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Record of Decision for Interim Actions in Bethel Valley, Oak Ridge, Tennessee

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Record of Decision for Interim Actions in Bethel Valley, Oak Ridge, Tennessee

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Prepared for the
U.S. Department of Energy
Office of Environmental Management

BECHTEL JACOBS COMPANY LLC
managing the
Environmental Management Activities at the
East Tennessee Technology Park
Y-12 National Security Complex Oak Ridge National Laboratory
Paducah Gaseous Diffusion Plant Portsmouth Gaseous Diffusion Plant
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for the
U.S. DEPARTMENT OF ENERGY

PREFACE

This *Record of Decision for Interim Actions in Bethel Valley, Oak Ridge, Tennessee* (DOE/OR/01-1862&D4) was prepared in accordance with requirements of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 to present the public with the selected remedy for environmental remediation of contaminated areas within the Bethel Valley area. This record of decision (ROD) documents the selected remedy agreed on by the U.S. Department of Energy, the Tennessee Department of Environment and Conservation, and the U.S. Environmental Protection Agency. The remedy addresses the inactive units, accessible sources of contamination, and contaminated media to the extent practicable while minimizing disruption of the continuing mission of Oak Ridge National Laboratory. This decision is based on the Administrative Record file for this project. Following are the principal documents supporting this ROD:

- *Remedial Investigation/Feasibility Study for Bethel Valley Watershed at Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE 1999a);
- *Proposed Plan for Interim Actions in Bethel Valley, Oak Ridge, Tennessee* (DOE 2000a); and
- *Memorandum of Understanding for Implementation of a Land Use Control Assurance Plan (LUCAP) for the United States Department of Energy Oak Ridge Reservation* (DOE, EPA, and TDEC 1999).

These documents and other information supporting the selected remedial action can be found at the Information Resource Center, 105 Broadway Avenue, Oak Ridge, TN, 37830, (865) 241-4582.

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ACRONYMS

ARAR	applicable or relevant and appropriate requirement
AWQC	ambient water quality criteria
CDI	chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	*Code of Federal Regulations*
COC	contaminant of concern
D&D	decontamination and decommissioning
DCE	dichloroethene
DNAPL	dense nonaqueous-phase liquid
DOE	U.S. Department of Energy
EDE	effective dose equivalent
ELCR	excess lifetime cancer risk
EMWMF	Environmental Management Waste Management Facility
EPA	U.S. Environmental Protection Agency
ETTP	East Tennessee Technology Park
EUWG	End Use Working Group
FFA	Federal Facility Agreement
FR	*Federal Register*
FS	feasibility study
FWPA	Former Waste Pile Area
FY	fiscal year
GAAT	Gunite and Associated Tanks
GRA	general response action
HFIR	high flux isotope reactor
HI	hazard index
HQ	hazard quotient
HSWA	Hazardous and Solid Waste Amendments of 1984
LCL	lower confidence limit
LLLW	liquid low-level (radioactive) waste
LUC	land use control
LUCAP	Land Use Control Assurance Plan
LUCIP	Land Use Control Implementation Plan
MCL	maximum contaminant level
MOU	Memorandum of Understanding
NAWQC	National Ambient Water Quality Criteria
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act of 1969
NHPA	National Historic Preservation Act
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRWTP	Nonradiological Wastewater Treatment Plant
NWT	Northwest Tributary
O&M	operation and maintenance
ORNL	Oak Ridge National Laboratory
ORO	Oak Ridge Operations
ORR	Oak Ridge Reservation

ORSSAB	Oak Ridge Site Specific Advisory Board
OU	operable unit
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PWTC	Process Waste Treatment Complex
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act of 1976
RDR	Remedial Design Report
RDWP	Remedial Design Work Plan
RER	Remediation Effectiveness Report
RfD	reference dose
RI	remedial investigation
RME	reasonable maximum exposure
ROD	record of decision
S&M	surveillance and maintenance
SARA	Superfund Amendments and Reauthorization Act of 1986
SHPO	State Historic Preservation Officer
SIOU	Surface Impoundments Operable Unit
SWMU	Solid Waste Management Unit
SWSA	solid waste storage area
TCE	trichloroethene
TDEC	Tennessee Department of Environment and Conservation
UCL_{95}	95% upper confidence limit
VOC	volatile organic compound
WAG	waste area grouping

PART 1. DECLARATION

1.1 SITE NAME AND LOCATION

Oak Ridge Reservation (DOE)
Bethel Valley area at Oak Ridge National Laboratory
Oak Ridge, Tennessee
CERCLIS ID TN1890090003

1.2 STATEMENT OF BASIS AND PURPOSE

This record of decision (ROD) for interim actions presents the selected remedy for environmental remediation of various contaminated areas within the Bethel Valley area on the U.S. Department of Energy (DOE) Oak Ridge Reservation (ORR) in Oak Ridge, Tennessee. The remedy addresses inactive units, accessible sources of contamination, and contaminated media to the extent practicable. The scope includes buildings and other facilities designated for decontamination and decommissioning (D&D), buried waste, underground liquid low-level waste (LLLW) tanks, accessible underground process and LLLW transfer pipelines, accessible contaminated surface and subsurface soil, contaminated sediment and surface water, contaminated groundwater, and groundwater monitoring wells, and piezometers no longer needed for monitoring. The scope does not include active facilities and infrastructure (e.g., Bldg. 4500 N) at the Oak Ridge National Laboratory (ORNL) that have vested, ongoing missions, nor does it include contaminated media or sources that are considered inaccessible due to the presence of the active facilities and infrastructure.

Environmental remediation is accomplished through a combination of responses that includes containment, stabilization, removal, treatment, monitoring, and land use controls (LUCs). Because this is an interim remedy, interim LUCs and monitoring are specified as appropriate; however, final LUCs are not within the scope of this decision. Additionally, a final groundwater decision is not part of this remedy; however, interim actions are included to treat contaminated groundwater that is impacting surface water in Bethel Valley. A final groundwater decision is not being made at this time for several reasons. The participating federal and state agencies' desire to complete source control actions, monitor their effectiveness, and collect limited additional characterization data. These activities will allow the agencies to make a more informed decision for the final groundwater remediation.

This set of remedial actions for Bethel Valley was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) (42 *United States Code* Sect. 9601 et seq.), and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) [40 *Code of Federal Regulations* (*CFR*) 300]. The Federal Facility Agreement (FFA) for the ORR (DOE 1992a) was developed to coordinate CERCLA and the Resource Conservation and Recovery Act of 1976 (RCRA) and to provide a legal framework for remediation activities at the ORR. The FFA's integrated approach extends to preparation of decision documents under CERCLA and RCRA. In addition, National Environmental Policy Act of 1969 (NEPA) values are incorporated in the documents prepared for this project in accordance with the *Secretarial Policy Statement on the National Environmental Policy Act of 1969* (DOE 1994a). This policy states that DOE will rely on the CERCLA process for review of actions taken under CERCLA and will address and incorporate NEPA values to the extent practicable in CERCLA evaluations.

The Bethel Valley area was divided into four areas in the remedial investigation (RI) for purposes of reporting the investigation results (DOE 1999a). These areas are East Bethel Valley, Central Bethel Valley, West Bethel Valley, and Raccoon Creek. East Bethel Valley includes the plant maintenance area of ORNL. Central Bethel Valley includes the ORNL main plant area, which consists of active and

inactive buildings, former burial grounds, underground liquid low-level (radioactive) waste (LLLW) tanks, underground process and LLLW pipelines, and associated underground and aboveground facilities. West Bethel Valley contains a burial ground area and a small portion of the plant area. Raccoon Creek is an undeveloped area that primarily contains slightly contaminated media resulting from contaminant migration from West Bethel Valley. For reasons detailed later in this document, DOE developed and evaluated separate sets of remediation alternatives for Central/East Bethel Valley and West Bethel Valley/Raccoon Creek in the feasibility study (FS) and proposed plan (DOE 2000a). This ROD combines the preferred alternatives from the proposed plan for Central/East Bethel Valley and West Bethel Valley/Raccoon Creek into a single selected remedy for Bethel Valley.

The selected remedy is considered interim in nature for the following reasons:

(1) **The long-term land use may change from that currently anticipated.** At some time in the future, the current mission of ORNL may change significantly. When this occurs, the selected remedy and the anticipated future land use upon which the remedy is based will be re-evaluated.

(2) **Final groundwater remediation is deferred to a future remedial decision.** The source controls and interim groundwater actions in the selected remedy will minimize further impacts to groundwater and will prevent groundwater from causing surface water exceedances. However, a final decision for groundwater is being deferred until the effectiveness of source actions is evaluated.

(3) **Final LUCs are deferred to a future remedial decision.** The selected remedy leaves hazardous substances in place that pose a future potential risk and that would require land use restrictions for hundreds of years or longer. Interim LUCs and monitoring, as appropriate, are included as part of this selected remedy to ensure protectiveness until a final remedial decision is made for Bethel Valley. The long-term risk and final LUCs will be addressed in a future decision.

Future decisions regarding long-term land use, final groundwater cleanup, and final LUCs may result in the need to augment or replace certain components of this remedy. Actions in this ROD do not preclude final remediation in a future decision. While additional measures (beyond those presented in this ROD) may be necessary to complete remediation activities in Bethel Valley, implementation of the remedial measures in this ROD will considerably improve environmental conditions. The selected remedial activities are expected to reduce significantly the release of contaminants from Bethel Valley source areas into White Oak Creek, Raccoon Creek, Bearden Creek, and the Clinch River. These activities will mitigate ecological and human health hazards from contaminated media within Bethel Valley.

Remediation measures presented in this ROD are intended to protect human receptors from exposure to hazardous substances in the Bethel Valley area. The primary receptor is the industrial worker both inside and outside of the main plant area of ORNL. Actions are also taken to protect future recreational users in selected waste management areas, future recreational users of the surface water bodies, and future residential users of undeveloped areas.

The selected remedy ensures that ambient water quality criteria (AWQC) will be met to protect surface water resources. Aquatic populations and terrestrial species using surface water will be protected by removal of contaminated sediment and floodplain soil. The selected remedy will also reduce risk in surface water at the 7500 Bridge by at least 45% relative to 1994 levels. The 7500 Bridge is the point at which surface water exits Bethel Valley and enters Melton Valley. Based on the anticipated effectiveness of the Melton Valley remedy, the 45% risk reduction is necessary to meet the Melton Valley watershed ROD goal of protecting the off-site resident user of surface water at the confluence of White Oak Creek with the Clinch River.

The selected remedy leaves hazardous substances in place that pose a future potential risk and that would require land use restrictions for hundreds of years or longer. The interim LUCs selected in this ROD will continue in effect and remain enforceable as part of the selected CERCLA remedy until such time as they may be changed by a future CERCLA decision. DOE has developed a Land Use Control Assurance Plan (LUCAP) for the ORR to help ensure that land use restrictions are maintained and periodically verified. DOE will develop a specific Land Use Control Implementation Plan (LUCIP) that will further detail the specific measures required for land use restrictions as part of this action. DOE is committed to implementing and maintaining LUCs, including institutional controls, to ensure that the selected remedy remains protective of human health and the environment. The implementation and funding of these activities will take place in accordance with the ORR FFA. The public will be informed and involved in a timely manner in the CERCLA decision-making processes consistent with requirements of CERCLA, the NCP, the ORR FFA, and the DOE Oak Ridge Operations (ORO) CERCLA public involvement plan. Documents pertaining to the implementation and performance of the remedial actions, including five-year reviews, will be placed in a post-ROD file, which will be available to the public.

This decision is based on documents contained in the Administrative Record file for the Bethel Valley area, including the RI/FS (DOE 1999a) and the proposed plan (DOE 2000a). In addition, DOE has considered all comments received on the proposed plan in preparing this ROD. DOE, the U.S. Environmental Protection Agency (EPA), and the Tennessee Department of Environment and Conservation (TDEC) (parties to the FFA) concur with the selected remedy.

1.3 ASSESSMENT OF THE SITE

The response action selected in this ROD is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

1.4 DESCRIPTION OF THE SELECTED REMEDY

All inactive facilities in Bethel Valley, along with all areas of accessible contamination in the valley from the easternmost portion of the plant westward to the Clinch River, are part of this ROD. There are isolated areas of potential contamination to the east in Bethel Valley or on adjacent ridges, some distance from the laboratory, which will be part of another decision. This decision recognizes the numerous early actions conducted in Bethel Valley and the grouting of two FFA tanks under an early action in Melton Valley. The FFA parties agree in this document to defer a final decision on groundwater to allow an evaluation of the effectiveness of the actions presented in this decision. Once the actions in this ROD are implemented and an evaluation of the effectiveness of the actions has been completed, a final decision on groundwater and LUCs will be made. If the anticipated land use changes in the future, the decision in this ROD will be re-evaluated.

The major problems identified in Bethel Valley are consistent with the historical use of the land. Raccoon Creek and West Bethel Valley are generally undeveloped and uncontaminated, but West Bethel Valley contains discrete waste disposal areas [Solid Waste Storage Area (SWSA) 3 and the Contractor's Landfill]. Conversely, Central Bethel Valley contains widespread contamination in soil, groundwater, surface water, and sediment consistent with its use as a radiochemical development and processing laboratory. East Bethel Valley contains limited groundwater and soil contamination consistent with its use as an industrial maintenance facility. Table 1.1 shows the remedial action objective (RAO) of the selected remedy to address these environmental problems.

Bethel Valley is currently a restricted area under DOE control. Remediation levels have been established to support the reasonably anticipated future land use for each remediation area and are

consistent with recommendations from stakeholders [including the Oak Ridge Site Specific Advisory Board (ORSSAB)]. The following conditions will be met by the selected remedy:

(1) The ORNL main plant area in central Bethel Valley (i.e., 2000 area, 3000 area, and the western portion of the 4000 area) will be remediated to meet a controlled industrial land use. Industrial uses will be allowed of the upper 0.6 m (2 ft) of the area. Use of the subsurface below the depth of 0.6 m (2 ft) will be restricted.

(2) The remainder of the ORNL main plant area (i.e., 1000 area in West Bethel Valley, the 4000–6000 areas in Central Bethel Valley, and the 6000–7000 areas in East Bethel Valley) will be remediated to meet an unrestricted industrial land use. Industrial uses will be allowed of the upper 3 m (10 ft) of the area. Use of the area below the depth of 3 m (10 ft) will be restricted.

(3) SWSA 3 and the Contractor's Landfill will be remediated to meet a recreational land use. The three waste disposal areas in Central Bethel Valley [SWSA 1, the Nonradiological Wastewater Treatment Plant (NRWTP) Debris Pile, and the Former Waste Pile Area (FWPA)] will be included in the controlled industrial land use boundary of the main plant area.

Table 1.1. RAO for the selected remedy for Bethel Valley, ORNL, Oak Ridge, Tennessee

Issue	Protection goals
Future land use	Protect human health for (1) controlled industrial use in ORNL's main plant area, (2) unrestricted industrial use in the remainder of the ORNL developed areas, (3) recreational use of selected burial grounds, and (4) unrestricted use in the undeveloped areas, all to a risk level of 1×10^{-4}
Protection of surface water bodies	• Achieve AWQC for designated stream uses in all waters of the state • Achieve at least 45% risk reduction from 1994 levels at 7500 Bridge • Maintain surface water and achieve sediment recreational risk-based limits to a goal of 1×10^{-4}
Groundwater protection	• Minimize further impacts to groundwater • Prevent groundwater from causing surface water exceedances in all waters of the state
Protection of ecological receptors	Maintain protection for area populations of terrestrial organisms; protect reach-level populations of aquatic organisms

AWQC = ambient water quality criteria
ORNL = Oak Ridge National Laboratory
RAO = remedial action objective

(4) The undeveloped areas in Bethel Valley and the disturbed areas around SWSA 3 and the Contractor's Landfill will be remediated as needed to a condition consistent with an unrestricted land use. Contamination, if encountered above remediation levels, will be removed to the water table or bedrock, whichever comes first.

(5) Through selected source and groundwater actions, impacts to surface water designated as waters of the state will be controlled and minimized to allow streams to meet their stream use classification. Sediment will be remediated consistent with the stream's classification.

(6) Remediation efforts and other improvements will achieve a 45% risk reduction from 1994 levels at the 7500 Bridge, the surface water integration point for Bethel Valley. This risk reduction at the 7500 Bridge will reduce releases into the Clinch River and provide additional protection for an off-site user of surface water, which is one of the goals under the Melton Valley watershed ROD.

(7) The impacts from sources of groundwater contamination will be minimized.

(8) Ecological populations will be protected in Bethel Valley.

Interim LUCs are a necessary part of the selected remedy to ensure its protectiveness. Because the final groundwater decision is being deferred, groundwater use restrictions in contaminated areas will be required regardless of land use. Other objectives of the LUCs are as follows:

- **Controlled industrial area:** Control excavations or penetrations below 0.6 m (2 ft) and prevent uses of the land more intrusive than industrial use above 0.6 m (2 ft).

- **Unrestricted industrial area:** Control excavations or penetrations below 3 m (10 ft) and prevent uses of the land more intrusive than industrial use above 3 m (10 ft).

- **Recreational area (as applied to the SWSA 3 burial ground and the Contractor's Landfill):** Restrict recreational activity to passive surface use of disposal areas; prevent unauthorized contact, removal, or excavation of waste material; prevent unauthorized destruction or modification of engineered controls; and preclude use of the areas for additional future waste disposals or alternate uses inconsistent with the management of currently disposed waste.

- **Unrestricted areas:** None required.

The NCP established an expectation that treatment will be used to address the principal threats posed by a site wherever practicable [40 *CFR* 300.430(a)(1)(iii)(A)]. Principal threat wastes are those contaminated materials considered highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur. Most of the principal threat wastes in Bethel Valley have already been remediated through removal, treatment, and final disposal. Through early actions, sludges from the Gunite Tanks have been removed, and ongoing early actions are removing sludges from the FFA steel tanks, sediments from the surface impoundments, and a tank with associated highly contaminated subsurface soil in the North Tank Farm. These wastes were all considered to be both highly mobile and very toxic. The remainder of the principal threat waste in Bethel Valley consists of other subsurface soil sources of groundwater contamination (highly mobile) and the material disposed in SWSA 3 (highly toxic). The selected remedy removes the highly mobile soil contamination that is a primary contributor to groundwater contamination. Containment is selected for SWSA 3 for two reasons. First, the material in SWSA 3 is quite old and, based on available data, appears no longer to be a significant source of media contamination. The groundwater contamination beneath the burial ground is above maximum contaminant levels (MCLs). Containment is expected to provide some reduction in groundwater contamination, but any failure of the containment system is unlikely to result in significantly increased contaminant levels in groundwater. Second, the cost of excavating SWSA 3 is significant. Additionally, worker risk from excavating SWSA 3, although difficult to quantify because of the great uncertainty of what is buried there, would also be significant.

The selected remedy for Bethel Valley is the combination of FS Alternative C-3b (DOE 1999a) for the central/east portion of the valley and FS Alternative W-5 for the west portion of the valley, including the Raccoon Creek area. Some modifications were made to each alternative as presented in the FS to accommodate implementation issues considered during the proposed plan development and to respond to regulatory comments on the proposed plan (DOE 2000a). Additionally, some scope was removed from Alternative C-3b because it was performed pursuant to an early action decision that expedited one of the actions originally included in that alternative. These modifications did not alter the alternatives sufficiently to change the evaluation conducted during the FS. Costs were reduced slightly.

Following are the major components of the selected remedy:

- Removal of inactive buildings and other facilities to grade level. Remaining structures at or below grade will undergo decontamination and stabilization or removal depending on such factors as cost effectiveness and the extent of soil contamination in the area. The Graphite Reactor, which is a National Historic Landmark, will be stabilized in place. Demolition material will be disposed at the planned Environmental Management Waste Management Facility (EMWMF) or another suitable facility;

- Installation of caps on SWSAs 1 and 3;

- Maintenance or enhancements of soil covers on the NRWTP Debris Pile, the FWPA, and the Contractor's Landfill;

- Removal of contents from remaining FFA steel tanks [S-424, T-1, T-2, and high flux isotope reactor (HFIR)] and stabilization of the tanks with grout;

- Stabilization of inactive LLLW pipelines in the controlled industrial area, and removal of LLLW and process pipelines in the unrestricted industrial area. Pipeline bedding material demonstrated to be a contamination migration pathway will be contained through a combination of grouted barriers and enhanced shallow groundwater collection. Structures associated with inactive LLLW and contaminated process lines (e.g., pump pits) will be stabilized or removed;

- Removal of surface soil above remediation levels established for worker protection to a maximum depth of 0.6 m (2 ft) in the controlled industrial area, and removal of soil above remediation levels established for worker protection to a maximum depth of 3 m (10 ft) in the unrestricted industrial area. Soil remediation levels are discussed in Sect. 2.12.8.3. These soils will be disposed at the EMWMF or another suitable facility. Contaminated soil near SWSA 3 will also be removed to levels established for unrestricted use and may be used as fill material for the SWSA 3 cap;

- Removal above the water table of soils that exceed remediation levels established for minimizing impacts to groundwater (Sect. 2.12.8.3). These soils will also be disposed at the EMWMF or another suitable facility;

- Removal of local creek sediment above recreational remediation levels (Sect. 2.12.8.3) in the local creeks and disposal at the EMWMF or another suitable facility;

- Collection of contaminated shallow groundwater in sumps and junction boxes in Central Bethel Valley and extraction of contaminated groundwater from the Core Hole 8 Plume. Groundwater removed from Central Bethel Valley will be treated at existing treatment facilities. Pretreatment is anticipated to be needed for some waste streams. In situ biodegradation of a groundwater volatile organic compound (VOC) plume in East Bethel Valley will be performed;

- Monitoring to verify the effectiveness of remedial actions and to support a future decision on groundwater; and

- Implementation of LUCs to protect against unacceptable exposures to contamination during the remedial actions as well as after completion of all remedial actions in Bethel Valley.

While numerous community comments have been made on previous ORNL decisions [e.g., Melton Valley ROD (DOE 2000c)] expressing an interest in a final decision being made regarding permanent LUCs, information is currently insufficient to make such a final decision. However, interim LUCs are being imposed and will remain until permanent LUCs are established in future remedial decisions for this area. DOE and the other FFA parties are committed to ensuring that LUCs included in a remedial action decision made under the FFA will be implemented and maintained for as long as they remain necessary to protect public health and the environment.

1.5 STATUTORY DETERMINATIONS

The selected remedy is protective of human health and the environment, complies with federal and State requirements that are applicable or relevant and appropriate (ARAR) to the remedial action, is cost effective, and uses permanent solutions and alternative treatment technologies to the maximum extent practicable. No ARAR waivers are required for this remedy. This remedy also satisfies the statutory preference for treatment as a principal element of the remedy (i.e., it reduces the toxicity, mobility, or volume of hazardous substances, pollutants, or contaminants as a principal element through treatment).

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure, the statutory CERCLA reviews will be scheduled, conducted, and reported in the ORR-wide Remediation Effectiveness Reports following the initiation of remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

Hazardous substances above health-based levels will remain in Bethel Valley after implementation of this remedy. Because hazardous substances are to remain, DOE, TDEC, and EPA recognize that Natural Resource Damage claims, in accordance with CERCLA, may be applicable. This document does not address restoration or rehabilitation of all natural resource injuries that may have occurred or the question of whether such injuries have occurred. DOE has agreed to fund a pilot study of the Watts Bar Operable Unit (OU) that will examine natural resource issues and may provide a model for addressing such issues for Bethel Valley; however, this study is not completed. In the interim, neither DOE nor TDEC waives any rights or defenses it may have under CERCLA, Sect. 107(a)4(c).

1.6 ROD CERTIFICATION CHECKLIST

The following information is included in Part 2, "Decision Summary," of this ROD:

- contaminants of concern (COCs) and their respective concentrations;
- baseline risk represented by the COCs;
- remediation levels established for COCs and the basis for the levels;
- current and future land and groundwater use assumptions used in the baseline risk assessment and ROD;
- decisive factor(s) that led to selection of the remedy;
- land and groundwater use that will be available at the site as a result of the selected remedy;

- estimated capital, operation and maintenance, and total present worth costs; discount rate; and the number of years over which the remedy cost estimates are projected; and

- ways in which source materials constituting principal threats are addressed.

Additional information regarding Bethel Valley can be found in the Administrative Record for this site.

APPROVALS

Record of Decision for Interim Actions in Bethel Valley, Oak Ridge, Tennessee

DOE/OR/01-1862&D4

M. Holland 5/2/02

Michael D. Holland, Acting Manager — Date
Oak Ridge Operations
U.S. Department of Energy

John A. Owsley 5/2/02

John A. Owsley, Director — Date
U.S. Department of Energy Oversight Division
Tennessee Department of Environment and Conservation

2 MAY 02

Richard D. Green, Director — Date
Waste Management Division
U.S. Environmental Protection Agency – Region 4

PART 2. DECISION SUMMARY

2.1 SITE NAME, LOCATION, AND DESCRIPTION

Oak Ridge Reservation (DOE)
Bethel Valley area at Oak Ridge National Laboratory
Oak Ridge, Tennessee
CERCLIS ID TN1890090003

The 34,516-acre DOE ORR is located within and adjacent to the corporate limits of the city of Oak Ridge, Tennessee, in Roane and Anderson counties. The ORR is bounded to the east, south, and west by the Clinch River and on the north by the developed portion of the city of Oak Ridge. The ORR hosts three major industrial research and production facilities originally constructed as part of the World War II-era Manhattan Project: East Tennessee Technology Park (ETTP, formerly the K-25 Site), ORNL (formerly X-10), and the Y-12 National Security Complex (Fig. 2.1).

ORNL is an active laboratory that occupies approximately 3560 acres in Melton Valley and Bethel Valley and is located approximately 16 km (10 miles) southwest of downtown Oak Ridge, Tennessee. Although ORNL was originally constructed in 1943 to support the Manhattan Project, ORNL's current missions are to conduct applied research and engineering development in support of DOE programs in nuclear fusion and fission, energy conservation, fossil fuels, and other energy technologies, and to perform basic scientific research in selected areas of the physical, life, and environmental sciences.

Bethel Valley is a 1734-acre area defined by the upper drainage area of White Oak Creek and its tributaries in Bethel Valley. Bethel Valley includes the neighboring Raccoon Creek watershed and a small portion of Bearden Creek (Fig. 2.2). Raccoon Creek is included because contaminants detected in the surface waters are attributed to contaminant migration from releases in West Bethel Valley. Bethel Valley includes headwaters for White Oak Creek, which exits the valley through a water gap into Melton Valley. A tributary of Bearden Creek begins in East Bethel Valley and flows through Haw Ridge and into Clinch River (Melton Hill Lake). Adjacent Melton Valley includes former waste areas derived from operations at ORNL and comprises the Melton Valley watershed administrative area.

The Bethel Valley area was divided into the following four areas for the RI (Fig. 2.2) to simplify discussion of RI findings (DOE 1999a):

- East Bethel Valley,
- Central Bethel Valley,
- West Bethel Valley, and
- Raccoon Creek.

East Bethel Valley includes the ORNL plant maintenance area. Central Bethel Valley includes the main ORNL plant area, which consists of active and inactive buildings, former burial grounds, underground LLLW tanks, underground process and LLLW pipelines, and associated underground and aboveground utilities. West Bethel Valley contains a burial ground area and a small portion of the plant area. Raccoon Creek contains primarily slightly contaminated media that have migrated from West Bethel Valley. The RI further divided the heavily industrialized Central Bethel Valley area into four subareas (based on building numbers): Central Bethel Valley 2000 Area, Central Bethel Valley 3000 North Area, Central Bethel Valley 3000 South Area, and Central Bethel Valley 4000–6000 Area (Fig. 2.2) (DOE 1999a).

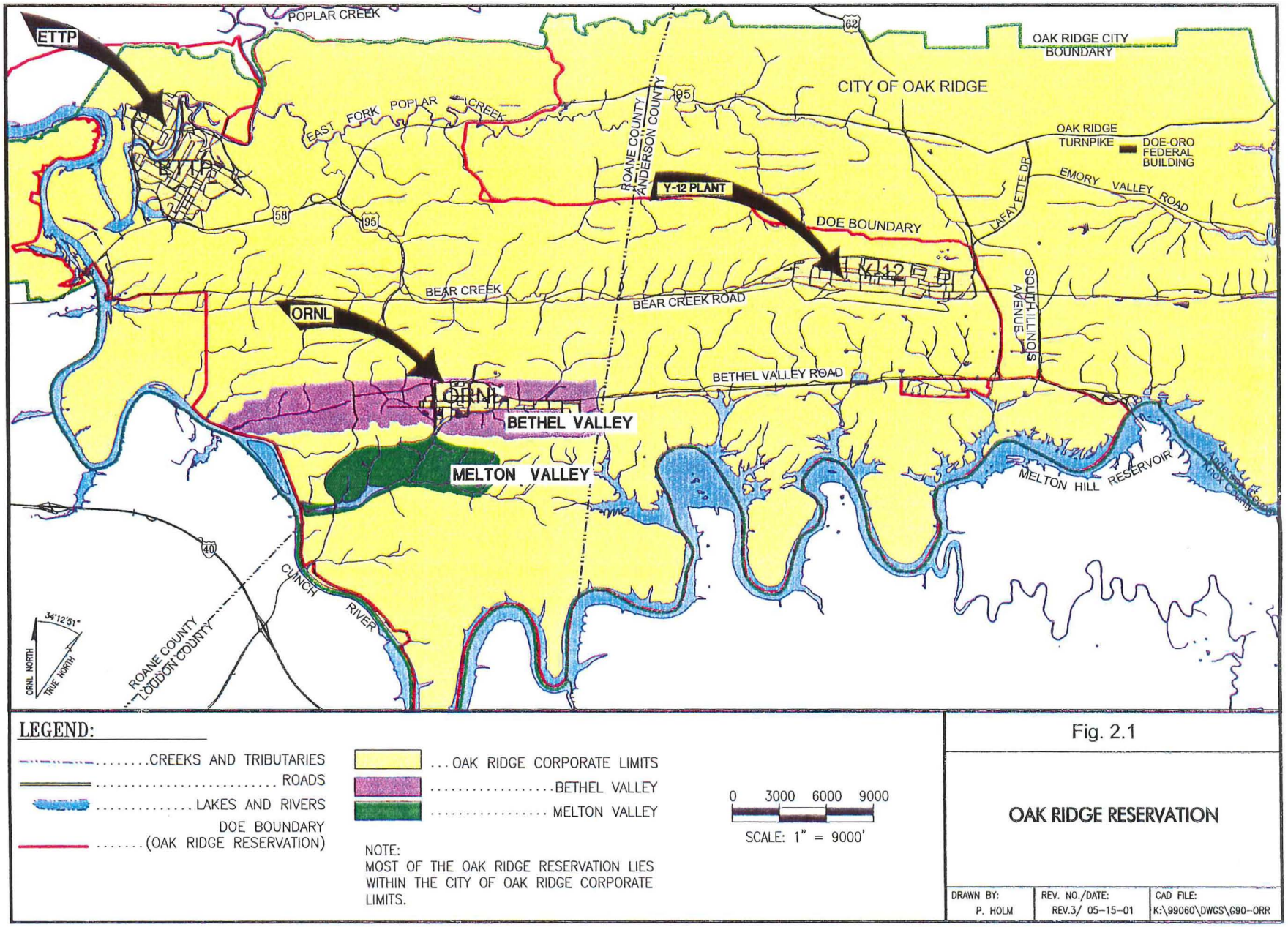

Fig. 2.1. Bethel Valley area, Oak Ridge Reservation.

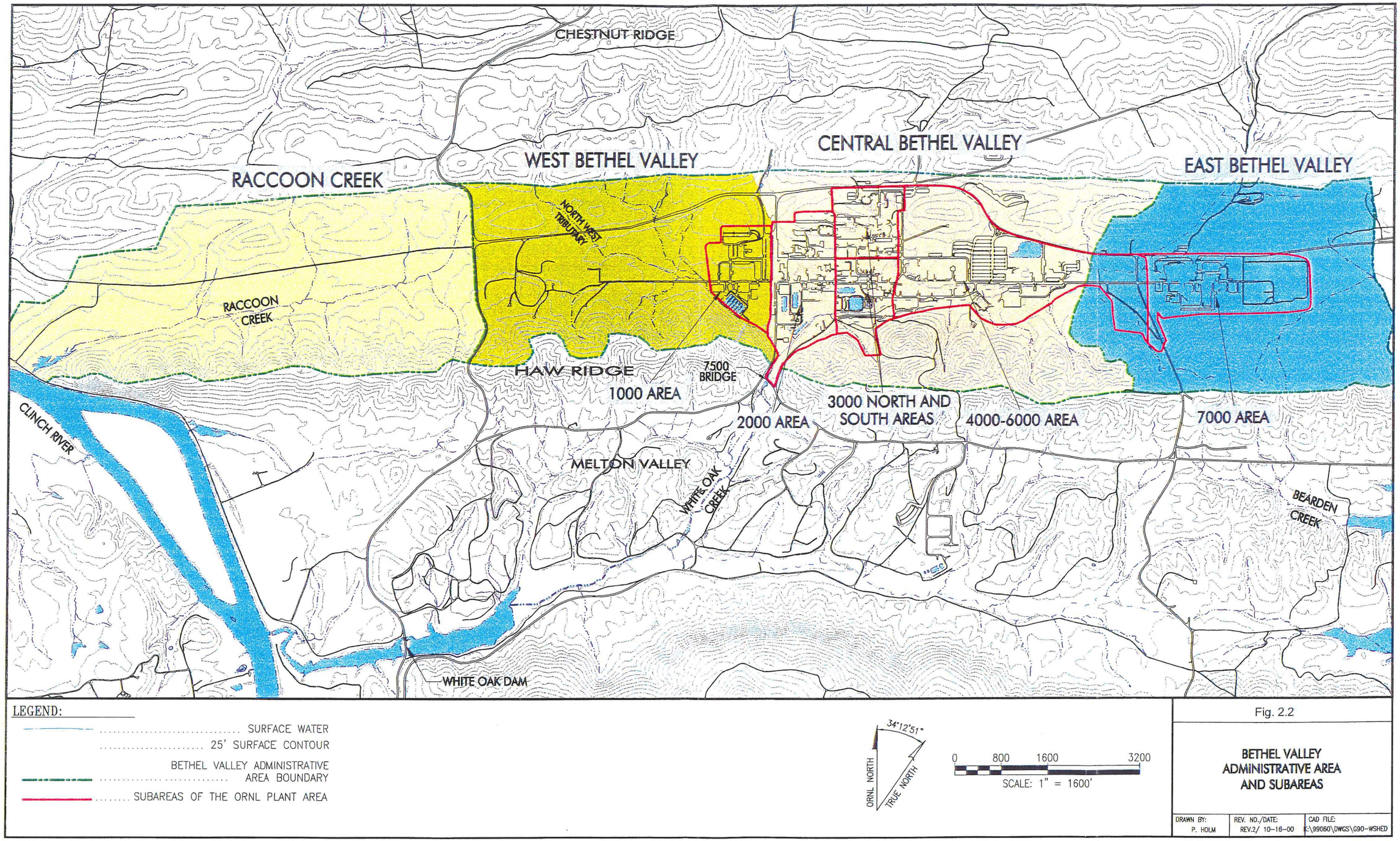

Fig. 2.2. Bethel Valley administrative area and subareas.

Historical processes, programs, and waste management practices associated with the mission of the laboratory have led to environmental contamination in Bethel Valley. The estimated geographical extent of contamination is approximately 100 acres. These processes included chemical separation techniques, reactor research and development, radioactive waste storage, and waste burial. Table A.1 in Appendix A of this document lists each contaminated area from the FFA included in the scope of this decision and the corresponding selected remedial action. A large inventory of radioactive waste combined with other hazardous waste constituents in numerous locations, which together release contaminants into the environment at concentrations exceeding legal or risk-based criteria, are present in the Bethel Valley area. The pervasiveness of contamination in the ORNL complex and the similarity of contaminants found from different source units complicate determination of well-defined contaminant plumes and distinct areas of contamination. Current releases from Bethel Valley exit the ORR via White Oak Creek at the confluence of White Oak Creek and the Clinch River.

In accordance with CERCLA Sect. 120 and 40 *CFR* 300.430(f)(4) and the FFA, DOE is acting as the lead agency for this action. TDEC and EPA, as parties to the FFA, provide oversight and approval of the remedy selection and related cleanup decisions.

2.2 SITE HISTORY AND ENFORCEMENT ACTIVITIES

Weapons research facilities were established in 1943 on the ORNL site as part of the World War II Manhattan Project. ORNL's original mission was to produce and chemically separate the first gram quantities of plutonium as part of the national effort to produce the atomic bomb. As its role in the development of nuclear weapons decreased over time, the scope of work at ORNL expanded to include production of radioactive isotopes, fundamental research in a variety of sciences, research involving hazardous and radioactive materials, environmental research, and radioactive waste disposal. These activities, as well as activities at the Y-12 and ETTP, have resulted in the release of contaminants to the environment. Because of these contaminant releases, the ORR was placed on the EPA National Priorities List (NPL) established under CERCLA [54 Federal Register (*FR*) 48184, November 21, 1989].

As a result of the NPL listing, the EPA, TDEC, and DOE signed an FFA for the ORR (DOE 1992a), effective January 1, 1992. The general purposes of the FFA include ensuring that the environmental impacts associated with past and present activities on the ORR are thoroughly investigated; ensuring that appropriate remedial action is taken as necessary to protect the public health and welfare and the environment; and establishing a procedural framework and schedule for developing, implementing, and monitoring appropriate response actions on the ORR in accordance with CERCLA, the NCP, RCRA, NEPA, appropriate guidance and policy, and in accordance with Tennessee State law.

