioactive waste and hazardous waste)
- Investigation-derived waste associated with these waste sites.

4.1 WASTE CHARACTERIZATION AND DESIGNATION

Waste will be characterized and designated in accordance with the requirements of the receiving facility, and in accordance with the approved SAP (DOE-RL 2000).

Wastes destined for the ERDF will be designated in accordance with the following:

- BHI-EE-10, Attachment 1, "Characterization and Designation"
- BHI-FS-03, Instruction W002, "Waste Certification"
- ERDF waste acceptance criteria (BHI 1998 [most recent revision]).

4.2 WASTE HANDLING, STORAGE, AND PACKAGING

Any material that exceeds the ERDF waste acceptance criteria, which would include RCRA LDRs, would be stored on the Hanford Site in compliance with ARARs until treated to meet waste acceptance criteria. In general, disposal of waste recovered in support of this RDR/RAWP will either be disposed at the ERDF or at an inert demolition waste landfill.

Waste from the 116-N-1, 116-N-3, and UPR-100-N-31 sites, and their connecting pipelines, is currently designated as state-only listed waste (F003 due to methanol) in accordance with the Part A RCRA Permit application for these units. Equipment that is removed from these waste sites will be surveyed for radioactive contamination. It is assumed that, if equipment can be radiologically released, then no F003 waste is present on the equipment. If required, equipment will be decontaminated as described in Section 3.1.1.6. It is anticipated that any F003 wastes will meet ERDF waste acceptance criteria without the need for treatment. Secondary waste (e.g., decontamination solutions, personal protective equipment, and miscellaneous trash) that have come in contact with contaminated soil or debris from these sites must also be managed as state-only listed waste. It is anticipated that these state-only F003 wastes will meet ERDF waste acceptance criteria without the need for treatment.

The DOE is currently seeking a “contained-in” determination from Ecology. If granted, this determination will remove the state-only F003 listing for this waste and will eliminate the need for transportation, waste management, or other restrictions that are based solely on the state-only F003 listing.

4.3 AREA OF CONTAMINATION

Waste from the 116-N-1, 116-N-3, and UPR-100-N-31 sites and their connecting pipelines that are excavated and not transported to the ERDF will be temporarily stored in the area of contamination (AOC) or the onsite area (it is preferential to store this waste in the AOC). Management of waste in an onsite area outside the AOC must meet all substantive requirements of ARARs, including RCRA standards for management of dangerous waste, if applicable. Waste managed within the AOC is not subject to RCRA substantive provisions. A map outlining the AOC and onsite area is presented in Figure 4-1. The map will be posted at the construction office and will be updated in the field as needed if plumes or other contamination is discovered that change the AOC or onsite areas.

4.4 120-N-1, 120-N-2, AND 100-N-58 SITES

The 120-N-1 and 120-N-2 sites are managed in accordance with RCRA. The closure plan (DOE-RL 1998a) concludes that contamination above cleanup levels is not present at these sites. The closure plan requires removal of surface structures and piping unless, through process knowledge, sampling, or both, piping can be determined to be uncontaminated and, therefore, be left in place (see Section 3.1.2.2). Debris from demolished surface structures will be disposed of as demolition waste in an inert demolition landfill. “Demolition waste” means solid waste, largely inert waste, resulting from the demolition or razind of buildings, roads, or other man-made structures. Demolition waste consists of, but is not limited to, concrete, brick, bituminous concrete, wood and masonry, composition roofing and roofing paper, steel, and minor amounts of other metals like copper. Plaster (i.e., sheetrock or plasterboard) or any other material, other than wood, that is likely to produce gases or a leachate during the decomposition process and asbestos wastes are not considered to be demolition waste. Disposal action levels for demolition waste from 120-N-1, 120-N-2, and 100-N-58 are shown in Table 4-1. Solid waste destined for an inert demolition waste landfill will follow the acceptance criteria in BHI-FS-03, Instruction W005, "Nonhazardous Solid Waste Disposal." After sampling of piping (as specified in the SAP [DOE-RL 2000]) to determine whether piping is contaminated, any contaminated piping will be disposed at the ERDF; with Ecology's concurrence, uncontaminated piping will be left in place.

Should sampling at the 120-N-1 and 120-N-2 sites indicate the presence of waste that cannot be disposed in an inert demolition waste landfill, then the waste will be managed according to the substantive and administrative requirements of RCRA. The DOE would then initiate a TSD ROD ESD notification. This notification would request Tri-Party approval for inclusion of these sites, as well as site 100-N-58, in the TSD ROD, thus allowing shipment of waste from these sites to the ERDF. If needed, this action would be conducted in conjunction with a RCRA Permit modification.

4.5 WASTE TREATMENT

Soils contaminated with chemicals at levels exceeding waste disposal acceptance criteria (if any) would be treated by solidification/stabilization or other appropriate treatment technology. Solidification and stabilization are treatment technologies designed to reduce contaminant solubility, mobility, or toxicity through chemical or physical changes. Typical solidification and stabilization agents include cement-based materials, clays, asphalt, and resins (e.g., epoxies). Contaminated soil and/or contaminated products resulting from treatment technologies would be disposed in the same manner as materials that meet the waste acceptance criteria without treatment.

Figure 4-1. 100-NR-1 Area of Contamination

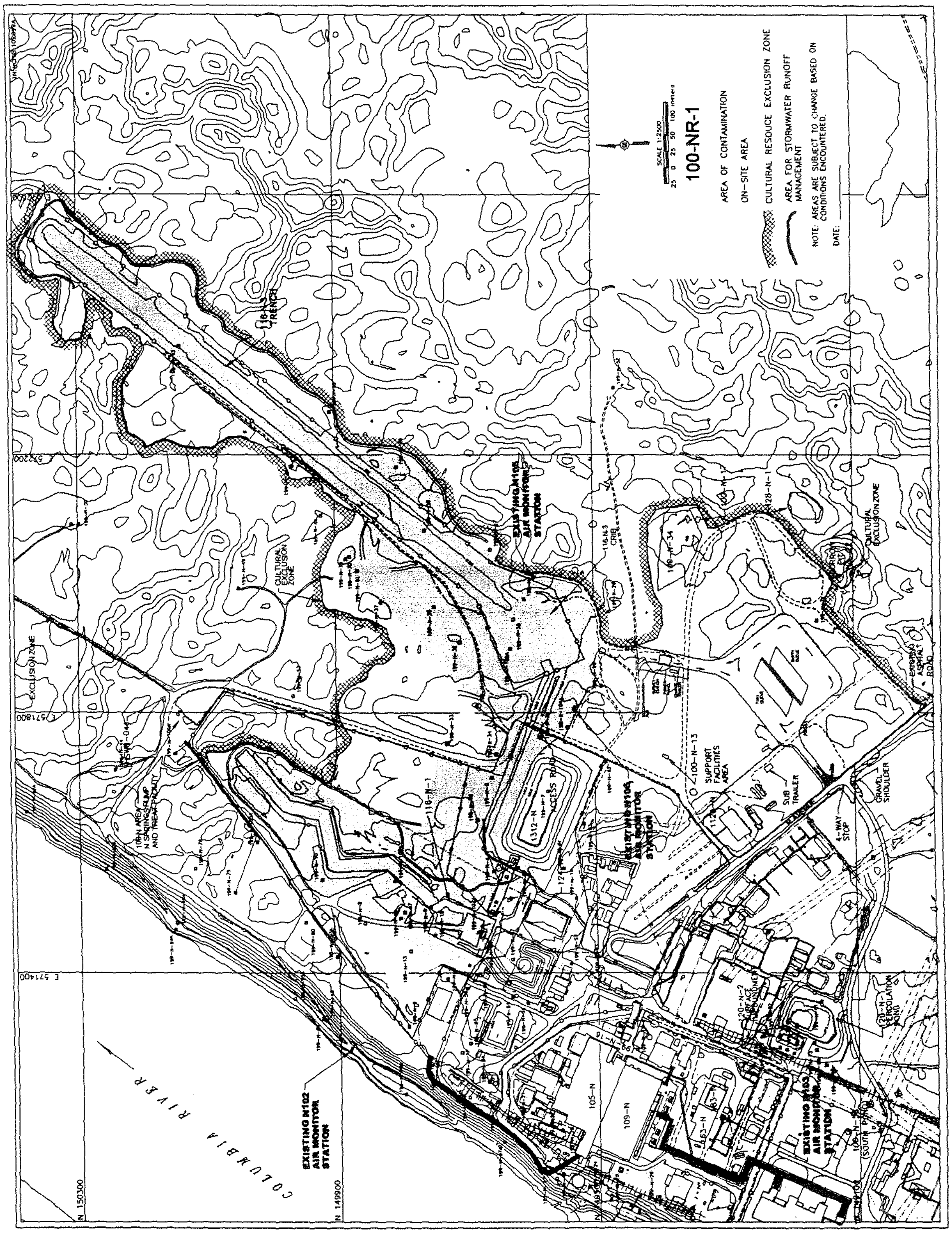

Table 4-1. Disposal Action Level for Inert Demolition Waste from the 120-N-1, 120-N-2, and 100-N-58 Sites.