ORNL historical missions have produced a diverse legacy of the following contaminated inactive facilities, waste disposal areas, and secondarily contaminated media that are potential candidates for remediation:

- buildings and other facilities;
- buried waste (burial grounds and landfills);
- buried tanks (gunite, other concrete, and steel);
- underground process and LLLW pipelines;
- contaminated surface and subsurface soil;
- contaminated surface water/sediment; and
- contaminated groundwater.

Historical information identified 173 potential source units (i.e., potential sources of contamination) in Bethel Valley. Appendix A of the RI/FS lists and briefly describes each unit (DOE 1999a). Specific areas that are identified in the RI/FS and the proposed plan (DOE 2000a) as contributors to unacceptable risk are the focus of proposed cleanup actions.

2.2.1 Previous Investigations and Data Sources

A comprehensive field investigation for the main ORNL plant area [previously referred to as Waste Area Grouping (WAG) 1 and now roughly equivalent to Central Bethel Valley] followed the placement of the ORR on the NPL. This activity is documented in the Site Characterization Summary Report for Waste Area Grouping 1 (DOE 1992b). DOE and its contractors have performed numerous smaller investigations to comply with RCRA, the National Pollutant Discharge Elimination System (NPDES), and other environmental statutes, regulations, and permits. Data used for the RI/FS include environmental sampling data extending from 1979 to 1997. These data are available in the Oak Ridge Environmental Information System, a database that houses environmental data, and can be accessed at the ORR web site (http://eimdb-web.bechteljacobs.org: 8080).

2.2.2 Previous Cleanup Decisions

Previous cleanup decisions under CERCLA and other authorities have addressed, or are now addressing, some of the contaminant sources and contaminated media in Bethel Valley, as follows:

- catch basin improvements at the Core Hole 8 Plume under an action memorandum (DOE 1994b) (completed);
- partial removal of the Waste Evaporator Facility (Bldg. 3506) under an action memorandum (DOE 1995) (completed);
- grouting of the 3001 Storage Canal under an action memorandum (DOE 1996) (completed);
- removal of the thorium storage wells after NEPA assessment (Herron 1997) (completed);
- groundwater extraction from existing building and tank sumps (ongoing as part of ORNL operations);
- removal of contaminated liquids and sludges at the North and South Tank Farms under an interim ROD for the Gunite and Associated Tanks (GAAT) OU (DOE 1997a) (ongoing);
- removal, treatment, and disposal of sludges and liquids from the surface impoundments under a ROD (DOE 1997b) (ongoing);
- excavation of Tank W-1A and associated contaminated soil from a line-leak site thought to be the source of the Core Hole 8 Plume, now being conducted under an action memorandum (DOE 1998a) (ongoing);
- sludge removal and grouting of 24 steel inactive tanks under an action memorandum (DOE 1999b and addended in 1999c) (ongoing);
- groundwater extraction from Well 4411 to enhance containment of the Core Hole 8 Plume now being conducted under an addendum to a Core Hole 8 Plume action memorandum (DOE 1999d) (ongoing); and
- partial removal of the Metal Recovery Facility (Bldg. 3505) under an action memorandum (DOE 2000b) (ongoing).

Stabilization of eight GAAT shells and risers (Tanks W-3 through W-10) is expected to occur in the near future under an action memorandum.

2.2.3 Land Use Controls

By separate Memorandum of Understanding (MOU), EPA, TDEC, and DOE have agreed to implement facilitywide certain periodic site inspections, certification, and notification procedures set forth in a LUCAP (DOE, EPA, and TDEC 1999). These procedures are designed to ensure DOE maintenance of any waste-unit-specific LUCs set forth in this ROD and deemed necessary for future protection of human health and the environment. A fundamental premise underlying execution of the MOU is that, through DOE's substantial good-faith compliance with the procedures called for in the LUCAP, reasonable assurances would be provided to EPA and TDEC as to the permanency of those remedies which include the use of waste-unit-specific LUCs at the ORR.

The terms and conditions of the LUCAP or MOU are not specifically incorporated or made enforceable herein by reference. However, DOE, EPA, and TDEC understand and agree that the contemplated permanence of the remedy reflected herein is dependent in part on DOE's substantial good-faith compliance with the specific LUC maintenance commitments reflected herein. Should such compliance not occur or should the MOU be terminated, it is understood that the protectiveness of the remedy may be reconsidered; consequently, additional measures may be needed to ensure adequate and necessary future protection of human health and the environment.

Pursuant to the ORR LUCAP (DOE, EPA, and TDEC 1999), when a remedial action that includes LUCs has been selected, a LUCIP will be developed as a component of the post-ROD documentation. DOE will develop a LUCIP for Bethel Valley that addresses the same units covered under the ROD and submit it to EPA and TDEC for approval. The LUCIP will specify LUC objectives for Bethel Valley, identify the controls and mechanisms required to achieve each objective, and describe the actions necessary to implement and maintain the LUCs. The LUCIP for the LUC(s) selected as part of this action will be submitted concurrently with (and have the same review periods and procedures as) the remedial design work plan (RDWP) for review and approval by EPA and TDEC. Upon final approval, the LUCIP (and any approved modifications thereto) will be appended to and become a part of the RDWP and will establish LUC implementation and maintenance requirements enforceable under CERCLA and the FFA.

2.3 HIGHLIGHTS OF COMMUNITY PARTICIPATION

DOE published a public notice of availability for the *Proposed Plan for Interim Actions in Bethel Valley, Oak Ridge, Tennessee* in *The Oak Ridger*, *The Knoxville News-Sentinel*, *The Roane County News*, the *Clinton Courier News*, and other local newspapers within the region. The public notice established a public comment period from June 26, 2000, to August 24, 2000. This public comment period was subsequently extended by an additional 30 days to September 25, 2000. A public meeting was held July 27, 2000, to present the preferred alternative described in the proposed plan (DOE 2000a) and solicit public input. All comments on the proposed plan are identified and responses are included in Part 3, "Responsiveness Summary," of this ROD.

DOE has invited public participation on the Bethel Valley project through publication of fact sheets (Fall 1998, Winter 1998, and July 2000) and at multiple public meetings. Additionally, DOE has held regular public briefings with the ORSSAB, a citizen's panel that provides advice and recommendations to the DOE Environmental Management Program. The ORR End Use Working Group (EUWG), a subcommittee of ORSSAB, is a community-based advisory organization established in 1996 to provide recommendations to DOE on postremediation ORR land use, cleanup assumptions and goals, and beneficial reuse of portions of the ORR. DOE, TDEC, and EPA consider EUWG input for revising FFA schedules, planning and scheduling future CERCLA evaluations, and implementing remedial actions. Further, DOE, EPA, and TDEC use input from organizations such as the ORSSAB, the Oak Ridge Reservation Local Oversight Committee Inc., the Oak Ridge Environmental Peace Alliance, the U.S. Fish and Wildlife Service, and the City of Oak Ridge, as well as members of the general public, to assist in selecting and implementing remediation programs that reflect local community values. Comments received throughout the evaluation process have influenced, to the extent practicable, the approach, content, and conclusions of this CERCLA decision document.

The goals and the selected remedy presented in this ROD are consistent with publicly recommended end uses. For example, the EUWG recommended that "DOE remediation decisions achieve, at a minimum, a controlled industrial end use for the entire ORNL Bethel Valley area." The EUWG also recommended that "A controlled industrial end use should at least provide for surface use of contaminated lands. Currently, there are areas where contamination results in the need for controlled access. Reducing such areas would enhance the overall viability of the Laboratory. Remediation should result in lands that are safe for surface use by ORNL employees."

This ROD for interim actions presents the selected remedy for portions of Bethel Valley. It is anticipated that actions taken as part of this remedy will be consistent with final actions selected in future decisions for Bethel Valley. This remedy was chosen in accordance with CERCLA as amended by SARA and, to the extent practicable, the NCP. This decision is based on the Administrative Record for this project. Following are the principal documents supporting this ROD:

- *Remedial Investigation/Feasibility Study for Bethel Valley Watershed at Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE 1999a);
- *Proposed Plan for Interim Actions in Bethel Valley, Oak Ridge, Tennessee* (DOE 2000a); and
- *Memorandum of Understanding for Implementation of a Land Use Control Assurance Plan (LUCAP) for the United States Department of Energy Oak Ridge Reservation* (DOE, EPA, and TDEC 1999).

These documents and other information supporting the selected remedy can be found at the Information Resource Center, 105 Broadway Avenue, Oak Ridge, TN, 37830, (865) 241-4582.

2.4 SCOPE AND ROLE OF THE ACTION

The scope of the remedial actions in this interim decision is focused on a 1734-acre area in Bethel Valley (Fig. 2.2). This area includes buildings and other facilities designated for D&D, buried waste, underground LLLW tanks (including five in Melton Valley), underground process and LLLW transfer pipelines, contaminated surface and subsurface soil, contaminated sediment and surface water, contaminated groundwater, and groundwater monitoring wells and piezometers no longer needed for monitoring. Additional detail on these scope items is provided in Sect. 2.5.1, Areas of Concern, and Table A.1, Selected Remedy for Individual Potential Source Units in Bethel Valley.

Previous CERCLA response actions addressed a variety of units located within Bethel Valley. These actions included the removal of liquids and sludges from the Gunite Tanks and other tanks at the site, the removal of liquids and sludges from the Surface Impoundments, and the removal of Tank W-1A and contaminated soils associated with the Core Hole 8 groundwater plume. These previous actions were considered in the development of the selected remedy. While some of these early actions will be augmented with additional response actions as discussed in this ROD, others will require no additional response actions.

The scope of the selected remedy does not include active facilities and infrastructure (e.g., Bldg. 4500 N). Additionally, a final groundwater decision is not part of the selected remedy. However, this action does include interim actions associated with contaminated groundwater within the valley. A final groundwater decision is not being made at this time for several reasons. The agencies desire to complete source control actions, monitor their effectiveness, and collect limited additional characterization data. These activities will allow the agencies to make a more informed decision for the final groundwater remediation. Because this remedy does not make a final groundwater decision, and because it does not include active facilities or final LUCs, it is an interim remedy.

The selected remedy uses contaminant source control and the imposition of LUCs as the overall cleanup strategy for Bethel Valley. Contaminant sources will be removed or physically isolated, depending on waste characteristics, location, and volume. Source control actions, coupled with LUCs, protect human health and the environment by controlling the level of exposure to hazardous substances. Extraction and/or in situ treatment of groundwater minimizes further impacts to groundwater and protects surface water by reducing the mass of contamination present. How particular source units covered by this ROD are to be remediated is detailed in Appendix A. The remedial actions described in this ROD are expected to be consistent with the final action that will be selected for the Bethel Valley area.

The selected remedy leaves hazardous substances in place, which would require land use restrictions for hundreds of years or longer if no additional remedial action is taken. The selected remedy is considered to be an interim decision and will be re-evaluated in the future. Any future measures, including final long-term LUCs, will be addressed in a future decision document. However, the interim LUCs selected in this ROD will continue in effect and remain enforceable as part of the selected CERCLA remedy until such time as they may be changed by a future CERCLA decision.

Bethel Valley sources are upstream from Melton Valley. The primary waterway through which contamination is conveyed out of Bethel Valley is White Oak Creek. This creek flows through a gap in Haw Ridge into Melton Valley. The Melton Valley sources and contaminated media have undergone an earlier decision. The decision in this ROD acknowledges the level of remediation required by the Melton Valley ROD and considers the Bethel Valley contribution of contamination into Melton Valley. An element of the RAO for Bethel Valley ties directly to meeting the Melton Valley RAO.

Many waste areas addressed in this ROD are solid waste management units (SWMUs) as defined in the RCRA Hazardous and Solid Waste Amendments of 1984 (HSWA) Permit for the ORR (#TN 001). In accordance with FFA Sect. IV (RCRA/CERCLA Coordination), the parties have agreed that, for the inactive SWMUs listed in Appendix A-1(a) of the HSWA Permit, RCRA corrective action that would otherwise be required under that permit will be deferred to the CERCLA response action process as implemented under the FFA. FFA-listed sites in Bethel Valley are presented in Appendix A (Table A.1) of this ROD, along with the ways in which that site is being addressed under this remedy. A note is added if the FFA site is also a designated a SWMU.

2.5 SITE CHARACTERISTICS

Data used in characterizing the Bethel Valley area include environmental sampling data extending from 1979 to 1997. A summary of the data sources used in the RI is presented in Table 2.1. Chapter 4 of the Bethel Valley RI/FS (DOE 1999a) identifies the historical data and the ORNL data sets that were used in the Bethel Valley RI and also describes the data usability evaluation that determined whether the data met the requirements of the project and identified any data gaps. This section summarizes the data presented in the RI to broadly depict the primary contamination in Bethel Valley.

2.5.1 Areas of Concern

Bethel Valley is contaminated from past ORNL operations and waste management practices. Sources of contamination include buildings and other facilities designated for D&D, buried waste, buried tanks, and underground process and LLLW pipelines. Most of these sources are found in the ORNL main plant area. Contaminated media include soil, groundwater, surface water, and sediment.

Figure 2.3 shows the Areas of Concern identified in the RI for Bethel Valley.

Buildings and Other Facilities. The scope of this decision includes a total of 58 inactive buildings and other facilities designated for decontamination and decommissioning (D&D). Three of these have already been removed, and another has been stabilized. The remaining 54 facilities have been deactivated (i.e., placed in a safe and stable condition that is protective of workers, the public, and the environment) and incorporated into an ongoing surveillance and maintenance (S&M) program until D&D is completed. Although all of the remaining facilities have inactive status, not all are abandoned. Some are still being used by DOE for various purposes (e.g., office and storage space) and may continue to be used by DOE until D&D begins. One of the remaining 54 facilities, the Graphite Reactor, is a designated National Historic Landmark. Some of the facilities have basements extending below ground surface, although most are constructed on a slab on grade. Some facilities contain reactors, hot cells, and other areas that are highly contaminated with radioactive material. Other facility contaminants may include polychlorinated biphenyls (PCBs), lead, and asbestos.

Buried Waste (Burial Grounds and Landfills). The principal buried waste disposal areas in Bethel Valley are SWSA 1, SWSA 2, the FWPA, the NRWTP Debris Pile, SWSA 3, and the Contractor's Landfill. Between 1943 and 1951, solid low-level radioactive waste was routinely buried at shallow depths in the subsurface soil. Early burial procedures involved using unlined trenches covered by soil or a combination of concrete caps and soil. SWSA 1, in Central Bethel Valley, is a 1-acre burial ground used from 1943 to 1944. The volume of waste in SWSA 1 is estimated at 12,400 m^3 (16,200 yd^3). SWSA 2 received waste from 1944 to 1946 in an area in Central Bethel Valley covering about 3.6 acres. The contents of SWSA 2 were later excavated and moved to the eastern end of SWSA 3 in West Bethel Valley. (The residual contamination at the SWSA 2 area is addressed in this ROD as an area of subsurface soil contamination.) The FWPA is estimated to have a volume of 1600 m^3 (2100 yd^3) of primarily soil and construction/demolition debris. The NRWTP Debris Pile is estimated to have a volume of 3170 m^3 (4150 yd^3) of primarily construction/demolition debris.

SWSA 3 is a 7-acre burial ground located in West Bethel Valley that received waste from multiple sources from 1946 to 1951. During this time, ORNL served as a disposal site for wastes from such facilities as the Mound Laboratory and the University of Chicago, as well as the three ORR plants. Alpha-emitting radioactive wastes were contained in drums, set on concrete, and covered with concrete. Beta/gamma-emitting radioactive wastes were buried in unlined trenches and backfilled with soil. The contents of SWSA 2 were excavated and moved to the eastern end of SWSA 3 after SWSA 2 was closed in 1946. The volume of waste and contaminated soil in SWSA 3 is estimated at 96,700 m^3 (126,500 yd^3).

Table 2.1. Data used in the Bethel Valley RI, ORNL, Oak Ridge, Tennessee

Media	Source	Dates
SE	Spalding and Cerling (1979) sediment data	1981
SE, SW	Compliance radionuclide data	1991–1996
SE, SW	Mercury-compliance data (Taylor 1989, 1990, 1992)	1987–1990
SW	Inorganic data—WAG 2 seeps	1993–1995
SW	Radionuclide data—WAG 2 seeps	1993–1995
SW	VOC data—WAG 2 seeps	1993–1995
SW	92—WAG 2 seeps	1991–1992
SW	Organic data—WAG 2 seeps	1993–1995
SE	TDEC sediment sampling	1997
GW, SO	7000 Area sampling (Rowher 1987) (four data sets)	1986
SW	Raccoon Creek surface water (Steuber et al. 1981)	1981
SO	WAG 3 soil sampling (Steuber 1979)	1979
SO	WAG 1 SCSR radionuclide soil data	1991
GW	WAG 1 SCSR radionuclide groundwater data	1990–1992
SW	Raccoon Creek data subset of SWSA 3 data set	1996
GW	WAG 1 EE/CA	1995

Sources: Rowher, P.S. 1987. Personal communication to H. Wayne Hibbits, Director, Environmental Protection Division, U.S. Department of Energy, Oak Ridge Operations, "Site Characterization—Gasoline Tank—Oak Ridge National Laboratory." April 13, 1976, ORNL, Oak Ridge, TN.

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CA = cost analysis
EE = engineering evaluation
GW = groundwater
ORNL = Oak Ridge National Laboratory
RI = remedial investigation
SCSR = site characterization summary report
SE = sediment
SO = soil
SW = surface water
SWSA = solid waste storage area
TDEC = Tennessee Department of Environment and Conservation
VOC = volatile organic compound
WAG = waste area grouping

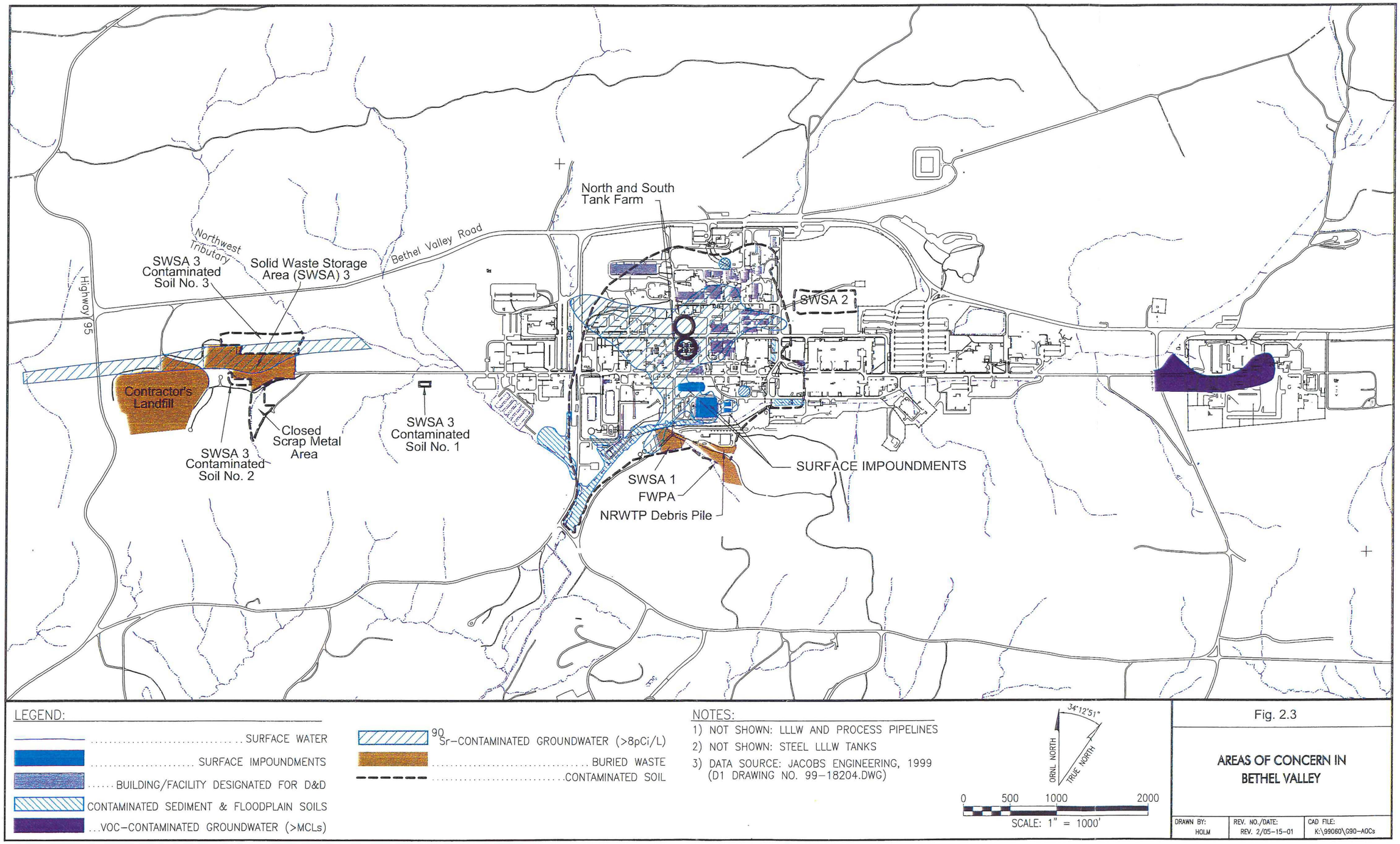


Fig. 2.3. Areas of concern in Bethel Valley.

The Contractor's Landfill, also in West Bethel Valley, was used as a disposal site for construction debris and noncontaminated demolition materials; its volume is estimated at 105,500 m^3 (138,000 yd^3). Some material may be lightly contaminated.

Buried Tanks. Most of the LLLW system in Bethel Valley was installed during the late 1940s and 1950s. The system was designed to collect LLLW in buried tanks (usually outside of work areas) to protect workers from unnecessary exposure. Various actions to reconfigure and improve the LLLW system over the last 40 years have resulted in a variety of tank construction, containment, and radioactive inventories. The scope of this decision includes most of those portions of the LLLW system that have been taken out of service. Table A.1 lists 61 tanks, 5 of which are in Melton Valley. These tanks are made of gunite, concrete, or steel. Forty-three of them have previously been emptied of remaining materials and grouted in place or removed. Early actions are addressing or will address 14 tanks. The four remaining tanks, Tank S-424 in Bethel Valley and Tank T-1, Tank T-2, and the HFIR Tank in Melton Valley, are remediated under this decision. The latter three tanks were until recently included with 24 other inactive tanks under an action memorandum (DOE 1999b and addended in 1999c). The action memorandum specified sludge removal from the tanks and transfer of the sludge to the Melton Valley Storage Tanks to await final processing at the TRU Waste Treatment Facility. However, the sludge in the HFIR Tank and Tanks T-1 and T-2 contain ion exchange resin that is not compatible with the process employed at the TRU Waste Treatment Facility, and there is no proven technology that can be readily applied to resolve the incompatibility. Since the sludge from the three tanks will need to be evaluated and treated separately from the sludge of the other inactive tanks, remediation of the three tanks has been incorporated into the selected remedy.

A non-time-critical removal action is planned in the near future to stabilize eight GAAT shells and risers (Tanks W-3 through W-10) located in the North Tank Farm and South Tank Farm. A recently completed interim action (DOE 1997a) has removed the tank contents to the extent practical, and the tanks are currently being maintained under an S&M program. Although the stabilization of these tanks was included in the Bethel Valley alternatives during the RI/FS and proposed plan stages of decision development, the action has been removed from the scope of the remedy and placed in a non-time-critical removal action where its implementation schedule will be accelerated. Concerns associated with tank shell integrity precluded postponement of the stabilization until after ROD approval.

Underground Process and LLLW Pipelines. Central/East Bethel Valley contains more than 17,000 lin m (56,000 lin ft) of inactive pipelines constructed of various materials (vitrified clay, steel, etc.) with diameters of up to 15 cm (6 in.) Most (90%) of these pipelines were used to transfer waste from the research facilities (LLLW pipelines) to the tanks, impoundments, and/or treatment facilities. The remainder (process waste pipelines) transported lightly contaminated stormflow. In addition to the potential for unacceptable human exposure from those pipelines and any remaining radioactive contents, these pipelines and their trenches and backfill represent a potential flow pathway for contaminated groundwater.

Associated with the underground pipelines are a number of pump pits, valve boxes, manholes, manways, vaults, dry wells, and other subsurface structures used to house, control, or monitor utilities. Those subsurface structures containing LLLW pipelines are generally highly contaminated with radioactive material.

Soil. Contamination is present in surface soil [defined here as less than 0.6 m (2 ft) deep] and in subsurface soil [defined here as greater than 0.6 m (2 ft) deep]. Ultrasonic Ranging and Data System data indicate several areas that exhibit surface radioactivity (Fig. 2.4). These areas are listed here in general order of largest areas of contaminant extent:

- White Oak Creek floodplain soils,
- South Tank Farm,

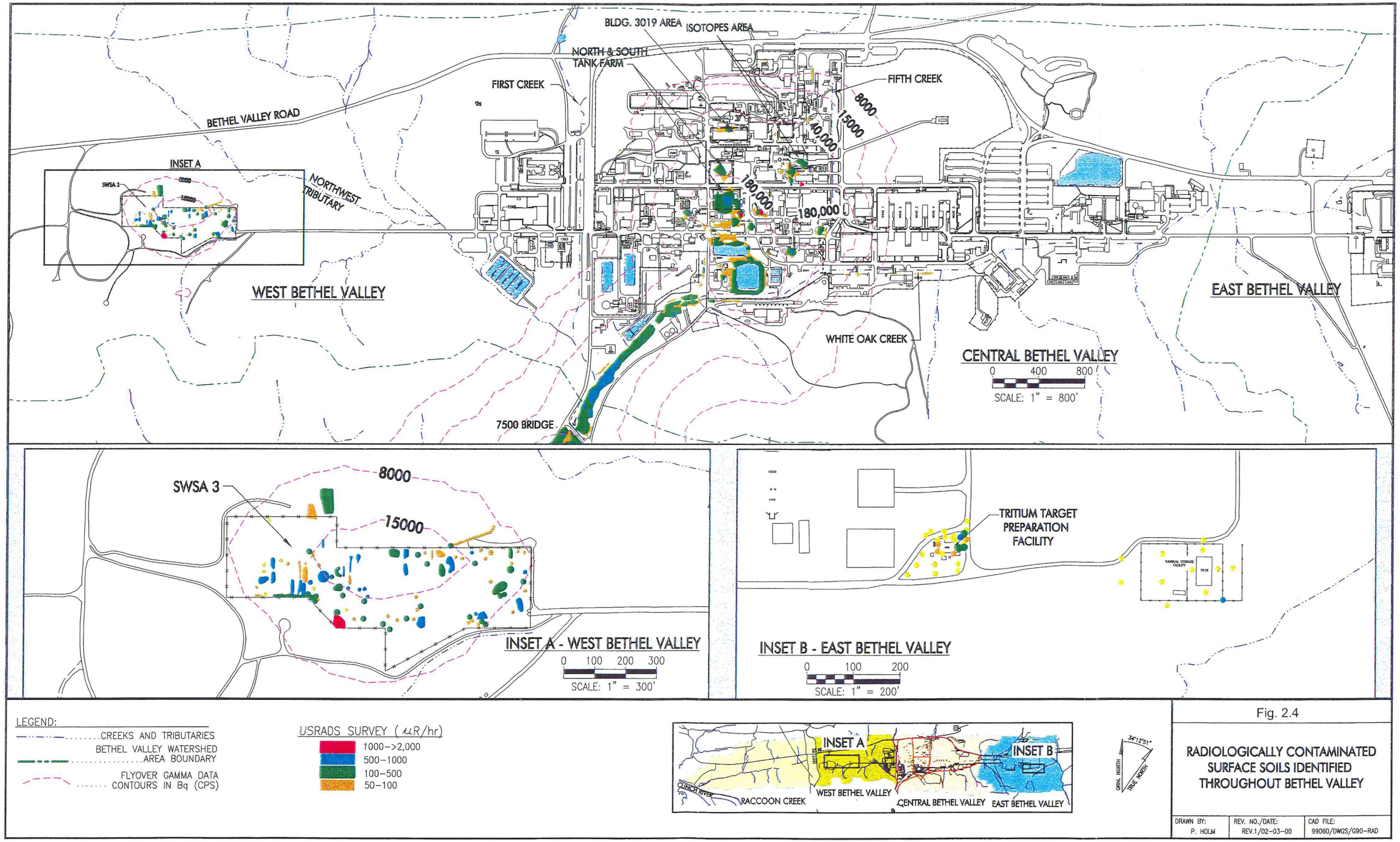


Fig. 2.4. Radiologically contaminated surface soils identified throughout Bethel Valley.

- SWSA 3,
- North Tank Farm, and
- Isotopes Area.

Analyses of soil samples reveal many different radionuclides in these areas. Cesium-137 is the most common radionuclide present, with ^{60}Co, ^{228}Ra, $^{214/212}Pb$, ^{228}Ac, ^{90}Sr, and ^{208}Tl also prevalent. Cesium-137 can be found at concentrations of 28,000 pCi/g (compared to a background level of 0.9 pCi/g). Cesium-137 is found extensively in the White Oak Creek floodplain, reflecting the affinity of this constituent to sorb to soils and sediment. Other radionuclides are found disseminated throughout the main ORNL complex, resulting from various accidental releases. Samples of surface soil collected from about 220 locations throughout Bethel Valley have been analyzed for both radiological and chemical constituents. Compared to radiological constituents, the distribution of chemicals in surface soil is less extensive and the concentrations not as high. Contaminated soils in West Bethel Valley include several discrete areas of surface soil contamination. Surface soil contamination hot spots are present over a total of approximately 3 acres in the vicinity of SWSA 3, the Contractor's Landfill, and the Closed Scrap Metal Area. Cesium-137 is common in SWSA 3 soils.

There were numerous subsurface releases at ORNL, including leaks from pipelines. Subsurface samples were collected from more than 195 locations throughout Bethel Valley and analyzed for radionuclides, metals, or organics. Analytical results indicate at least four areas of significant subsurface contamination: Bldg. 3019, both the North and South tank farms, and the Isotopes Area. Soils surrounding Bldg. 3019 are contaminated from a series of historical pipeline leaks with gross beta activity as high as 16,005 pCi/g and gross alpha as high as 1043 pCi/g. Samples in the area contain elevated concentrations of radionuclides such as ^{137}Cs, total radioactive strontium, ^{60}Co, and $^{238/239/240}Pu$. Soils near a historical pipeline leak north of Bldg. 3019 contained gross beta activity as high as 1855 pCi/g and gross alpha up to 3104 pCi/g. Specific radionuclides occurring at this leak site include ^{241}Am, ^{60}Co, ^{137}Cs, ^{152}Eu, ^{244}Cm, and $^{239/240}Pu$. As with other samples in the vicinity of Bldg. 3019, the highest concentrations were found in samples collected from the 3- to 5-m- (10- to 15-ft-) depth interval.

Subsurface soil samples at the North Tank Farm exhibited up to 62,600 pCi/g gross beta activity and 2570 pCi/g gross alpha at a depth of 5 m (15 ft). Soils surrounding Tank W-1A in the North Tank Farm are highly contaminated with alpha-, beta-, and gamma-emitting radionuclides. Gross alpha activity levels ranged from 13,000 to 84,000 pCi/g; the highest levels were detected immediately adjacent to the tank. Gross beta activity levels ranged from 40,000 to over 500,000 pCi/g. Strontium-90 levels ranged from 9 to 33,500 pCi/g (DOE 1998a). In addition to ^{90}Sr, radiological contamination in soil surrounding the tank (and in tank liquid samples) included ^{137}Cs, ^{60}Co, ^{3}H, $^{233/234}U$, ^{238}U, and ^{239}Pu.

Analytical results from soil borings in the South Tank Farm indicate that soil contamination is dominated by ^{90}Sr (0 to 539 pCi/g) and ^{137}Cs (0 to 760 pCi/g). Soils in the Isotopes Area exhibited activities of up to 1890 pCi/g gross alpha and 3218 pCi/g gross beta.

Mercury contamination is present in soil near Bldgs. 3503, 3592, 4501, and 4508. The highest mercury concentrations in soil borings were detected adjacent to Bldg. 3592. The concentrations in the borings ranged from <5 mg/kg to 548 mg/kg; concentrations generally decreased with depth, suggesting a surface release. Mercury in soil underneath Bldg. 4501 is the suspected source of contamination in multiple basement sumps that are being pumped and discharged to the Process Waste Treatment Complex (PWTC) or White Oak Creek.

East Bethel Valley soils are not extensively sampled, and there are limited subsurface soil data in parts of the main plant area such as the 2000 Area. These and other uncertainties will be managed through the use of contingent actions and decision rules, which are described in Sect. 2.12.5.

Groundwater. Groundwater contamination is detected in most subareas. The most significant contaminant plumes are identified as Core Hole 8, the Central Bethel Valley South Area, SWSA 3, and East Bethel Valley (Fig. 2.5). These areas differ considerably in the nature and severity of contamination. The Core Hole 8 Plume has ^{90}Sr and ^{234}U to levels of 532,632 and 58,700 pCi/L, respectively. The MCL for ^{90}Sr is 8 pCi/L. The Central Bethel Valley South Area contains much less ^{90}Sr (max of 10,300 pCi/L) and some ^{3}H (max of 897,000 pCi/L compared to an MCL of 20,000 pCi/L). The SWSA 3 plume is primarily ^{90}Sr, with only one well above 1000 pCi/L immediately under the burial ground. East Bethel Valley has a VOC plume consisting largely of trichloroethene (TCE) and probable degradation compounds, including 1,2-dichloroethene (DCE) and vinyl chloride. In addition to contaminant plumes, groundwater in the Central Bethel Valley area contains numerous radionuclides of varied concentrations not associated with a particular plume. Several metals are also present including arsenic, antimony, and vanadium.

The Core Hole 8 Plume migrates across the Central Bethel Valley 2000 Area and discharges to First Creek. The lateral extent and depth is not completely characterized, although the plume reaches at least 27 m (90 ft) deep. Strontium-90 is the leading constituent of the plume, which originates from long-term leakage from the North Tank Farm in the Central Bethel Valley 3000 North Area. Discharge of this plume to First Creek has historically accounted for 20% of the ^{90}Sr released over White Oak Dam (DOE 1998b). A removal site evaluation concluded in 1994 that contaminated groundwater seeping into the storm sewer system was being routed to storm sewer outfalls discharging to First Creek. Further investigation showed that contaminated groundwater entered the sewer system through three catch basins in the western part of ORNL. A removal action was initiated in December 1994 to install a groundwater collection and transmission system to intercept groundwater containing ^{90}Sr before it discharged to First Creek. Two inoperative storm sewer catch basins were replaced with porous sumps; the third basin remained operational but was modified so that groundwater entered a porous sump beneath the basin while the basin itself was sealed to prevent groundwater infiltration. In March 1998, an additional groundwater interceptor trench was installed that connects to the original system. This trench provides additional contamination release control. All collected groundwater is piped to the PWTC for treatment and discharged through an existing NPDES outfall.

Tritium is present in groundwater throughout the area, and areas of elevated concentrations reveal probable release points and suggest migration pathways. In the ORNL main plant area, the surface impoundments in the Central Bethel Valley 3000 South Area are an apparent source of ^{3}H; a second ^{3}H source may be the Radioactive Waste Evaporator (Bldg. 2531) in the Central Bethel Valley 2000 Area. The radionuclide migrates in the shallow subsurface and discharges to White Oak Creek. Concentrations of ^{3}H are apparently diminishing as a result of radioactive decay. The lateral extent of elevated ^{3}H concentrations is well defined at ORNL, and the depth of contamination extends to >150 m (200 ft) in the subsurface.

Contaminants such as ^{90}Sr are known to occur in some of the monitoring wells around SWSA 3 at depths generally <30 m (100 ft) below the ground surface. The distribution of contaminants indicates a long [>900 m (3000 ft)], narrow [approximately 80 m (250 ft)] plume (Fig. 2.5), suggesting flow through a discrete bedrock pathway. The highest ^{90}Sr concentration (1000 pCi/L) occurred at a depth of approximately 9 m (30 ft) at Well 493. The well, located within SWSA 3, has been sampled once (1996). A ^{90}Sr concentration of 661 pCi/L occurred at an approximate depth of 11 m (35 ft) at Well 41, which is located between the eastern edge of SWSA 3 and Northwest Tributary (NWT).

Tritium has exceeded the MCL (20,000 pCi/L) at a single well (994) in SWSA 3. The ^{3}H concentration in the well has decreased from a maximum of 32,432 pCi/L in 1991 to 14,595 pCi/L in 1996. Tritium exceeded the MCL on one occasion (1991) at Well 0535 in the Central Bethel Valley 1000 Area, but the concentration has diminished significantly since that single event. Chlorinated solvents have been detected in several wells in the West Bethel Valley area; however, only TCE, vinyl chloride, and methylene chloride were detected at levels that slightly exceed MCLs at four wells (985, 986, 996, and 998) in and near SWSA 3. MCLs for these compounds are 5, 2, and 5 μg/L, respectively. Inorganic constituents are frequently detected in groundwater samples in the West Bethel Valley area; however, only antimony and cadmium exceeded MCLs in two wells (533 and 536). Arsenic was also detected in unfiltered water samples from a number of monitoring wells in West Bethel Valley.

Groundwater is known to discharge through seeps and springs in both the NWT within the West Bethel Valley area and in the headwaters of Raccoon Creek to the west. Analysis of the ^{90}Sr release signature for these two streams suggests that the Raccoon Creek contaminant source travels through a bedrock flow pathway and may be fed by a secondary contaminant source in bedrock or sediment in cavities. This is supported by the relatively consistent contaminant flux through a wide range of surface water discharge rates at the surface water monitoring station in the Raccoon Creek subwatershed. The contaminant release through the NWT, on the other hand, though traveling through conduits, shows increasing contaminant flux with increasing surface water flow, suggesting a fairly direct link between hydrologic activity in the SWSA 3 waste burial area and contaminant discharge into the stream.

Measurements of contaminant concentrations in the tributaries of White Oak Creek have generally shown a decreasing trend, suggesting that the peak concentrations have passed through the system. However, if there are readily transported contaminants that have not yet been released to the groundwater within SWSA 3, concentrations could increase. This scenario presumes that containers exist that have not fully degraded and previously released contaminants.

VOCs are detected in several areas of ORNL, but the only identifiable plume is found in East Bethel Valley. TCE and TCE degradation products extend into the bedrock aquifer to depths >30 m (100 ft). The lateral extent has not been defined. Concentrations of TCE in one well (up to 15,000 μg/L in Well 1201) and increasing concentrations with depth suggest this plume may include dense nonaqueous-phase liquid (DNAPL). Solvent-related contaminants are detected in groundwater in other areas of ORNL, but the data indicate no large releases or potential source areas. The pervasiveness of vinyl chloride (a degradation product of TCE) in wells containing VOCs suggests some natural degradation of these contaminants. Very little is known about the extent of this plume or its concentration trend over time.

Surface Water. Surface streams that drain Bethel Valley receive contamination from direct groundwater discharge and infiltration of groundwater into utility lines that ultimately discharge to the streams. The most pervasive surface water contaminants include ^{90}Sr and ^{3}H. These radionuclides enter surface streams from diffuse areal discharges (e.g., ^{3}H along the southern portion of the main plant, ^{90}Sr from SWSA 3 into NWT) or more discreet areas (^{90}Sr from the Core Hole 8 Plume) to point sources (discharge from the PWTC and other permitted facilities). Cesium-137 may also be derived from resuspension of contaminated sediment during sampling events. Surface waters in NWT and Raccoon Creek are lightly contaminated with ^{90}Sr as a result of discharge of groundwater to these tributaries. Total radioactive strontium was detected in 130 out of 131 samples from the waters of the NWT during the 1987–1996 time period. Strontium-90 concentrations ranged from 0.703 to 104 pCi/L at the NWT monitoring station.

Strontium-90 in surface water emanating from the Central Bethel Valley 2000 Area is a significant source of off-site contamination from ORNL. Surface waters in the Central Bethel Valley 2000 Area include First

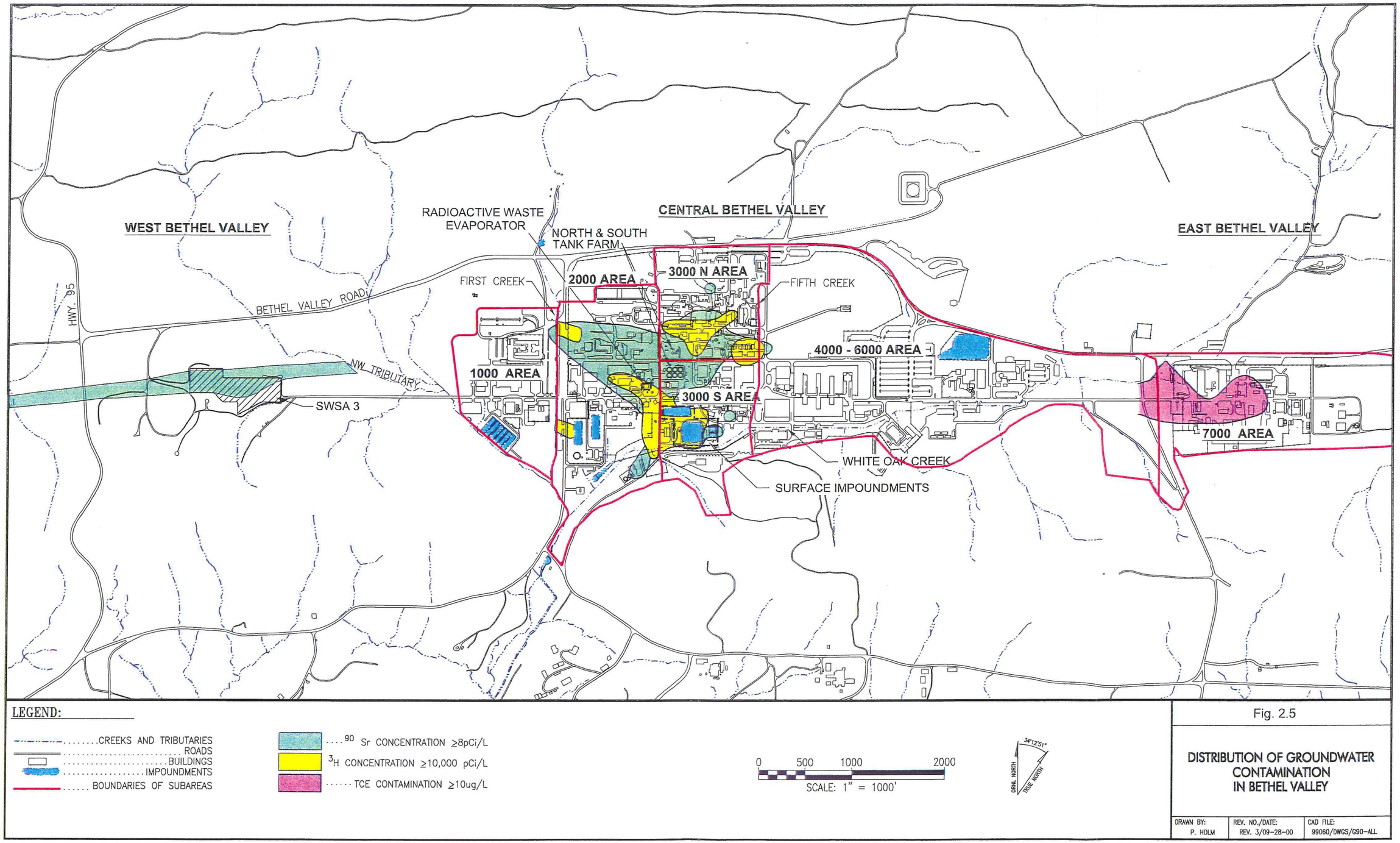


Fig. 2.5. Distribution of groundwater contamination in Bethel Valley.

Creek and a segment of White Oak Creek. Monitoring at the First Creek weir for 83 months yielded positive detections for ^{90}Sr for all sampling events. The range in ^{90}Sr concentrations is 10 to 480 pCi/L, with approximately 70% of the data in the lower half of that range. Contaminant discharges into First Creek have been reduced as a result of the completion of several removal actions in the last five years designed to mitigate discharge from the Core Hole 8 Plume. Central Bethel Valley 3000 South receives the greatest discharge from ungauged sources of radiological contamination from ORNL because of its downgradient position between many of the ORNL experimental, research, and production facilities and White Oak Creek. Strontium-90 and ^{3}H migrate readily within White Oak Creek and exit the watershed past the 7500 Bridge and ultimately are discharged over White Oak Dam.

Inorganics such as arsenic and mercury are also detected in surface water. Mercury is present at concentrations in excess of AWQC within the ORNL complex, but concentrations diminish before exiting the watershed (Fig. 2.6). No obvious source of arsenic has been determined, but arsenic is also present downstream in the Melton Valley watershed. Arsenic data are limited. Concentrations of arsenic up to approximately 20 times background were found.

Sediment. Generally, contaminated sediment has accumulated in the lower reach of White Oak Creek in Bethel Valley. Sediment from White Oak Creek below the ORNL complex has been regularly sampled, but sediment sampling data are limited for smaller tributaries. Cesium-137 is the most pervasive contaminant, with ^{60}Co, mercury, and PCBs also present. Cesium values in sediment in White Oak Creek vary from 10 pCi/g to a maximum of 4160 pCi/g, with an average concentration of 20.5 pCi/g. Cesium levels in First Creek are lower, with a maximum of 66 pCi/g. Little cesium has been detected in sediment samples collected from NWT and Raccoon Creek. Historical data reveal high levels of mercury in Fifth Creek sediment (Fig. 2.6). For example, sediment sampled at Outfall 261 had mercury levels >1000 mg/kg before 1990. Those levels had fallen to roughly 100 mg/kg in 1996. Most of the sediment in White Oak Creek is lightly contaminated with mercury (<10 mg/kg) although levels in White Oak Creek sediment above Fifth Creek increased since 1993 to a 1996 maximum of 15 mg/kg. The sources of mercury are past releases that continue to migrate into surface water from sumps and storm drains that discharge to surface water. There are limited sediment data in these tributaries (three sampling stations). Samples from these stations have had contaminant levels mostly at or below background.

2.5.2 Conceptual Model

The data compiled for the Bethel Valley RI (DOE 1999a) provide a general framework of contaminant distribution that is interpreted in a sitewide conceptual model. This model focuses on contamination that covers broad areas and may migrate outside the area. Figure 2.7 illustrates some of the elements of this model.

Mobile contaminants in West Bethel Valley are derived from SWSA 3 leachate infiltrating to groundwater, and surface exposure and erosion of uncovered contaminated material. SWSA 3 is located on a groundwater divide, allowing contaminants that have leached to the groundwater to migrate west to Raccoon Creek and east to NWT. Groundwater discharging to these surface water bodies contaminate the surface water. Contaminants that are eroded from exposed material or contaminated soil at the burial ground enter an unnamed tributary that enters NWT. This contamination can settle into the sediment.

In the ORNL main complex (Central Bethel Valley 3000 Area), areas of exposed radioactive materials (including buildings) are common. These areas are well delineated, and institutional controls minimize risk to workers. Contaminated soils and buried sources leach contaminants to groundwater that discharge to First Creek, Fifth Creek, and White Oak Creek. Leaks from process lines, tanks, and

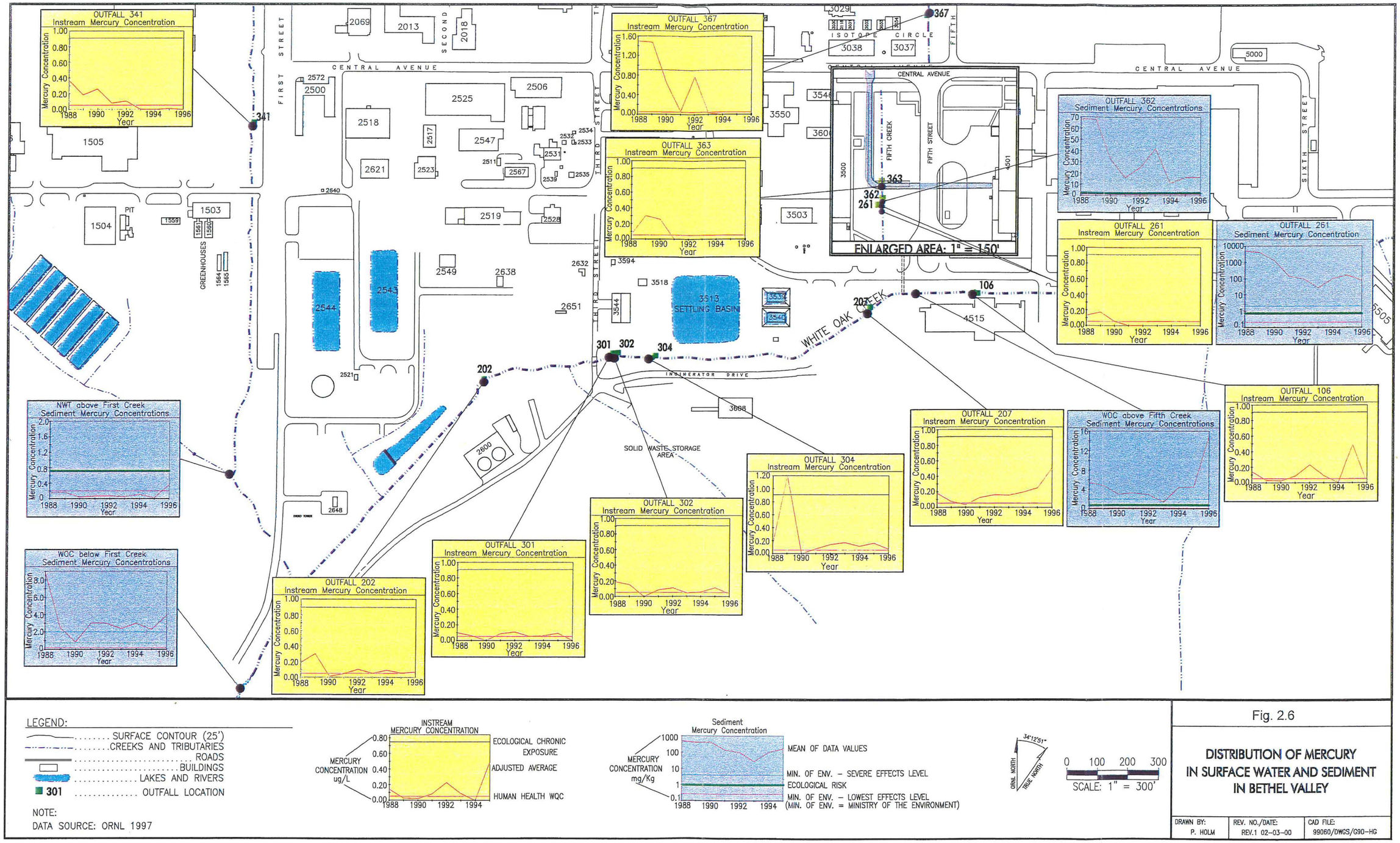


Fig. 2.6. Distribution of mercury in surface water and sediment in Bethel Valley.

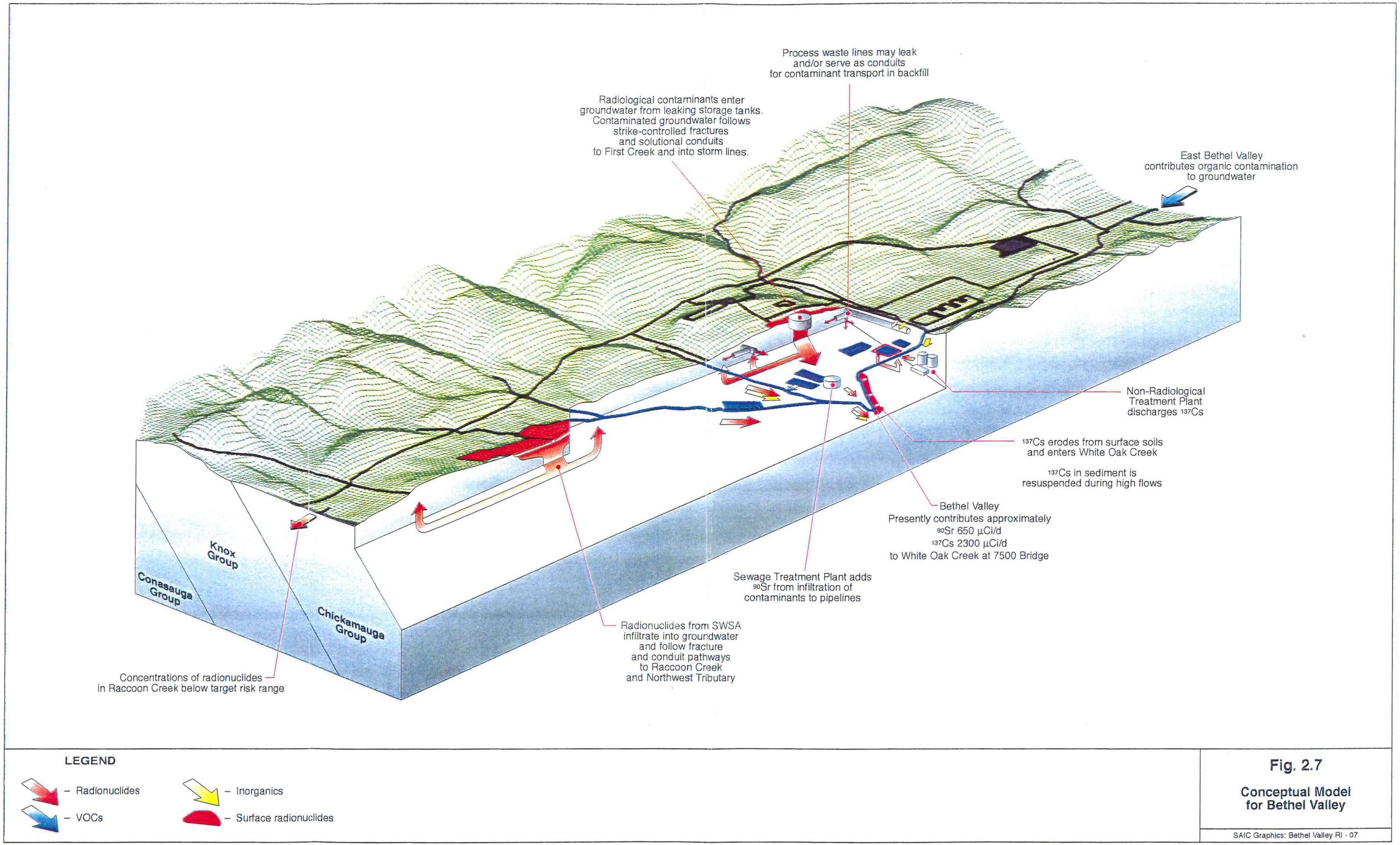


Fig. 2.7. Conceptual model for Bethel Valley.

buildings are the primary sources of groundwater contamination. Groundwater traveling in bedrock follows fractures and solutional conduits preferentially along strike toward the creeks or man-made features such as pipelines or sumps. Recovery of contaminated groundwater by building sumps is an important mechanism that limits further spread of some contaminant plumes.

A VOC plume in East Bethel Valley is not fully characterized, but the distribution of contamination suggests a surface or shallow subsurface release of TCE. It is most likely that the dense solvent has migrated below the water table and into the bedrock aquifer, subsequently following discreet fracture and solutionally enhanced conduits to deeper intervals in the bedrock. An area of DNAPL may reside in the bedrock and act as a secondary source of dissolved VOC contamination that travels downgradient with the groundwater.

Surface waters in Bethel Valley serve as the integration point for contaminant migration out of the area. Once contaminated groundwater enters the surface water, the material may react to the change in physicochemical properties of the receiving stream, be adsorbed to sediment, or be taken up by biota. Mobile contaminants such as ^{90}Sr and ^{3}H remain as dissolved constituents of surface water and migrate downstream, out of the Bethel Valley area. Less mobile contaminants such as ^{137}Cs and mercury adsorb to sediment and are periodically resuspended during high flows to be either transported downstream or deposited along the floodplain.

2.6 CURRENT AND POTENTIAL FUTURE LAND AND RESOURCE USES

In order to focus remedial planning, DOE evaluated and determined current and anticipated future land and resource uses. This allowed DOE to propose and select remedial actions protective of receptors consistent with exposure under these land and resource use scenarios.

2.6.1 Current Land Uses

The ORNL complex in both Bethel Valley and Melton Valley is currently a restricted area under DOE control. Public access is restricted. ORNL also implements a variety of institutional controls to control access to surficial and subsurface contamination. Areas surrounding ORNL are periodically used for hunting. Although these areas are considered clean, access to them is controlled for security reasons and because roaming wildlife taken during hunts may be contaminated. In general, this land is not used by humans for purposes other than hunting, but it does include areas being considered for continuing growth of the laboratory.

2.6.2 Current Surface Water and Groundwater Uses

Surface water bodies in Bethel Valley are currently used for supporting wildlife and aquatic life. While humans may have some limited access to streams outside the laboratory during the annual hunts, there is no routine use of any streams on the ORR by humans. Groundwater, which is contaminated throughout much of Bethel Valley, currently has its use restricted by DOE.

2.6.3 Anticipated Future Uses

Reasonably anticipated future uses of land in Bethel Valley are an important consideration in determining the types and frequencies of exposures to residual contamination and the appropriate extent of remediation. Consistent with EPA guidance *Land Use in the CERCLA Remedy Selection Process* (EPA 1995), DOE solicited input on anticipated future land use from the other FFA parties (EPA and TDEC), local land use planning authorities, and the local public during the scoping phase of the RI/FS (DOE 1999a). Anticipated future uses considered during development of the ROD and prior CERCLA documentation are as follows:

- controlled industrial,
- unrestricted industrial,
- restricted access waste disposal,
- unrestricted, and
- recreational.

Since ORNL is an active industrial facility and is expected to remain government owned and operated for the foreseeable future, the unrestricted (i.e., residential) land use scenario was eliminated as a likely future use for the Central/East Bethel Valley area and the industrial portion of the West Bethel Valley area (ORNL 1000 Area). Cleanup options, therefore, focused on industrial land use scenarios in those areas. Achieving unrestricted industrial use requires removal of all contaminated media in the top 3 m (10 ft) of soil that are above remediation levels. Because of past and current usage, the presence of extensive subsurface contamination, and DOE's likely long-term presence at the laboratory, controlled industrial use is also considered for these areas. Controlled industrial use depends more on isolation of subsurface contamination than removal.

Unrestricted use is a reasonable cleanup objective for all areas outside of the industrial development within Central/East Bethel Valley and in the nonindustrial portion of West Bethel Valley/Raccoon Creek Area (i.e., west of the ORNL 1000 Area). Achieving unrestricted use requires removal of all contaminated soil that is above remediation levels. Because buried waste is costly to remove and dispose of, recreational (passive surface) land use was also considered for SWSA 3 and the Contractor's Landfill. [Note: During alternative development, the anticipated land use for SWSA 3 and the Contractor's Landfill was restricted access waste disposal. This land use was modified to recreational during development of the proposed plan (DOE 2000a).] In the event property on the Bethel Valley site is transferred to non-federal ownership before completion of remedial actions in the area to be transferred, CERCLA requirements, if any, associated with the transfer will be addressed separately from this ROD. Approximately 6.6 acres, predominantly an asphalt-paved parking lot east of Bldg. 4500 North, has been transferred to non-federal ownership. Two more parcels (1.7-acre parking lot area northeast of Bldg. 5002 and approximately 1-acre parking lot area northwest of Bldg. 1505) are being considered for transfer to non-federal ownership. These three areas do not require any soil cleanup for unrestricted industrial land use. Information considered in making this determination included the RI/FS, historical ORNL activities, and confirmatory walkover surveys. Locations of these three parcels are shown in Fig. E.1 in Appendix E.

The future use for surface water and underlying streambed sediment was selected to be consistent with the state's stream use classification. White Oak Creek is currently classified by the State of Tennessee for *Fish and Aquatic Life*, *Recreation*, and *Livestock Watering and Wildlife* uses, but not for *Domestic* or *Industrial Water Supply* or *Irrigation*. All other named and unnamed surface waters in the watershed are classified for *Irrigation*, in addition to the same three basic uses as White Oak Creek, by default under the Rules of the TDEC Chap. 1200-4-4. Therefore, protection of the surface water bodies for recreational use (considered representative of the classifications listed above), in combination with ecological protection, has been selected as the basis for surface water and sediment remediation.

The ability of remedial actions to restore groundwater has been shown to be directly related to the ability to find and remediate ongoing sources of contamination to the groundwater. Therefore, a decision on the future use of groundwater has been deferred pending an evaluation on the effectiveness of source actions presented in the selected remedy.

2.7 SUMMARY OF SITE RISKS

The baseline risk assessment estimates the risks that the site poses to human and ecological receptors if no action is taken. It provides the basis for action and identifies the contaminants and exposure pathways that need to be addressed by the remedial action. This section of the ROD summarizes the methods used to complete the human health and ecological risk assessments and their pertinent results for the Bethel Valley area. The information is presented here to support the selected remedies and to familiarize the reader with the basis for undertaking remedial action within the Bethel Valley area. The full results of the human health and ecological risk assessments can be found in Vols. 1 and 2 of the RI/FS (DOE 1999a).

This section was prepared in accordance with recommendations for writing the "Summary of Site Risks" section in EPA's "A Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents" (July 1999). The summary of the Baseline Human Health Risk Assessment and Ecological Risk Assessment in this ROD is quite lengthy due to the size of the Bethel Valley RI and the fact that it was organized around a number of geographic areas and functional subareas (e.g., East Bethel Valley, Central Bethel Valley 3000 North, Central Bethel Valley 3000 South, West Bethel Valley, etc). Readers desiring to review only the overall conclusions of the baseline risk assessment and the corresponding basis for action at this site are directed to Sect. 2.7.3 (p. 2-83), Conclusions from Baseline Risk Assessment and Basis for Action.

2.7.1 Summary of Baseline Human Health Risk Assessment

This section summarizes the various steps of the baseline human health risk assessment and presents significant results used in making decisions for Bethel Valley. The risk assessment is based on a set of identified COCs that are present at the site. Pathways of exposure to a potential receptor are identified, and a toxicity assessment is then done to evaluate the risk these contaminants pose to the potential receptor.

2.7.1.1 Identification of contaminants of concern

This section presents the COCs for each of the environmental media addressed by the baseline human health risk assessment for Bethel Valley. In this section, the COCs are presented in tables by area within media type (i.e., soil, sediment, surface water, and groundwater).

The COCs presented in the tables were selected following EPA Region 4 guidance. Specifically, COCs are defined in that guidance as contaminants detected at a site that significantly contribute to a pathway in a use scenario for a receptor that either (a) exceeds a cumulative excess lifetime cancer risk (ELCR) of 1×10^{-4} or (b) exceeds a cumulative noncarcinogenic hazard index (HI) of 1. Contaminants are not considered to be significant contributors to risk if their individual carcinogenic risk contribution is less than 1×10^{-6} and their noncarcinogenic hazard quotient (HQ) is less than 0.1.

In the tables, the following information is presented:

- exposure point (i.e., the location where the receptor contacts the contaminated media),
- COC,
- minimum and maximum detected concentration,
- units of measure for the detected concentration,
- frequency of detection,

- exposure point concentration (i.e., the concentration of the chemical used in deriving the risk estimate);
- percent of total risk (i.e., ELCR) posed by the individual COC, and
- statistical measure (i.e., the summary statistic used to represent the chemical's average exposure point concentration).

The media addressed in Tables 2.2–2.5 are soil, sediment, surface water, and groundwater, respectively. Assessment results for soil are those derived over all sampling results collected within each of the Bethel Valley areas (i.e., area assessment results) and are for industrial use, the anticipated future land use for most of the Bethel Valley developed area. Assessment results for sediment and surface water are those derived from data collected at individual sampling locations (i.e., point-by-point assessment results) and are for recreational use, a future use consistent with the state's stream use classification. Assessment results for groundwater are those derived over all sampling results collected within each of the Bethel Valley areas (i.e., area assessment results) and are for industrial use. Industrial use is assumed only for the purpose of presenting a summary of groundwater COC results, and is not a goal for this ROD. The groundwater will not have an anticipated future use until DOE goes through the state's procedure for classifying groundwater on the ORR, and/or until the final groundwater decision is made for Bethel Valley. Generally, lists of COCs for other potential future uses (e.g., residential use) are similar to those presented in Tables 2.2–2.5.

Conclusions drawn from Tables 2.2–2.5 are as follows:

- the most common class of COCs detected in soil was radionuclides (e.g., ^{137}Cs);
- the majority of the total risk for an industrial worker (i.e., total ELCR) was due to exposure to radionuclides;
- the most common class of COCs detected in sediment was radionuclides (e.g., ^{137}Cs), but semivolatile organic compounds and metals were also important;
- the majority of the total risk for a recreational user (i.e., total ELCR) was due to exposure to radionuclides;
- not all areas had COCs in sediment;
- no COCs were identified for surface water;
- the most common class of COCs detected in groundwater was radionuclides (e.g., ^{137}Cs) and organic compounds (e.g., 1,1-DCE and vinyl chloride); and
- not all areas had COCs in groundwater.

2.7.1.2 Exposure assessment

As noted above, COCs were selected for each of the use scenarios addressed in the human health risk assessment. These scenarios were selected as part of the exposure assessment contained in the risk assessment. This section describes the exposure assessment process and summarizes the results of the exposure assessment with specific attention to the exposure routes that were quantitatively evaluated. Generally, exposure

Table 2.2. Summary of COCs and exposure point concentrations for soil under future conditions (i.e., industrial use), Bethel Valley, ORNL, Oak Ridge, Tennessee

Scenario timeframe: future
Medium: soil
Exposure medium: soil

Exposure point	COC	Concentration detected Min	Concentration detected Max	Units	Frequency of detection	Exposure point conc.	% Total risk	Statistical measure
Raccoon Creek Area	None No data	—	—	—	—	—	—	—
West Bethel Valley	Beryllium	0.53	2.60	mg/kg	21/21	1.37	<0.01	UCL95(L)
	Benz(a)anthracene	0.040	0.520	mg/kg	5/8	0.424	<0.01	UCL95(L)
	Benzo(a)pyrene	0.038	0.530	mg/kg	4/8	0.370	<0.01	UCL95(N)
	Benzo(b)fluoranthene	0.040	0.700	mg/kg	6/8	0.534	<0.01	UCL95(L)
	Dibenz(a,h)anthracene	0.120	0.240	mg/kg	3/8	0.240	<0.01	MAX(N)
	Ac-228	1	193	pCi/g	10/10	25.5	0.21	UCL95(L)
	Bi-214	0	0.920	pCi/g	9/10	0.920	0.01	MAX(N)
	Co-60	0	11.8	pCi/g	5/11	3.47	0.08	UCL95(N)
	Cs-134	0	0.064	pCi/g	7/10	0.064	<0.01	MAX(N)
	Cs-137	0.044	28,000	pCi/g	19/19	21,000	100.0	UCL95(L)
	Eu-154	0	0.069	pCi/g	2/10	0.069	<0.01	MAX(N)
	K-40	6.16	25.6	pCi/g	18/18	18.5	<0.01	UCL95(L)
	Pb-212	1	165	pCi/g	10/10	165	0.02	MAX(L)
	Pb-214	0	1.31	pCi/g	9/12	0.981	<0.01	UCL95(L)
	Ra-228	0.41	1.21	pCi/g	6/9	1.01	0.01	UCL95(N)
	Tl-208	0.3	54.8	pCi/g	10/10	7.40	0.27	UCL95(L)
Central Bethel Valley 2000 Area	Arsenic	0.6	15.1	mg/kg	47/74	5.56	0.03	UCL95(L)
	Beryllium	0.12	2.30	mg/kg	72/74	1.02	0.10	UCL95(N)
	Benzo(a)pyrene	0.03	2.40	mg/kg	28/73	0.294	0.07	UCL95(L)
	Benzo(b)fluoranthene	0.03	2.50	mg/kg	37/73	0.323	0.03	UCL95(L)
	Ac-228	0.50	2.45	pCi/g	40/40	1.59	0.44	UCL95(N)
	Be-7	3.91	3.91	pCi/g	2/2	3.91	0.06	UCL95(N)
	Bi-212	0.57	2.40	pCi/g	14/14	2.01	0.11	UCL95(N)
	Bi-214	0.37	1.40	pCi/g	26/26	0.981	0.49	UCL95(L)
	Ce-144	2.09	2.09	pCi/g	2/2	2.09	0.03	UCL95(N)
	Co-57	0.30	1.99	pCi/g	5/5	1.72	0.03	UCL95(N)
	Co-58	0.25	0.250	pCi/g	1/1	0.250	0.08	MAX(NT)
	Co-60	0.04	28.9	pCi/g	49/49	8.23	6.73	UCL95(L)
	Cs-134	0.4	70.9	pCi/g	9/9	70.9	34.55	MAX(L)
	Cs-137	0.035	22,220	pCi/g	121/127	229	40.00	UCL95(L)
	Eu-152	0.9	34.0	pCi/g	6/6	27.1	9.27	UCL95(N)
	Eu-154	0.8	11.7	pCi/g	8/8	10.5	4.00	UCL95(L)
	K-40	2.55	39.4	pCi/g	116/116	16.3	0.01	UCL95(L)
	Pb-212	0.34	1.62	pCi/g	24/24	1.10	0.03	UCL95(N)
	Pb-214	0.47	1.69	pCi/g	59/59	1.06	0.06	UCL95(L)
	Pm-147	12	6,650	pCi/g	5/5	4,180	0.04	UCL95(N)
	Ra-226	0.15	1.40	pCi/g	93/116	0.862	0.49	UCL95(L)
	Ra-228	0.24	2.40	pCi/g	93/116	1.15	0.31	UCL95(N)
	Ru-106	1.13	1.13	pCi/g	2/2	1.13	0.07	UCL95(N)
	Th-228	0.24	4.28	pCi/g	106/106	1.35	0.69	UCL95(L)
	Tl-208	0.26	2.44	pCi/g	50/50	0.863	1.04	UCL95(L)
	Zr-95	0.230	0.415	pCi/g	3/3	0.415	0.10	UCL95(N)

Table 2.2. Summary of COCs and exposure point concentrations for soil under future conditions (i.e., industrial use), Bethel Valley, ORNL, Oak Ridge, Tennessee (continued)

Scenario timeframe: future
Medium: soil
Exposure medium: soil

Exposure point	COC	Concentration detected Min	Concentration detected Max	Units	Frequency of detection	Exposure point conc.	% Total risk	Statistical measure
Central Bethel Valley 3000 North Area	Arsenic	0.9	13.1	mg/kg	56/56	6.84	0.05	UCL95(L)
	Beryllium	0.095	212	mg/kg	42/56	1.42	0.20	UCL95(L)
	Benzo(a)pyrene	0.04	0.69	mg/kg	9/33	0.227	0.07	UCL95(L)
	Benzo(b)fluoranthene	0.02	2.20	mg/kg	6/32	0.338	0.04	UCL95(L)
	Ac-228	0.73	2.93	pCi/g	58/58	1.59	0.60	UCL95(L)
	Am-241	0.1	37.6	pCi/g	14/14	37.6	0.12	MAX(L)
	Bi-212	0.89	6.03	pCi/g	26/26	2.68	0.21	UCL95(L)
	Bi-214	0.41	1.07	pCi/g	15/15	0.896	0.63	UCL95(L)
	Co-60	0.1	31.5	pCi/g	15/15	14.2	15.75	UCL95(L)
	Cs-137	0	3,030	pCi/g	96/118	8.4	2.00	UCL95(L)
	Eu-152	1	141	pCi/g	4/4	141	65.00	MAX(N)
	Eu-154	0.7	12.1	pCi/g	6/6	10.3	5.50	UCL95(N)
	I-129	18	689	pCi/g	4/4	689	1.20	MAX(N)
	K-40	2.14	26.9	pCi/g	103/103	14.4	1.00	UCL95(N)
	Pb-210	1	319	pCi/g	12/12	319	2.50	UCL95(L)
	Pb-212	0.22	6.44	pCi/g	79/79	1.43	0.05	UCL95(L)
	Pb-214	0.22	1.60	pCi/g	91/91	0.92	0.08	UCL95(N)
	Pu-240	0.005	41.0	pCi/g	8/10	41.0	0.10	MAX(L)
	Ra-226	0.22	1.30	pCi/g	113/113	0.845	0.65	UCL95(N)
	Ra-228	0.24	2.93	pCi/g	114/114	1.32	0.50	UCL95(N)
	Th-228	0.23	5.83	pCi/g	117/118	1.83	1.30	UCL95(L)
	Tl-208	0.25	5.40	pCi/g	85/85	1.34	2.20	UCL95(L)
Central Bethel Valley 3000 South Area	Arsenic	0.6	27.4	mg/kg	66/69	8.01	0.02	UCL95(L)
	Beryllium	0.22	2.50	mg/kg	64/69	1.13	0.06	UCL95(N)
	Benz(a)anthracene	0.1	11.0	mg/kg	18/55	0.406	0.01	UCL95(L)
	Benzo(a)pyrene	0.1	12.0	mg/kg	17/55	0.409	0.05	UCL95(L)
	Benzo(b)fluoranthene	0.1	13.0	mg/kg	19/55	0.455	0.02	UCL95(L)
	Ac-228	0.81	9.09	pCi/g	36/36	2.22	0.33	UCL95(L)
	Bi-212	0.9	10.1	pCi/g	13/13	5.58	0.17	UCL95(L)
	Bi-214	0.45	1.24	pCi/g	22/22	0.944	0.26	UCL95(N)
	Co-57	0.11	2.03	pCi/g	2/2	2.03	0.02	MAX(N)
	Co-58	2.19	2.19	pCi/g	2/2	2.19	0.37	UCL95(N)
	Co-60	0.027	75.7	pCi/g	49/51	2.72	1.20	UCL95(L)
	Cs-134	3.91	3.91	pCi/g	2/2	3.91	1.10	UCL95(N)
	Cs-137	0.03	12,700	pCi/g	140/151	64.7	6.20	UCL95(L)
	Eu-152	1	274	pCi/g	3/3	274	51.00	MAX(N)
	Eu-154	3	172	pCi/g	7/7	172	36.00	MAX(L)
	Eu-155	1.36	5.90	pCi/g	5/5	5.58	0.02	UCL95(N)
	K-40	1.55	37.7	pCi/g	101/101	16.3	0.45	UCL95(L)
	Na-22	0.14	1.68	pCi/g	5/5	1.22	0.45	UCL95(N)
	Ni-63	92	33,000	pCi/g	10/10	19,300	0.03	UCL95(N)
	Pb-210	0.92	7.99	pCi/g	5/5	5.58	0.02	UCL95(N)
	Pb-212	0.22	9.13	pCi/g	55/55	1.63	0.02	UCL95(L)
	Pb-214	0.21	1.33	pCi/g	52/52	0.879	0.03	UCL95(N)
	Pu-240	0	206	pCi/g	33/49	22.8	0.02	UCL95(N)
	Ra-226	0.09	1.37	pCi/g	110/118	0.834	0.26	UCL95(L)

Table 2.2. Summary of COCs and exposure point concentrations for soil under future conditions (i.e., industrial use), Bethel Valley, ORNL, Oak Ridge, Tennessee (continued)

Scenario timeframe: future
Medium: soil
Exposure medium: soil

Exposure point	COC	Concentration detected Min	Concentration detected Max	Units	Frequency of detection	Exposure point conc.	% Total risk	Statistical measure
Central Bethel Valley 3000 South Area (continued)	Ra-228	0.20	9.09	pCi/g	113/119	1.52	0.23	UCL95(L)
	Th-228	0.3	27.1	pCi/g	124/128	2.30	0.65	UCL95(N)
	Tl-208	0.31	7.89	pCi/g	55/55	1.46	0.97	UCL95(L)
	U-238	0.3	4,260	pCi/g	111/117	177	0.57	UCL95(N)
	Y-91	543	543	pCi/g	2/2	543	0.37	UCL95(N)
	Zr-95	18.4	18.4	pCi/g	2/2	18.4	2.40	UCL95(N)
Central Bethel Valley 4000 Area	Arsenic	1.2	27.0	mg/kg	17/21	16.1	2.45	UCL95 (L)
	Benz(a)anthracene	0.07	6.60	mg/kg	9/15	1.45	1.85	UCL95(L)
	Benzo(a)pyrene	0.07	8.00	mg/kg	8/15	1.59	9.50	UCL95(L)
	Benzo(b)fluoranthene	0.14	9.70	mg/kg	7/15	2.07	4.95	UCL95(L)
	Dibenz(a,h)anthracene	0.16	1.70	mg/kg	4/15	0.639	1.85	UCL95(L)
	Ac-228	0.79	0.79	pCi/g	2/2	0.79	6.00	UCL95(N)
	Bi-212	1.35	1.35	pCi/g	2/2	1.35	2.05	UCL95(N)
	Co-60	0.14	1.02	pCi/g	2/2	3.37	22.50	MAX(N)
	Cs-137	0.02	20.6	pCi/g	11/21	0.999	4.75	UCL95(L)
	Pb-212	0.12	1.23	pCi/g	14/14	0.783	0.55	UCL95(L)
	Pb-214	0.200	0.930	pCi/g	10/10	0.612	1.00	UCL95(N)
	Ra-228	0.39	1.16	pCi/g	17/17	0.911	7.00	UCL95(N)
	Tl-208	0.23	1.10	pCi/g	10/10	1.01	33.50	UCL95(L)
	U-238	0.3	11.8	pCi/g	11/12	6.80	1.10	UCL95(L)
East Bethel Valley area	None Area Risk < 1×10^{-4} and HI < 1	—	—	—	—	—	—	—

This table presents the COCs and EPCs for each of the COCs detected in soil (i.e., the concentration that was used to estimate the exposure and risk from each COC in soil). The table includes the range of concentrations detected for each COC, as well as the frequency of detection (i.e., the number of times the chemical was detected in samples collected at the site), the EPC, and how the EPC was derived (statistical measure).