Contaminant	Practical Quantitation Limit (mg/L)	Disposal Action Level (mg/L)[a]
Arsenic	0.01	5
Barium	0.20	100
Cadmium	0.005	1
Chromium (total)	0.010	5
Lead	0.1	5
Mercury	0.001	0.2
Selenium	0.10	1
Silver	0.020	5
pH	0.1	$\leq$2 or $\geq$12.5 pH units

[a] Via toxicity characteristic leachate procedure analysis based on the sampling and analysis plan (DOE-RL 2000) and on the definition of hazardous waste (40 CFR 261.3).

5.0 REFERENCES

10 CFR 62, "Requirements for Land Disposal of Radioactive Wastes," *Code of Federal Regulations*, as amended.

29 CFR 1926.65 "Hazardous Waste Operations and Emergency Response," *Code of Federal Regulations*, as amended.

36 CFR 65, "National Historic Landmarks Program," *Code of Federal Regulations*, as amended.

36 CFR 800, "Protection of Historic Properties," *Code of Federal Regulations*, as amended.

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

40 CFR 131, 1996, "Water Quality Standards," *Code of Federal Regulations*, as amended.

40 CFR 141, "National Primary Drinking Water Regulations," *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.

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

40 CFR 264, "RCRA Standards for Miscellaneous Treatment Units," *Code of Federal Regulations*, as amended.

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

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

40 CFR 761, "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions," *Code of Federal Regulations*, as amended.

43 CFR 7, "Protection of Archaeological Resources," *Code of Federal Regulations*, as amended.

50 CFR 200 and 402, "Endangered Species Act of 1973," *Code of Federal Regulations*, as amended.

ANL, 1993, *Manual for Implementing Residual Radioactive Materials Guidelines Using RESRAD*, Version 5.0, ANL/EAD/LD-2, Environmental Assessment Division, Argonne National Laboratory, Argonne, Illinois.

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APPENDIX A

WASTE SITE INFORMATION

Waste Sites Identified in the Interim Record of Decision for the 100-NR-1 Operable Unit and Revision 5 of the Hanford Facility RCRA Permit. (2 Pages)

WIDS Designation	Waste Site Information		Assumptions on Volumes			Contaminants of Concern[a]		
	Dimensions	Volume/ Demolition Waste Volume	Excavation	Contaminated/ Potentially Contaminated	Noncontaminated	Radionuclides	Inorganics	Organics
100-NR-1 Operable Unit								
116-N-1 Crib	88.5 m long, 38.1 m wide, 3.7 m deep	34,200 loose cubic meters soil, 3,050 loose cubic meters demolition (total for both facilities and associated piping)	Top of excavation based on 1:1 slope from 4.6-m bottom depth as determined from agreed-to backfill elevation. Bottom area footprint based on nominal high water level of the facility.	Assume all contaminated soils below 4.6 m from agreed-to backfill elevation meet human health, groundwater, and the Columbia River protection criteria.	Assume 1:1 layback	Am-241, Cs-137, Co-60, Eu-154, Eu-155, Ni-63, Pu-239/240, Sr-90, H-3	NO3, Hg, Cr-T, Cr-Hex,	None identified
116-N-1 Trench	488 m long, 15.3 m wide, 3.7 m deep; covered with precast concrete panels	See above	Top of excavation based on 1:1 slope from 4.6-m bottom depth as determined from agreed-to backfill elevation. Bottom area footprint based on nominal high water level of the facility.	Assume all contaminated soils below 4.6 m from agreed-to backfill elevation meet human health, groundwater, and the Columbia River protection criteria.	Assume 1:1 layback	Am-241, Cs-137, Co-60, Eu-154, Eu-155, Ni-63, Pu-239/240, Sr-90, H-3	NO3, Hg, Cr-T, Cr-Hex,	None identified
UPR-100-N-31 Unplanned Release	Area of approx. 188 m^2	1,760 loose cubic meters soil	Top of excavation based on approximate area of contamination. Bottom area footprint based on assumed surface area of contamination using 1:1 slope to 4.6-m bottom depth.	Assume all contaminated soils below 4.6 m from agreed-to backfill elevation meet human health, groundwater, and the Columbia River protection criteria.	Assume 1:1 layback	Am-241, Cs-137, Co-60, Eu-154, Eu-155, Ni-63, Pu-239/240, Sr-90, H-3	NO3, Hg, Cr-T, Cr-Hex,	None identified
116-N-3 Crib	76 m long, 73 m wide, 3 m deep; concrete distribution system covered with precast concrete panels	26,200 loose cubic meters soil, 4,025 loose cubic meters demolition (total for both facilities and associated piping)	Top of excavation based on 1:1 slope from 4.6-m bottom depth as determined from agreed-to backfill elevation. Bottom area footprint based on nominal high water level of the facility.	Assume all contaminated soils below 4.6 m from agreed-to backfill elevation meet human health, groundwater, and the Columbia River protection criteria.	Assume 1:1 layback	Am-241, Cs-137, Co-60, Eu-154, Eu-155, Ni-63, Pu-239/240, Sr-90, H-3	NO3, Hg, Cr-T, Cr-Hex,	None identified
116-N-3 Trench	915 m long, 10 m wide, 2.1 m deep; covered with precast concrete panels	See above	Top of excavation based on 1:1 slope from 4.6-m bottom depth as determined from agreed-to backfill elevation. Bottom area footprint based on nominal high water level of the facility.	Assume all contaminated soils below 4.6 m from agreed-to backfill elevation meet human health, groundwater, and the Columbia River protection criteria.	Assume 1:1 layback	Am-241, Cs-137, Co-60, Eu-154, Eu-155, Ni-63, Pu-239/240, Sr-90, H-3	NO3, Hg, Cr-T, Cr-Hex,	None identified

Waste Sites Identified in the Interim Record of Decision for the 100-NR-1 Operable Unit and Revision 5 of the Hanford Facility RCRA Permit. (2 Pages)

WIDS Designation	Waste Site Information		Assumptions on Volumes			Contaminants of Concern[a]		
	Dimensions	Volume/ Demolition Waste Volume	Excavation	Contaminated/ Potentially Contaminated	Noncontaminated	Radionuclides	Inorganics	Organics
100-N-63 Radioactive Process Sewer	Approx. 4,900 m of various sizes and depths	Volumes included in associated facility totals	Top of excavation based on 1:1 slope from 4.6-m bottom depth as determined from agreed-to backfill elevation. Bottom area footprint based on width of piping plus access to pipe for manipulation.	Assume all contaminated soils below 4.6 m from agreed-to backfill elevation meet human health, groundwater, and the Columbia River protection criteria.	Assume 1:1 layback	Am-241, Cs-137, Co-60, Eu-154, Eu-155, Ni-63, Pu-239/240, Sr-90, H-3	NO3, Hg, Cr-T, Cr-Hex,	None identified
120-N-1 Percolation Pond	Approx. 90 m long by 53 m wide at the surface and 7 m deep	All material assumed to clean debris for disposal at demolition landfill	Remove associated piping and structures up to valve pit #1. Remainder of piping will be removed only if found to be contaminated.	Potentially contaminated material consists of piping only.	Assume 1:1 layback . All material assumed to be clean debris.	None identified	As, Ba, Cd, Cr-T, Cr-Hex, Pb, Hg, Se, Ag, pH, SO4	None identified
120-N-2 Surface Impoundment, formerly the North Settling Pond	Approx. 43 m long by 23 m wide at the surface and 4.6 m deep	All material assumed to be clean debris for disposal at demolition landfill	Remove liner, leak detection system, associated piping and structures up to valve pit #1. Remainder of piping will be removed only if found to be contaminated.	Potentially contaminated material consists of piping only.	Assume 1:1 layback . All material assumed to be clean debris.	None identified	As, Ba, Cd, Cr-T, Cr-Hex, Pb, Hg, Se, Ag, pH, SO4	None identified
100-N-58 South Settling pond	34 m long, 15 m wide at the surface	None identified	None identified; site has been backfilled.	None identified.	None identified	None identified	As, Ba, Cd, Cr-T, Cr-Hex, Pb, Hg, Se, Ag, pH, SO4	None identified

[a] Contaminants of concern, taken from DOE/RL-2000-07, *Sampling and Analysis Plan for the 100-NR-1 Treatment, Storage, and Disposal Units During Remediation and Closeout*, represent the total waste site and are not differentiated as to matrix or depth. See latest revision for details and final list of contaminants.