The table indicates that the most common class of contaminants detected in soil was radionuclides (e.g., 137Cs) and that the majority of the total risk for an industrial worker (i.e., total excess lifetime cancer risk) was due to exposure to radionuclides.

% Total risk = Excess lifetime cancer risk due to exposure to the single analyte divided by risk from exposure to all contaminants in soil. Note that the sum of all percentages may not equal 100% due to rounding error.

COC = contaminant of concern
EPC = exposure point concentration
HI = hazard index
Max = Maximum detected concentration
MAX(L) = EPC is the maximum detected concentration of a log normal distribution.
MAX(N) = EPC is the maximum detected concentration of a normal distribution.
MAX(NT) = EPC is the detected concentration in a single sample.
Min = Minimum detected concentration
ORNL = Oak Ridge National Laboratory
UCL95(L) = EPC is the 95% upper confidence level on the mean concentration of a log normal distribution.
UCL95(N) = EPC is the 95% upper confidence level on the mean concentration of a normal distribution.
For equations used to derive the UCL95(L) and UCL95(N), see Sect. C.2 (Data Evaluation) of the approved RI/FS for Bethel Valley Watershed (DOE 1999a).

Table 2.3. Summary of COCs and exposure point concentrations for sediment under future conditions (i.e., recreational use), Bethel Valley, ORNL, Oak Ridge, Tennessee

Scenario timeframe: future
Medium: sediment
Exposure medium: sediment

Exposure point	COC	Concentration detected Min	Concentration detected Max	Units	Frequency of detection	Exposure point conc.	COC type	Statistical measure
Raccoon Creek Area	None No COPCs	—	—	—	—	—	—	—
West Bethel Valley	None No COPCs	—	—	—	—	—	—	—
Central Bethel Valley 2000 Area	^{137}Cs	1.46	2480	pCi/g	6/6	Various	>	Various
	^{60}Co	0.027	12.6	pCi/g	3/4	Various	<	Various
	^{22}Na	0.814	0.815	pCi/g	2/2	Various	<	Various
	^{152}Eu	2.57	4.81	pCi/g	2/2	Various	<	Various
	^{154}Eu	2.04	2.16	pCi/g	2/2	Various	<	Various
	Aroclor-1260	0.57	3.9	mg/kg	3/5	Various	<	Various
	Aroclor-1254	0.46	12.0	mg/kg	4/5	Various	<	Various
	Benzo(a)pyrene	5.0	5.0	mg/kg	1/7	Various	<	Various
	Hexachlorobenzofuran	0.001	0.001	mg/kg	1/1	Various	<	Various
Central Bethel Valley 3000 North Area	None All Point Risks < 1×10^{-4} and Point HIs < 1	—	—	—	—	—	—	—
Central Bethel Valley 3000 South Area	None All Point Risks < 1×10^{-4} and Point HIs < 1	—	—	—	—	—	—	—
Central Bethel Valley 4000 Area	None All Point Risks < 1×10^{-4} and Point HIs < 1	—	—	—	—	—	—	—
East Bethel Valley area	None No COPCs	—	—	—	—	—	—	—

This table presents the COCs and EPCs for each of the COCs detected in sediment (i.e., the concentration that was used to estimate the exposure and risk from each COC in sediment). The table includes the range of concentrations detected for each COC, as well as the frequency of detection (i.e., the number of times the chemical was detected in samples collected at the site), the EPC, and how the EPC was derived (statistical measure).

Most importantly, the table indicates that COCs were not identified for all areas. However, for those areas with COCs, the classes of contaminants identified were radionuclides (e.g., ^{137}Cs), semivolatile organic compounds (e.g., Aroclors and polycyclic aromatic hydrocarbons), and metals (e.g., mercury).

COC = contaminant of concern
COPC = contaminant of potential concern
COC Type = In the point-by-point assessment, COCs with individual excess lifetime cancer risks greater than (>) 1×10^{-4} or with hazard quotients greater than 1 were termed "primary COCs." COCs with individual excess lifetime cancer risks less than (<) 1×10^{-4} but greater than 1×10^{-6} or with hazard quotients less than 1 but greater than 0.1 were termed "secondary COCs." Here, ">" is used to denote "primary COCs" and "<" is used to denote "secondary COCs."
EPC = exposure point concentration
HI = hazard index
Max = maximum detected concentration
Min = minimum detected concentration
ORNL = Oak Ridge National Laboratory
Various = Both the exposure point concentration and the statistical measure varied with location. For most locations, the statistical measure used was the maximum detected concentrations.

Table 2.4. Summary of COCs and exposure point concentrations for surface water under future conditions (i.e., recreational use), Bethel Valley, ORNL, Oak Ridge, Tennessee

Scenario timeframe: future Medium: surface water Exposure medium: surface water								
Exposure point	COC	Concentration detected Min	Max	Units	Frequency of detection	Exposure point conc.	COC type	Statistical measure
Raccoon Creek Area	None All Point Risks < 1×10^{-4} and Point HIs < 1	—	—	—	—	—	—	—
West Bethel Valley	None All Point Risks < 1×10^{-4} and Point HIs < 1	—	—	—	—	—	—	—
Central Bethel Valley 2000 Area	None All Point Risks < 1×10^{-4} and Point HIs < 1	—	—	—	—	—	—	—
Central Bethel Valley 3000 North Area	None No COPCs	—	—	—	—	—	—	—
Central Bethel Valley 3000 South Area	None All Point Risks < 1×10^{-4} and Point HIs < 1	—	—	—	—	—	—	—
Central Bethel Valley 4000 Area	None No COPCs	—	—	—	—	—	—	—
East Bethel Valley area	None No COPCs	—	—	—	—	—	—	—

This table presents the COCs and EPCs for each of the COCs detected in surface water (i.e., the concentration that was used to estimate the exposure and risk from each COC in surface water). The table includes the range of concentrations detected for each COC, as well as the frequency of detection (i.e., the number of times the chemical was detected in samples collected at the site), EPC, and how the EPC was derived (statistical measure).

As indicated above, there were no COCs in surface water for the recreational user because risks did not exceed the benchmarks used to select COCs.

COC = contaminant of concern

COC Type = In the point-by-point assessment, COCs with individual excess lifetime cancer risks greater than (>) 1×10^{-4} or with hazard quotients greater than 1 were termed "primary COCs." COCs with individual excess lifetime cancer risks less than (<) 1×10^{-4} but greater than 1×10^{-6} or with hazard quotients less than 1 but greater than 0.1 were termed "secondary COCs." Here, ">" is used to denote "primary COCs" and "<" is used to denote "secondary COCs."

COPC = contaminant of potential concern

EPC = exposure point concentration

HI = hazard index

Min = minimum detected concentration

Max = maximum detected concentration

NA = Value was not available from documentation at the time the table was prepared.

ORNL = Oak Ridge National Laboratory

Table 2.5. Summary of COCs and exposure point concentrations for groundwater under future conditions (i.e., industrial use), Bethel Valley, ORNL, Oak Ridge, Tennessee

Scenario timeframe: future
Medium: groundwater
Exposure medium: groundwater

Exposure point	COC	Concentration detected Min	Max	Units	Frequency of detection	Exposure point conc.	% Total risk	Statistical measure
Raccoon Creek Area	None	—	—	—	—	—	—	—
	No Data							
West Bethel Valley	None	—	—	—	—	—	—	—
	Area Risk < 1×10^{-4} and HI < 1							
Central Bethel Valley 2000 Area	Arsenic	0.001	0.282	mg/L	22/174	0.0177	0.93	UCL95(N)
	Beryllium	0.0002	0.0310	mg/L	55/176	0.00416	0.62	UCL95(N)
	Chromium	0.002	0.387	mg/L	88/176	0.0369	NC	UCL95(N)
	Fluoride	0.05	5.90	mg/L	97/165	0.675	NC	UCL95(L)
	Manganese	0.0005	9.40	mg/L	160/176	2.01	NC	UCL95(N)
	Am-241	0.02	28.4	pCi/L	7/14	4.24	0.09	UCL95(L)
	C-14	189	112,000	pCi/L	25/25	112,000	7.20	MAX(L)
	Ca-45	59	45,000	pCi/L	2/2	45,000	5.70	MAX(N)
	Ce-144	36	36.0	pCi/L	1/1	36.0	0.07	MAX(NT)
	Cm-244	0.6	87.6	pCi/L	1/3	87.6	1.20	MAX(N)
	Cs-137	0	6,400	pCi/L	27/168	115	0.23	UCL95(N)
	H-3	0	360,000	pCi/L	162/188	19,600	0.09	UCL95(N)
	K-40	1.59	1,940	pCi/L	5/16	547	0.43	UCL95(L)
	Pb-210	443	443	pCi/L	1/1	443	28.00	MAX(NT)
	Pb-212	2.9	56.8	pCi/L	4/5	54.5	0.06	UCL95(N)
	Pm-147	0	47,400	pCi/L	20/35	6,280	0.55	UCL95(N)
	Pu-242	0.59	1.28	pCi/L	2/2	1.28	0.02	MAX(N)
	Ra-226	0	52.0	pCi/L	35/55	3.92	0.07	UCL95(N)
	Ra-228	1	1,980	pCi/L	12/31	25.4	0.39	UCL95(L)
	Sr-89	0	6,690	pCi/L	2/4	5,770	3.70	UCL95(N)
	Sr-90	0	312,000	pCi/L	97/140	14,100	49.00	UCL95(N)
	Tc-99	0	1,360	pCi/L	16/45	135	0.01	UCL95(N)
	Th-228	0	240	pCi/L	52/72	11.8	0.17	UCL95(N)
	U-232	16.2	29.3	pCi/L	4/4	29.3	0.15	MAX(N)
	U-234	0.09	4,560	pCi/L	66/77	178	0.49	UCL95(N)
	U-235	0	43.0	pCi/L	28/77	3.53	0.01	UCL95(N)
	U-238	0.07	324	pCi/L	60/77	10.4	0.04	UCL95(L)
Central Bethel Valley 3000 North Area	Arsenic	0.0010	0.0241	mg/L	12/64	0.00354	0.13	UCL95(L)
	Beryllium	0.0002	0.0300	mg/L	28/64	0.00177	0.18	UCL95(L)
	Trichloroethene	0.002	0.440	mg/L	14/58	0.0410	0.01	UCL95(N)
	Chromium	0.002	0.263	mg/L	46/64	0.0332	NC	UCL95(L)
	Uranium	NA	2.20	mg/L	3/4	1.85	NC	UCL95(N)
	Pyridine	0.0260	0.0260	mg/L	1/1	0.0260	NC	MAX(NT)
	Am-241	0.02	20.4	pCi/L	3/10	1.96	0.03	UCL95(L)
	Bi-212	366	366	pCi/L	1/1	366	0.01	MAX(NT)
	C-14	50.0	4,660	pCi/L	5/6	2,910	0.12	UCL95(N)
	Ce-144	41.3	41.3	pCi/L	1/1	41.3	0.05	MAX(NT)
	Cm-244	3	108	pCi/L	2/3	108	0.93	MAX(N)
	Cs-137	0	2,730	pCi/L	12/66	136	0.18	UCL95(N)
	H-3	0	236,000	pCi/L	64/78	26,500	0.08	UCL95(N)

Table 2.5. Summary of COCs and exposure point concentrations for groundwater under future conditions (i.e., industrial use), Bethel Valley, ORNL, Oak Ridge, Tennessee (continued)

Scenario timeframe: future
Medium: groundwater
Exposure medium: groundwater

Exposure point	COC	Concentration detected Min	Max	Units	Frequency of detection	Exposure point conc.	% Total risk	Statistical measure
Central Bethel Valley 3000 North Area (continued)	K-40	107	254	pCi/L	2/9	249	0.12	UCL95(L)
	Ni-63	9	673	pCi/L	5/5	514	0.01	UCL95(N)
	Pb-212	49.1	71.4	pCi/L	3/3	71.4	0.05	UCL95(N)
	Ra-226	0	6.75	pCi/L	12/20	2.37	0.03	UCL95(N)
	Ra-228	0.4	938	pCi/L	13/16	157	1.60	UCL95(L)
	Sr-90	0	724,000	pCi/L	41/59	41,100	93.33	UCL95(N)
	Tc-99	0	5,020	pCi/L	11/17	1,170	0.07	UCL95(N)
	Th-228	0	8.67	pCi/L	16/23	2.77	0.03	UCL95(N)
	U-232	NA	1,020	pCi/L	2/2	1,020	3.47	MAX(N)
	U-234	0.215	64,000	pCi/L	26/31	48.0	0.09	UCL95(L)
	U-235	0.01	3,080	pCi/L	9/31	273	0.53	UCL95(N)
	U-236	NA	152	pCi/L	3/4	127	0.22	UCL95(N)
	U-238	0.11	7,040	pCi/L	21/31	13.6	0.04	UCL95(L)
Central Bethel Valley 3000 South Area	Arsenic	0.0010	0.0110	mg/L	16/82	0.00257	2.17	UCL95(L)
	Beryllium	0.0002	0.030	mg/L	12/82	0.000619	1.55	UCL95(L)
	Manganese	0.0029	14.4	mg/L	82/82	8.94	NC	UCL95(L)
	Vinyl chloride	0.0050	0.0280	mg/L	13/79	0.00780	8.67	UCL95(N)
	Am-241	0.50	1.69	pCi/L	1/3	1.69	0.58	UCL95(N)
	C-14	188	27,800	pCi/L	5/5	18,100	20.00	UCL95(N)
	Ca-45	27	1,860	pCi/L	2/2	1,860	3.83	MAX(N)
	Cm-244	34.2	34.2	pCi/L	1/1	34.2	7.50	MAX(NT)
	H-3	0	897,000	pCi/L	100/112	111,000	8.33	UCL95(N)
	K-40	96.0	385	pCi/L	1/4	356	4.67	UCL95(N)
	Pb-212	29.7	29.7	pCi/L	1/1	29.7	0.55	MAX(NT)
	Pm-147	0	490	pCi/L	3/9	187	0.28	UCL95(N)
	Ra-226	0.10	8.00	pCi/L	10/30	1.33	0.42	UCL95(L)
	Ra-228	2	1,870	pCi/L	14/24	45.2	11.67	UCL95(L)
	Sr-90	0	10,300	pCi/L	54/76	503	30.00	UCL95(N)
	Th-228	0.03	13.9	pCi/L	16/35	1.28	0.30	UCL95(L)
	U-234	0.5	25.0	pCi/L	22/35	4.10	0.18	UCL95(L)
	Zn-65	53.4	53.4	pCi/L	1/1	53.4	0.55	MAX(NT)
Central Bethel Valley 4000 Area	Beryllium	0.0002	0.030	mg/L	13/97	0.00133	10.00	UCL95(N)
	H-3	0	14,100	pCi/L	74/75	3,340	0.75	UCL95(N)
	Ra-226	0.26	2.00	pCi/L	7/13	0.985	0.90	UCL95(L)
	Ra-228	1	1,400	pCi/L	5/11	48.8	38.00	UCL95(L)
	Sr-90	0	3,900	pCi/L	19/59	251	44.00	UCL95(N)
	Th-228	0.09	1.56	pCi/L	10/13	1.27	0.90	UCL95(L)
	Th-232	0	53.0	pCi/L	3/14	10.8	1.10	UCL95(N)
	U-234	1	118	pCi/L	7/11	41.9	6.00	UCL95(L)
East Bethel Valley area	1,1-Dichloroethene	0.003	0.026	mg/L	7/57	0.0113	7.06	UCL95(N)
	1,2-Dichloroethene	0.001	4.00	mg/L	15/57	0.545	NC	UCL95(N)
	Benzene	0.0025	0.0210	mg/L	8/57	0.0105	0.32	UCL95(N)
	Tetrachloroethene	0.0025	0.0320	mg/L	7/57	0.0110	0.59	UCL95(N)
	Trichloroethene	0.001	15.0	mg/L	20/57	2.22	25.0	UCL95(N)
	Vinyl chloride	0.005	0.160	mg/L	7/57	0.0332	64.7	UCL95(N)
	H-3	0	15,100	pCi/L	46/48	6,000	0.79	UCL95(N)

Table 2.5. Summary of COCs and exposure point concentrations for groundwater under future conditions (i.e., industrial use), Bethel Valley, ORNL, Oak Ridge, Tennessee (continued)

This table presents the COCs and EPCs for each of the COCs detected in surface water (i.e., the concentration that was used to estimate the exposure and risk from each COC in surface water). The table includes the range of concentrations detected for each COC, as well as the frequency of detection (i.e., the number of times the chemical was detected in samples collected at the site), the EPC, and how the EPC was derived.

Most importantly, the table indicates that COCs were not identified for all areas. However, for those areas with COCs identified, the most common classes of contaminants were radionuclides (e.g., ^{137}Cs) and organic compounds (e.g., 1,1-dichloroethene, vinyl chloride).

% Total risk = Excess lifetime cancer risk due to exposure to the single analyte divided by risk from exposure to all contaminants in groundwater. Note that the sum of all percentages may not equal 100% due to rounding error.

COC = contaminant of concern
EPC = exposure point concentration
HI = hazard index
Max = maximum detected concentration
MAX(L) = EPC is the maximum detected concentration of a log normal distribution.
MAX(N) = EPC is the maximum detected concentration of a normal distribution.
MAX(NT) = EPC is the detected concentration in a single sample.
Min = minimum detected concentration
NA = Value was not available from documentation at the time the table was prepared.
NC = COC is a noncarcinogen and % total risk could not be calculated.
ORNL = Oak Ridge National Laboratory
UCL95(L) = EPC is the 95% upper confidence level on the mean concentration of a log normal distribution.
UCL95(N) = EPC is the 95% upper confidence level on the mean concentration of a normal distribution.
For equations used to derive the UCL95(L) and UCL95(N), see Sect. C.2 (Data Evaluation) of the approved RI/FS for Bethel Valley Watershed (DOE 1999a).

assessment is a procedure whereby significant pathways of human exposure are identified via pathway analysis and doses to receptors are quantified in the risk assessment. Throughout the exposure assessment the guiding principle is that in order to be quantified, the exposure pathway has to be complete either now or in the future. A complete pathway is one that includes a source of contamination and mechanism of release, a method of transport or retention, an exposure point, and a route of exposure. If any of these parts are absent, then the exposure pathway is deemed incomplete and is not quantified in the risk assessment.

Pathway analysis identified three human health exposure scenarios to be evaluated for the Bethel Valley area in the baseline human health risk assessment. These were the unrestricted industrial worker exposure scenario, the recreational exposure scenario, and the residential exposure scenario. These scenarios are the primary scenarios evaluated at all Oak Ridge sites and reflect the consensus among decision makers about what land use scenarios should be evaluated in baseline human health risk assessments for the DOE ORR. Although current contaminant concentrations were used for the calculation of risk under all scenarios, the scenarios were determined to be applicable to hypothetical future and not current conditions only because of the site controls in place within ORNL. Risks to workers and other receptors under current conditions were not estimated and were assumed to be below levels of concern due to these site controls. Note that the use of current concentrations for future exposures generally defines the maximum exposure to Bethel Valley contaminants under all future land use scenarios because the majority of the risk-driving radionuclides will decay over time to lower concentrations.

A quantitative analysis of risk is presented in the baseline risk assessment for exposure to environmental media (i.e., soil, sediment, surface water, and groundwater) within each area, and a qualitative analysis of risk is presented for exposure to residual radioactive contamination in buildings. Because risks and hazards from exposures to primary waste units (e.g., waste disposal areas, tanks, and pipelines) were assumed to be very high and to exceed the risk range, quantitative analyses of these risks were not performed. However, remedies for contamination within primary waste areas are considered later in the FS.

The conceptual model for the exposure assessment is depicted in Fig. 2.8. As shown in this figure, routes evaluated for the future unrestricted industrial exposure scenario for surface soil and sediment were incidental ingestion (i.e., ingestion of soil through inhalation and subsequent ingestion of large particulates and through hand-to-mouth actions), inhalation of dust/particulates, dermal contact, and external exposure to ionizing radiation. For surface water and groundwater, the route evaluated for the industrial scenario was ingestion of water. In addition, the industrial exposure scenario was used to qualitatively evaluate external exposure to contaminants in some buildings.

The recreational scenario assumes the area is developed as a recreational area (e.g., park, hunting area) and receptors are incidentally exposed to contaminants in soil, surface water, and sediment. Routes evaluated for the future recreational exposure scenario for surface soil and sediment were also incidental ingestion, inhalation of dust/particulates, dermal contact, and external exposure to ionizing radiation. For surface water and groundwater, the route evaluated was ingestion of water. Consumption of biota (i.e., fish) was not considered in the Bethel Valley baseline human health risk assessment because streams in Bethel Valley were deemed incapable of supporting subsistence fishing (i.e., fishing that provides a catch that is large enough to become a substantial portion of an individual's diet) due to a limited game fish population.

The residential scenario assumes the area is developed for housing and residents are exposed through drinking the groundwater and coming in contact with other contaminated media over a lifetime. This scenario evaluates risk associated with the site in the absence of any controls. Routes evaluated for the future residential exposure scenario were quite extensive and included several direct contact and

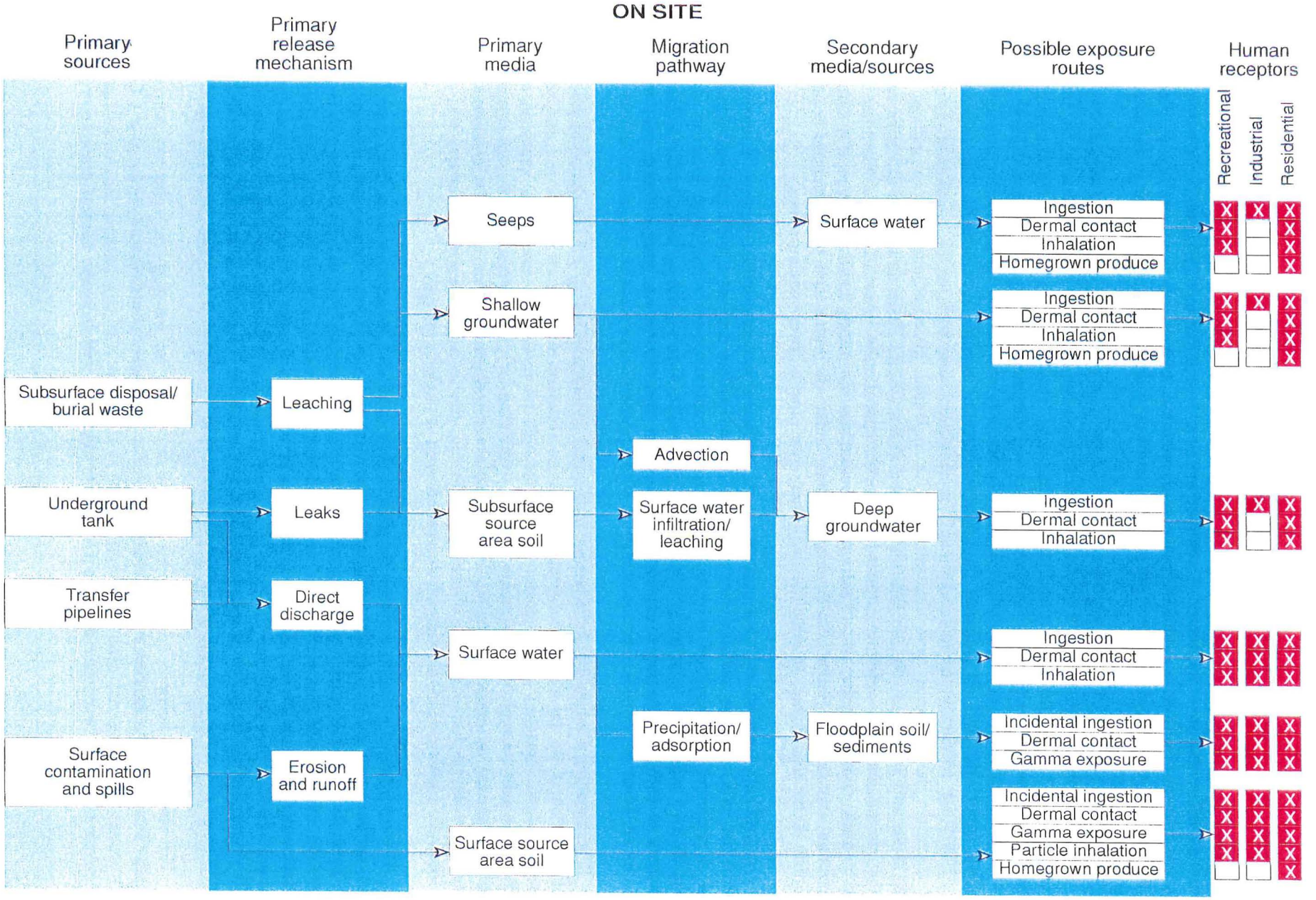


Fig. 2.8. Conceptual model for potential human health exposure scenarios.

indirect exposure routes. Direct contact exposure routes included incidental ingestion of soil and sediment, inhalation of dust/particulates emitted by soil and sediment, dermal contact with soil and sediment, external exposure to ionizing radiation emitted by soil and sediment, ingestion of surface water and groundwater as a drinking water source, dermal contact with surface water and groundwater during household use, and inhalation of VOCs and radionuclides emitted by surface water and groundwater during household use. Indirect exposure routes included consumption of homegrown produce and inhalation of particulates emitted by soil contaminated through irrigation with contaminated surface water.

Exposure parameters used in all exposure equations were those used to derive chronic dose estimates (i.e., chronic daily intakes and chronic absorbed dose). The value of each of these parameters was approved by stakeholders. Additionally, use of these parameters yielded dose estimates that allowed for the estimation of dose over a lifetime of exposure (i.e., 25 years for the industrial worker and 30 years for the resident and recreational user) under frequent use (i.e., 250 days per year for the industrial worker, 350 days/year for the resident, and 75 days/year for the recreational user.) Finally, in keeping with current guidance, doses used to calculate residential and recreational cancer risk estimates included exposure durations as both a child (6 years) and an adult (24 years), and doses used to calculate residential and recreational systemic toxicity hazard estimates were calculated separately for a child and an adult.

2.7.1.3 Toxicity assessment

As noted above, the toxicity of the COCs was used along with the dose calculations to quantify the ELCRs and systemic toxicity to potential receptors. This section describes the toxicity assessment process and summarizes the results of the toxicity assessment. As with the earlier discussion of COCs, most information is contained in the tables presented in this section.

In order to characterize risk using the dose estimates calculated as part of the exposure assessment, toxicity values for cancer effects and noncancer (i.e., systemic toxicity) effects were gathered from approved sources. Primary among these sources were EPA's Integrated Risk Information System and Health Effects Assessment Summary Tables. Additional toxicity values were from communications with the Superfund Technical Support Center in Cincinnati, Ohio. Toxicity values from all of these sources are in Tables 2.6 and 2.7. Table 2.6 presents toxicity values used to estimate cancer risks, and Table 2.7 presents toxicity values used to estimate the potential for systemic toxicity.

The toxicity values used in the risk assessment were slope factors, for cancer risks, and reference doses (RfDs) and reference concentrations, for systemic toxicity. Slope factors were used to quantitatively define the relationship between daily intake of a chemical and ELCR, and RfDs and concentrations were used to quantitatively define the relationship between daily intake of a chemical and systemic toxicity. Specifically, the slope factors used in the assessment are upper-bound estimates of the probability of a response per unit intake of a carcinogen over a lifetime, and the RfDs and concentrations used in the assessment are estimates of a daily exposure level for the human population that is likely to be without an appreciable risk of deleterious effects during a lifetime. Section 2.7.1.4 provides the mathematical expressions used to combine the chemical intakes with the toxicity values to derive estimates of ELCR and systemic toxicity.

As shown in Tables 2.6 and 2.7, toxicity values were lacking for some chemical/endpoint combinations. However, these tables also show that cancer toxicity values were available for each of the radionuclides. (The systemic toxicity endpoint does not apply to radionuclides.)

Table 2.6. Cancer toxicity data summary for the baseline human health risk assessment for Bethel Valley, ORNL, Oak Ridge, Tennessee

Route: ingestion and dermal contact					
Contaminant of concern	Oral slope factor (mg/kg-d)	Dermal slope factor (mg/kg-d)	Weight of evidence/ types of cancer	Source	Date accessed
Ac-228	1.62E-12	NA	A, various	HEAST	1999
Am-241	3.28E-10	NA	A, various	HEAST	1999
Aroclor-1260	2.00E+00	2.22E+00	B2	IRIS	1999
Aroclor-1254	2.00E+00	2.22E+00	B2	IRIS	1999
Arsenic	1.50E+00	3.66E+00	A, respiratory system tumors	IRIS	1999
Be-7	8.64E-14	NA	A, various	HEAST	1999
Benz(a)anthracene	7.30E-01	2.35E+00	B2, stomach	IRIS	1999
Benzene	2.90E-02	2.99E-02	A, pulmonary tissue, leukemia	IRIS	1999
Benzo(a)pyrene	7.30E+00	2.35E+01	B2, stomach, nasal cavity, larynx, trachea, and pharynx	IRIS	1999
Benzo(b)fluoranthene	7.30E-01	2.35E+00	B2	IRIS	1999
Beryllium[a]	4.30E+00	4.30E+02	B1, breast, uterus, lung, bone tumors	IRIS	1999
Bi-212	6.20E-13	NA	A, various	HEAST	1999
Bi-214	1.95E-13	NA	A, various	HEAST	1999
C-14	1.03E-12	NA	A, various	HEAST	1999
Ca-45	2.02E-12	NA	A, various	HEAST	1999
Ce-144	2.96E-11	NA	A, various	HEAST	1999
Chromium (III) (Salts)	NA	NA	D	IRIS	1999
Chromium (VI)	NA	NA	A, lung tumors	IRIS	1999
Cm-244	2.11E-10	NA	A, various	HEAST	1999
Co-57	9.71E-13	NA	A, various	HEAST	1999
Co-58	2.82E-12	NA	A, various	HEAST	1999
Co-60	1.89E-11	NA	A, various	HEAST	1999
Cs-134	4.73E-11	NA	A, various	HEAST	1999
Cs-137	3.16E-11	NA	A, various	HEAST	1999
Dibenz(a,h)anthracene	7.30E+00	2.35E+01	B2, immunodepressive effects	IRIS	1999
Eu-152	5.73E-12	NA	A, various	HEAST	1999
Eu-154	9.37E-12	NA	A, various	HEAST	1999
Eu-155	1.65E-12	NA	A, various	HEAST	1999
H-3	7.15E-14	NA	A, various	HEAST	1999
Hexachlorodibenzofuran	1.50E+04	3.00E+04	B2, liver	IRIS	1999
I-129	1.84E-10	NA	A, various	HEAST	1999
K-40	1.25E-11	NA	A, various	HEAST	1999
Na-22	8.02E-12	NA	A, various	HEAST	1999
Ni-63	5.50E-13	NA	A, various	HEAST	1999
Pb-210	6.75E-10	NA	A, various	HEAST	1999
Pb-212	1.80E-11	NA	A, various	HEAST	1999
Pb-214	2.94E-13	NA	A, various	HEAST	1999
Pm-147	1.41E-12	NA	A, various	HEAST	1999
Pu-240	3.15E-10	NA	A, various	HEAST	1999
Pu-242	3.00E-10	NA	A, various	HEAST	1999
Ra-226	2.95E-10	NA	A, various	HEAST	1999
Ra-228	2.46E-10	NA	A, various	HEAST	1999
Ru-106	3.45E-11	NA	A, various	HEAST	1999
Sr-89	1.03E-11	NA	A, various	HEAST	1999

Table 2.6. Cancer toxicity data summary for the baseline human health risk assessment for Bethel Valley, ORNL, Oak Ridge, Tennessee (continued)

Route: ingestion and dermal contact (continued)					
Contaminant of concern	Oral slope factor (mg/kg-d)	Dermal slope factor (mg/kg-d)	Weight of evidence/ types of cancer	Source	Date accessed
Sr-90	4.09E-11	NA	A, various	HEAST	1999
Tc-99	1.40E-12	NA	A, various	HEAST	1999
Tetrachloroethene	5.20E-02	5.20E-02	PROV, leukemia, liver cancer	OTHER	1999
Th-228	6.29E-11	NA	A, various	HEAST	1999
Th-232	3.28E-11	NA	A, various	HEAST	1999
Tl-208	1.75E-14	NA	A, various	HEAST	1999
Trichloroethene	1.10E-02	7.33E-02	PROV, liver, lung cancer	OTHER	1999
U-232	8.12E-11	NA	A, various	HEAST	1999
U-234	4.44E-11	NA	A, various	HEAST	1999
U-235	4.52E-11	NA	A, various	HEAST	1999
U-236	4.21E-11	NA	A, various	HEAST	1999
U-238	4.27E-11	NA	A, various	HEAST	1999
Vinyl chloride	1.90E+00	1.90E+00	A, liver, lung, digestive track, brain tumors	HEAST	1999
Y-91	1.35E-11	NA	A, various	HEAST	1999
Zn-65	9.93E-12	NA	A, various	HEAST	1999
Zr-95	3.92E-12	NA	A, various	HEAST	1999
Route: inhalation					
Contaminant of concern	Inhalation slope factor (mg/kg-d)		Weight of evidence/ types of cancer	Source	Date accessed
Ac-228	3.27E-11		A, various	HEAST	1999
Am-241	3.85E-08		A, various	HEAST	1999
Aroclor-1260	2.00E+00		B2	IRIS	1999
Aroclor-1254	2.00E+00		B2	IRIS	1999
Arsenic	5.00E+01		A, respiratory system tumors	IRIS	1999
Be-7	1.78E-13		A, various	HEAST	1999
Benz(a)anthracene	3.10E-01		B2, stomach tumors	IRIS	1999
Benzene	2.90E-02		A, pulmonary tissue, leukemia	HEAST	1999
Benzo(a)pyrene	3.10E+00		B2, stomach, nasal cavity, larynx, trachea, and pharynx	IRIS	1999
Benz(b)fluoranthene	3.10E-01		B2	IRIS	1999
Beryllium	8.40E+00		B1, breast, uterus, lung, bone tumors	HEAST	1999
Bi-212	3.65E-11		A, various	HEAST	1999
Bi-214	1.46E-11		A, various	HEAST	1999
C-14	6.99E-15		A, various	HEAST	1999
Ca-45	2.51E-12		A, various	HEAST	1999
Ce-144	1.08E-10		A, various	HEAST	1999
Chromium (III) (salts)	NA		D	IRIS	1999
Chromium (VI)	4.10E+01		A, lung tumors	IRIS	1999
Cm-244	2.43E-08		A, various	HEAST	1999
Co-57	2.88E-12		A, various	HEAST	1999
Co-58	5.17E-12		A, various	HEAST	1999
Co-60	6.88E-11		A, various	HEAST	1999
Cs-134	2.89E-11		A, various	HEAST	1999
Cs-137	1.91E-11		A, various	HEAST	1999
Dibenz(a,h)anthracene	3.10E+00		B2, immunodepressive effects	IRIS	1999