APPENDIX B

SUMMARY OF RESRAD METHODOLOGY AND DETERMINATION OF CONTAMINANT MOBILITY

APPENDIX B

SUMMARY OF RESRAD METHODOLOGY AND DETERMINATION OF CONTAMINANT MOBILITY

B.1 INTRODUCTION

Cleanup of radionuclides in soils at the 100-N Area waste sites is intended to achieve a cumulative 15 mrem/yr above background dose rate. Determining when remedial action has achieved this cleanup level involves converting radionuclide concentrations (pCi/g) in soil into dose rates (mrem/yr) using a dose assessment model. Use of a model requires an exposure scenario that specifies a hypothetical receptor (i.e., a resident, worker, or recreational user of a site), pathways of exposure from radionuclides in soil to the receptor, and assumptions and parameters to estimate exposures and doses to the receptor from radionuclides in soil. This appendix describes the model selected to perform dose assessments and nonradionuclide contaminant mobility modeling for the 100-NR-1 Operable Unit, describes the exposure scenario, and presents the parameters and assumptions used in the model.

B.2 MODEL SELECTION

The RESidual RADioactivity (RESRAD) model has been selected for all 100 Area projects as the dose assessment model for generating remedial action goals (RAGs) for radionuclide contaminants in soil and for verifying that concentrations remaining after remedial action achieve the 15 mrem/yr cleanup level. The RESRAD model was developed by Argonne National Laboratory (ANL) to implement U.S. Department of Energy (DOE) guidelines for residual radioactive material in soil (ANL 1993). The model has been accepted by the U.S. Environmental Protection Agency (EPA) for performing dose assessments to support the U.S. Nuclear Regulatory Commission (NRC) and EPA proposed radionuclide soil cleanup standard of 15 mrem/yr above background (EPA 1994).

B.3 EXPOSURE SCENARIO

A primary goal of the Interim Record of Decision (ROD) signed in January 2000 by the Tri-Parties (EPA 2000) is to achieve cleanup levels that would not preclude future uses in the 100-N Area. This general goal must be specified in terms of an exposure scenario and exposure pathways to use RESRAD to convert radionuclide concentrations in soil into a dose.

For the purpose of using RESRAD, unrestricted future use in the 100-N Area is represented by an individual resident in a rural-residential setting. This resident is assumed to consume crops raised in a backyard garden; consume animal products, such as meat and milk from locally raised livestock or meat from game animals (including fish); and live in a residence on the waste site. The exposure pathways considered in estimating dose from radionuclides in soil are inhalation; soil ingestion; ingestion of crops, meat, fish, and milk; and external gamma exposure. It is assumed that contaminated groundwater would not be used for drinking, irrigation, or any other use. This individual is conservatively assumed to spend 80% of his or her lifetime on site.

The selected exposure pathways are consistent with the recommendations provided by the RESRAD user's manual (ANL 1993), except for exclusion of the radon gas inhalation pathway (radon is not a contaminant of potential concern). Protection of groundwater is intended to achieve maximum contaminant levels (MCLs), which is consistent with the NRC and EPA proposed radionuclide soil cleanup standard (40 *Code of Federal Regulations* 196). For most of the contaminants of concern in the 100-N Area, external exposure would be the dominant exposure pathway (ingestion and inhalation exposure pathways contribute little to total exposure). However, for strontium-90, ingestion pathways are the dominant exposure pathways and should be included to properly address cleanup of strontium-90 in soil.

B.4 EXPOSURE PATHWAYS

The following exposure pathways were used to convert radionuclide concentrations in soil to doses:

- External exposure
- Inhalation of suspended dust
- Crop ingestion
- Meat ingestion
- Milk ingestion
- Aquatic foods ingestion
- Soil ingestion.

B.5 ASSUMPTIONS

The input parameters and assumptions used in RESRAD to generate the lookup values presented in the Remedial Design Report/Remedial Action Work Plan (RDR/RAWP) for the 100-NR-1 treatment, storage, and disposal (TSD) units are summarized in Table B-1. One different assumption for 100-N Area cleanup as stated in the corrective measures study (CMS) (DOE-RL 1998a) is that contaminated groundwater will not be used for any purpose. For the purpose of site closeout verification, the RESRAD input values (e.g., the thickness of the contaminated zone, the thickness of the uncontaminated zone, and the size of the waste site) will be determined on a site-specific basis. RESRAD calculates all radionuclides in the decay chain (daughters) in calculating ingrowth and decay. It has not been determined what daughters were present at the time of waste emplacement, but they would be insignificant dose contributors; therefore, estimated daughters are not input.

Table B-1. Input Parameter Values Used in RESRAD to Calculate Remedial Action Goals for Direct Exposure and Groundwater/River Protection. (6 Pages)

RESRAD Category	Parameter	Units	User Input, Direct Exposure[a]	User Input, Groundwater/ River Protection[b]	Rationale	Reference
Exposure Pathways		NA	External Gamma, Inhalation, Plant Ingestion, Meat Ingestion, Milk Ingestion, Aquatic Foods, Soil Ingestion	Drinking water	Presented in Section 3.3.1 of the TSD CMS	DOE/RL-96-39 (DOE-RL 1998a)
R011 – CZ	Area of CZ	m^2	10,000	10,000	Generic site model[c]	
	Thickness of CZ[d]	m	4.6	7.6	Direct exposure - cleanup standards apply to upper 4.6 m (15 ft); GW/River – apply to the entire soil column	DOE/RL-96-39 (DOE-RL 1998a)
	Length Parallel to Aquifer Flow	m	100	425	Square root of contaminated site area	DOE/RL-96-11[b] (DOE-RL 1996)
	Radiation Dose Limit	mrem/yr	15	4	Direct exposure - proposed federal standard for soil; GW/River - standard promulgated under SDWA	40 CFR 196; 40 CFR 141
	Elapsed Time of Waste Placement	yr	0	0	RESRAD default	
R012 – Initial Concentrations of Principal Radionuclides	All radionuclide contaminants of concern	pCi/g	95% UCL values	95% UCL values		
R013 – Cover and CZ Hydrological Data	Cover Depth	m	0	4.6	Generic Site Model; GW/River - Assume clean fill is used to applicable depth of remediation	
	Density of Cover Material	g/cm^3	Not used	2.0	N Area-specific data	DOE/RL-96-11[b] (DOE-RL 1996)
	Cover Erosion Rate	m/yr	Not used	0.001	Default	
	Density of CZ	g/cm^3	2.0	2.0	N Area-specific data	DOE/RL-96-11 (DOE-RL 1996)
	CZ Erosion Rate	m/yr	0.001	0.001	RESRAD default	
	CZ Total Porosity		0.3	0.3	N Area specific data	DOE/RL-96-11[b] (DOE-RL 1996)
	CZ Field Capacity		0.25	0.25	WDOH guidance	WDOH/320-015 (WDOH 1997)
	CZ Hydraulic Conductivity	m/yr	250	250	N Area-specific data	DOE/RL-96-11 (DOE-RL 1996)

Table B-1. Input Parameter Values Used in RESRAD to Calculate Remedial Action Goals for Direct Exposure and Groundwater/River Protection. (6 Pages)