Table 2.6. Cancer toxicity data summary for the baseline human health risk assessment for Bethel Valley, ORNL, Oak Ridge, Tennessee (continued)

Route: inhalation (continued)				
Contaminant of concern	Inhalation slope factor (mg/kg-d)	Weight of evidence/ types of cancer	Source	Date accessed
Eu-152	7.91E-11	A, various	HEAST	1999
Eu-154	9.15E-11	A, various	HEAST	1999
Eu-155	9.60E-12	A, various	HEAST	1999
H-3	9.59E-14	A, various	HEAST	1999
Hexachlorodibenzofuran	1.50E+04	B2,liver	IRIS	1999
I-129	1.22E-10	A, various	HEAST	1999
K-40	7.46E-12	A, various	HEAST	1999
Na-22	4.88E-12	A, various	HEAST	1999
Ni-63	1.01E-12	A, various	HEAST	1999
Pb-210	1.67E-09	A, various	HEAST	1999
Pb-212	3.85E-11	A, various	HEAST	1999
Pb-214	6.23E-12	A, various	HEAST	1999
Pm-147	7.49E-12	A, various	HEAST	1999
Pu-240	2.78E-08	A, various	HEAST	1999
Pu-242	2.64E-08	A, various	HEAST	1999
Ra-226	2.72E-09	A, various	HEAST	1999
Ra-228	9.61E-10	A, various	HEAST	1999
Ru-106	1.15E-10	A, various	HEAST	1999
Sr-89	3.68E-12	A, various	HEAST	1999
Sr-90	5.94E-11	A, various	HEAST	1999
Tc-99	2.89E-12	A, various	HEAST	1999
Tetrachloroethene	2.00E-03	PROV, leukemia, liver cancer	OTHER	1999
Th-228	9.45E-08	A, various	HEAST	1999
Th-232	1.93E-08	A, various	HEAST	1999
Tl-208	1.36E-14	A, various	HEAST	1999
Trichloroethene	6.00E-03	PROV, liver, lung cancer	OTHER	1999
U-232	5.29E-08	A, various	HEAST	1999
U-234	1.40E-08	A, various	HEAST	1999
U-235	1.30E-08	A, various	HEAST	1999
U-236	1.32E-08	A, various	HEAST	1999
U-238	1.24E-08	A, various	HEAST	1999
Vinyl chloride	3.00E-01	A, liver, lung, digestive track, brain tumors	HEAST	1999
Y-91	1.85E-11	A, various	HEAST	1999
Zn-65	9.98E-12	A, various	HEAST	1999
Zr-95	6.48E-12	A, various	HEAST	1999
Route: external exposure				
Contaminant of concern	External slope factor (mg/kg-d)	Weight of evidence/ types of cancer	Source	Date accessed
Ac-228	3.28E-06	A, various	HEAST	1999
Am-241	4.59E-09	A, various	HEAST	1999
Be-7	1.73E-07	A, various	HEAST	1999
Bi-212	6.67E-07	A, various	HEAST	1999
Bi-214	6.02E-06	A, various	HEAST	1999
C-14	0.00E+00	A, various	HEAST	1999
Ca-45	3.88E-18	A, various	HEAST	1999
Ce-144	2.58E-08	A, various	HEAST	1999

Table 2.6. Cancer toxicity data summary for the baseline human health risk assessment for Bethel Valley, ORNL, Oak Ridge, Tennessee (continued)

Route: external exposure (continued)				
Contaminant of concern	External slope factor (mg/kg-d)	Weight of evidence/ types of cancer	Source	Date accessed
Cm-244	2.07E-11	A, various	HEAST	1999
Co-57	2.07E-07	A, various	HEAST	1999
Co-58	3.73E-06	A, various	HEAST	1999
Co-60	9.76E-06	A, various	HEAST	1999
Cs-134	5.88E-06	A, various	HEAST	1999
Cs-137	0.00E+00	A, various	HEAST	1999
Eu-152	4.08E-06	A, various	HEAST	1999
Eu-154	4.65E-06	A, various	HEAST	1999
Eu-155	6.08E-08	A, various	HEAST	1999
H-3	0.00E+00	A, various	HEAST	1999
I-129	2.69E-09	A, various	HEAST	1999
K-40	6.11E-07	A, various	HEAST	1999
Na-22	8.18E-06	A, various	HEAST	1999
Ni-63	0.00E+00	A, various	HEAST	1999
Pb-210	1.12E-10	A, various	HEAST	1999
Pb-212	3.00E-07	A, various	HEAST	1999
Pb-214	7.09E-07	A, various	HEAST	1999
Pm-147	6.35E-12	A, various	HEAST	1999
Pu-240	1.87E-11	A, various	HEAST	1999
Pu-242	1.55E-11	A, various	HEAST	1999
Ra-226	1.31E-08	A, various	HEAST	1999
Ra-228	0.00E+00	A, various	HEAST	1999
Ru-106	0.00E+00	A, various	HEAST	1999
Sr-89	5.38E-10	A, various	HEAST	1999
Sr-90	0.00E+00	A, various	HEAST	1999
Tc-99	6.19E-13	A, various	HEAST	1999
Th-228	5.28E-10	A, various	HEAST	1999
Th-232	1.97E-11	A, various	HEAST	1999
Tl-208	1.45E-05	A, various	HEAST	1999
U-232	3.42E-11	A, various	HEAST	1999
U-234	2.14E-11	A, various	HEAST	1999
U-235	2.63E-07	A, various	HEAST	1999
U-236	1.72E-11	A, various	HEAST	1999
U-238	1.50E-11	A, various	HEAST	1999
Y-91	1.41E-08	A, various	HEAST	1999
Zn-65	2.27E-06	A, various	HEAST	1999
Zr-95	2.81E-06	A, various	HEAST	1999

Table 2.6. Cancer toxicity data summary for the baseline human health risk assessment for Bethel Valley, ORNL, Oak Ridge, Tennessee (continued)

This table provides carcinogenic risk information that is relevant to the COCs in soil, sediment, water, and biota for all routes of exposure over all COCs identified in Bethel Valley. In this table, the slope factors for dermal contact were extrapolated from oral values using adjustment factors based upon the absorption that occurs in the gut.

[a]EPA no longer classifies the chemical beryllium as a carcinogen via ingestion. The oral slope factor reported here was withdrawn in April 1998.

A = human carcinogen
B1 = probable human carcinogen—limited human information available
B2 = probable human carcinogen—sufficient evidence for animals but inadequate or no evidence from humans
C = possible human carcinogen
COC = contaminant of concern
D = not classifiable as a human carcinogen
E = evidence of noncarcinogenicity
HEAST = Health Effect Assessment Summary Tables, EPA
IRIS = Integrated Risk Information System, EPA
NA = no information available
ORNL = Oak Ridge National Laboratory
OTHER = Value is withdrawn or was obtained from the EPA Superfund Health Risk Support Center
PROV = The toxicity value is a provisional value

Table 2.7. Noncancer toxicity data summary for the baseline human health risk assessment for Bethel Valley, ORNL, Oak Ridge, Tennessee

Route: ingestion, dermal						
Contaminant of concern	Oral RfD (mg/kg-d)	Dermal RfD (mg/kg-d)	Primary target organ	Combined uncertainty/ modifying factors	Source	Date accessed
1,1-Dichloroethene	0.009	0.009	Kidney, liver	1000	IRIS	1999
1,2-Dichloroethene (mixed)	0.009	0.0072	liver	1000	HEAST	1999
1,2-Dichloroethene (Cis)	0.01	0.01	Hematocrit, liver	300	HEAST	1999
1,2-Dichloroethene (Trans)	0.02	0.02	Increased serum alkaline phosphatase	1000	IRIS	1999
Aroclor-1254	0.00002	0.000018	Immune system	300	IRIS	1999
Arsenic	0.0003	0.000123	Skin	3	IRIS	1999
Barium	0.07	0.0049	Increased blood pressure	3	IRIS	1999
Beryllium	0.002	0.00002	Weight loss	100	IRIS	1999
Chromium (III) (salts)	1.0	0.005	GI	1000	IRIS	1999
Chromium (VI)	0.005	0.0001	GI, lungs	500	IRIS	1999
Fluoride	0.06	0.0582	Dental fluorosis	1	IRIS	1999
Manganese (diet)	0.140	0.0056	Central nervous system, lungs	1	IRIS	1999
Manganese (water)	0.046	0.00184	Central nervous system, lungs	3	IRIS	1999
Pyridine	0.001	0.0005	Liver	1000	IRIS	1999
Tetrachloroethene	0.01	0.01	Hepatotoxicity, weight gain	1000	IRIS	1999
Trichloroethene	0.006	0.0009	Liver	NA	OTHER	1999
Route: inhalation						
Contaminant of concern	Inhalation RfC (mg/kg-d)		Primary target organ	Combined uncertainty/ modifying factors	Source	Date accessed
1,1-Dichloroethene	NA		NA	NA	NA	NA
1,2-Dichloroethene (mixed)	NA		NA	NA	NA	NA
1,2-Dichloroethene (Cis)	NA		NA	NA	NA	NA
1,2-Dichloroethene (Trans)	NA		NA	NA	NA	NA
Aroclor-1254	NA		NA	NA	NA	NA
Arsenic	NA		NA	NA	NA	NA
Barium	0.0005		Baritosis	1000	HEAST	1999
Benzene	NA		NA	NA	NA	NA
Beryllium	0.02		Beryllium sensitization	10	IRIS	1999
Chromium (III) (salts)	NA		NA	NA	NA	NA
Chromium (VI)	NA		NA	NA	NA	NA
Fluoride	NA		NA	NA	NA	NA
Manganese (diet)	0.00005		Central nervous system, lungs	1000	IRIS	1999
Manganese (water)	0.00005		Central nervous system, lungs	1000	IRIS	1999
Pyridine	NA		NA	NA	NA	NA
Tetrachloroethene	NA		NA	NA	NA	NA
Trichloroethene	0.021		Liver	NA	OTHER	1999

This table provides noncarcinogenic risk information that is relevant to the contaminants of concern in soil, sediment, water, and biota over all areas assessed in Bethel Valley. As with carcinogenic data, dermal RfDs were extrapolated from oral RfDs applying an adjustment factor based upon absorption from the gut.

GI = gastrointestinal
HEAST = Health Effect Assessment Summary Tables, EPA
IRIS = Integrated Risk Information System, EPA
NA = no information available
ORNL = Oak Ridge National Laboratory
OTHER = Value is withdrawn from IRIS or HEAST
RfD = reference dose

2.7.1.4 Risk characterization

This section describes how the outputs from the exposure assessment (i.e., doses) and toxicity assessment (toxicity values) are combined to characterize the baseline risks. As with the earlier sections, most information is presented in tables. This section concludes with a short discussion of the uncertainties affecting the results of the baseline human health risk assessment.

For carcinogens, risks are generally expressed as the incremental probability of an individual's developing cancer over a lifetime because of exposure to the carcinogen. ELCR is calculated from the following equation:

$$Risk = CDI \times SF,$$

where

Risk = the increased probability of an individual's developing cancer over a lifetime,
CDI = chronic daily intake averaged over a 70-year lifetime (mg/kg-day),
SF = slope factor, a measure of carcinogenicity (see Sect. 2.7.1.3), ([mg/kg-day]$^{-1}$).

These risks are probabilities that usually are expressed in scientific notation (e.g., 1×10^{-6}). An ELCR of 1×10^{-6} indicates that an individual experiencing the reasonable maximum exposure (RME) estimate has a 1 in 1 million chance of developing cancer as a result of site-related exposure. This is referred to as an "excess lifetime cancer risk" because it would be in addition to the risks of cancer individuals face from other causes such as smoking or exposure to too much sun. The chance of an individual's developing cancer from all other causes has been estimated to be as high as one in three. EPA's target risk range for site-related exposures is 1×10^{-4} to 1×10^{-6}.

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

The HQ is calculated as follows:

$$Noncancer\ HQ = CDI \div RfD,$$

where

CDI = chronic daily intake, and
RfD = reference dose.

CDI and RfD are expressed in the same units and represent the same exposure period (i.e., chronic, subchronic, or short-term).

Figures 2.9–2.14 depict the industrial use cancer risk results for individual soil sampling locations used in the Bethel Valley RI/FS report (DOE 1999a). These figures show that the risks associated with many of

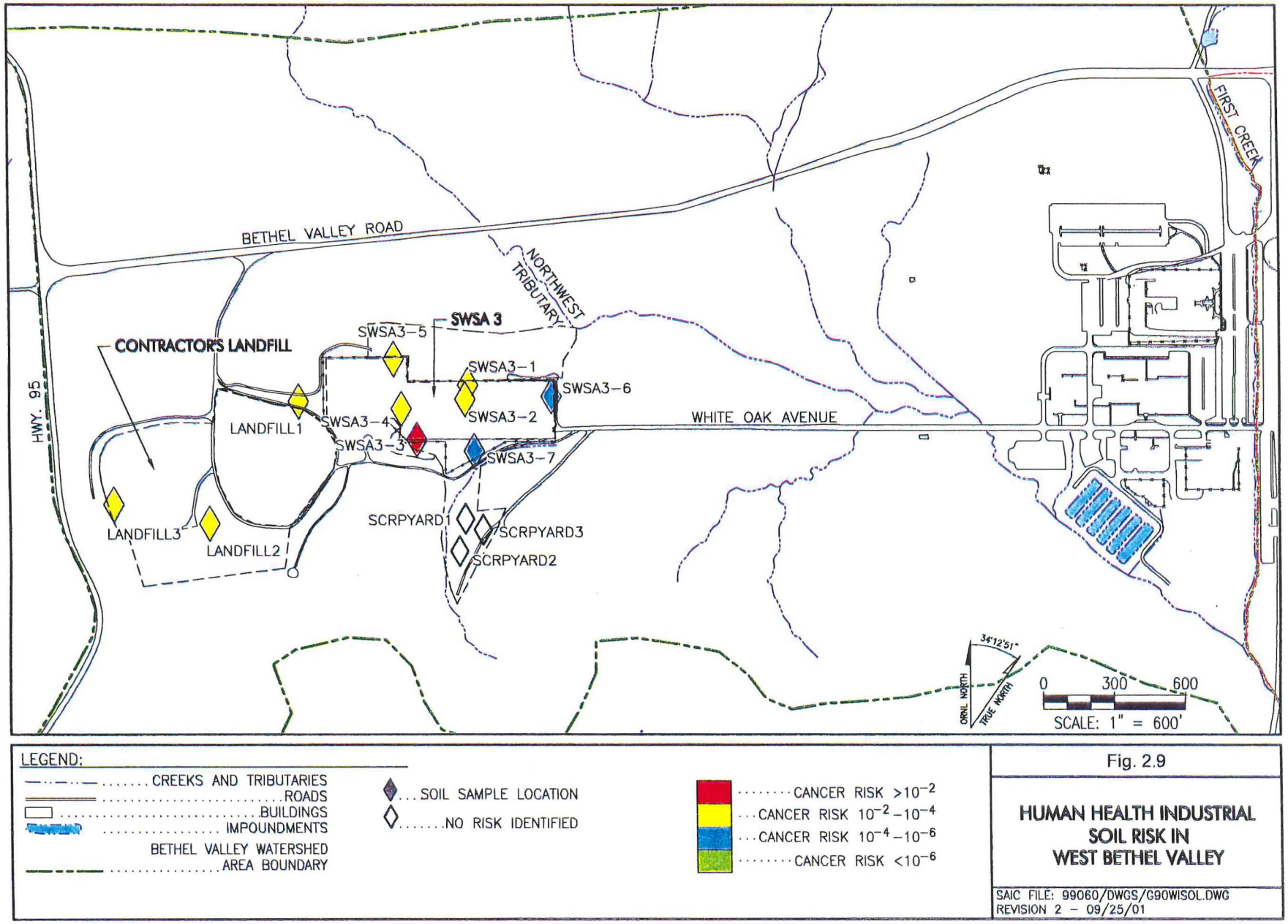
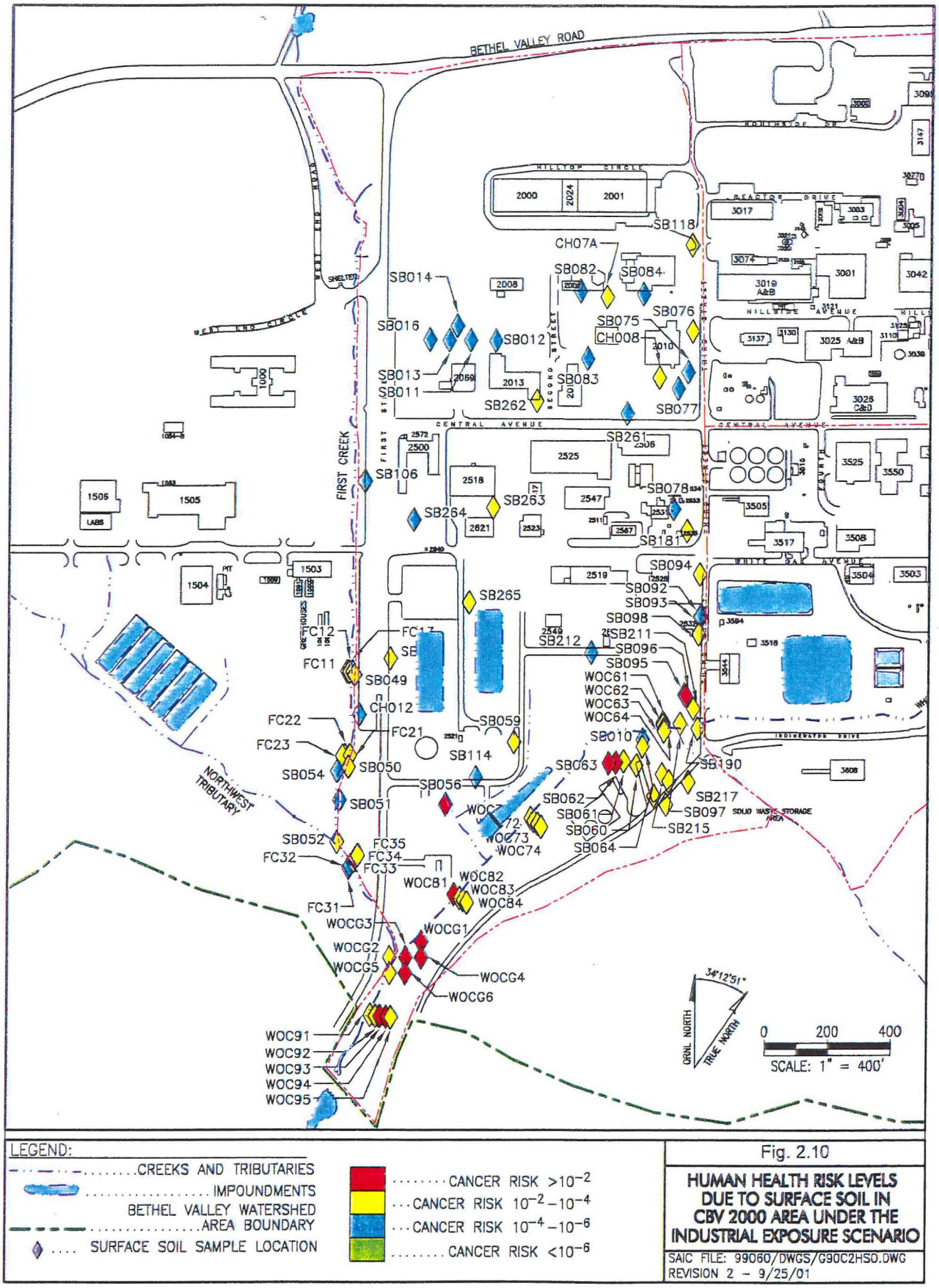


Fig. 2.9. Human health industrial soil risk in West Bethel Valley.



LEGEND:

- CREEKS AND TRIBUTARIES
- IMPOUNDMENTS
- BETHEL VALLEY WATERSHED AREA BOUNDARY
- SURFACE SOIL SAMPLE LOCATION
- CANCER RISK $>10^{-2}$
- CANCER RISK $10^{-2}-10^{-4}$
- CANCER RISK $10^{-4}-10^{-6}$
- CANCER RISK $<10^{-6}$

Fig. 2.10

HUMAN HEALTH RISK LEVELS DUE TO SURFACE SOIL IN CBV 2000 AREA UNDER THE INDUSTRIAL EXPOSURE SCENARIO

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REVISION 2 – 9/25/01

Fig. 2.10. Human health risk levels due to surface soil in the Central Bethel Valley 2000 Area under the industrial exposure scenario.

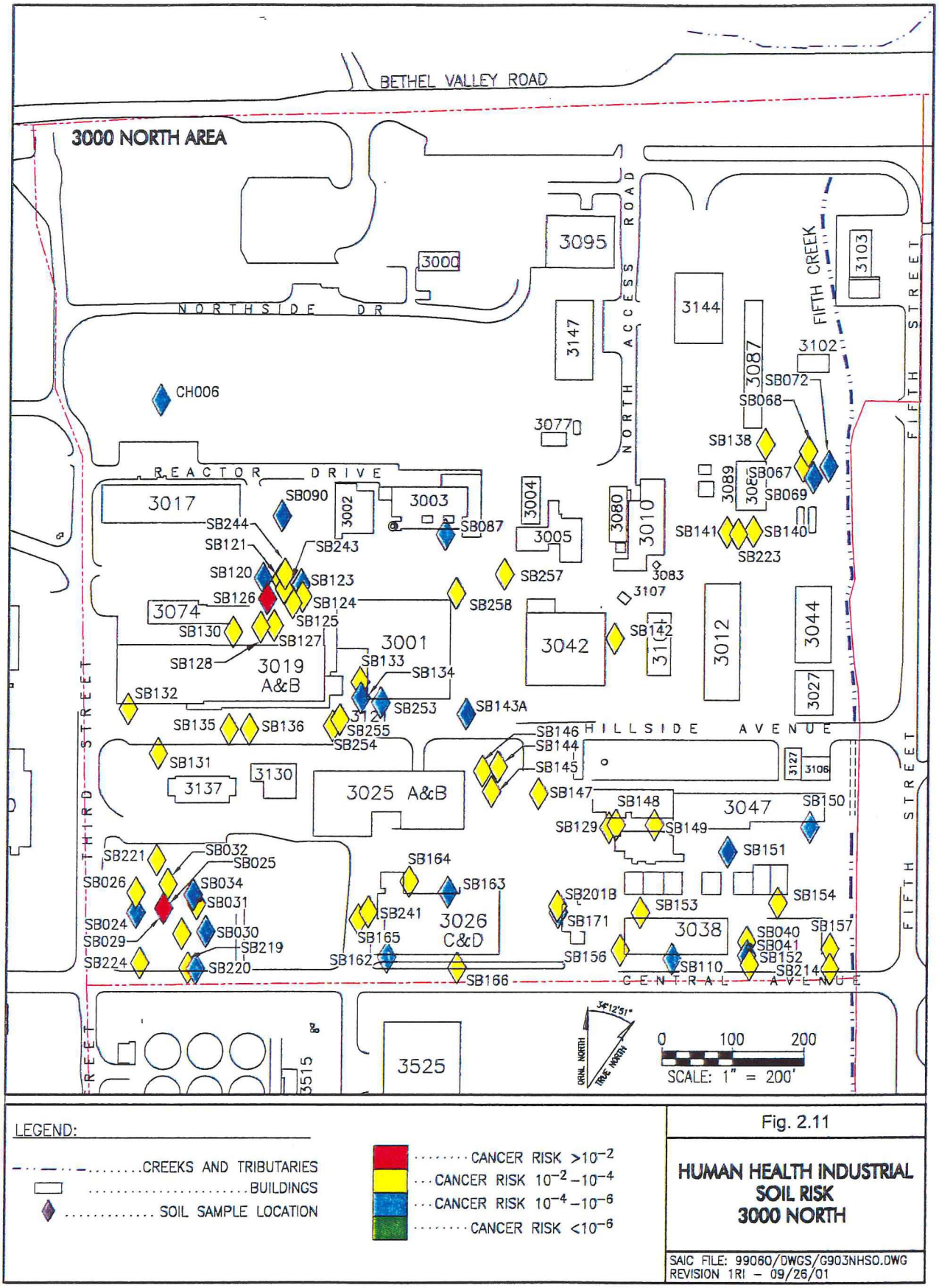
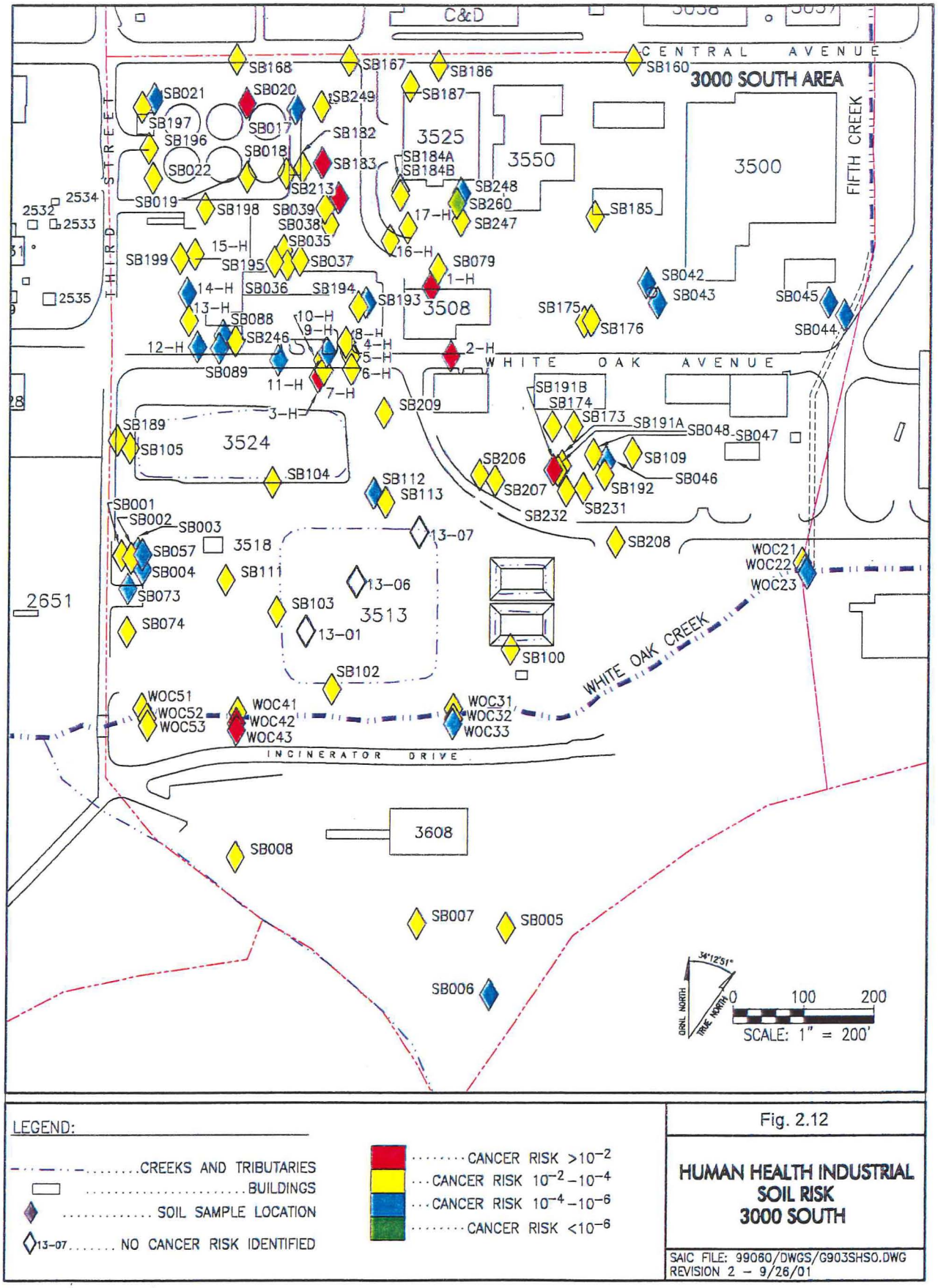


Fig. 2.11. Human health industrial soil risk - 3000 North.



LEGEND:

- CREEKS AND TRIBUTARIES
- BUILDINGS
- SOIL SAMPLE LOCATION
- 13-07 NO CANCER RISK IDENTIFIED
- CANCER RISK $>10^{-2}$
- CANCER RISK $10^{-2}-10^{-4}$
- CANCER RISK $10^{-4}-10^{-6}$
- CANCER RISK $<10^{-6}$

Fig. 2.12

HUMAN HEALTH INDUSTRIAL SOIL RISK 3000 SOUTH

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REVISION 2 – 9/26/01

Fig. 2.12. Human health industrial soil risk - 3000 South.

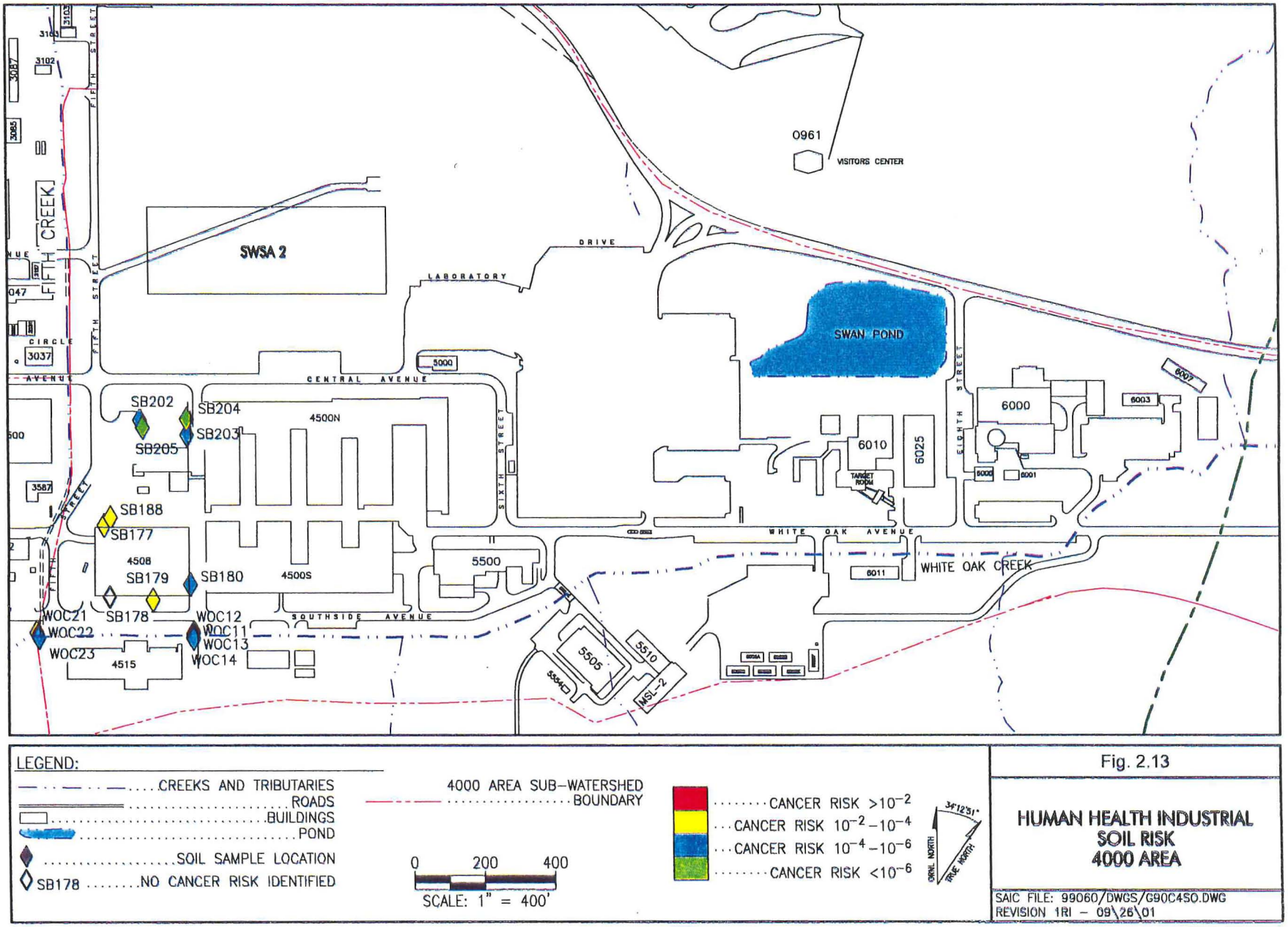


Fig. 2.13. Human health industrial soil risk - 4000 Area.

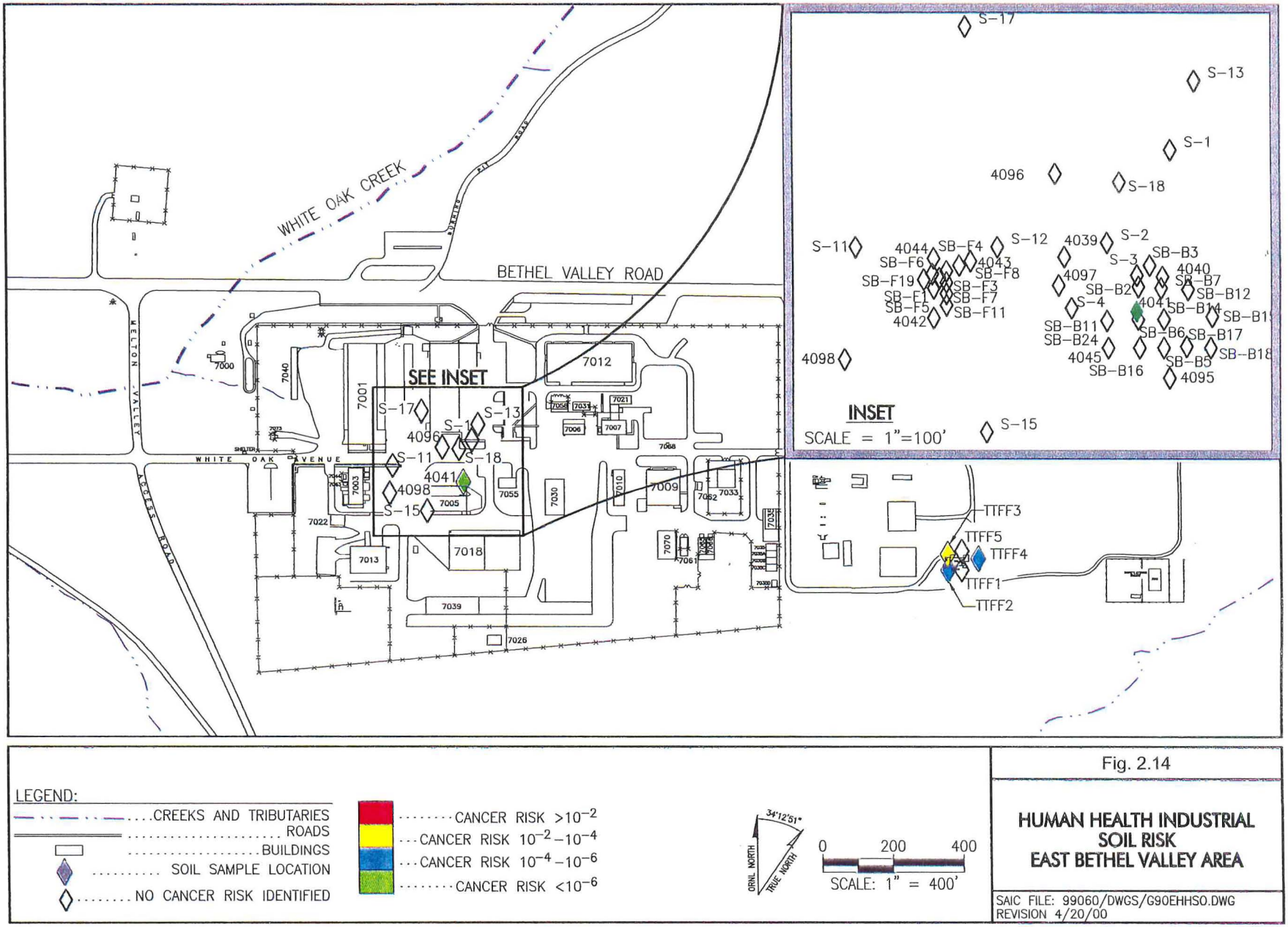


Fig. 2.14. Human health industrial soil risk - East Bethel Valley Area.

the soil sampling points exceed the EPA threshold of 1×10^{-4}. Additionally, these figures show that the soils presenting potential risks greater than the EPA threshold are found throughout the Central Bethel Valley areas.