RESRAD Category	Parameter	Units	User Input, Direct Exposure[a]	User Input, Groundwater/ River Protection[b]	Rationale	Reference
R013 – Cover and CZ Hydrological Data (cont.)	CZ b Parameter		4.05	4.05	Consistent with N Area soil profile	RESRAD manual (ANL 1993[d])
	Humidity in Air	g/cm^3	8	8	RESRAD default	
	Evapotranspiration Rate		0.91	0.91	EPA, Region X guidance	Letter from EPA
	Wind Speed	M/s	3.4	3.4	Hanford Site average	PNNL-12087 (Burk et al. 1999)
	Precipitation	m/yr	0.16	0.16	Based on 16 cm (6.3 in.) average annual rainfall	DOE/RL-90-07[c] (DOE-RL 1992)
	Irrigation Rate	m/yr	0.76	0.76	EPA, Region X guidance	Letter from EPA (EPA and Ecology 1996)
	Irrigation Mode		Overhead	Overhead	RESRAD default	
	Runoff Coefficient		0.2	0.2	RESRAD default	
	Watershed Area for Nearby Stream or Pond	m^2	1,000,000	1,000,000	RESRAD default	
	Accuracy for Water/Soil Computations		0.001	0.001	RESRAD default	
R014 – SZ Hydrological Data	Density of SZ	g/cm^3	2.0	2.0	N Area-specific data	DOE/RL-96-11 (DOE-RL 1996)
	SZ Total Porosity		0.3	0.3	N Area-specific data	DOE/RL-96-11 (DOE-RL 1996)
	SZ Effective Porosity		0.25	0.25	WDOH guidance	WDOH/320-015 (WDOH 1997)
	SZ Hydraulic Conductivity	m/yr	5,530	5,530	N Area-specific data	DOE/RL-93-37 (DOE-RL 1993), DOE/RL-95-83 (DOE-RL 1995a), DOE/RL-95-100 (DOE-RL 1995b)
	SZ Hydraulic Gradient		0.00125	0.00125	Based on GW velocity = 27.8 m/yr, porosity = 0.25, hydraulic conductivity = 5,530	1994 RCRA annual report, DOE/RL-94-136 (DOE-RL 1994)
	SZ b Parameter		4.05	4.05	Consistent with N Area soil profile	RESRAD manual (ANL 1993)
	Water Table Drop Rate	m/yr	0	0	N Area-specific data	DOE/RL-96-11[b] (DOE-RL 1996)
	Well Pump Intake Depth	m below water table	NA	4.6	Typical RCRA well screen length	
	Nondispersion or Mass-Balance		ND	ND	RESRAD default	

Table B-1. Input Parameter Values Used in RESRAD to Calculate Remedial Action Goals for Direct Exposure and Groundwater/River Protection. (6 Pages)

RESRAD Category	Parameter	Units	User Input, Direct Exposure[a]	User Input, Groundwater/ River Protection[b]	Rationale	Reference
	Well Pumping Rate	m^3/yr	NA	250	RESRAD default	
R015 – Uncontaminated and Unsaturated Strata Hydrological Data	Number of Unsaturated Strata		1	1	Generic site model; one contaminated zone, one uncontaminated zone	DOE/RL-96-39 (DOE-RL 1998a)
	Thickness[d]	m	15.2	7.6	Generic site model	DOE/RL-96-11[b] (DOE-RL 1996)
	Soil Density	g/cm^3	2.0	2.0	N Area-specific data	DOE/RL-96-11[b] (DOE-RL 1996)
	Total Porosity		0.3	0.3	N Area-specific data	DOE/RL-96-11[b] (DOE-RL 1996)
	Effective Porosity		0.25	0.25	WDOH guidance	WDOH/320-015 (WDOH 1997)
	CZ Field Capacity		0.25	0.25	WDOH guidance	WDOH/320-015 (WDOH 1997)
	Soil-specific b Parameter		4.05	4.05	Consistent with site soil profile	RESRAD manual (ANL 1993[d])
	Hydraulic Conductivity	m/yr	250	250	N Area-specific data	DOE/RL-96-11[b] (DOE-RL 1996)
R016 – Distribution Coefficients and Leach Rates	Kd	mL/g	Contaminant specific	Contaminant specific	Contaminant specific, N Area-specific data	DOE/RL-96-17[c] (DOE-RL 1998b)
	Leach Rate	yr	Contaminant-specific	Contaminant-specific	RESRAD manual	
	Saturated Solubility		0	0	RESRAD default	
	Inhalation Rate	m^3/yr	7,300	Not used	WDOH guidance	WDOH/320-015 (WDOH 1997)
	Mass Loading for Inhalation	g/m^3	0.0001	Not used	WDOH guidance	WDOH/320-015 (WDOH 1997)
R017 – Inhalation and External Gamma	Exposure Duration	yr	30	30	RESRAD default	
	Indoor Dust Filtration Factor		0.4	Not used	RESRAD default	
	External Gamma Shielding Factor		0.8	Not used	WDOH guidance	WDOH/320-015 (WDOH 1997)
	Indoor Time Factor		0.6	Not used	WDOH guidance	WDOH/320-015 (WDOH 1997)
	Outdoor Time Factor		0.2	Not used	WDOH guidance	WDOH/320-015 (WDOH 1997)
	Shape Factor		1	Not used	RESRAD default	
	Fruits, Vegetables, and Grain Consumption	kg/yr	110	Not used	WDOH guidance	WDOH/320-015 (WDOH 1997)
	Leafy Vegetable Consumption	kg/yr	2.7	Not used	WDOH guidance	WDOH/320-015 (WDOH 1997)
	Milk Consumption	L/yr	100	Not used	WDOH guidance	WDOH/320-015 (WDOH 1997)

Table B-1. Input Parameter Values Used in RESRAD to Calculate Remedial Action Goals for Direct Exposure and Groundwater/River Protection. (6 Pages)

RESRAD Category	Parameter	Units	User Input, Direct Exposure[a]	User Input, Groundwater/ River Protection[b]	Rationale	Reference
R018 – Ingestion Pathway Data, Dietary Parameters	Meat and Poultry Consumption	kg/yr	36	Not used	WDOH guidance	WDOH/320-015 (WDOH 1997)
	Fish Consumption	kg/yr	19.7	Not used	MTCA guidance	WAC 173-340
	Other Seafood Consumption	kg/yr	0.9	Not used	RESRAD Default	
	Soil Ingestion	g/yr	7.3	Not used	MTCA guidance	WAC 173-340
	Drinking Water Intake	L/yr	730	730	WDOH guidance	WDOH/320-015 (WDOH 1997)
	Drinking Water Contamination Fraction		0	0	Contaminated groundwater will not be used for any purpose	DOE/RL-96-39 (DOE-RL 1998a)
	Household Water Contamination Fraction		0		Contaminated groundwater will not be used for any purpose	DOE/RL-96-39 (DOE-RL 1998a)
	Livestock Water Contamination Fraction		0	0	Contaminated groundwater will not be used for any purpose	DOE/RL-96-39 (DOE-RL 1998a)
	Irrigation Water Contamination Fraction		0	0	Contaminated groundwater will not be used for any purpose	DOE/RL-96-39 (DOE-RL 1998a)
	Aquatic Food Contamination Fraction		0.5	Not used	WDOH guidance	
	Plant Food Contamination Fraction		-1	Not used	RESRAD default	
	Meat Contamination Fraction		-1	Not used	RESRAD default	
	Milk Contamination Fraction		-1	Not used	RESRAD default	
	Livestock Fodder Intake for Meat	kg/d	68	Not used	RESRAD default	
	Livestock Fodder Intake for Milk	kg/d	55	Not used	RESRAD default	
	Livestock Water Intake for Meat	L/d	50	Not used	RESRAD default	
R019 – Ingestion Pathway Data, Nondietary	Livestock Water Intake for Milk	L/d	160	Not used	RESRAD default	
	Livestock Intake of Soil	kg/d	0.5	Not used	RESRAD default	
	Mass Loading for Foliar Deposition	g/m^3	0.0001	Not used	RESRAD default	
	Depth of Soil Mixing Layer	m	0.15	Not used	RESRAD default	
	Depth of Roots	m	0.9	Not used	RESRAD default	

Table B-1. Input Parameter Values Used in RESRAD to Calculate Remedial Action Goals for Direct Exposure and Groundwater/River Protection. (6 Pages)