Tables 2.8 and 2.9 present the results of risk characterization for cancer and systemic toxicity, respectively. In each of these tables, risks are shown by media within area for the future unrestricted industrial worker, future recreational user, and future resident scenarios.

In the qualitative assessment of external exposure to ionizing radiation inside buildings assigned to the D&D program, the EPA benchmark of 15 mrem/year effective dose equivalent (EDE) was used to determine if unacceptable risk to workers may be present in the absence of site controls. The results of the qualitative evaluation are as follows:

- Raccoon Creek, West Bethel Valley, and Central Bethel Valley 2000: No buildings to assess.
- Central Bethel Valley 3000 North (42 inactive buildings), Central Bethel Valley 3000 South (4 inactive buildings), Central Bethel Valley 4000 (2 inactive buildings), and East Bethel Valley (1 inactive building): All buildings were determined to contain areas in which exposure to ionizing radiation could exceed 15 mrem/year and, therefore, pose a potential unacceptable risk to industrial workers in the absence of site controls.

Although the baseline human health risk assessment was completed using the best site information available and following regulatory agency-approved methods, there are several uncertainties that should be considered when using the risk assessment results in decision making. These uncertainties are listed in Table 2.10 along with their estimated effect range (i.e., low, moderate, or high) and the direction each is expected to change the magnitude of the risk estimate (i.e., make larger or smaller).

Of the uncertainties listed in Table 2.10, the following four are given a high estimated effect range:

- the use of historical data in the selection of chemicals that may pose unacceptable risk,
- the probability that the land use considered in the risk assessment will actually occur at some time in the future,
- the assumption of equilibrium conditions for exposure point concentrations, and
- the statistical variability in the toxicity values.

Each of these uncertainties should be especially considered when making remedial decisions for the Bethel Valley area.

2.7.2 Summary of Baseline Ecological Risk Assessment

This section summarizes the various steps of the baseline ecological risk assessment and presents significant results used in making decisions for Bethel Valley. Similar to the human health risk assessment, the ecological risk assessment is based on a set of COCs that are present at the site. Pathways of exposure to a potential ecological receptor are identified, and an assessment is done to evaluate the ecological effects of exposure and the risk the contaminants pose to the potential receptor.

Table 2.8. Risk characterization summary for carcinogens for the baseline human health risk assessment for Bethel Valley, ORNL, Oak Ridge, Tennessee

Area	Exposure to soil[a]	Exposure to sediment[b]	Exposure to surface water[b]	Exposure to groundwater[a]
Scenario: future industrial worker				
Raccoon Creek	No Data	No COPCs	3×10^{-6} to 6×10^{-5}	No value
West Bethel Valley	2×10^{-1}	3×10^{-7} to 3×10^{-7}	4×10^{-5} to 7×10^{-5}	7×10^{-5}
Central Bethel Valley 2000	6×10^{-3}	2×10^{-5} to 2×10^{-2}	4×10^{-8} to 4×10^{-4}	1×10^{-2}
Central Bethel Valley 3000 North	4×10^{-3}	2×10^{-6} to 2×10^{-6}	No COPCs	2×10^{-2}
Central Bethel Valley 3000 South	1×10^{-2}	3×10^{-6} to 3×10^{-4}	5×10^{-7} to 5×10^{-5}	6×10^{-4}
Central Bethel Valley 4000	2×10^{-4}	2×10^{-6} to 4×10^{-6}	No COPCs	2×10^{-4}
East Bethel Valley	4×10^{-5}	No COPCs	No COPCs	3×10^{-4}
Scenario: future recreational user				
Raccoon Creek	No Data	No COPCs	4×10^{-8} to 6×10^{-7}	No value
West Bethel Valley	9×10^{-3}	1×10^{-8} to 1×10^{-8}	2×10^{-6} to 7×10^{-6}	8×10^{-7}
Central Bethel Valley 2000	3×10^{-4}	4×10^{-6} to 1×10^{-3}	8×10^{-9} to 8×10^{-6}	1×10^{-4}
Central Bethel Valley 3000 North	3×10^{-4}	1×10^{-6} to 1×10^{-6}	No COPCs	2×10^{-4}
Central Bethel Valley 3000 South	5×10^{-4}	1×10^{-6} to 2×10^{-5}	4×10^{-8} to 6×10^{-7}	1×10^{-5}
Central Bethel Valley 4000	3×10^{-5}	9×10^{-8} to 2×10^{-6}	No COPCs	1×10^{-5}
East Bethel Valley	2×10^{-6}	No COPCs	No COPCs	5×10^{-5}
Scenario: future resident				
Raccoon Creek	No Data	No COPCs	2×10^{-5} to 3×10^{-4}	No value
West Bethel Valley	6×10^{-1}	1×10^{-5} to 1×10^{-5}	2×10^{-4} to 3×10^{-4}	2×10^{-4}
Central Bethel Valley 2000	3×10^{-2}	7×10^{-4} to 1×10^{-1}	1×10^{-5} to 2×10^{-3}	3×10^{-2}
Central Bethel Valley 3000 North	2×10^{-2}	3×10^{-4} to 3×10^{-4}	No COPCs	5×10^{-2}
Central Bethel Valley 3000 South	5×10^{-2}	5×10^{-4} to 7×10^{-3}	6×10^{-6} to 2×10^{-4}	2×10^{-3}
Central Bethel Valley 4000	9×10^{-4}	1×10^{-5} to 9×10^{-4}	No COPCs	7×10^{-4}
East Bethel Valley	2×10^{-4}	No COPCs	No COPCs	3×10^{-3}

This table provides total excess lifetime cancer risk estimates for the routes of exposure quantified for the future industrial worker, recreational user, and resident. These total risk estimates were based upon reasonable maximum exposure for each receptor and were developed taking into account various conservative assumptions about the frequency and duration of the receptors' exposure to soil, sediment, groundwater, and surface water.

The COCs associated with these values are presented Tables 2.2 through 2.5.

[a] Risk estimates for soil and groundwater are area estimates.
[b] Risk estimates for sediment and surface water are the minimum and maximum values from the assessment of individual locations.

COC = contaminant of concern
COPC = contaminant of potential concern
ORNL = Oak Ridge National Laboratory

Table 2.9. Risk characterization summary for systemic toxicity for the baseline human health risk assessment for Bethel Valley, ORNL, Oak Ridge, Tennessee

Area	Exposure to soil[a]	Exposure to sediment[b]	Exposure to surface water[b]	Exposure to groundwater[a]
Scenario: future industrial worker				
Raccoon Creek	No data	No COPCs	0.2 to 0.2	No data
West Bethel Valley	0.08	No COPCs	0.2 to 0.4	0.2
Central Bethel Valley 2000	0.1	.02 to 2	0.002 to 1	2
Central Bethel Valley 3000 North	0.06	0.09 to 0.09	0.06 to 0.06	7
Central Bethel Valley 3000 South	0.1	0.07 to 20	0.002 to 0.2	2
Central Bethel Valley 4000	0.2	0.2 to 0.2	No COPCs	0.4
East Bethel Valley	No COPCs	No COPCs	No COPCs	4
Scenario: future recreational user				
Raccoon Creek	No data	No COPCs	0.02 to 0.02	No data
West Bethel Valley	0.02	No COPCs	0.03 to 0.06	0.02
Central Bethel Valley 2000	0.02	0.004 to 0.6	0.0003 to 0.06	0.1
Central Bethel Valley 3000 North	0.01	0.04 to 0.04	0.004 to 0.004	0.2
Central Bethel Valley 3000 South	0.03	0.02 to 6	0.0006 to 0.02	0.2
Central Bethel Valley 4000	0.04	0.004 to 0.004	No COPCs	0.05
East Bethel Valley	No COPCs	No COPCs	No COPCs	1
Scenario: future resident				
Raccoon Creek	No Data	No COPCs	1 to 1	No data
West Bethel Valley	0.3	No COPCs	0.6 to 2	0.7
Central Bethel Valley 2000	0.4	10 to 200	0.01 to 8	5
Central Bethel Valley 3000 North	0.2	10 to 10	0.3 to 0.3	20
Central Bethel Valley 3000 South	0.5	20 to 15,000	0.02 to 0.7	7
Central Bethel Valley 4000	0.6	10 to 10	No COPCs	100
East Bethel Valley	No COPCs	No COPCs	No COPCs	10

This table provides total hazard indices for the routes of exposure quantified for the future industrial worker, recreational user, and resident. These total hazard indices were based upon reasonable maximum exposure for each receptor and were developed taking into account various conservative assumptions about the frequency and duration of the receptors' exposure to soil, sediment, groundwater, and surface water.

The COCs associated with these values are presented Tables 2.2 through 2.5.

[a] Hazard indices for soil and groundwater are area estimates.
[b] Hazard indices for sediment and surface water are the minimum and maximum values from the assessment of individual locations.

COC = contaminant of concern
COPC = contaminant of potential concern
ORNL = Oak Ridge National Laboratory

Table 2.10. Sources of uncertainty in the Bethel Valley human health risk assessment, Bethel Valley, ORNL, Oak Ridge, Tennessee

Step	Uncertainty	Estimated effect range	Bias
COPC selection	Assumption of most toxic chemical form	Moderate	Over
	Retention of infrequently detected contaminants	Low to moderate	Over
	Retention of infrequently analyzed contaminants	Low to moderate	Over
	Inclusion of common laboratory contaminants	Low	Over
	Use of historical data (Data are limited for some area-environmental medium combinations.)	Low to high	Over or under
	Use of filtered background groundwater data	Moderate	Over
	Removal of contaminants based on background comparison	Low	Under
	Removal of contaminants based on toxicity screen	Low	Under
	Use of total versus filtered water samples	Low to moderate	Over
Exposure assessment	Probability of land uses occurring	High	Over
	Use of minimum of UCL_{95} and maximum for exposure concentration	Low	Over
	Assumed equilibrium conditions for exposure concentration	Low to high	Over or under
	Use of reasonable maximum exposure default exposure parameters for land use scenarios	Low to moderate	Over or under
	Evaluation of media separately for land use scenarios	Low to moderate	Under
Toxicity assessment	Lack of toxicity information for some contaminants	Low	Under
	Uncertainty in toxicity values from IRIS and HEAST	Low to high	Over
Risk characterization	Presenting risk results by sample location	Low to moderate	Over
	Presentation of total risk versus excess risk	Low	Over
	Addition of risks from radionuclides and chemicals	Low to moderate	Over or under
	Addition of pathway risks to determine scenario risks	Low	Over or under

Please see the baseline human health risk assessment in Vol. 2 of the Bethel Valley RI/FS report (DOE 1999a) for additional discussion of each of these uncertainties.

ORNL = Oak Ridge National Laboratory
COPC = contaminant of potential concern
RI/FS = remedial investigation/feasibility study
HEAST = Health Effect Assessment Summary Tables, EPA
IRIS = Integrated Risk Information System, EPA
UCL_{95} = 95% upper confidence limit

2.7.2.1 Identification of contaminants of concern

This section presents the COCs for each of the environmental media addressed by the baseline ecological risk assessment for Bethel Valley. In this section, the COCs are presented by area within media type (i.e., soil, sediment, and surface water). For each media type, the following information is presented in Table 2.11:

- exposure medium (i.e., surface water or sediment),
- exposure area (i.e., the location where the receptor contacts the contaminated medium),
- COC (i.e., contaminant that was identified as eliciting a deleterious effect to an ecological receptor),
- minimum and maximum detected concentrations,
- mean concentration,
- background concentration (i.e., the concentration found in samples collected from areas not impacted by releases from contaminant sources in Bethel Valley),
- screening toxicity value (i.e., a value to which the environmental concentrations are compared to determine if the environmental concentration may elicit a deleterious effect to an ecological receptor), and
- HQ (i.e., for all but radionuclides, a value derived by dividing the maximum concentration by the most conservative screening toxicity value. For radionuclides, a value derived by comparing an estimated dose against the screening value. Values greater than 1 indicate that a deleterious effect may be caused by exposure to the contaminated medium.).

In this presentation, only contaminants determined to be of concern are listed. If additional information concerning the list of contaminants of potential concern is of interest, the reader is referred to the RI/FS report (DOE 1999a).

2.7.2.2 Exposure assessment

As noted above, COCs were selected for ecological receptors by considering the media in which contaminants were found and the pathways of exposure. This process, which is called exposure assessment, ultimately results in the development of a conceptual site model for the Bethel Valley area.

This section presents the exposure assessment for the Bethel Valley area including the conceptual site model used for the Bethel Valley area and brief descriptions and discussions of the aquatic and terrestrial habitats and other information used in model development. Specifically, the complete exposure pathways for each selected receptor species are discussed and exposure concentrations are presented.

The area evaluated for aquatic species in the baseline ecological risk assessment for Bethel Valley consists of White Oak Creek and its tributaries (i.e., NWT, First Creek, and Fifth Creek) from the headwaters downstream to the 7500 Bridge as well as the Raccoon Creek drainage area (Fig. 2.2). Specific water courses examined for aquatic ecosystems were Raccoon Creek in the Raccoon Creek area, NWT in the West Bethel Valley area, First Creek on the border between the West Bethel Valley and

Table 2.11. Occurrence, distribution, and COCs from baseline ecological risk assessment for Bethel Valley, ORNL, Oak Ridge, Tennessee

Contaminant of concern	Minimum conc.[a]	Maximum conc.	Mean conc.	Background conc.	Screening toxicity value[b]	Screening toxicity value source[b]	HQ value[c]	Receptor[d]
Exposure medium: soil (all values in units of mg/kg) **Area:** Raccoon Creek								
No data	—	—	—	—	—	—	—	—
Exposure Medium: soil (all values for chemicals in mg/kg; ^{137}Cs values in pCi/g except screening toxicity value, which is in mrad/day.) **Area:** West Bethel Valley								
Boron	8.30	5,680	1,580	37.7	NA 0.50	Shrew Plant	2.2 11,400	Short-tailed shrew Terrestrial plants
Cadmium	0.39	5.00	1.42	ND	3.0	Plant	1.7	Terrestrial plants
Cobalt	6.30	38.8	15.8	36.7	20.0	Plant	1.9	Terrestrial plants
Silver	0.80	22.0	2.78	ND	2.0	Plant	11.0	Terrestrial plants
Tin	41.6	73.9	54.4	NV	50.0	Plant	1.5	Terrestrial plants
Zinc	33.5	921	106	108	50.0 200	Plant Earthworm	18.4 4.6	Terrestrial plants Soil invertebrates
^{137}Cs	0.044	28,000	1,550	1.53	1000[e] 100[e]	Earthworm Shrew	1.4 6.8	Soil invertebrates Short-tailed shrew
Exposure medium: soil (all values in units of mg/kg) **Area:** Central Bethel Valley 2000								
Not assessed	—	—	—	—	—	—	—	—
Exposure medium: soil (all values in units of mg/kg) **Area:** Central Bethel Valley 3000 North								
Not assessed	—	—	—	—	—	—	—	—
Exposure medium: soil (all values in units of mg/kg) **Area:** Central Bethel Valley 3000 South								
Not assessed	—	—	—	—	—	—	—	—
Exposure medium: soil (all values in units of mg/kg) **Area:** Central Bethel Valley 4000								
Not assessed	—	—	—	—	—	—	—	—
Exposure medium: soil (all values in units of mg/kg) **Area:** East Bethel Valley								
Not assessed	—	—	—	—	—	—	—	—
Exposure medium: sediment (all values in units of mg/kg) **Area:** Raccoon Creek								
None	—	—	—	—	—	—	—	—

Table 2.11. Occurrence, distribution, and COCs from baseline ecological risk assessment for Bethel Valley, ORNL, Oak Ridge, Tennessee (continued)

Contaminant of concern	Minimum conc.[a]	Maximum conc.	Mean conc.	Background conc.	Screening toxicity value[b]	Screening toxicity value source[b]	HQ value[c]	Receptor[d]
Exposure medium: sediment (all values in units of mg/kg) **Area:** West Bethel Valley (Northwest Tributary)								
bis(2-ethylhexyl)-phthalate	1.30	1.30	1.30	NV	7.14	0.182	TEL	Benthic organisms
Exposure medium: sediment (all values in units of mg/kg) **Area:** Central Bethel Valley 2000 (White Oak Creek and First Creek)								
Mercury	0.27	7.90	3.67	NV	0.13	TEL	60.77	Benthic organisms
Silver	0.25	19.7	8.14	1.70	0.73	TEL	26.99	Benthic organisms
Zinc	3.70	424	190	117	120	MOE_LEL	3.53	Benthic organisms
Polynuclear aromatic hydrocarbons								
Benz(a)anthracene	0.50	5.00	2.91	NV	0.075	MOE_LEL	30.75	Benthic organisms
Benzo(a)pyrene	0.50	5.00	3.02	NV	0.089	TEL	9.91	Benthic organisms
Chrysene	0.50	5.00	3.15	NV	0.108	TEL	30.56	Benthic organisms
Fluoranthene	0.50	5.10	3.49	NV	0.113	TEL	45.13	Benthic organisms
Phenanthrene	0.50	5.00	3.22	NV	0.087	TEL	47.29	Benthic organisms
Pyrene	0.50	5.00	3.35	NV	0.153	TEL	30.07	Benthic organisms
Polychlorinated biphenyls								
Aroclor-1254	0.46	12.0	3.42	NV	0.06	MOE_LEL	200	Benthic organisms
Aroclor-1260	0.57	3.9	1.42	NV	0.005	MOE_LEL	780	Benthic organisms
Exposure medium: sediment (all values in units of mg/kg) **Area:** Central Bethel Valley 3000 North (Fifth Creek)								
Silver	4.50	4.50	4.50	1.70	0.73	TEL	6.16	Benthic organisms
Polychlorinated biphenyls								
Aroclor-1248	0.62	0.62	0.62	NV	0.03	MOE_LEL	20.67	Benthic organisms
Aroclor-1254	0.41	0.41	0.41	NV	0.06	MOE_LEL	6.83	Benthic organisms
Exposure medium: sediment (all values in units of mg/kg) **Area:** Central Bethel Valley 3000 South (White Oak Creek and Fifth Creek)								
Cadmium	3.10	4.30	3.70	3.30	0.6	MOE_LEL	7.17	Benthic organisms
Mercury	0.05	120	30	NV	0.13	TEL	923.08	Benthic organisms
Silver	7.50	16.0	11.8	1.70	0.73	TEL	21.9	Benthic organisms
Zinc	419	458	439	117	120	TEL	3.82	Benthic organisms

Table 2.11. Occurrence, distribution, and COCs from baseline ecological risk assessment for Bethel Valley, ORNL, Oak Ridge, Tennessee (continued)

Contaminant of concern	Minimum conc.[a]	Maximum conc.	Mean conc.	Background conc.	Screening toxicity value[b]	Screening toxicity value source[b]	HQ value[c]	Receptor[d]
Polynuclear aromatic hydrocarbons								
Acenaphthene	0.49	3.00	1.75	NV	0.007	TEL	73.03	Benthic organisms
Anthracene	0.63	0.85	0.74	NV	0.027	EQPCVF1	31.60	Benthic organisms
Benz(a)anthracene	1.50	4.30	2.90	NV	0.075	TEL	57.49	Benthic organisms
Benzo(a)pyrene	2.20	3.40	2.80	NV	0.089	TEL	38.29	Benthic organisms
Chrysene	2.30	6.50	4.40	NV	0.108	TEL	60.19	Benthic organisms
Fluoranthene	3.90	9.80	6.85	NV	0.113	TEL	86.73	Benthic organisms
Phenanthrene	4.20	5.00	4.60	NV	0.087	TEL	57.67	Benthic organisms
Pyrene	3.60	8.00	5.80	NV	0.153	TEL	52.29	Benthic organisms
Polychlorinated biphenyls								
Aroclor-1254	0.63	2.10	1.39	NV	0.06	MOE_LEL	35.0	Benthic organisms
Aroclor-1260	0.55	3.10	1.83	NV	0.005	MOE_LEL	620.0	Benthic organisms
Exposure medium: sediment (all values in units of mg/kg) **Area:** Central Bethel Valley 4000 (White Oak Creek)								
Silver	1.50	12.1	6.80	1.70	0.73	TEL	16.58	Benthic organisms
Polynuclear aromatic hydrocarbons								
Anthracene	0.13	0.13	0.13	NV	0.027	EQPCVF1	4.83	Benthic organisms
Benz(a)anthracene	0.63	0.63	0.63	NV	0.075	TEL	8.42	Benthic organisms
Benzo(a)pyrene	0.56	0.56	0.56	NV	0.089	TEL	6.31	Benthic organisms
Chrysene	1.00	1.00	1.00	NV	0.108	TEL	9.26	Benthic organisms
Fluoranthene	1.40	1.40	1.40	NV	0.113	TEL	12.39	Benthic organisms
Phenanthrene	0.71	0.71	0.71	NV	0.087	TEL	8.19	Benthic organisms
Pyrene	1.20	1.20	1.20	NV	0.153	TEL	7.84	Benthic organisms
Polychlorinated biphenyls								
Aroclor-1260	0.65	0.65	0.65	NV	0.005	MOE_LEL	130.0	Benthic organisms
Exposure medium: sediment (all values in units of mg/kg) **Area:** East Bethel Valley								
None	—	—	—	—	—	—	—	—
Exposure medium: surface water (all values in units of mg/L) **Area:** Raccoon Creek								
Aluminum	0.026	2.10	0.411	0.339	0.075	SS_EC20	28.0	Aquatic organisms
Copper	0.0015	0.0044	0.0023	NV	0.000205	LTV_DAPH	13.62	Aquatic organisms
Iron	0.0025	1.20	0.301	0.806	0.0160	LTV_DAPH	75.0	Aquatic organisms
Silver	0.0015	0.0062	0.0030	NV	0.000012	REGIV_CH	516.67	Aquatic organisms

Table 2.11. Occurrence, distribution, and COCs from baseline ecological risk assessment for Bethel Valley, ORNL, Oak Ridge, Tennessee (continued)

Contaminant of concern	Minimum conc.[a]	Maximum conc.	Mean conc.	Background conc.	Screening toxicity value[b]	Screening toxicity value source[b]	HQ value[c]	Receptor[d]
Exposure medium: surface water (all values in units of mg/L) **Area:** West Bethel Valley (Northwest Tributary)								
Aluminum	0.015	3.12	0.753	0.339	0.075	SS_EC20	24.83	Aquatic organisms
Cadmium	0.0005	0.0024	0.0012	NV	0.0000130	SS_EC20	184.62	Aquatic organisms
Chromium	0.0015	0.00113	0.0044	NV	0.000266	SS_EC20	20.16	Aquatic organisms
Copper	0.0016	0.0050	0.0038	NV	0.000205	LTV_DAPH	22.17	Aquatic organisms
Iron	0.010	2.60	0.714	0.806	0.0160	LTV_DAPH	158.75	Aquatic organisms
Mercury	0	0.0001	0	NV	4.53E-07	Kingfisher NOAEL	155	Piscivores
Nickel	0.0025	0.0155	0.0083	NV	0.005	LCV_DAPH	1.20	Aquatic organisms
Silver	0.0015	0.0107	0.004	NV	0.0000120	REGIV_CH	891.67	Aquatic organisms
Thallium	0.001	0.075	0.0202	NV	0.004	REGV_CH	11.48	Aquatic organisms
Exposure medium: surface water (all values in units of mg/L) **Area:** Central Bethel Valley 2000 (White Oak Creek and First Creek)								
Aluminum	0.015	1.95	0.449	0.339	0.075	SS_EC20	14.71	Aquatic organisms
Cadmium	0	0.0025	0.0013	NV	0.0000130	SS_EC20	192.31	Aquatic organisms
Chromium	0.0012	0.0136	0.004	NV	0.000266	SS_EC20	50.00	Aquatic organisms
Copper	0.0013	0.0967	0.0094	NV	0.000205	LTV_DAPH	471.71	Aquatic organisms
Fluoride	0.050	1.29	0.561	NV	1.08	EC20_POP	1.19	Aquatic organisms
Iron	0.010	2.43	0.505	0.806	0.0160	LTV_DAPH	77.92	Aquatic organisms
Nickel	0.0024	0.0155	0.00680	NV	0.00500	LCV_ALLO	1.38	Aquatic organisms
Mercury	0	0.0018	0.0002	NV	0.0000123 4.53E-07	REGIV_CH Kingfisher NOAEL	56.91 265	Aquatic organisms Piscivores
Silver	0.0015	0.0123	0.004	NV	0.0000120	REGIV_CH	1,025	Aquatic organisms
Exposure medium: surface water (all values in units of mg/L) **Area:** Central Bethel Valley 3000 North (Fifth Creek)								
None	—	—	—	—	—	—	—	—
Exposure medium: surface water (all values in units of mg/L) **Area:** Central Bethel Valley 3000 South (White Oak Creek and Fifth Creek)								
Aluminum	0.005	1.49	0.393	0.339	0.075	SS_EC20	14.71	Aquatic organisms
Chromium	0.0006	0.0108	0.0042	NV	0.000266	SS_EC20	40.23	Aquatic organisms
Iron	0.010	1.69	0.415	0.806	0.0160	LTV_DAPH	89.36	Aquatic organisms

Table 2.11. Occurrence, distribution, and COCs from baseline ecological risk assessment for Bethel Valley, ORNL, Oak Ridge, Tennessee (continued)

Contaminant of concern	Minimum conc.[a]	Maximum conc.	Mean conc.	Background conc.	Screening toxicity value[b]	Screening toxicity value source[b]	HQ value[c]	Receptor[d]
Mercury	0	0.0048	0.0003	NV	0.0000123 4.53E-07	REGIV_CH Kingfisher NOAEL	44.72 1,210	Aquatic organisms Piscivores
Silver	0.0025	0.0102	0.0043	NV	0.0000120	REGIV_CH	850	Aquatic organisms
Exposure medium: surface water (all values in units of mg/L) **Area:** Central Bethel Valley 4000 (White Oak Creek)								
Mercury	0	0.013	0.0005	NV	0.000123 4.53E-07	REGIV_CH Kingfisher NOAEL	81.30 2,210	Aquatic organisms Piscivores
Exposure medium: surface water (all values in units of mg/L) **Area:** East Bethel Valley								
NONE	—	—	—	—	—	—	—	—

[a] Minimum reported and maximum detected concentration.

[b] For soil, surface water, and sediment, a range of screening values were used in the Bethel Valley Baseline Ecological Risk Assessment. Only the value of the most conservative screening criterion is presented in the table.

[c] For all but radionuclides, the hazard quotient derived by dividing the maximum concentration by the most conservative screening value. For radionuclides, the hazard quotient derived from dose calculations presented in Sect. D.7.1.1 of the approved RI/FS for Bethel Valley Watershed.

[d] Receptor for which the analyte is a COC.

[e] Screening toxicity values for radionuclides are in units of mrad/day.

For soil, the screening values included those for plants, earthworms, and wildlife. Species of terrestrial wildlife considered were short-tailed shrew, white-footed mice, red fox, white-tailed deer, red-tailed hawk, wild turkey, and mink.

For surface water, the evaluation included both piscivores and organisms living in water. The species of piscivores considered included the river otter, belted kingfisher, great blue huron, and mink. For water-dwelling organisms, the abbreviations and definitions of screening values include the following:

- NAWQC_ACU—Current national criteria for protection of aquatic life from lethal effects in episodic exposures. Adjusted for hardness of 100 mg/L $CaCO_3$.
- NAWQC_CHR—Current national criteria for protection of aquatic life from lethal and sublethal effects in extended exposures. Also adjusted for hardness of 100 mg/L $CaCO_3$.
- S_ACU_V—Value estimated with 80% confidence to not exceed the unknown acute NAWQC. Derived when NAWQC_ACU is not available.
- S_CHR_V—Value estimated with 80% confidence to not exceed the unknown chronic NAWQC. Derived when NAWQC_CHR is not available.
- LCV_FISH—The lowest value, from acceptable fish chronic toxicity tests, of the geometric mean of the LOEC (lowest observed effects concentration) and NOEC (no observed effects concentration).
- LCV_DAPH—The lowest value, from acceptable daphnid chronic toxicity tests, of the geometric mean of the LOEC and the NOEC.
- LCV_NDI—The lowest value, from acceptable chronic toxicity test of nondaphnid invertebrate species, of the geometric mean of the LOEC and the NOEC.
- LCV_AQPL—The lowest value, from acceptable aquatic plant toxicity tests, of the geometric mean of the LOEC and the NOEC.
- LTV_FISH—The lowest value, from acceptable fish toxicity tests, causing at least a 20% reduction in the weight of young per female or weight of young per egg.
- LTV_DAPH—The lowest value, from acceptable daphnid toxicity tests, causing at least a 20% reduction in the product of survivorship and fecundity.
- SS_EC20—Sensitive species test that approximates the fifth percentile of the species sensitivity distribution.

Table 2.11. Occurrence, distribution, and COCs from baseline ecological risk assessment for Bethel Valley, ORNL, Oak Ridge, Tennessee (continued)

- EC20_POP—An estimate of the concentration that would cause a 20% reduction in the recruit abundance of large mouth bass.

For sediment, the abbreviations and the definitions of the screening values include the following:

- ER_L—The tenth percentile of the estuarine sediment concentrations reported to be associated with some level of toxic effects.
- ER_M—The fiftieth percentile of the estuarine sediment concentrations reported to be associated with some level of toxic effects.
- REGIV_SV—The higher of two values, the EPA Contract Laboratory Program (CLP) practical quantitation limit (PQL) and the Effects Value that is the lower of the ER_L and the Florida NOEL (no observed effects level).
- TEL—The geometric mean of the fiftieth percentile of the reported concentrations that were associated with some level of effects and the fiftieth percentile of reported concentrations that were associated with no adverse effects.
- PEL—The geometric mean of the fiftieth percentile of the reported concentrations that were associated with some level of effects and the 85th percentile of reported concentrations that were associated with no adverse effects.
- EPASQC1—Proposed sediment quality criteria based on toxicity in water expressed as chronic water quality criteria and partitioning of the contaminant between organic matter and pore water.
- EQPAWQC1, EQPAWQC2, EQPCVD1, EQPCVF1, EQPCVI1—Benchmarks derived using the same method as EPASQC1 except that the expression of aqueous toxicity is one of five benchmarks: the chronic NAWQC, the Secondary Chronic Value, the Lowest Chronic Value for Daphnids, the Lowest Chronic Value for Fish, and the Lowest Chronic Value for Nondaphnid Invertebrates.
- MOE_LEL—Concentrations determined by the Ontario Ministry of Environment (MOE) to constitute thresholds for toxic effects in Ontario sediments.
- MOE_SEL—Concentrations determined by the Ontario MOE to constitute thresholds for severe toxic effects in Ontario sediments.
- WS_AET—A concentration above which toxic effects occurred at all sites in Puget Sound.

Conc. = Concentration
HQ = hazard quotient
NA = a value is not reported in the RI/FS for Bethel Valley Watershed
ND = not detected in background sample
NV = a value is not reported in the background data set
ORNL = Oak Ridge National Laboratory

Central Bethel Valley 2000 Areas, Fifth Creek on the border between the Central Bethel Valley 3000 and 4000 Areas, and reaches of White Oak Creek that lie in East Bethel Valley and the Central Bethel Valley 2000, 3000, and 4000 areas.

Terrestrial receptors are considered quantitatively in the assessment of West Bethel Valley. This is the only area of Bethel Valley with quality habitat for terrestrial receptors. The terrestrial ecosystems in Bethel Valley vary from highly disturbed to relatively undisturbed. Where highly disturbed, the current vegetative cover is primarily grass and other herbaceous vegetation. Where undisturbed (i.e., outside the industrialized regions of ORNL), vegetation consists of second-growth mixed oak-hickory forests on ridges and dry slopes and pine and pine-hardwood forests on lower slopes and in valleys.

Species of wildlife found within or near to the Bethel Valley area include more than 60 species of reptiles and amphibians, more than 150 species of birds, and about 40 mammal species. Habitats include hardwood, mixed, and coniferous woods; wetlands; and streams.

No federally listed or proposed threatened and endangered plant or animal species, or designated or proposed critical habitats, occur regularly in the area encompassed by the Bethel Valley area. However, both the bald eagle and peregrine falcon, listed as threatened at the time the risk assessment was prepared, are believed to be transient visitors to the area. Several state-listed threatened and endangered plants have been found in the area, and one state-listed threatened and endangered vertebrate species (osprey) has been seen within the area. In addition, several species listed by the State of Tennessee as "in need of management" have been observed. These include the Cooper's hawk, anhinga, great egret, double-crested cormorant, and southeastern shrew. Populations of state-listed threatened and endangered plant species are located primarily upstream or away from the industrialized areas and include the whorled mountain mint (*Pycanthemum verticillatum*), pink lady's slipper (*Cypripedium acaule*), tall larkspur (*Delphinium exaltatum*), golden seal (*Hydrastis canadensis*), spreading false-foxglove (*Aureolaria patula*), Nuttal waterweed (*Elodea nuttallii*), ginseng (*Panax quinquifolius*), and Canada lily (*Lilium canadense*).

Habitat and contaminant distribution information was used to develop conceptual models for potential ecological exposure scenarios and select assessment endpoints. These models are in Figs. 2.15 and 2.16. Assessment endpoints are defined as any adverse effects on ecological receptors for which exposure pathways are complete and are listed below:

- reduction in species richness or abundance or increased frequency in gross pathologies in fish communities resulting from toxicity,
- reduction in species richness or abundance of benthic macroinvertebrate communities resulting from toxicity,
- reduction in abundance or production of piscivorous wildlife populations resulting from toxicity,
- reduction in abundance or production of earthworms resulting from toxicity,
- reduction in production of terrestrial plant communities resulting from toxicity, and
- reduction in abundance or production of terrestrial wildlife populations resulting from toxicity.

Table 2.12 summarizes the ecological receptors, exposure routes, available data, and assessment and measurement endpoints by exposure medium.

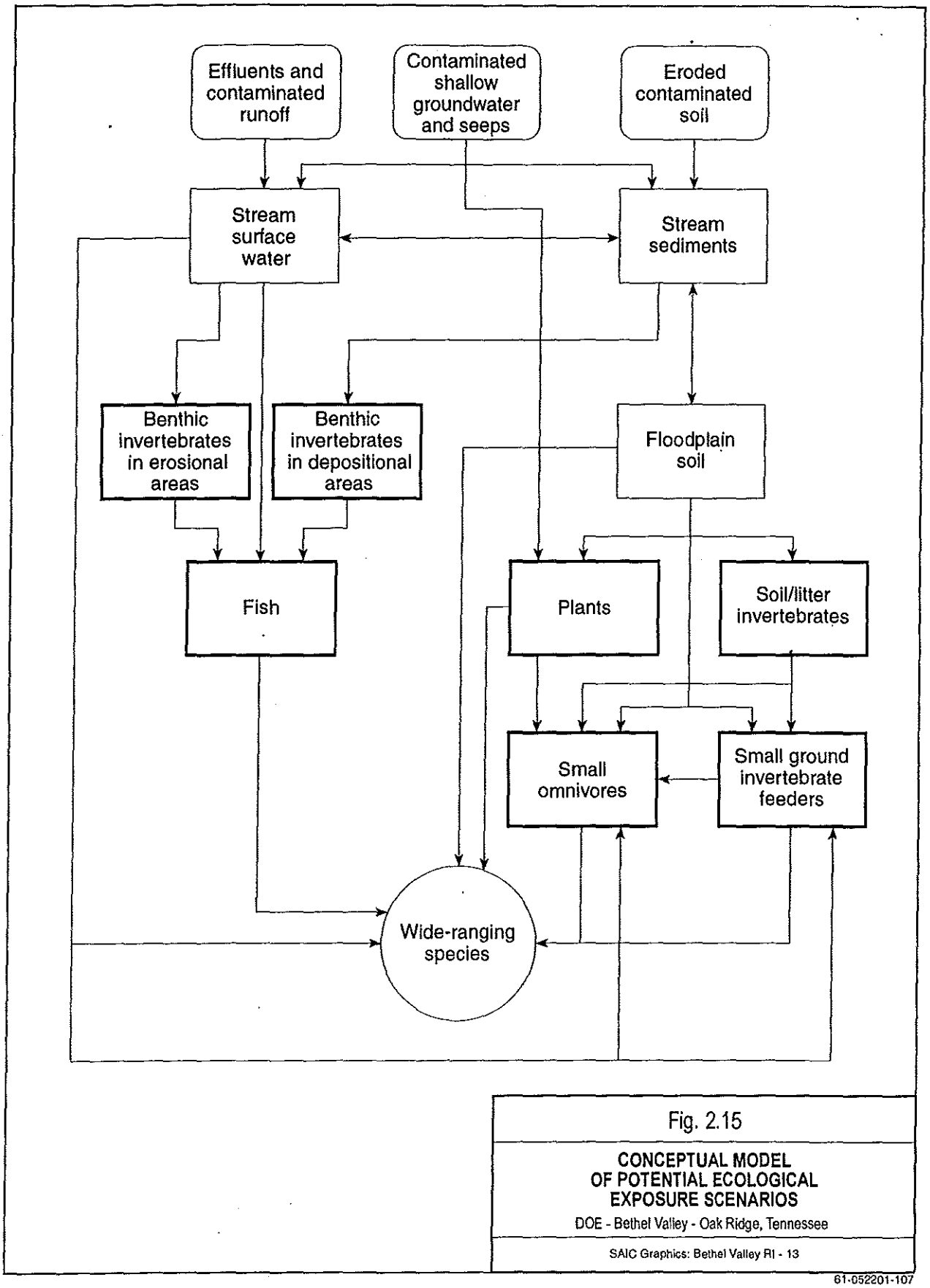


Fig. 2.15. Conceptual model of potential ecological exposure scenarios.