RESRAD Category	Parameter	Units	User Input, Direct Exposure[a]	User Input, Groundwater/ River Protection[b]	Rationale	Reference
R019 – Ingestion Pathway Data, Nondietary (cont.)	Groundwater Fractional Usage - Drinking Water		0	0	Contaminated groundwater will not be used for any purpose	DOE/RL-96-39 (DOE-RL 1998a)
	Groundwater Fractional Usage - Household Usage		0	0	Contaminated groundwater will not be used for any purpose	DOE/RL-96-39 (DOE-RL 1998a)
	Groundwater Fractional Usage - Livestock Water		0	Not used	Contaminated groundwater will not be used for any purpose	DOE/RL-96-39 (DOE-RL 1998a)
R020 – Groundwater Usage	Groundwater Usage - Irrigation		0	Not used	Contaminated groundwater will not be used for any purpose	DOE/RL-96-39 (DOE-RL 1998a)
	Cover Material Thickness	m	Not used	Not used	Radon is not a COPC	
	Cover Material Density	g/m^3	Not used	Not used	Radon is not a COPC	
	Cover Material Total Porosity		Not used	Not used	Radon is not a COPC	
R021 – Radon	Cover Material Volumetric Water Content		Not used	Not used	Radon is not a COPC	
	Cover Material Effective Radon Diffusion Coefficient	m/sec	Not used	Not used	Radon is not a COPC	
	Building Foundation Thickness		Not used	Not used	Radon is not a COPC	
	Building Foundation Density	g/m^3	Not used	Not used	Radon is not a COPC	
	Building Foundation Total Porosity		Not used	Not used	Radon is not a COPC	
	Building Foundation Volumetric Water Content		Not used	Not used	Radon is not a COPC	
	Building Foundation Effective Radon Diffusion Coefficient	m/sec	Not used	Not used	Radon is not a COPC	
	CZ Radon Diffusion Coefficient	m/sec	Not used	Not used	Radon is not a COPC	
	Radon Vertical Dimension of Mixing	m	Not used	Not used	Radon is not a COPC	
	Average Annual Wind Speed	m/sec	Not used	Not used	Radon is not a COPC	
	Building Air Exchange Rate	1/hr	Not used	Not used	Radon is not a COPC	
	Building Room Height	m	Not used	Not used	Radon is not a COPC	
	Building Indoor Area Factor		Not used	Not used	Radon is not a COPC	

Table B-1. Input Parameter Values Used in RESRAD to Calculate Remedial Action Goals for Direct Exposure and Groundwater/River Protection. (6 Pages)

RESRAD Category	Parameter	Units	User Input, Direct Exposure[a]	User Input, Groundwater/ River Protection[b]	Rationale	Reference
R021 – Radon (cont.)	Foundation Depth Below Ground Surface	m	Not used	Not used	Radon is not a COPC	
	Radon Emanation Coefficient – Rn-222		Not used	Not used	Radon is not a COPC	
	Radon Emanation Coefficient – Rn-220		Not used	Not used	Radon is not a COPC	

Note: Site-specific input parameters, such as the thickness of the contaminated zone and the thickness of the uncontaminated zone, will be determined on a site-specific basis for cleanup verification calculations.

[a] Input parameters used to calculate single radionuclide soil concentrations corresponding to a 15 mrem/yr dose.

[b] Input parameters used to determine if contaminants in soil will reach groundwater within a 1,000-year time frame.

[c] Generic site model parameters will be changed to site-specific values for cleanup verification.

[d] These values are for preliminary use only. The thickness of the contaminated zone and the thickness of the uncontaminated zone will be determined on a site-specific basis for cleanup verification calculations.

COPC = contaminant of potential concern
CZ = contaminated zone
EPA = U.S. Environmental Protection Agency
GW = groundwater
SDWA = *Safe Drinking Water Act*
SZ = saturated zone
WDOH = Washington State Department of Health

Values for some of these parameters (e.g., thickness of the contaminated zone, thickness of the uncontaminated zone, and areal extent of the site) depend on specific site characteristics. For purposes of developing lookup values to guide field excavation, generic values have been assumed; however, to verify whether a specific site has met cleanup goals, input values will be determined on a site-specific basis.

The nature and extent of residual contamination (concentrations and thickness of contaminated zone[s]) will be determined from data presented in the limited field investigation (LFI) (DOE-RL 1996). It is anticipated that sufficient data are available for the 116-N-1 and 116-N-3 waste sites. This information will then be input to the RESRAD model to evaluate migration potential. The specific process to determine the thickness of the contaminated zone(s) and the associated contaminant profile will follow a hierarchy as shown by the following steps:

1. **Site-Specific Information:** Use LFI data, process knowledge, historic sampling data, remediation data, etc., to determine profile.

2. **Analogous Site Information:** Compare the site to other sites for which a profile has been determined to determine if appropriate analogies can be made. The factors considered could include site stratigraphy, depth to groundwater, volume of liquid disposed, type of contaminants, and range of deep zone closeout samples. It is possible that correlations can be made using the existing LFI borehole data and final closeout samples for the pipelines and the UPR-N-31 site.

B.6 DISTRIBUTION COEFFICIENTS

The distribution coefficient (K_d) is an empirical parameter that represents the tendency for a chemical substance to adsorb to soil. Typically, it is measured in the laboratory as the ratio of concentration in soil (C_s) to concentration in water (C_w), at equilibrium, as shown below:

$$K_d = \frac{C_s}{C_w}$$

The greater the extent of adsorption in soil, the greater the value of K_d. Values for K_d can be used in models such as RESRAD to quantify the amount of contaminant in soil that can leach to groundwater. K_d values measured for an individual substance can vary substantially based on differences in soil properties. The variables affecting K_d include the relative abundance of different cations and anions in soil, soil pH, redox potential, cation exchange capacity, and organic matter content.

Ideally, the K_d value used to model leaching potential in Hanford Site 100-N soils should be based on site-specific measurements. However, sole reliance on site-specific measurements is generally not feasible. An alternate approach to developing K_d values for modeling is to (1) identify K_d values measured in, or under, conditions similar to those encountered in Hanford Site soils, and (2) select a value that provides a conservatively reasonable estimate of contaminant leaching to groundwater.

Several studies have compiled K_d values for a variety of soil, sediment, and leachate conditions at the Hanford Site. The hierarchy of data used to select K_d values was to (1) use Hanford Site 100-N-specific data, if available; (2) if unavailable, use Hanford Site-specific data; and (3) if Hanford Site-specific data are unavailable, use more general compilations of K_d values in the literature.

B.6.1 K_d Data Sources

The principal sources of information on 100-N Area K_d values were Serne and LeGore (1996) and Johnson et al. (1995), where 100-N-specific strontium-90 and tritium-3 K_d values were calculated. For other contaminant K_d values, Appendix E in DOE-RL (1998b) provides a discussion for the K_d values selected. The selection of these K_d values was reaffirmed in the LFI and CMS (DOE-RL 1996, 1998a). Hanford Site-specific K_d values are found in Ames and Serne (1991) and Serne and Wood (1990). These references provided information on most of the radionuclide and nonradioactive inorganic contaminants in soil in the 100 Areas. The K_d values selected for modeling contaminant concentrations leaching to groundwater are summarized in Table B-2.

Table B-2. Distribution Coefficient (K_d) Values.

Contaminant	Distribution Coefficient (mL/g)	Reference
Am-241	200	Ames and Serne 1991
Cs-137	50	Ames and Serne 1991
Co-60	50	Ames and Serne 1991
Eu-154	200	Ames and Serne 1991
Eu-155	200	Ames and Serne 1991
H-3	0	Serne and LeGore 1996
Ni-63	30	Ames and Serne 1991
Pu-239/240	200	Serne and Wood 1990
Sr-90	15	Serne and LeGore 1996
Arsenic	3	Baes and Sharp 1983
Barium	25	Ames and Serne 1991
Cadmium	30	Ames and Serne 1991
Chromium (III)	200	Ames and Serne 1991
Chromium (VI)	0	Ames and Serne 1991
Lead	30	Ames and Serne 1991
Mercury	30	Ames and Serne 1991

B.6.2 Leachability

An alternate and more accurate approach in determining contaminant mobility is to use the leachability of a specific contaminant. The leachability is the rate contaminants desorb from soil particles and is thus a more accurate representation of mobility in the subsurface. Unfortunately, there are very little site-specific leach rate data available. Desorption data are available from the 100-N Area for strontium-90 and tritium-3 (Serne and LeGore 1996, Johnson et al. 1995). These data have not yet been analyzed to calculate the leach rate, but once the calculations have been performed, the leach rate may be used in the RESRAD modeling with regulator approval.