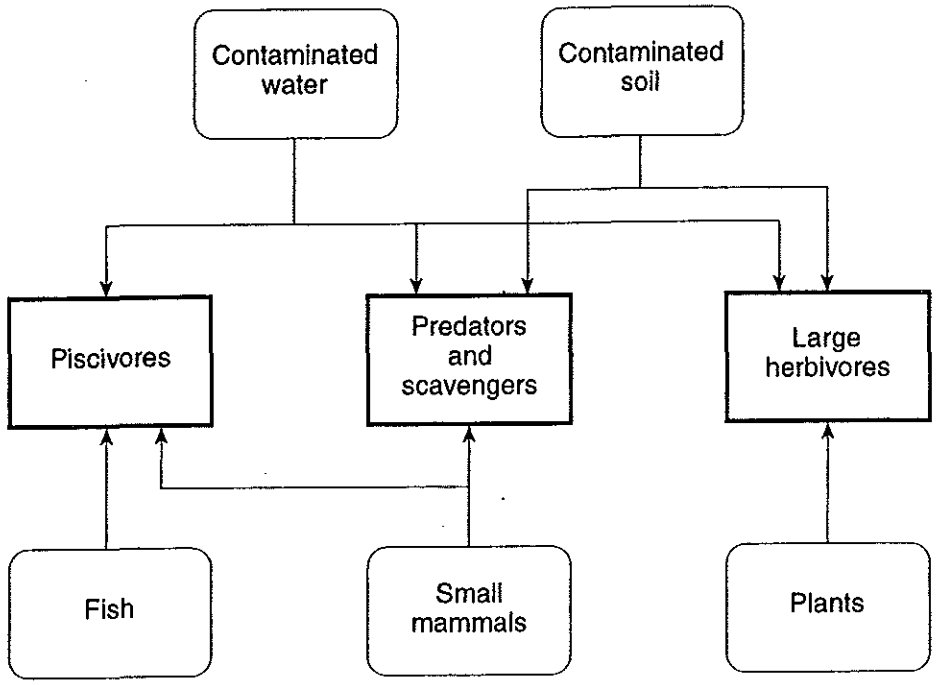


Fig. 2.16

CONCEPTUAL MODEL OF EXPOSURE SCENARIOS FOR WIDE-RANGING WILDLIFE SPECIES

DOE - Bethel Valley - Oak Ridge, Tennessee

SAIC Graphics: Bethel Valley RI - 14

61-052201-109

Fig. 2.16. Conceptual model of exposure scenarios for wide-ranging wildlife species.

Table 2.12. Ecological exposure media, endpoints, exposure routes, and assessment and measurement endpoints for the baseline ecological risk assessment for Bethel Valley, ORNL, Oak Ridge, Tennessee

Exposure medium[a]	Sensitive environment flag[b] (Y or N)	Receptor[c]	Endangered/ threatened species flag[d] (Y or N)	Exposure routes[e]	Assessment endpoints[f]	Available data types[g]	Measurement endpoints[h]
Soil	N	Terrestrial plant (community)	Y	Uptake via root system	• Maintenance of native vegetation • Restoration of impacted areas	• Single chemical toxicity • Qualitative observations	• Species diversity • Chronic toxicity thresholds
		Soil invertebrates (earthworms)	N	Ingestion and direct contact	• Maintenance of functions, including litter degradation, nutrient cycling, and soil structure maintenance	• Single chemical toxicity	• Chronic toxicity thresholds
		Terrestrial wildlife (short-tailed shrew, white-footed mouse, red fox, white-tailed deer, red-tailed hawk, wild turkey, mink)	N	Ingestion and direct contact	• Species richness and diversity • Reproductive success	• Single chemical toxicity	• Chronic toxicity thresholds
Sediment	N	Riffle benthic organisms (community)	N	Ingestion, respiration, and direct contact	• Species richness and abundance	• Biological survey • Media toxicity • Single chemical toxicity	• Species diversity and abundance surveys • Survival of fathead minnows • Survival and reproductive success of water flea • Chronic toxicity thresholds
		Sediment benthic organisms (community)	N	Ingestion, respiration, and direct contact	• Species richness and abundance	• Biological survey • Media toxicity • Single chemical toxicity	• Chronic toxicity thresholds
Surface water	N	Fish (community)	N	Ingestion, respiration, and direct contact	• Species richness and abundance	• Biological survey • Biological indicators • Media toxicity • Single chemical toxicity	• Species richness and abundance surveys • Physiological and histological observations • Survival of fathead minnow • Survival and reproductive success of water flea • Hatching and survival of Japanese medaka • Chronic toxicity thresholds

Table 2.12. Ecological exposure media, endpoints, exposure routes, and assessment and measurement endpoints for the baseline ecological risk assessment for the Bethel Valley, ORNL, Oak Ridge, Tennessee (continued)

Exposure medium[a]	Sensitive environment flag[b] (Y or N)	Receptor[c]	Endangered/ threatened species flag[d] (Y or N)	Exposure routes[e]	Assessment endpoints[f]	Available data types[g]	Measurement endpoints[h]
		Piscivorous wildlife (belted kingfisher, great blue , mink, river otter)	Y	Ingestion and direct contact	• Species richness and abundance	• Biological survey • Media toxicity data • Single chemical toxicity	• Species abundance surveys • Reproductive toxicity results from mink • Chronic toxicity thresholds • Body burdens of a kingfisher

[a]Exposure medium—the environmental medium to which a receptor may be exposed

[b]Sensitive environment flag—environments meeting the definition of a sensitive environment in the HRS for listing hazardous waste sites on the National Priorities List are given a "Yes." Examples of sensitive environments include but are not limited to the following:

- critical habitat for federal designated endangered or threatened species, designated federal wilderness area,
- habitat known to be used by federal designated or proposed endangered or threatened species,
- national or state wildlife refuge,
- federal land designated for protection of natural ecosystems,
- terrestrial areas utilized for breeding by large or dense aggregations of animals, federal- or state-designated scenic or wild river,
- state land designated for wildlife or game management,
- particular areas, relatively small in size, important to maintenance of unique biotic communities, and
- wetlands.

[c]Receptor—class of receptor used in the risk assessment

[d]Endangered/threatened species flag—indicator if federal- or state-listed endangered or threatened species of the receptor class are present

[e]Exposure route—the route through which contaminants may impact the receptor class

[f]Assessment endpoint—the endpoint used for the receptor class in the risk assessment

[g]Available data types—the types of data available in the Bethel Valley data set for the receptor class

[h]Measurement endpoint—the environmental metric (i.e., measurement) used in the effects assessment contained in the risk assessment

HRS = Hazard Ranking System
ORNL = Oak Ridge National Laboratory

2.7.2.3 Ecological effects assessment

In order to determine if adverse ecological effects resulted from exposure to contaminated media within the Bethel Valley area, several types of toxicity tests and field studies were completed. This section summarizes the types of toxicity tests and field studies used for the baseline ecological risk assessment and presents the results of the effects assessment performed as part of the baseline ecological risk assessment.

The information used to complete the effects assessment varied for aquatic organisms, terrestrial plants and soil invertebrates, and terrestrial wildlife. For aquatic organisms, the information used to complete the effects assessment consisted of results from single-chemical toxicity evaluations, estimates of fish body burden estimates, results of ambient water toxicity tests, surveys of the fish community surveys, selected indicators of fish reproduction, and surveys of the benthic invertebrate community. For terrestrial plants and soil invertebrates, the information used to complete the effects assessment was single-chemical toxicity evaluations and, for plants, qualitative observations. For terrestrial wildlife, the information used to complete the effects assessment consisted of single-chemical toxicity evaluations and biological surveys (mink only).

For aquatic organisms, single-chemical toxicities for surface water and sediment were evaluated separately. For surface water, the screening benchmarks were taken from a database that includes National Ambient Water Quality Criteria (NAWQC); secondary values that approximate the NAWQC for chemicals without approved values; lowest chronic values for fish, invertebrates, and aquatic plants; lowest test EC_{20}s for fish and daphnids (i.e., water fleas); Ecotox Threshold values issued by the EPA; and EPA Region 4 surface water screening values. In applying the NAWQC, values were corrected for a water hardness of 100 mg/L. For sediment, the screening benchmarks were taken from a database that includes a set of benchmarks derived using equilibrium partitioning procedures and EPA Region 4 sediment screening values.

The effects assessment for fish body burdens utilized comparisons against thresholds for toxic effects expressed as geometric means of body burdens measured at the no observed effect and lowest observed effect concentrations. Only mercury and PCBs were considered because they were the only contaminants believed to bioaccumulate in fish through dietary exposure. (The production of chemicals through degradation and transformation of detected constituents was not considered in the assessment.)

The effects assessment for ambient water toxicity utilized information from several tests. These tests included the standard 7-day tests of growth and survival for fathead minnow larvae; the standard 7-day tests of reproductive fitness and survival for water fleas; an early lifestage test with Japanese medaka eggs and larvae (White Oak Creek sites only); and a limited number of in situ toxicity tests performed using the snail *Elimia claveformis*.

The effects assessments for fish community surveys, indicators of fish reproduction, and benthic invertebrate community surveys utilized information from several sampling events performed as part of monitoring activities. These assessments compared observed species abundance and diversity against those found in similar surveys at reference locations (fish) or in the literature (benthic invertebrate).

The effects assessments for single-chemical toxicity to plants and soil invertebrates were completed using a comparison between maximum contaminant concentrations in soil and toxicological benchmarks for earthworms and plants. These benchmarks were compiled from results reported in the literature. As mentioned earlier, no other effects assessments were performed for plants and soil invertebrates.

The effects assessments for single-chemical toxicity to terrestrial wildlife were completed using models to estimate contaminant intake. In total, models were used to estimate intake via ingestion of food, water, and soil. Intake via dermal contact and inhalation were not estimated because intake via these routes was deemed negligible. All ingestion estimates were converted to a body weight-normalized daily dose so that exposure estimates could be compared to benchmark doses above which undesirable effects may be seen.

2.7.2.4 Ecological risk characterization

This section provides the conclusions of the ecological risk characterization (Tables 2.13–2.20) and the methods used to derive these conclusions. This section concludes with a short discussion of the uncertainties affecting the results of the baseline ecological risk assessment.

Risk characterization is the phase of the ecological risk assessment in which the information concerning the potential effects of exposure is integrated to estimate risks. The risk characterization is performed for each assessment endpoint by (1) screening all measured contaminants against toxicological benchmarks and background concentrations, (2) considering the implications of other types of data (e.g., lines of evidence such as community surveys and toxicity tests and information regarding process history) for the hypothesis that a hazard exists that requires further assessment or other action, (3) logically integrating the screening results with the other evidence to determine whether there is a credible hazard to the endpoint, and (4) listing and discussing the uncertainties in the assessment.

As demonstrated by the summaries in Tables 2.13–2.20, unacceptable ecological risk is not evident in the West Bethel Valley and East Bethel Valley areas. Additionally, evidence of unacceptable ecological risk is conflicting for the Raccoon Creek, Central Bethel Valley 3000 North, Central Bethel Valley 3000 South, and Central Bethel Valley 4000 areas. However, evidence of unacceptable ecological risk was evident for the Central Bethel Valley 2000 Area.

The COCs for ecological receptors over all areas are presented in Table 2.20 by medium of exposure. As shown there, the greatest number of COCs are inorganic chemicals, and these inorganic chemicals are relatively consistent over the three media. Additionally, as shown in Table 2.20, only two radionuclides (^{137}Cs and ^{234}U) and two classes of organic compounds [polycyclic aromatic hydrocarbons (PAHs) and PCBs] are of concern. The radionuclides are COCs for wildlife, and the organic compounds are COCs for aquatic organisms.

Although the baseline ecological risk assessment was completed using the best site information available and following regulatory agency-approved methods, there are several uncertainties that should be considered when using the risk assessment results in decision making. These uncertainties are listed in Table 2.21 along with their estimated effect range (i.e., low, moderate, or high) and the direction each is expected to change the magnitude of the risk estimate (i.e., make larger or smaller). Of the uncertainties listed in Table 2.21, two are given a high estimated effect range:

- bioavailability of contaminants and
- extrapolation from published toxicity data when deriving toxicity values.

These uncertainties should be considered especially when making remedial decisions for the Bethel Valley area.

Table 2.13. Ecological risk characterization summary for Raccoon Creek, Bethel Valley, ORNL, Oak Ridge, Tennessee

Line of Evidence	Effects	Comments
		Soil
No results		
		Sediment
Single-chemical toxicity data	-	No toxicological benchmarks were exceeded.
Standard toxicity tests	-	Not available
Weight-of-evidence conclusion	-	**Aquatic organisms exposed to Raccoon Creek sediments are not expected to experience any significant adverse effects.**
		Surface water
Single-chemical toxicity data	+/-	Probable effects-level benchmarks were exceeded by aluminum at four locations and by iron, copper, and silver at one location. However, these metals are likely associated with the particulate fraction of unfiltered water and may not be bioavailable.
Standard toxicity tests	-	There was no acute or chronic toxicity in Northwest Tributary water, and aluminum, copper, iron, and silver concentrations in Raccoon Creek were similar to concentrations in the Northwest Tributary
Piscivorous wildlife	-	No analytes exceeded screening-level benchmarks for effects on piscivorous wildlife.
Weight-of-evidence conclusion	+/-	**It is unlikely that contaminants exceeding benchmarks in Raccoon Creek represent a significant risk to aquatic organisms. Concentrations in filtered water samples are unlikely to be fully bioavailable. Lack of toxicity at similar or higher concentrations in Northwest Tributary indicates a similar conclusion**

"+" indicates that results are consistent with the hypothesis that effects are occurring.

"-" indicates results are not consistent with the hypothesis that effects are occurring and suggests no significant risks are at the site.

"+/-" indicates that the evidence is inconclusive or conflicting, and a definitive determination of whether adverse effects are occurring is not possible.

ORNL = Oak Ridge National Laboratory

Table 2.14. Ecological risk characterization summary for West Bethel Valley, Bethel Valley, ORNL, Oak Ridge, Tennessee

Line of evidence	Effects	Comments
		Soil
Single-chemical toxicity data: wildlife	-	Population-level effects are unlikely for terrestrial wildlife. However, a single hot spot for ^{137}Cs is at SWSA 3-3, and hot spots for boron are at two additional locations.
Single-chemical toxicity data: plants	+/-	Boron, silver, and zinc exceed benchmarks at four locations. However, the sites are vegetated, suggesting limited toxicity.
Single-chemical toxicity: soil invertebrates	+	Both zinc and ^{137}Cs exceed their benchmark at a single location.
Weight of evidence conclusion	**+/-**	**While risks from chemicals in soil are limited in extent, they are apparent at five locations. However, population-level effects are deemed unlikely.**
		Sediment (Northwest Tributary)
Benthic community surveys	+/-	Density and species richness are similar to upstream reference location, but there is a noticeable lack of mayflies.
Single-chemical toxicity data	-	No analytes exceeded probable-effects-level benchmarks, and only bis(2-ethylhexyl)phthalate, a probable laboratory contaminant, exceeded possible-effects-level benchmarks.
Weight-of-evidence conclusion	**-**	**Northwest Tributary is relatively unimpacted.**
		Surface water (Northwest Tributary)
Fish community survey	-	While fish density declined, biomass increased. Length/frequency patterns were similar to those of normal populations.
Benthic community survey	+/-	Density and species richness are similar to upstream reference location, but metal sensitive mayflies may be affected.
Aqueous toxicity tests	-	No indication of acute or chronic toxicity.
Fish chemical body burdens	-	Mean mercury concentrations in sunfish were similar to concentrations in fish from an uncontaminated reference site. Mean polychlorinated biphenyl concentrations were below FDA action levels.
Single-chemical toxicity data	+	Aluminum, cadmium, chromium, iron, nickel, and silver exceed probable-effects-level benchmarks at Northwest Tributary and at sampling location SW-8. Copper and thallium in the Northwest Tributary also exceed the benchmark.
Piscivorous wildlife	+/-	While exposure estimates based on fish tissue data marginally exceeded lowest-observed-effect levels for river otter and kingfisher, mean mercury concentrations in sunfish were similar to concentrations in fish from an uncontaminated reference site.
Weight-of-evidence conclusion	**-**	**Northwest Tributary is relatively unimpacted.**

"+" indicates that results are consistent with the hypothesis that effects are occurring.

"-" indicates results are not consistent with the hypothesis that effects are occurring and suggest no significant risks are at the site.

"+/-" indicates that the evidence is inconclusive or conflicting, and a definitive determination of whether adverse effects are occurring is not possible.

FDA = U.S. Food and Drug Administration
ORNL = Oak Ridge National Laboratory
SWSA = solid waste storage area

Table 2.15. Ecological risk characterization summary for Central Bethel Valley 2000 Area, Bethel Valley, ORNL, Oak Ridge, Tennessee

Line of evidence	Effects	Comments
		Soil
Not assessed		
		Sediment (White Oak Creek)
Benthic community surveys	+	Total and EPT species richness are lower than upstream reference location; community dominated by pollutant-tolerant taxa; gradual improvement since 1987.
Single-chemical toxicity data	+	Mercury, silver, zinc, polycyclic aromatic hydrocarbons, and polychlorinated biphenyls exceeded probable-effects-level benchmarks at two locations; mercury, silver, and Aroclor-1260 exceeded at on location; and mercury alone exceeded probable-effects-levels at a single location.
Weight-of-evidence conclusion	**+**	**The benthic invertebrate community in the 2000 Area reach of White Oak Creek has been impacted.**
		Sediment (First Creek)
Benthic community surveys	+	Total and EPT species richness are lower than upstream reference location; community dominated by pollutant-tolerant taxa; gradual improvement since 1987.
Single-chemical toxicity data	+	Mercury, silver, zinc, and Aroclor-1254 exceeded probable-effects-level benchmarks at one location; silver and Aroclor-1254 exceeded at another location.
Weight-of-evidence conclusion	**+**	**The benthic invertebrate community in lower First Creek has been severely impacted.**
		Surface water (White Oak Creek)
Fish community survey	+/-	Fish density and biomass increased from 1991 to 1995 but has decreased since then. Length/frequency patterns were similar to those of normal populations during the increase.
Benthic community survey	+	Total and EPT species richness are lower than upstream reference location. Community dominated by pollutant-tolerant types.
Aqueous toxicity tests	+/-	No indication of acute or chronic toxicity in standard tests, but survival of Japanese madaka embryos was lower than in controls
Single-chemical toxicity data	+	Aluminum, cadmium, chromium, copper, iron, fluoride, nickel, and silver exceeded probable-effects-level benchmarks at one location. Mercury exceeded probable effects levels at an outfall.
Piscivorous wildlife	-	While exposure estimates from mercury in water concentrations indicate potential effects, exposure based on fish tissue data suggest mercury does not pose a risk.
Weight-of-evidence conclusion	**+**	**Impacts on benthic community continue to be evident, single-chemical toxicity data suggest effects are probable, and water may be toxic to sensitive receptors. However, standard toxicity tests do not indicate toxicity to fish or aquatic invertebrates.**
		Surface water (First Creek)
Fish community survey	+	Fish density and biomass declined from 1992 to 1997. Length/frequency patterns were not similar to those of normal populations.
Benthic community survey	+	Total and EPT species richness are much lower than upstream reference location. Community dominated by pollutant-tolerant types.
Aqueous toxicity tests	-	No indication of acute or chronic toxicity in standard tests.
Single-chemical toxicity data	+	Aluminum, cadmium, chromium, iron, and silver exceeded probable effects level benchmarks at two locations.
Piscivorous wildlife	-	While exposure estimates from mercury in water concentrations indicate potential effects, exposure based on fish tissue from downstream in White Oak Creek, where mercury concentrations were higher, suggest mercury does not pose a risk.
Weight-of-evidence conclusion	**+**	**While impacts on fish and benthic communities continue to be evident, toxicity tests suggest the water is not toxic.**

"+" indicates that results are consistent with the hypothesis that effects are occurring.

"-" indicates results are not consistent with the hypothesis that effects are occurring and suggest no significant risks are at the site.

"+/-" indicates that the evidence is inconclusive or conflicting, and a definitive determination of whether adverse effects are occurring is not possible.

EPT = Ephemoroptera, Plecoptera, and Trichoptera
ORNL = Oak Ridge National Laboratory

Table 2.16. Ecological risk characterization summary for Central Bethel Valley 3000 North Area, Bethel Valley, ORNL, Oak Ridge, Tennessee

Line of Evidence	Effects	Comments
		Soil
Not assessed		
		Sediment (Fifth Creek)
Benthic community surveys	+	Total and EPT species richness are lower than upstream reference location; community is dominated by pollution-tolerant types; gradual improvement since 1987.
Single-chemical toxicity data	+	Polychlorinated biphenyls and silver exceeded probable-effects-level benchmarks at one location.
Weight-of-evidence conclusion	+	**The benthic invertebrate community in the 3000 North Area reach of Fifth Creek has been impacted.**
		Surface water (Fifth Creek)
Fish community survey	-	The fish community has improved since 1992 and appears stable.
Benthic community survey	+/-	Total and EPT species richness are lower than upstream reference location; however, communities have shown improvement and appear stable.
Aqueous toxicity tests	-	No indication of acute or chronic toxicity in standard tests.
Single-chemical toxicity data	-	No analytes exceeded probable-effects-level benchmarks.
Piscivorous wildlife	-	No identified risk to piscivorous wildlife.
Weight-of-evidence conclusion	+/-	**Impacts on the benthic community continue to be evident; however, single-chemical toxicity data and toxicity tests do not indicate risk to fish or aquatic invertebrates.**

"+" indicates that results are consistent with the hypothesis that effects are occurring.

"-" indicates results are not consistent with the hypothesis that effects are occurring and suggest no significant risks are at the site.

"+/-" indicates that the evidence is inconclusive or conflicting, and a definitive determination of whether adverse effects are occurring is not possible.

EPT = Ephemoroptera, Plecoptera, and Trichoptera
ORNL = Oak Ridge National Laboratory

Table 2.17. Ecological risk characterization summary for Central Bethel Valley 3000 South Area, Bethel Valley, ORNL, Oak Ridge, Tennessee

Line of evidence	Effects	Comments
		Soil
Not assessed		
		Sediment (White Oak Creek)
Benthic community surveys	+	Total and EPT species richness are lower than upstream reference location. Community is dominated by pollutant-tolerant taxa.
Single-chemical toxicity data	+	Mercury, silver, zinc, polycyclic aromatic hydrocarbons, and polychlorinated biphenyls exceeded probable-effects-level benchmarks at one location near an outfall.
Weight-of-evidence conclusion	**+**	**The benthic invertebrate community in the 3000 Area reach of White Oak Creek has been impacted.**
		Sediment (Fifth Creek)
Benthic community surveys	+	Total and EPT species richness are lower than upstream reference location; community dominated by pollutant-tolerant taxa but shows improving trend.
Single-chemical toxicity data	+	Cadmium, silver, zinc, and polychlorinated biphenyls exceeded probable-effects-level benchmarks at one location; and mercury exceeded at two locations near outfalls.
Weight-of-evidence conclusion	**+**	**The benthic invertebrate community in the 3000 Area reach of Fifth Creek has been impacted.**
		Surface water (White Oak Creek)
Fish community survey	-	Fish density and biomass increased from 1992 to 1993. Length/frequency patterns were similar to those of normal populations.
Benthic community survey	+	Total and EPT species richness are lower than upstream reference location. Community is dominated by pollution-tolerant types.
Aqueous toxicity tests	+/-	There is no indication of acute or chronic toxicity in standard tests, but survival of Japanese medaka embryos was lower than in controls.
Single-chemical toxicity data	+	Aluminum, chromium, iron, and silver exceeded probable-effects-level benchmarks a one location. Mercury exceeded probable effects levels at two outfalls.
Piscivorous wildlife	+/-	While exposure estimates from modeled mercury water concentrations indicated potential effects, exposures based on fish tissue data from downstream suggest mercury does not pose a risk.
Weight-of-evidence conclusion	**+**	**Impacts on the benthic community continue to be evident, single-chemical toxicity data suggest effects are probable, and water may be toxic to sensitive receptors. However, the fish community is improving, and standard toxicity tests do not indicate toxicity to fish or aquatic invertebrates.**
		Surface water (Fifth Creek)
Fish community survey	-	Fish density and biomass indicate improvement over pre-1991 years. Species richness remained stable.
Benthic community survey	+	Total and EPT species richness are lower than upstream reference location. Community is dominated by pollutant-tolerant types but shows improving trend.
Aqueous toxicity tests	-	There is no indication of acute or chronic toxicity in standard tests.
Single-chemical toxicity data	+	Aluminum, chromium, and iron exceeded probable-effects-level benchmarks at one location.
Piscivorous wildlife	+/-	While exposure estimates from mercury in water concentrations indicate potential effects, exposure based on fish tissue data from downstream suggest mercury does not pose a risk.
Weight-of-evidence conclusion	**+/-**	**Impacts on benthic community continue to be evident, and single-chemical toxicity data suggest effects are probable. However, the fish community is stable or improving, the benthic community is improving, and standard toxicity tests do not indicate toxicity to fish or aquatic invertebrates.**

"+" indicates that results are consistent with the hypothesis that effects are occurring.

"-" indicates results are not consistent with the hypothesis that effects are occurring and suggest no significant risks are at the site.

"+/-" indicates that the evidence is inconclusive or conflicting, and a definitive determination of whether adverse effects are occurring is not possible.

EPT = Ephemoroptera, Plecoptera, and Trichoptera
ORNL = Oak Ridge National Laboratory

Table 2.18. Ecological risk characterization summary for Central Bethel Valley 4000 Area, Bethel Valley, ORNL, Oak Ridge, Tennessee

Line of evidence	Effects	Comments
		Soil
Not assessed		
		Sediment (White Oak Creek)
Benthic community surveys	+	Total and EPT species richness are lower than upstream reference location. Community is dominated by pollution-tolerant types but shows improving trend.
Single-chemical toxicity data	+	Silver, polycyclic aromatic hydrocarbons, and polychlorinated biphenyls exceeded probable-effects-level benchmarks at one location, and mercury exceeded probable-effects-levels at a location on White Oak Creek upstream of Fifth Creek.
Weight-of-evidence conclusion	**+**	**The benthic invertebrate community in the 4000 Area reach of White Oak Creek has been impacted.**
		Surface water (White Oak Creek)
Fish community survey	-	The fish community is stable, with normal length/frequency relationships.
Benthic community survey	+	Total and EPT species richness are lower than upstream reference location but show a trend of steady improvement.
Aqueous toxicity tests	+/-	There is no indication of acute or chronic toxicity in standard tests; however, embryo-larval toxicity tests suggest a major source of toxicity possibly related to chlorine from an outfall.
Single-chemical toxicity data	+/-	Mercury exceeded probable-effects-levels at an outfall in 1995, but not in 1994 or 1996.
Piscivorous wildlife	+/-	Exposure estimates modeled from mercury water concentrations indicated potential effects; there were no fish tissue data for further evaluation.
Weight-of-evidence conclusion	**+/-**	**Impacts on the benthic community continue to be evident; single-chemical toxicity data suggest effects are possible, and embryo-larval toxicity tests suggest a major source of toxicity. However, the fish community is stable or improving, the benthic community is improving, and standard toxicity tests do not indicate risk to fish or aquatic invertebrates. Main concern in this reach may be chlorine from a single outfall.**

"+" indicates that results are consistent with the hypothesis that effects are occurring.

"-" indicates results are not consistent with the hypothesis that effects are occurring and suggest no significant risks are at the site.

"+/-" indicates that the evidence is inconclusive or conflicting, and a definitive determination of whether adverse effects are occurring is not possible.

EPT = Ephemoroptera, Plecoptera, and Trichoptera
ORNL = Oak Ridge National Laboratory

Table 2.19. Ecological risk characterization summary for East Bethel Valley area, Bethel Valley, ORNL, Oak Ridge, Tennessee

Line of Evidence	Effects	Comments
		Soil
Not assessed		
		Sediment (White Oak Creek)
Standard toxicity tests	-	Not available.
Single-chemical toxicity data	-	No toxicological benchmarks were exceeded.
Weight-of-evidence conclusion	**-**	**Aquatic organisms exposed to White Oak Creek sediments in East Bethel Valley are not expected to experience any significant adverse effects.**
		Surface water (White Oak Creek)
Aqueous toxicity tests	-	There was no indication of acute or chronic toxicity based on standard or medaka tests.
Single-chemical toxicity data	-	No analytes exceeded probable-effects-levels benchmarks.
Piscivorous wildlife	-	No analytes exceeded screening level benchmarks for effects on piscivorous wildlife.
Weight-of-evidence conclusion	**-**	**It is unlikely that contaminants in East Bethel Valley surface water pose risk to aquatic organisms.**

"+" indicates that results are consistent with the hypothesis that effects are occurring.

"-" indicates results are not consistent with the hypothesis that effects are occurring and suggest no significant risks are at the site.

"+/-" indicates that the evidence is inconclusive or conflicting, and a definitive determination of whether adverse effects are occurring is not possible.

ORNL = Oak Ridge National Laboratory

Table 2.20. COCs for ecological receptors, Bethel Valley, ORNL, Oak Ridge, Tennessee

Exposure medium	COC	Assessment endpoint
Soil	Boron	Wildlife, plants
	Cadmium	Plants
	Cobalt	Plants
	Silver	Plants
	Tin	Plants
	Zinc	Soil invertebrates, plants
	^{137}Cs	Wildlife
	^{234}U	Wildlife
Sediment	Cadmium	Aquatic organisms
	Mercury	Aquatic organisms
	Silver	Aquatic organisms
	Zinc	Aquatic organisms
	PAHs	Aquatic organisms
	PCBs	Aquatic organisms
Surface water	Cadmium	Aquatic organisms
	Chromium	Aquatic organisms
	Cobalt	Aquatic organisms
	Iron	Aquatic organisms
	Mercury	Aquatic organisms, Piscivores
	Selenium	Piscivores
	Silver	Aquatic organisms

COC = contaminant of concern
ORNL = Oak Ridge National Laboratory
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl

Table 2.21. Sources of uncertainty in the Bethel Valley ecological risk assessment, Bethel Valley, ORNL, Oak Ridge, Tennessee

Step	Uncertainty	Estimated effect range	Bias
COPC selection	Estimating whole fish concentrations from fillet concentrations	Moderate	Over or under
Exposure assessment	Bioavailability of contaminants	Moderate to high	Over or under
	Lack of consideration of variable food consumption when deriving dose estimates	Moderate	Over or under
	Contaminant concentrations in prey and foodstuffs	Moderate	Over or under
	Physical size of prey versus size consumed	Low	Over or under
	Variable response to contaminants	Low to moderate	Over
	Uptake factors	Low to moderate	Over or under
Toxicity assessment	Extrapolation from published toxicity data when deriving toxicity values	Moderate to high	Over
	Lack of benchmarks for some metals and most organic compounds	Moderate	Under
Risk characterization	Consideration of chemicals individually versus as a group.	Moderate	Over or under
	Assumption that most toxic form of inorganic chemical present	Moderate	Over

Please see the baseline ecological risk assessment in Vol. 2 of the Bethel Valley RI/FS report (DOE 1999a) for additional discussion of each of these uncertainties.

Low—Uncertainty may cause the risk estimate to vary up to one order of magnitude.
Moderate—Uncertainty may cause the risk estimate to vary up to two orders of magnitude.
High—Uncertainty may cause the risk estimate to vary by more than two orders of magnitude

COPC = contaminant of potential concern
ORNL = Oak Ridge National Laboratory

2.7.3 Conclusions from Baseline Risk Assessment and Basis for Action

This section presents the overall conclusions reached in the baseline risk assessment for Bethel Valley that drive the need for action and concludes with the basis for action statement for the Bethel Valley area. The conclusions in this section integrate the risk information with that from the site characterization discussions.

2.7.3.1 Risks associated with Central/East Bethel Valley

Contaminants of Concern. Central/East Bethel Valley contains numerous COCs, including radionuclides, metals, and VOCs. COCs are contaminants that could potentially cause a threat to human health or the environment that need to be addressed by a response action. These constituents are found in soil, surface water, sediment, and groundwater. Following are the predominant site-related COCs:

- soil: ^{137}Cs, ^{60}Co, ^{228}Th, and ^{228}Ra;
- surface water: mercury for protection of aquatic species;
- sediment: ^{137}Cs for protection of human health and mercury, silver, zinc, cadmium, PCBs, and PAHs for protection of aquatic species; and
- groundwater: ^{90}Sr, ^{228}Ra, ^{3}H, arsenic, antimony, manganese, TCE, and vinyl chloride.

Soils and Sediment Contamination. Contaminated soils and sediment throughout the area exhibit unacceptable risk levels (above 1×10^{-4}) of radionuclide contamination, particularly by gamma emitters (i.e., ^{137}Cs) to industrial workers. These areas are concentrated in the main ORNL complex [Surface Impoundments Operable Unit (SIOU) and GAAT area, in particular], White Oak Creek floodplain, and SWSA 1. Radiologically contaminated areas are properly isolated, and controls are in place to protect the current workers. In the absence of these controls, current or future workers would be at risk for unacceptable radiological exposure. In addition, sediment contamination associated with First Creek poses unacceptable risk greater than 1×10^{-4} to the recreational user as a result of ^{137}Cs. The surface water bodies have been classified by the State of Tennessee for *Recreation*, *Fish and Aquatic Life*, *Livestock Watering and Wildlife*, and *Irrigation* uses.

Groundwater Contamination. Groundwater contamination exceeds MCLs throughout Central/East Bethel Valley. Radionuclide groundwater contamination (primarily ^{90}Sr and ^{3}H) underlies Central Bethel Valley, and a VOC plume (primarily TCE) underlies East Bethel Valley. Groundwater is not used for industrial purposes; however, it has been significantly impacted by historical activities. In addition, groundwater seeps into utility lines and trench backfill and migrates into treatment facilities, accumulates in building sumps, and discharges directly to surface water.

Surface Water Contamination. First Creek, Fifth Creek, and White Oak Creek surface water do not exhibit risk values that exceed human health risk greater than 1×10^{-4} to recreational users (maximum of 8×10^{-6}). However, in Bethel Valley, ^{90}Sr contributes to risks at White Oak Dam in Melton Valley. First Creek surface waters also exceed 1×10^{-4} risk to industrial users, primarily as a result of ^{90}Sr and ^{228}Ra.

Building and Facility Contamination. Buildings and other facilities, tanks, and pipelines in Central/East Bethel Valley are contaminated and pose potential unacceptable risk to industrial workers.

Risks to Ecological Receptors. In Central/East Bethel Valley, unacceptable risk is posed to aquatic organisms in First Creek and White Oak Creek surface water and sediment. Unacceptable risk occurs when ecological receptors are exposed to contamination to the extent that local populations and/or communities of plants and animals on or near the site are unable to maintain a healthy state. This can be indicated by a reduction in diversity of species, increases in mortality, or diminished reproductive capacity.

Surface water and sediment in First Creek and the lower reach of White Oak Creek (downstream of the confluence with First Creek) pose the greatest risk. Ecological COCs include metals (predominantly mercury) in surface water and metals, PCBs, and PAHs in sediment. Piscivores (fish-eating animals) exposed to organisms in White Oak Creek may be adversely affected by mercury. Radionuclide exposures do not pose an unacceptable risk to either group of organisms.

2.7.3.2 Risks associated with West Bethel Valley/Raccoon Creek

Site risks associated with West Bethel Valley/Raccoon Creek are summarized as follows.

Contaminants of Concern. West Bethel Valley/ Raccoon Creek contains multiple COCs in soil and groundwater. Following are the predominant site-related COCs:

- soil: ^{137}Cs, ^{60}Co, ^{228}Th, and ^{228}Ra; and
- groundwater: ^{90}Sr.

Soil and Burial Ground Contamination. SWSA 3 and associated soils present an unacceptable risk to on-site industrial workers. Presence of long half-life radionuclides in the former disposal area poses a future potential unacceptable risk. Isotopes of uranium and other radionuclides, as well as various other solid wastes, reportedly have been disposed of in SWSA 3. Some of these isotopes will continue to release radiation for thousands of years; however, the amount of these long-lived isotopes is a small portion of the total contaminant inventory.

Groundwater Contamination. Groundwater contamination exceeds MCLs at several locations in West Bethel Valley. A contaminant plume emanates from SWSA 3 from groundwater contact with wastes. The plume extends from the contaminant sources to nearby surface streams (NWT and Raccoon Creek). Strontium-90 concentrations exceed MCLs, as do ^{3}H and some VOCs.

Risks to Ecological Receptors. Potential ecological risks to terrestrial receptors from exposure to radionuclides in surface soil were identified but are limited in extent. Cesium-137 accounts for more than 85% of the risk, but it comes from one sample location. Boron also is of potential ecological concern, also at a few locations. Due to the minimal area of contamination, impacts to terrestrial populations within West Bethel Valley are not indicated.

Weight-of-evidence screening suggests NWT is relatively unaffected by activities in West Bethel Valley. However, there are no data in the stream closest to the disposal area.