B.7 DETERMINING IF CONTAMINANTS REACH GROUNDWATER OR THE COLUMBIA RIVER

Residual nonradioactive and radionuclide contaminants remaining in soil after remediation must be at levels such that concentrations of contaminants reaching groundwater and, eventually, the Columbia River by migration through the soil column do not exceed RAGs considered protective of these resources. For nonradioactive contaminants, the 100 times rule is applied first to determine soil concentrations that can remain in place without impacting groundwater. If residual contaminant concentrations exceed concentrations calculated using the 100 times rule, the RESRAD model can be used on a site-specific basis to determine if residual concentrations are protective. For radionuclide contaminants, RESRAD is used first to determine which contaminants reach groundwater, and then to calculate concentrations that can remain in place protective of groundwater and the river. Methodology for modeling to protect the Columbia River is the same as that for modeling protection of groundwater, with the concentration multiplied by a factor to account for dilution and attenuation as contaminants migrate through the groundwater to the river.

B.7.1 Calculational Methodology

To run the RESRAD model for protection of groundwater and the Columbia River, appropriate distribution coefficients for residual radioactive soil contaminants are selected from Table B-2, parameters for user input for groundwater protection are entered from Table B-1, and site-specific parameters are used when appropriate. For calculation purposes, the RESRAD model is run with only the drinking water exposure pathway active (all other exposure pathways are suppressed). The graphical and numerical output for a 1,000-year time frame for the drinking water pathway are inspected. If the concentration of a soil contaminant in drinking water is zero at all times, the contaminant does not reach groundwater. If a soil contaminant at its residual concentration is shown not to reach groundwater, or reaches groundwater at concentrations below the RAGs, then further remediation is not required.

B.7.2 Application of Resrad to Nonradioactive Contaminants

The RESRAD model is only applied to nonradioactive contaminants if they fail to meet cleanup levels calculated using the 100 times rule. Although RESRAD is intended to perform pathway analysis for exposures to radioactive materials, the calculations for environmental transport can be applied to any contaminant. Nonradioactive contaminants are introduced into the model using, as surrogates, radioisotopes with long half-lives. The ideal surrogate would have a half-life greater than 100,000 years (such as thorium-232 without daughter ingrowth). Because the model can be evaluated over a 1,000-year period, the effects of radioactive decay on the final result would be less than 0.7%.

Once a surrogate radionuclide is selected for a nonradionuclide, it is entered into the program and assigned the distribution coefficient from Table B-2. There is no need to convert to activity-based surrogate concentrations; the RESRAD output will be in the same units as the nonradionuclide value. The RESRAD model is run as described above using the parameters from Table B-1 for the drinking water pathway, and the graphical and numerical output are inspected. If the concentration of a soil contaminant in drinking water is zero at all times, the contaminant does not reach groundwater. If a soil contaminant at its residual concentration is shown not to reach groundwater, or reaches groundwater at concentrations below the RAGs, then further remediation is not required.

B.7.3 Protection of the Columbia River

To achieve protection of the Columbia River, the calculation of RAGs for residual soil contamination must consider two additional contaminant transport steps beyond the migration of contaminants through the soil column and their subsequent leaching into groundwater. The additional contaminant transport steps are as follows:

1. The transportation, from beneath the waste site to near-river wells (the point of compliance), of contaminants that have leached to groundwater

2. The mixing of groundwater contaminant concentrations with river water within the substrate at the groundwater/river interface.

The model that addresses these two steps is the dilution attenuation factor (DAF) model, summarized in Section B.7.5. This model accounts for the time required for a contaminant to travel through the groundwater underlying a site to the river, radionuclide decay during that travel-time period, and a 1:1 dilution factor applied to contaminant concentrations measured in near-river wells (to account for the difference in concentration between the near-river well and the substrate at the groundwater/river interface). In evaluating contaminant transport time, the model uses a 1,000-year period (starting from site closeout) and considers the effect of retardation as contaminants move from under the waste site to the river. As appropriate, dilution factors greater than 1:1 will be evaluated on a constituent-specific basis using Hanford Site data.

B.7.4 Application of Criteria for Protection of Groundwater and Surface Water

Residual contaminant concentrations remaining in soil after remediation must be at levels considered protective of groundwater and the Columbia River. The process for determining soil concentrations that are protective of groundwater and the river depends on whether the contaminant is a radionuclide or nonradioactive contaminant.

The *Model Toxics Control Act* (MTCA) states that concentrations of residual nonradioactive contaminants are considered protective of groundwater at levels equal to or less than 100 times the groundwater cleanup levels. The 100 times rule is applied to nonradioactive contaminants as the first step in calculating residual soil concentrations that are protective of groundwater. If residual concentrations exceed cleanup levels calculated using the 100 times rule, site-specific modeling (e.g., RESRAD) will be performed.

The same methodology applied to residual soil contamination to ensure protection of groundwater is applied to ensure protection of the Columbia River. To be protective of the Columbia River, residual soil concentrations of nonradioactive contaminants must also be less than or equal to 100 times applicable state and federal standards (MCLs and Ambient Water Quality Criteria [AWQC]) for surface water. For residual nonradioactive contaminants, protection of the river is achieved by reducing concentrations remaining in soil after remediation to concentrations less than or equal to 100 times the RAG after the DAF has been applied. If residual concentrations exceed river protection cleanup levels calculated using the 100 times rule, site-specific modeling will be performed. For residual radionuclide contaminants shown by the RESRAD model to reach groundwater, protection of the river is achieved by reducing concentrations remaining in soil after remediation to concentrations less than or equal to the value calculated by RESRAD to achieve the RAG after the DAF has been applied.

B.7.5 Estimating Groundwater/River Dilution/Attenuation Factors

Soil cleanup to protect surface water in the Columbia River involves calculating dilution factors between groundwater and the river and calculation of the attenuation of radionuclides as they migrate in groundwater to the river. These DAFs are used in conjunction with the river protection RAGs to calculate RAGs (after the DAF has been applied) that are concentrations in groundwater underlying a site that are protective of the river.

B.7.5.1 Calculation Method. The first step is to calculate the time required for a contaminant to reach the river from groundwater underlying a site. This time is calculated as follows:

$$T = \left(\frac{D}{V_w}\right) \times R_f$$

where:

T	=	Time for contaminant to reach the river (yr)
D	=	Distance from waste site to the river (m)
V_w	=	Average pore velocity in groundwater (m/yr)
R_f	=	Retardation factor in groundwater (unitless).

The average pore velocity in groundwater is assumed to be 27.82 m/yr (91.25 ft/yr) (DOE-RL 1995a).

The R_f values are estimated from soil/water distribution coefficients (K_d [mL/g]) with the following relationship (WHC 1990):

$$R_f = 1 + \left(\frac{P_b}{N_e} \times K_d \right)$$

where P_b is bulk density in soil (g/cm^3, noting that 1 cm^3 = 1 mL) and n_e is effective porosity at saturation of soil (WHC 1990).

The distribution coefficients are presented in Table B-2. The bulk density in soil and effective porosity values are presented in Table B-3.

Table B-3. Parameters Used to Calculate Relative Retardation Factors (R_f).

Parameter	Value	Source
Bulk density	1.7 g/cm^2	DOE-RL 1995a
Effective porosity at saturation	0.25	DOE-RL 1995a

Over the time period T, radionuclide contaminants in groundwater will decay as shown below:

$$\frac{C_{gw}}{C_{gw-onsite}} = 0.5^{T/t_{1/2}}$$

where:

C_{gw}	=	Concentration in groundwater at the groundwater/river interface (substrate) (pCi/L)
$C_{gw\text{-}onsite}$	=	Concentration in groundwater underlying the site (pCi/L)
$t_{1/2}$	=	Radionuclide half-life (yr), presented in Table B-4.

Table B-4. Radionuclide Half-Lives.

Radionuclide	Radionuclide Half-Life (yr)
Am-241	432
Cs-137	30.2
Co-60	5.27
Eu-154	8.8
Eu-155	4.96
H-3	12.3
Ni-63	100
Pu-239/Pu-240	2.439E+04
Sr-90	28.6

Concentrations in groundwater underlying a site corresponding to concentrations in near-river wells (the compliance point for the groundwater/river interface) are estimated using a dilution factor that accounts for mixing of groundwater and surface water in the river substrate. Comparison of near-river wells, seeps, and river water indicate that groundwater/river dilution factors can range from less than 2 to 10 (WHC 1993). A groundwater/river dilution factor of 1:1 was specified in the 100-HR-3 and 100-KR-4 ROD (EPA 1996).

This approach is summarized as follows to develop the DAF:

$$C_{river} \times 2 = C_{gw}$$

$$C_{gw-onsite} = \frac{C_{river} \times 2}{0.5^{(D/V_w \times R_f)/t_{1/2}}}$$

$$C_{gw-onsite} = \frac{C_{river} \times 2}{0.5^{T/t_{1/2}}}$$

B.7.5.2 Methodology Applied. The initial step in calculating concentrations in soil protective of the Columbia River is selecting surface water concentrations protective of human health and the environment. For an individual contaminant, the most restrictive value from the following is applicable: Washington State surface water quality criteria (WAC 173-201-045), Federal AWQC developed in accordance with the *Clean Water Act*, MTCA Method B values, and MCLs, or, if more restrictive, 1/25th of the derived concentration guide in surface water. These concentrations are used to calculate the corresponding concentrations in groundwater underlying the site that are protective of the river. The following example is presented for plutonium-239:

$$\frac{1.2\ pCi/L \times 2}{0.5^{[((200\,m/27.82\,m/yr)\times 1361)/24390\,yr]}} = 3.17\ pCi/L$$

where:

$$R_f = 1361 = 1 + \left[\left(1.7g/cm^3/0.25\right) \times 200\right]$$

This is the concentration in groundwater underlying a site (200 m from a near-river well) that corresponds to the RAG protective of the river for plutonium-239 (i.e., the RAG after the DAF has been applied). The RESRAD model is used to calculate a value in soil that meets this RAG after the DAF has been applied.

B.8 REFERENCES

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APPENDIX C

100-NR-1 TSD UNITS PUBLIC INVOLVEMENT PLAN

APPENDIX C

100-NR-1 TSD UNITS PUBLIC INVOLVEMENT PLAN

C.1 OVERVIEW

This plan outlines public involvement activities that will be conducted during the 100-NR-1 Area remedial design and remedial action of the treatment, storage, and disposal (TSD) units located in the 100-N Area. The interim action 100-NR-1 TSD Record of Decision (ROD) (EPA 2000) signed by the Tri-Parties in January 2000 defined remedial action as excavation, treatment as appropriate or required, and disposal of contaminated soils and debris from these sites.

C.2 PUBLIC INVOLVEMENT PLANNING

This public involvement plan outlines the strategy to be used to provide information during the remedial design and remedial action processes. Throughout the public involvement process, decision making is the responsibility of the U.S. Department of Energy, Richland Operations Office (RL), the Washington State Department of Ecology (Ecology), and the U.S. Environmental Protection Agency (EPA).

C.2.1 Actions to be Taken During Remedial Design and Remedial Action

The following actions will be taken during remedial design to provide information to interested stakeholders as pertinent information becomes available:

- Update the Hanford Advisory Board's Environmental Restoration Committee on remedial action progress; the committee will provide this information to the full board.

- Provide government-to-government consultation with the Native American Tribes during remedial design, periodically during remedial actions, and/or when pertinent information becomes available. RL will transmit documents to the Native American Tribes, Ecology, and the EPA.

  NOTE: A consultation was held with the Native American Tribes on August 20, 1999, to define the cultural Resource Exclusion Zone and receive their approval. The boundary was created to prevent impacts to cultural resources (i.e., *Mooli Mooli* - a significant area that is associated with legends, traditions, and spiritual powers important to local Native American Tribes) during remedial actions. The restricted area will be off limits to project operations and personnel throughout the duration of the remedial action.

- At least 1 month prior to startup of field work, Environmental Restoration Contractor Cultural Resource Staff, using project personnel, will field mark the boundary.

- Give presentations to the Natural Resource Trustee Council on the strategy to protect ecological and cultural resources during remedial action.

- Provide information for the general public (e.g., Hanford Update articles, as new information becomes available; *Hanford Reach* articles; information pamphlets; or press releases).

The following actions will be taken during remedial action to provide information to interested stakeholders as pertinent information becomes available:

- Update the Hanford Advisory Board's Environmental Restoration Committee on remedial action progress; the committee will provide this information to the full board (as needed or requested).

- Provide government-to-government consultation with the Native American Tribes (as needed or requested).

- Give presentations to the Natural Resource Trustee Council (as needed or requested).

- Provide information for the general public (e.g., Hanford Update articles, as new information becomes available; *Hanford Reach* articles; information pamphlets; or press releases).

C.2.2 Actions to be Taken for Changes/Modifications to the Record of Decision and Hanford Facility RCRA Permit

Any changes or deviations to the selected remedy and/or Hanford Facility RCRA permit conditions may require permit modifications and/or an explanation of significant difference (ESD). Examples of changes are defined as modifications of the scope, performance, or cost of a component of the remedy, scheduled as presented in the RCRA Closure Plan (DOE-RL 1998) and ROD (EPA 2000). Applicability of a permit modification and/or an ESD will determined on a case-by-case basis with input from the regulators.

The following actions will be taken if changes/modifications to the selected remedy and/or the Hanford Facility RCRA permit are needed:

- Update the Hanford Advisory Board's Environmental Restoration Committee on the need for permit modifications, and/or an ESD; the committee will provide this information to the full board.

- Provide government-to-government consultation with the Native American Tribes (as needed or requested).

- Give presentations to the Natural Resource Trustees (as needed or requested).

- Prepare necessary documentation (i.e., fact sheets, press releases) to describe the changes or deviations for public notification (send to mailing list).

- Provide information for the general public (Hanford Update articles, *Hanford Reach* articles, press releases).

- RL, at the request of the regulators, may hold public meetings regarding permit modifications and/or an ESD.

C.3 REFERENCES

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APPENDIX D

REVEGETATION PLAN FOR THE 100-NR-1 TSD UNITS

APPENDIX D

REVEGETATION PLAN FOR THE 100-NR-1 TSD UNITS

D.1 INTRODUCTION AND DESCRIPTION

This revegetation plan is for the 100-N Area waste sites that will be remediated as part of the interim action 100-NR-1 Treatment, Storage, and Disposal Units Record of Decision (ROD) (EPA 2000) and the adjacent areas used for support facilities.

This revegetation plan is based on the information provided in the *Revegetation Manual for the Environmental Restoration Contractor* (BHI 1997), the draft *Hanford Site Biological Resources Management Plan* (DOE-RL 1996a), from the preliminary results of the 116-C-1 revegetation project (Weiss and Kemp 1998, Gano et al. 1999), and from other revegetation activities that have occurred across the Hanford Site.

D.2 SUMMARY

The waste sites will be backfilled to the depth required by the cleanup criteria with clean overburden and material from nearby borrow pits. Contouring will generally match the surrounding terrain. Vegetation to be planted will be native species of Hanford Site genotype. The only irrigation will be for newly planted sagebrush tubelings.

D.3 APPROACH

D.3.1 Activity Description

The following activities may need to be completed for each site, or for each group of sites, depending on site conditions and the year that remedial action is completed.

1. Site-specific backfill contouring specifications completed, coordinated with

    - Cultural Resources Specialist
    - Site Engineer
    - Revegetation Specialist.

2. Site-specific conditions evaluated (e.g., backfill depth, slopes, Tribal Nation concerns).

3. Sources of seeds, tubeling sagebrush, fertilizer, straw, and heavy equipment (drill seeded, disk, straw spreader, watering truck) verified and reserved.

4. Site-specific revegetation specifications completed for contract

   - Area to be revegetated (waste site and areas used for support facilities)
   - Species and pounds/acre to be seeded (seeds provided by Bechtel Hanford, Inc.)
   - Tubeling sagebrush amounts and locations
   - Time of planting
   - Fertilizer and mulching requirements
   - Irrigation for tubelings.

5. Contract awarded.

6. Contractor supervised in activity.

7. Success monitored.

D.3.2 Schedule and Constraints

Specific resources and material are described in the following sections. The logic ties of each activity are demonstrated in the sequence of activities shown in Section D.3.1. This activity will need to be repeated every year that sites are remediated and backfilled.

Potential constraints may include the following:

- The final depth of the backfill and remaining contamination at the floor of the excavation may affect revegetation. A backfill depth of 4.6 m (15 ft) should be adequate to keep plants from contacting any remaining contaminants in the deep zone (Klepper et al. 1985).

- Recreated hills (e.g., *Mooli Mooli* – a significant area that is associated with legends, traditions, and spiritual powers important to local Native American Tribes) may need to be reseeded by hand if the slopes are steep.

D.3.3 Assumptions

- Changes to this revegetation plan may be made depending on the continuing success of the revegetation demonstration project at 116-C-1 (planted in the fall of 1998) (see Weiss and Kemp 1998, Rev. 1, *Revegetation Plan for the 116-C-1 Site*).

- Contracts with seed and sagebrush tubeling suppliers have been established that will continue to provide the needed materials.

D.4 DISCUSSION

D.4.1 Mitigation Action Plan

A mitigation action plan has been prepared (DOE-RL 1996b) for liquid waste sites in the 100-BC, 100-DR, and 100-HR Areas. The majority of the sites identified in the mitigation action plan and this revegetation plan are within the reactor boundary fences and are currently nonvegetated or sparsely vegetated with nonnative annual species. Therefore, the guidance provided in the mitigation action plan is applicable to these 100-N Area sites as well. Ecological surveys will be completed before ground-disturbing activities begin, per standard operating procedures, to further ensure that all ecological resources are protected.

D.4.2 Site Descriptions

The current vegetation status for most of the waste sites to be remediated, and the nearby areas for support facilities during remediation, can be estimated from Stegen (1994), who developed vegetation community maps for all the 100 Areas. Most of the area within the 100-N Area fence line and waste sites outside of the fence are currently nonvegetated; the soils at most of these sites consist of backfill from site stabilization. The nonvegetated sites have been kept free of plants through the use of herbicides and/or soil sterilants. The areas with vegetation are mostly cheatgrass/bluegrass (*Bromus tectorum/Poa sandbergii*), cheatgrass/knapweed (*Bromus tectorum/Centaurea diffusa*), and rabbitbrush/cheatgrass (*Chrysothamnus nauseosus*) communities. These communities are all of low habitat quality. Some of the conspicuous wildlife that use the 100 Areas are mule deer, coyote, geese, and rodents such as Great Basin Pocket mice and deer mice. Bald eagle use of the 100-N Area is minimal (Fitzner and Weiss 1994). No salmon redds are known to be adjacent to the 100-N Area, but they are a short distance downstream, and migrating salmon pass the 100-N Area (Dauble and Watson 1990).

D.4.3 Purpose of Revegetation

The eventual goal is to revegetate the waste sites and support facility areas to communities dominated by native plant species. Because of the large amount of land that will be revegetated, the methods used will reflect what is feasible on a large-scale basis. Ecological effects from remediation and revegetation activities at surrounding areas and borrow sites will be minimized.

D.4.4 Topsoil

Fine-grained topsoil, such as sandy loam, is not currently availability at active Hanford Site borrow pits. In locations where it is found, such as at McGee Ranch (west of the Yakima barricade), removal may cause unacceptable ecological effects. Therefore, backfill from borrow pits near the remediation sites will be used. The backfill is usually from the Hanford formation, which is composed of gravels, sands, and silts with many intermixed cobbles.

The material in the 100 Area borrow pits was originally deposited by the river. A slow, natural revegetation of this material can be seen at borrow sites that have been abandoned. Native species, including sagebrush and Sandberg’s bluegrass, have become established and appear to out compete nonnative species. The density of the vegetative cover at these abandoned borrow pits, however, is less than at other sites such as the old fields in the 100 Areas, which are usually dominated by cheatgrass and tumblemustard (*Sisymbrium altissimum*). The soils at the abandoned old fields consist of much finer grained materials that have different moisture-holding and nutrient properties than the borrow sites.

Other backfill that may be considered for use in the future includes ash piles and uncontaminated concrete rubble from nearby demolished buildings. If any of this secondary material is used, it will be placed at least 2 to 3 m (6 to 10 ft) below final grade to allow sufficient material for plant rooting.

D.4.5 Site Preparation

For those sites currently not vegetated, any excavated material that will remain at the site at the completion of the remedial action (i.e., that does not require disposal at the Environmental Restoration Disposal Facility) will be replaced in the bottom of the excavation and new material from the borrow pits placed on top. This will keep any residual herbicides or sterilants from affecting plant survivability. For those sites that are currently vegetated, approximately the top 15 cm (6 in.) of clean overburden will be scraped into a pile and used as the topsoil for the excavation. If needed, this material may be spread into a thinner layer (about 10 cm [4 in.]) and used as topsoil for several adjacent sites.

The final surface of the terrain will be graded to match the surrounding terrain, such as leaving slopes instead of a flat surface. Any large boulders remaining should be either buried deep in the excavation or randomly grouped on the surface to create additional wildlife habitat. For those sites not requiring a cover of clean material to surrounding grade, depressions may remain. These depressions should have sides sloped at a more gentle incline (no more than about 3:1 or 4:1) and irregular grade.

D.4.6 Species to be Planted

Native species of a Hanford Site genotype will be used for all reseeding. Sandberg's bluegrass (*Poa sandbergii*), needle-and-thread grass (*Stipa comata*), and Indian ricegrass (*Oryzhopsis hymenoides*) have been collected on the Hanford Site and grown under controlled agricultural production methods to provide a large source of seeds for revegetation. Seeds of other native plants, such as sagebrush (*Artemesia tridentata*), yarrow (*Achillea millefolium*), Carey's balsamroot (*Balsamorhiza careyana*), pine bluegrass (*Poa scabrella*), and snow buckwheat (*Eriogonum niveum*), have also been collected on the Hanford Site and will be added to the planting mixture as available and as appropriate to each site. Additional seeds of other species may be provided by the Natural Resource Trustees and combined with the species described above.

Guidance for the number of pounds of seeds per acre planted is provided in the *Revegetation Manual for the Environmental Restoration Contractor* (BHI 1997). The sites will typically be planted using a range drill. Seeds that are uncleaned or of an unsuitable shape or size may be broadcast over the site before the other seeds are drilled in. The action of the seed drill will then help to plant these broadcast seeds below the surface. Areas that have been used for support facilities may have ground that is more hard-packed than recent backfill, and not suitable for a seed drill. If necessary, the soils in these areas will be loosened by plowing or ripping the soil with heavy equipment. If a seed drill will not work in an area, broadcast seeding (with subsequent harrowing or disking) or land imprinting may be used to plant seed. Seeding each year will occur between approximately September and November.

Tubeling sagebrush will be planted in approximately September to November in the backfilled areas to the density specified in BHI (1997), at approximately 2.3-m centers and 1,900 plants per hectare (775 plants per acre). Each tubeling will be provided with approximately 20 L (5 gal) of water immediately after planting.

D.4.7 Fertilizer and Straw Mulch

Fertilizers are not specified at this time. Ongoing revegetation work at other 100 Area sites will evaluate the use of fertilizer for similar backfill material. If deemed advisable in the future, a fertilizer (e.g., 16-16-16 formulation) will be applied in the drill seeder at the same time as the seeds, at a rate of 134 kg/ha (120 lb/acre) for 100-N Area sites.

Straw will be spread on the surface at a rate of 4.5 Mg/ha (2 tons/acre) and crimped into the backfill.

D.4.8 Irrigation

No additional irrigation is planned at this time. The lack of irrigation may delay the return of a site to a functioning community by causing a slower rate of growth, but it is expected that the plant survivability will not be appreciably less, as the species planted are adapted to growth in this climate. The presence of cobble and larger gravels on the sites will act as a mulch, helping to conserve the precipitation. In addition, the quantity of water that would be applied is beyond the capability and reach of the water system in place, and truck application of water is not practical for the size of the areas to be reseeded.

D.4.9 Monitoring and Success Criteria

The revegetated areas will be monitored for 5 years after planting. Because monitoring each site and support area is not practical, monitoring will be done on representative sites only, and not each area revegetated. The number of representative sites will vary, depending on the number and distribution of the sites revegetated each year.

Monitoring will be done using methods from Daubenmire (1970) to estimate percent canopy cover and frequency of occurrence for each species. A list of all species on the site, including those not captured by the plots, will be recorded. A measure of the immediate ability of the planted seeds to survive after the first spring will also be made. If the cover of seeded plants is below 1% in the spring of the second year, the initial planting should be considered a failure and a reseeding should take place the next fall, if the cause of the failure can be identified and rectified. After 5 years, the criteria for success will be a total canopy cover of $\geq$20% for native plants. If this is not achieved, the cause for failure should be identified and rectified with additional plantings, fertilization, irrigation, or soil amendments, as applicable.

The final vegetative cover at each site from following this revegetation plan will not be as lush as sites with deep, fine topsoils for many years, but it will slowly become denser as the native species continue to grow, spread, and trap blowing soil and falling organic matter.

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