Surface Water Contamination. The surface waters pose less than 1×10^{-4} risk under the recreational scenario (maximum 7×10^{-6}). Total risk to surface water is also below a risk level of 1×10^{-4} for industrial workers (maximum of 6.7×10^{-5}) or recreational use in both creeks. Under the residential scenario, which assumes the creeks are a source of drinking water, ^{90}Sr exceeds acceptable (1×10^{-4}) risk in Raccoon Creek, and ^{90}Sr and ^{228}Ra exceed acceptable risk in NWT. There are limited data in the upstream locations on NWT, and few analyses other than radionuclides were done for either stream.

2.7.3.3 Basis for Action Statement

A response action is generally warranted if one or more of the following conditions exist at a site: (1) the cumulative ELCR to an individual exceeds 1×10^{-4} (using RME assumptions for either the current or reasonably anticipated future land use or current or potential beneficial use of groundwater and/or surface water); (2) the systemic toxicity HI is >1 (using RME assumptions for either the current or reasonably anticipated future land use or current or potential beneficial use of groundwater and/or surface water); (3) site contaminants cause adverse environmental impacts; or (4) chemical-specific standards or other measures that define acceptable risk levels are exceeded and exposure to contaminants above these levels is predicted under current or reasonably anticipated future land use.

Because each of the conditions listed in the preceding paragraph exists at some areas within Bethel Valley, a response action for those areas is appropriate. Following are specific conditions of note:

- Industrial risk levels for soil exceed 1×10^{-4} in West and Central Bethel Valley. Recreational risk levels for sediment exceed acceptable levels in Central Bethel Valley.

- Residential risk levels for groundwater exceed 10^{-4} in portions of Central Bethel Valley. Groundwater contamination exceeds MCLs throughout Central/East Bethel Valley and at several locations in West Bethel Valley.

- There are significant potential impacts to populations of benthic invertebrates in the sediments of Central Bethel Valley.

- The AWQC for several analytes, including mercury, have been exceeded.

The response action selected for those areas in this ROD is necessary to protect public health or welfare or the environment from actual or threatened releases from these areas of hazardous substances, pollutants, or contaminants that may present an imminent and substantial endangerment to public health and welfare.

2.8 REMEDIAL ACTION OBJECTIVES

RAOs provide a general description of what the cleanup will accomplish. This section outlines the RAOs, provides the basis and rationale for the RAOs, and describes how the RAOs address risks identified in the risk assessment. Section 2.8.1 focuses on the RAOs considered for alternative development and Sect. 2.8.2 focuses on the final RAO established for the selected remedy.

2.8.1 RAOs Considered for Alternative Development

Based on threats to human health and the environment, a range of protective RAOs was developed to focus the planning of remedial alternatives. RAOs were developed separately for the Central/East Bethel Valley and the West Bethel Valley/Raccoon Creek subareas. This was done because contamination in West Bethel Valley/Raccoon Creek is limited to discrete areas (i.e., SWSA 3, the Contractor's Landfill, the Closed Scrap Metal Area, and a few small areas of potential surface soil contamination), while Central/East Bethel Valley contains widespread contamination resulting from its use as a nuclear facility. Thus, land use options that were considered in the FS for West Bethel Valley/Raccoon Creek were different from those considered for Central/East Bethel Valley (DOE 1999a). Furthermore, because contamination in West Bethel Valley/Raccoon Creek and Central/East Bethel Valley is in separate watersheds, these subwatersheds have little impact on each other. The RAOs for each of these subareas are presented in this section.

2.8.1.1 RAOs for Central/East Bethel Valley

Major problems identified in Central/East Bethel Valley are the presence of (1) radiological contamination in buildings and other facilities, buried wastes, tanks, soil, and underground pipelines that poses an unacceptable risk to human health; (2) radiological contamination in groundwater that contributes to contamination of surface water; (3) mercury contamination in surface water that exceeds AWQC; (4) radiological contamination in surface water that contributes to excess human health risk at White Oak Dam as described in the Melton Valley watershed ROD (DOE 2000c); (5) radiological contamination in sediment that poses an unacceptable risk to human health; and (6) metal and organic contamination in sediment that poses an unacceptable risk to aquatic species.

Table 2.22 presents the protection goals (elements that when combined make a comprehensive RAO) associated with each RAO. These RAOs and protection goals were developed based on protecting human health under a range of land use scenarios and on protecting the environment. Because the final groundwater decision is being deferred, groundwater use restrictions in contaminated areas would be necessary regardless of land use. Following are potential land uses for the major portions of Central/East Bethel Valley:

- Unrestricted—no restrictions on surface or subsurface land use.
- Unrestricted industrial—unlimited industrial use to a depth of 3 m (10 ft).
- Controlled industrial—unlimited industrial surface use, with restrictions on excavations deeper than 0.6 m (2 ft).

Since ORNL is an active industrial facility and is expected to remain a government-owned and operated research facility for the foreseeable future, the unrestricted (i.e., residential) land use scenario was eliminated as a likely future use for the developed areas of Central/East Bethel Valley area (Sect. 2.6.3). Cleanup

Table 2.22. RAOs and protection goals for Central/East Bethel Valley, ORNL, Oak Ridge, Tennessee

Issue	RAO 1	RAO 2	Protection goals
Future land use	✓		Protect human health for (1) unrestricted industrial use in developed areas of Central/East Bethel Valley and (2) unrestricted use in undeveloped areas; all to a risk level of 1×10^{-4}
		✓	Protect human health for (1) controlled industrial use in the main plant area, (2) unrestricted industrial use in the remainder of the developed areas, and (3) unrestricted use in the undeveloped areas, all to a risk level of 1×10^{-4}
Protection of surface water bodies	✓	✓	Achieve AWQC for designated stream uses in all waters of the state
	✓	✓	Achieve at least 45% risk reduction at 7500 Bridge
	✓	✓	Maintain surface water and achieve sediment recreational risk-based limits to a risk level of 1×10^{-4}
Groundwater protection	✓	✓	Minimize further impacts to groundwater
	✓	✓	Prevent groundwater from causing surface water exceedances in all waters of the state
Protection of ecological receptors	✓	✓	Protect reach-level populations of aquatic organisms

AWQC = ambient water quality criteria
ORNL = Oak Ridge National Laboratory
RAO = remedial action objective

options for developed areas, therefore, are focused on industrial land use scenarios. Achieving unrestricted industrial use requires removal of all contaminated media in the top 3 m (10 ft) of soil that is above remediation levels. Because of the presence of extensive subsurface contamination and the high cost of removal and disposal of this material, controlled industrial use is also considered for the main plant area. Controlled industrial use depends more on isolation of subsurface contamination than on removal. The more extensive RAO (RAO 1) achieves unrestricted industrial use; the less extensive RAO (RAO 2) achieves controlled industrial use (Fig. 2.17). Unrestricted use (i.e., the most protective use scenario) is the protection goal for areas outside of the industrial development within the Central/East Bethel Valley area.

Both RAOs achieve AWQC for designated stream uses in waters of the state. All numeric AWQC and narrative criteria for the protection of human health and aquatic organisms will be met. Surface water and sediment recreational risk-based limits will also be maintained to a risk level of 1×10^{-4}. The surface water recreational risk-based goal is actually a consequence of using the CERCLA risk assessment process to quantify the narrative criteria that do not list contaminant-specific remediation levels. The recreational risk-based goal for surface water and sediment is selected because (1) recreational use is considered representative of the TDEC stream-use classifications for Bethel Valley streams that include *Recreation*, *Fish and Aquatic Life*, *Livestock Watering and Wildlife*, and *Irrigation*; and (2) no Bethel Valley stream is large enough to serve as a major public water supply under a residential or industrial scenario.

Both RAOs also achieve at least 45% risk reduction at the 7500 Bridge. This goal is a direct result of a goal in the Melton Valley watershed ROD to protect an off-site residential user of surface water at the confluence of White Oak Creek and the Clinch River (DOE 2000c). The Melton Valley watershed ROD established a remediation level of 1×10^{-4} ELCR (annual average) at the confluence. Because White Oak Creek receives water from Bethel Valley and Melton Valley watersheds, risk contributions from both watersheds are taken into account. Assuming 1994 baseline conditions, and assuming the Melton Valley remedy achieves at least an 82% reduction of the Melton Valley contribution to the residential risk at the confluence, then the Bethel Valley remedy must achieve at least a 45% risk reduction in surface water exiting Bethel Valley in order for the Melton Valley ROD goal of protecting the off-site resident to be met.

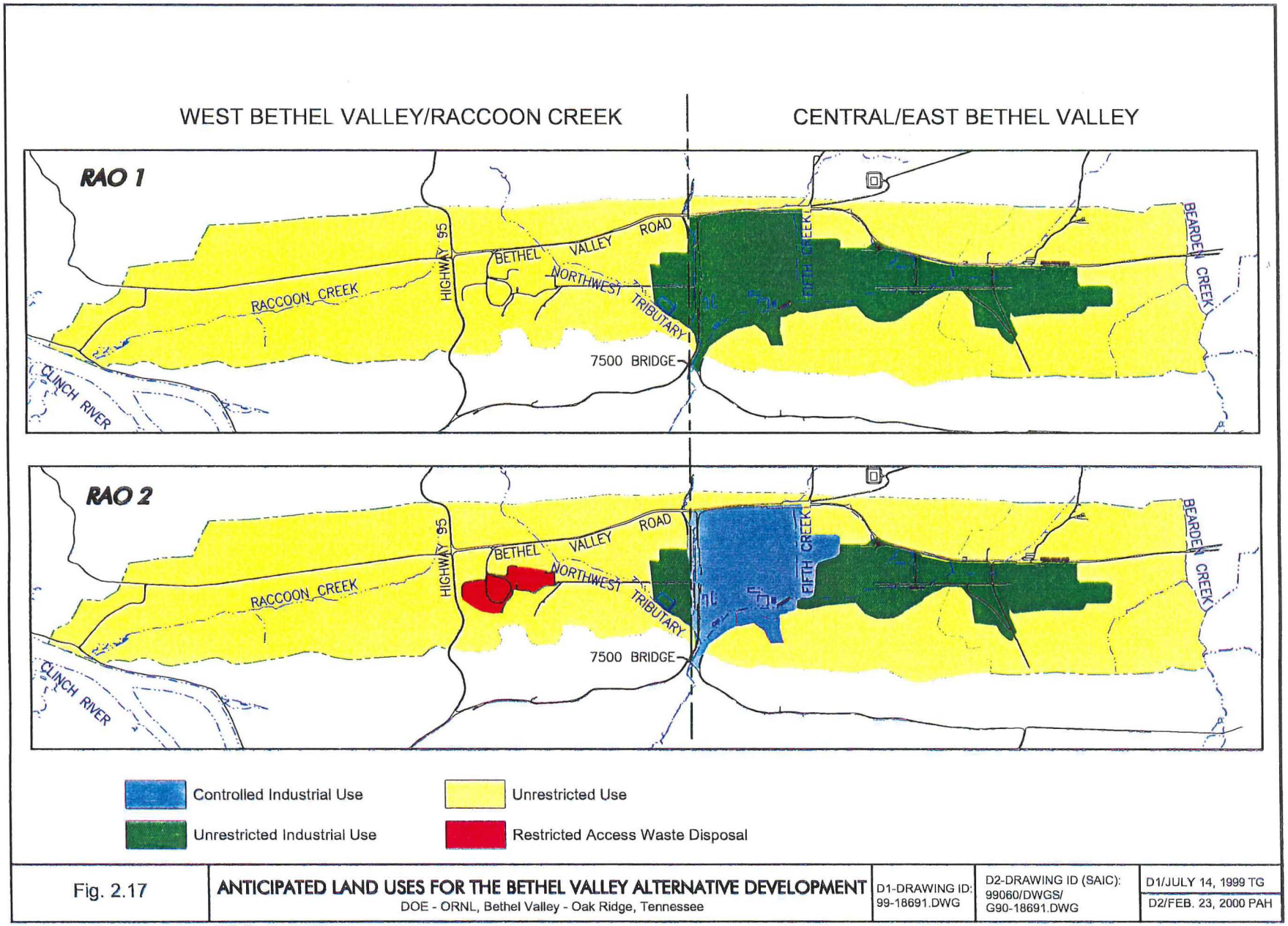


Fig. 2.17. Anticipated land uses for the Bethel Valley alternative development.

Both RAOs minimize further impacts to groundwater and prevent groundwater from causing surface water exceedances in waters of the state. This goal drives remediation of contaminated soil that is a significant and continuing source of groundwater contamination or AWQC exceedances in nearby streams. Identified plumes near surface water bodies do discharge to the surface water, albeit with relatively low contaminant concentration levels. Since final groundwater decisions are being deferred, these groundwater protection goals are considered interim.

Both RAOs protect reach-level populations of aquatic populations. Within ORNL, habitat for terrestrial organisms is insufficient to support significant populations. However, surface water does support limited populations of aquatic organisms.

2.8.1.2 RAOs for West Bethel Valley/Raccoon Creek

Major problems identified in West Bethel Valley/Raccoon Creek are the presence of (1) radiological contamination in buried wastes and soil that poses an unacceptable risk to human health and the environment and (2) radiological contamination in groundwater.

Table 2.23 presents the protection goals associated with each RAO. These RAOs and protection goals were developed based on protecting human health under a range of land use scenarios and on protecting the environment. Following are potential land uses for West Bethel Valley/Raccoon Creek:

- Unrestricted—no restrictions on surface or subsurface land use.
- Unrestricted industrial—unlimited industrial use to a depth of 3 m (10 ft).
- Restricted access waste disposal—access restrictions that limit surface use to monitoring and maintenance activities, with no soil disturbance.

Because of the ongoing mission of ORNL, the unrestricted (i.e., residential) land use scenario was eliminated as a likely future use for the industrial portion of the West Bethel Valley area (ORNL 1000 Area). Cleanup options, therefore, focused on industrial land use scenarios for that portion of the site. However, for the remainder of the West Bethel Valley/Raccoon Creek Area, unrestricted (residential) is a reasonable cleanup objective. Achieving unrestricted use requires removal of all contaminated soil above the groundwater table that is above remediation levels. Because buried waste is costly to remove and dispose of, restricted access waste disposal land use is also considered for SWSA 3 and the Contractor's Landfill. The more extensive RAO (RAO 1) achieves unrestricted use at SWSA 3 and the Contractor's Landfill; the less extensive RAO (RAO 2) achieves restricted access waste disposal use.

The surface water and groundwater protection goals are the same as for Central/East Bethel Valley, with the exception that the risk-reduction goal at the 7500 Bridge does not apply to West Bethel Valley/Raccoon Creek.

Both RAOs maintain protection of area populations of terrestrial organisms and provide protection for reach-level populations of aquatic populations. In the undeveloped portions of the valley, contamination is so isolated that terrestrial populations in the area are already protected. This protection will be maintained. Within the ORNL 1000 Area, habitat for terrestrial organisms is insufficient to support significant populations. However, surface water does support limited populations of aquatic organisms. The population, as defined by individuals within a reach of surface water, will be protected.

Table 2.23. RAOs and protection goals for West Bethel Valley/Raccoon Creek, ORNL, Oak Ridge, Tennessee

Issue	RAO		Protection goals
	1	2	
Future land use	✓		Protect human health for (1) unrestricted industrial use in the 1000 Area, (2) unrestricted use in the undeveloped areas, and (3) unrestricted use in the waste disposal areas, all to a risk level of 1×10^{-4}
		✓	Protect human health for (1) unrestricted industrial use in the 1000 Area, (2) unrestricted use in the undeveloped areas, and (3) restricted access waste disposal in the waste disposal areas, all to a risk level of 1×10^{-4}
Protection of surface water bodies	✓	✓	Maintain AWQC for designated stream uses in all waters of the state
	✓	✓	Maintain sediment and surface water recreational risk-based limits to a risk level of 1×10^{-4}
Groundwater protection	✓	✓	Minimize further impacts to groundwater
	✓	✓	Prevent groundwater from causing surface water exceedances in all waters of the state
Protection of ecological receptors	✓	✓	Maintain protection for area populations of terrestrial organisms and reach-level populations of aquatic organisms

AWQC = ambient water quality criteria
ORNL = Oak Ridge National Laboratory
RAO = remedial action objective

2.8.2 RAO for the Selected Remedy

The RAO for the selected remedy is presented in Table 2.24 and is a combination of RAO 2 for each subarea as presented previously, with minor modifications. Regulator comments on the draft proposed plan led to a change from the FS in the land use objectives for the waste disposal areas in West Bethel Valley. Instead of restricted access waste disposal land use for SWSA 3 and the Contractor's Landfill, the RAO for the selected remedy allows greater access to those areas by achieving a recreational land use for the remaining waste disposal areas. Figure 2.18 depicts this RAO for the selected remedy.

Table 2.24. RAO for the selected remedy for Bethel Valley, ORNL, Oak Ridge, Tennessee

Issue	Protection goals
Future land use	Protect human health for (1) controlled industrial use in ORNL's main plant area, (2) unrestricted industrial use in the remainder of the ORNL developed areas, (3) recreational use of SWSA 3 and the Contractor's Landfill, and (4) unrestricted use in the undeveloped areas, all to a risk level of 1×10^{-4}
Protection of surface water bodies	Achieve AWQC for designated stream uses in all waters of the state Achieve at least 45% risk reduction at 7500 Bridge Maintain surface water and achieve sediment recreational risk-based limits to a goal of 1×10^{-4}
Groundwater protection	Minimize further impacts to groundwater Prevent groundwater from causing surface water exceedances in all waters of the state
Protection of ecological receptors	Maintain protection for area populations of terrestrial organisms; protect reach-level populations of aquatic organisms

AWQC = ambient water quality criteria
ORNL = Oak Ridge National Laboratory
RAO = remedial action objective
SWSA = solid waste storage area

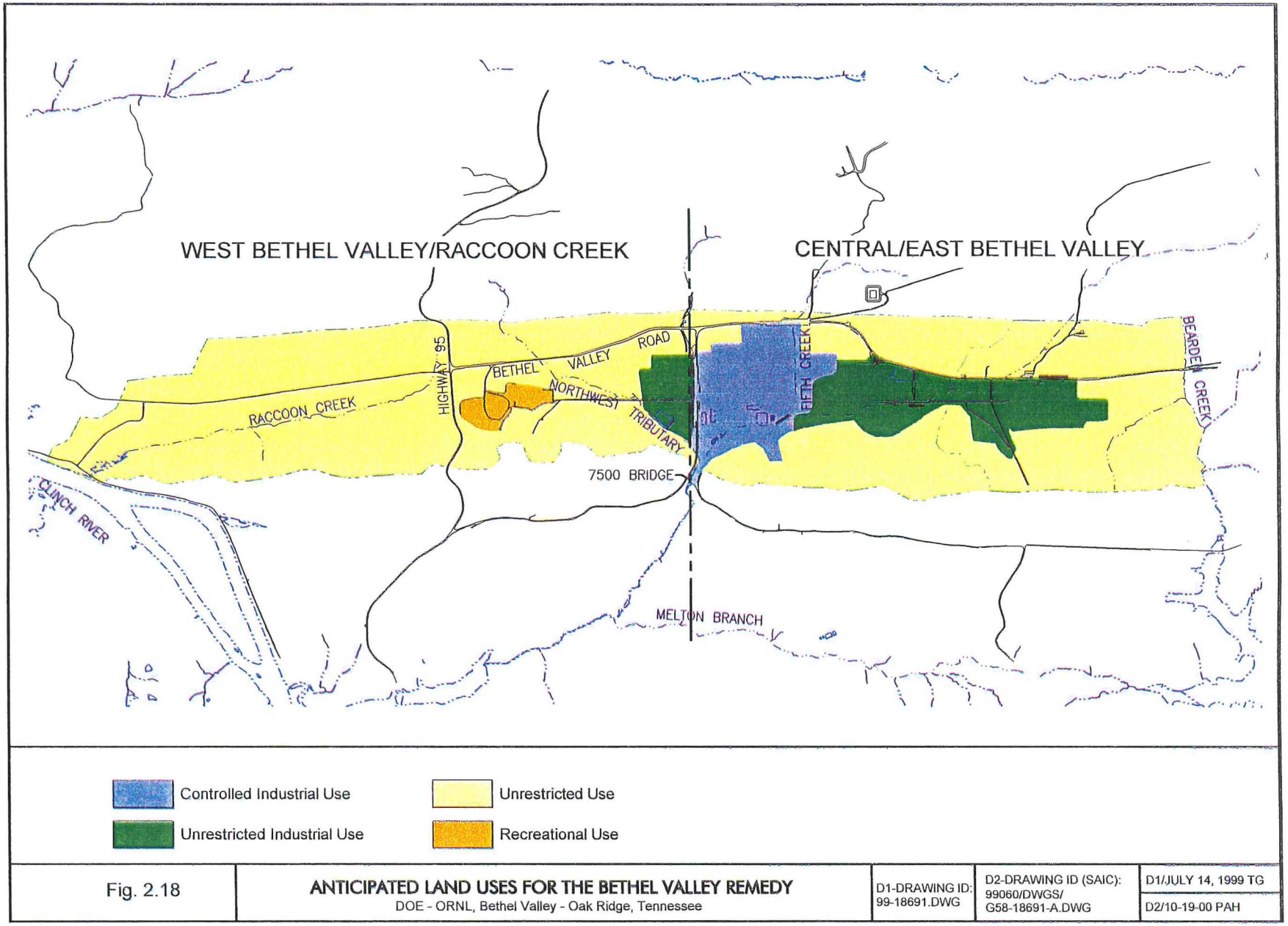


Fig. 2.18	ANTICIPATED LAND USES FOR THE BETHEL VALLEY REMEDY DOE - ORNL, Bethel Valley - Oak Ridge, Tennessee	D1-DRAWING ID: 99-18691.DWG	D2-DRAWING ID (SAIC): 99060/DWGS/ G58-18691-A.DWG	D1/JULY 14, 1999 TG D2/10-19-00 PAH

Fig. 2.18. Anticipated land uses for the Bethel Valley remedy.

2.9 SUMMARY OF REMEDIAL ALTERNATIVES

Having defined a range of cleanup goals, specific remediation alternatives and general responses were developed to achieve these goals (Table 2.25). As with the RAOs, a set of alternatives was developed for each of two subareas in Bethel Valley. Four remedial alternatives were developed for Central/East Bethel Valley, including the no action alternative. Five remedial alternatives were developed for West Bethel Valley/Raccoon Creek, including the no action alternative. The no action alternatives serve as baselines for comparison of the action alternatives as required by CERCLA and NEPA. Within Alternatives C-2 and C-3, subalternatives were developed based on differing remediation strategies for groundwater. For Alternatives C-2a and C-3a, the preferred remediation strategy for the East Bethel Valley Plume was removal; for Alternatives C-2b and C-3b, the preferred remediation strategy was in situ treatment. Within Alternative W-4 subalternatives were developed based on differing strategies for remediation of SWSA 3. Alternative W-4a includes both capping and in situ grouting of waste; Alternative W-4b does not include the in situ grouting.

Table 2.25. Remediation alternatives and key general responses, Bethel Valley, ORNL, Oak Ridge, Tennessee

Remedial Action Objective	Alternative	Primary general responses	
		Sources	Groundwater
Central/East Bethel Valley			
—	C-1	No action	No action
1	C-2	Removal	Extensive
2	C-3	Isolation	Extensive
2	C-4	Isolation	Limited
West Bethel Valley/Raccoon Creek			
—	W-1	No action	No action
1	W-2	Removal	Extensive
1	W-3	Removal	Limited
2	W-4	Isolation	Extensive
2	W-5	Isolation	Limited

ORNL = Oak Ridge National Laboratory

2.9.1 Remedial Alternatives for Central/East Bethel Valley

Four remedial alternatives were developed in the FS for Central/East Bethel Valley, including the no action alternative (DOE 1999a). The three action alternatives rely on removal or isolation of the multiple contaminated media types in Central/East Bethel Valley that contribute to unacceptable risk. These alternatives are presented in Table 2.25 and are summarized here. Remedial actions proposed for each alternative were designed to achieve corresponding RAOs. These actions address buildings/facilities, buried waste, tank sludge and shells, contaminated soil, pipelines, contaminated sediment, groundwater extraction and treatment, and waste disposal. To provide a complete basis of comparison among remediation strategies, Table 2.26 (and, similarly, Table 2.27 for West Bethel Valley/Raccoon Creek alternatives) also includes the selected remedy. The most extensive alternative (C-2) achieves unrestricted industrial use (RAO 1) primarily by relying on source removal coupled with certain LUCs to meet risk-based goals and ARARs (Appendix B) for protection of human health and the environment. The less extensive alternatives (C-3 and C-4) achieve controlled industrial use (RAO 2) of the site primarily by source isolation with more reliance on LUCs. The groundwater actions of Alternatives C-2 and C-3 are more extensive than those of Alternative C-4; Alternatives C-2 and C-3 include additional groundwater extraction and/or in situ treatment actions.

Table 2.26. Principal actions for Central/East Bethel Valley alternatives, ORNL, Oak Ridge, Tennessee

Alternative component or feature		Alternatives and remedial actions			
		C-2	C-3	C-4	Selected Remedy
Buildings/ facilities	Multiple structures	Remove all contaminated surface and subsurface structures to protect the unrestricted industrial worker	Remove all surface and subsurface structures to a depth of 0.6 m (2 ft) to protect the controlled industrial worker; decontaminate substructures to minimize impacts to groundwater; backfill with soil	Remove all surface and subsurface structures to a depth of 0.6 m (2 ft) to protect the controlled industrial worker; remove loose contamination and backfill with flowable fill to minimize impacts to groundwater; cover with soil	Remove inactive buildings/facilities to grade level. Decontaminate and stabilize or remove structures at or below grade, depending on cost effectiveness and extent of soil contamination. Dispose of debris at EMWMF.
	Graphite Reactor building	Grout Graphite Reactor core to protect the industrial worker			
Buried waste	SWSA 1	Remove buried waste and soil to protect the unrestricted industrial worker and to minimize impacts to groundwater [est. 12,200 m^3 (16,000 yd^3)]	Install a cap to protect the worker and to minimize impacts to groundwater		
	FWPA	Remove buried waste and soil to protect the unrestricted industrial worker [est. 1500 m^3 (2000 yd^3)]	maintain soil cover to protect the worker		
	NRWTP Debris Pile	Remove buried waste and soil to protect the unrestricted industrial worker [est. 3000 m^3 (4000 yd^3)]	maintain soil cover to protect the worker		
Tank sludge and linings	Tank contents	Remove sludge and liquid from all tanks to protect surface water and minimize impacts to groundwater			
	Gunite/concrete	**Near-term:** remove contaminated tank linings from 12 Gunite Tanks and grout to minimize impacts to groundwater; grout 3003-A **Future:** remove 3003-A with deep soil to protect the unrestricted industrial worker	Fill Gunite Tank shells with grout to minimize impacts to groundwater		
	Steel	**Near-term:** remove vaulted tank shells and grout below-ground tank shells to protect surface water and minimize impacts to groundwater **Future:** remove grouted tank shells with deep soil to protect the unrestricted industrial worker	Remove vaulted tank shells and grout or remove below-ground tank shells, according to decision diagram, to protect surface water and minimize impacts to groundwater (estimated removal of 7 vaulted tanks and grouting of 20 below-ground tank shells)		FFA inactive tanks (except GAAT OU and S-424) undergoing sludge removal and stabilization as part of early action. No further action required under this decision. Grout S-424. Land use controls

Table 2.26. Principal actions for Central/East Bethel Valley alternatives, ORNL, Oak Ridge, Tennessee (continued)

Alternative component or feature		Alternatives and remedial actions			
		C-2	C-3	C-4	Selected Remedy
Process and LLLW pipelines	Main Plant Area	**Near-term:** grout pipeline and associated bedding material to protect surface water and minimize impacts to groundwater [est. 16,000 lin m (52,000 lin ft)] **Future:** remove pipelines and bedding material with deep soil to protect the unrestricted industrial worker	Grout pipelines and associated bedding material to protect surface water and minimize impacts to groundwater [est. 16,000 lin m (52,000 lin ft)]; land use controls to protect the controlled industrial worker	Land use controls to protect the controlled industrial worker. If needed, grout pipelines and associated bedding materials to protect surface water (none assumed)	Grout LLLW pipelines [est. 15,000 lin m 50,000 lin ft)]. Install barriers in bedding material to prevent groundwater from contaminating surface water
	Outside Main Plant Area	Remove pipelines and contaminated bedding material to protect the unrestricted industrial worker [est. 1000 lin m (4000 lin ft)]			
Surface soil [< 0.6 m (2 ft)]	Main Plant Area	**Near-term:** remove surface soil to protect the industrial maintenance worker [est. 9000 m^3 (12,000 yd^3)] **Future:** remove with deep soil to protect the unrestricted industrial worker	Remove surface soil to protect the controlled industrial worker [est. 85,900 m^3 (112,300 yd^3)]		Remove surface soil to protect the controlled industrial worker [est. 9000 m^3 (12,000 yd^3)]
	Outside Main Plant Area	Remove soil to protect the unrestricted industrial worker [est. 500 m^3 (700 yd^3)]			
Deep soil [0.6–3 m (2–10 ft)]	Main Plant Area	**Near-term:** remove deep soil to minimize impacts to groundwater **Future:** remove soil to depth of 3 m (10 ft) to protect the unrestricted industrial worker [est. 656,000 m^3 (858,000 yd^3)]	Remove deep soil to minimize impacts to groundwater; land use controls to protect the controlled industrial worker	Land use controls to protect the controlled industrial worker	Remove deep soil to minimize impacts to groundwater; land use controls to protect the controlled industrial worker
	Outside Main Plant Area	Remove soil that exceeds remediation levels, if any, to protect unrestricted industrial worker			
Sediment and floodplain soils	WOC, First Creek, Fifth Creek	Remove sediment to achieve recreational risk-based limits and remove floodplain soils to protect the unrestricted industrial worker [est. 48,800 m^3 (63,800 yd^3)] and, as appropriate, remove sediment to protect ecological receptors	Remove sediment to achieve recreational risk-based limits and to control ^{137}Cs flux at the 7500 Bridge, remove floodplain soils to protect the controlled industrial worker [est. 13,500 m^3 (17,600 yd^3)] and, as appropriate, remove sediment to protect ecological receptors		

Table 2.26. Principal actions for Central/East Bethel Valley alternatives, ORNL, Oak Ridge, Tennessee (continued)

Alternative component or feature		Alternatives and remedial actions			
		C-2	C-3	C-4	Selected Remedy
Groundwater	Core Hole 8 Plume	Install linings in leaky stormwater junction boxes to protect surface water by limiting the migration of contaminated groundwater from the Core Hole 8 Plume into the storm drain system			
		Extract groundwater from four wells and from sumps at seven stormwater junction boxes near the Core Hole 8 Plume to protect surface water and minimize impacts to groundwater [est. combined rate of 416 L/min (110 gal/min)]; treat to remove ^{90}Sr and U		Extract groundwater from sumps at seven stormwater junction boxes near the Core Hole 8 Plume to protect surface water and minimize impacts to groundwater [est. combined rate of 265 L/min (70 gal/min)]; treat to remove ^{90}Sr and U	Extract groundwater from four wells and from sumps at seven stormwater junction boxes near the Core Hole 8 Plume to minimize impacts to groundwater and surface water [est. combined rate of 416 L/min (110 gal/min)]
	^{90}Sr-contaminated sumps	Pump from 27 existing sumps to protect surface water and minimize impacts to groundwater [est. combined rate of 307 L/min (81 gal/min)]; continue to treat to remove ^{90}Sr			
	Hg-contaminated sumps	Pump from four existing sumps [est. combined rate of 34 L/min (9 gal/min)]; add treatment to remove mercury to protect surface water			
	VOC Plume	Alternatives C-2a and C-3a: pump from two wells at a combined rate of 76 L/min (20 gal/min) to minimize impacts to groundwater; treat to remove VOCs Alternatives C-2b and C-3b: enhanced in situ bioremediation to minimize impacts to groundwater		Monitoring	Enhanced in situ bioremediation to minimize impacts to groundwater
	Well P&A	Grout poor-quality or obsolete monitoring wells and piezometers and abandon in place (est. 229 wells); in areas designated for unrestricted industrial or unrestricted use, remove contaminated well casings to depth of 3m (10 ft); in controlled industrial areas, remove contaminated well casing to a depth of 0.6 m (2 ft)			
	Contingency at Core Hole 8 Plume	Groundwater collection trenches to protect surface water			
	Contingency at South Area Plume	Groundwater collection trenches to protect surface water			
Land use controls	Main Plant Area	**Interim:** Fences; worker training; physical surveillance; permit program to restrict excavation and well installation; notice on court order **Final:** Permit program to restrict excavation and well installation, notice on original acquisition records	Fences; worker training; physical surveillance; permit program to restrict excavation and well installation; notice on original acquisition records		Property Record Restrictions, Property Record Notices, Zoning Notices, Permits Program, Access Controls (e.g., fences, gates, portals), Signs, Surveillance Patrols
	Remainder C/EBV	Permit program to restrict excavation and well installation, notice on original acquisition records			
Estimated waste disposal requirements	ORR EMWMF	106,200 m^3 (138,900 yd^3)	141,200 m^3 (184,700 yd^3)	139,400 m^3 (182,300 yd^3)	63,000 m^3 (82,000 yd^3)
	Future on-site waste disposal facility	656,000 m^3 (858,000 yd^3)	NA		
	Construction debris landfill	1,800 m^3 (2,400 yd^3)	1,500 m^3 (2,000 yd^3)	1,500 m^3 (2,000 yd^3)	1,500 m^3 (2,000 yd^3)

Table 2.26. Principal actions for Central/East Bethel Valley alternatives, ORNL, Oak Ridge, Tennessee (continued)

Alternative component or feature		Alternatives and remedial actions			
		C-2	C-3	C-4	Selected Remedy
	Off-site LLW repository	150 m^3 (200 yd^3)	150 m^3 (190 yd^3)	150 m^3 (190 yd^3)	150 m^3 (190 yd^3)
Estimated waste disposal requirements (continued)	Off-site RCRA TSD facility	64,000 L (17,000 gal)	64,000 L (17,000 gal)	64,000 L (17,000 gal)	64,000 L (17,000 gal)
	TSCA Incinerator	30,700 L (8,100 gal)	30,700 L (8,100 gal)	30,700 L (8,100 gal)	30,700 L (8,100 gal)
	On-site storage of Gunite (TRU)	150 m^3 (200 yd^3)	NA	NA	NA
	On-site storage of tank sludge (TRU/PCB)	1.5 m^3 (2 yd^3)	1.5 m^3 (2 yd^3)	1.5 m^3 (2 yd^3)	Addressed by early actions
	LLLW system	250,000 L (66,000 gal)	230,000 L (61,000 gal)	230,000 L (61,000 gal)	Addressed by early actions
	Recycle/storage	170 m^3 (220 yd^3)	170 m^3 (220 yd^3)	170 m^3 (220 yd^3)	170 m^3 (220 yd^3)
	PWTC	5,700,000 L (1,500,000 gal)	3,800,000 L (1,000,000 gal)	3,800,000 L (1,000,000 gal)	3,800,000 L (1,000,000 gal)
		738 L/min (195 gal/min) [432 L/min (114 gal/min) with pretreatment]	738 L/min (195 gal/min) [432 L/min (114 gal/min) with pretreatment]	587 L/min (155 gal/min) [280 L/min (74 gal/min) with pretreatment]	738 L/min (195 gal/min)
	VOC removal and local outfall	76 L/min (20 gal/min) (C-2a only)	76 L/min (20 gal/min) (C-3a only)	NA	NA
	Hg removal and local outfall	19 L/min (5 gal/min)	19 L/min (5 gal/min)	19 L/min (5 gal/min)	19 L/min (5 gal/min)

< = less than
C/EBV = Central/East Bethel Valley
EMWMF = Environmental Management Waste Management Facility
FFA = Federal Facility Agreement
FWPA = Former Waste Pile Area
GAAT = Gunite and Associated Tanks
LLLW = low-level (radioactive) liquid waste
LLW = low-level (radioactive) waste
NA = not applicable
NRWTP = Nonradiological Wastewater Treatment Plant
ORNL = Oak Ridge National Laboratory
ORR = Oak Ridge Reservation
OU = operable unit
P&A = plugging and abandonment
PCB = polychlorinated biphenyl
PWTC = Process Waste Treatment Complex
RCRA = Resource Conservation and Recovery Act of 1976
SWSA = solid waste storage area
TRU = transuranic
TSCA = Toxic Substances Control Act of 1976
TSD = treatment, storage, and disposal
VOC = volatile organic compound
WOC = White Oak Creek

Table 2.27. Principal actions for West Bethel Valley/Raccoon Creek alternatives, ORNL, Oak Ridge, Tennessee

Alternative component or feature		Alternatives and remedial actions				
		W-2	W-3	W-4	W-5	Selected Remedy
Buried waste	SWSA 3	Remove buried waste and soil to protect the unrestricted user and to minimize impacts to groundwater [est. 96,700 m^3 (126,500 yd^3)]		Grout waste (Alternative 4a only) to minimize impacts to groundwater; install multilayer cap to protect the maintenance worker and to minimize impacts to groundwater; install upgradient diversion trench to minimize impacts to groundwater. Fence site		Install multilayer cap to protect the maintenance worker and recreational user and to minimize impacts to groundwater; install upgradient diversion trench to minimize impacts to groundwater.
	Contractor's Landfill	Remove buried waste to protect the unrestricted user [est. 105,800 m^3 (138,400 yd^3)]		Maintain soil cover to protect the maintenance worker		Maintain soil cover to protect the maintenance worker and recreational user
Soil	1000 Area	Remove soil that exceeds remediation levels, if any, to protect the unrestricted industrial worker				
	Remainder WBV	Remove soil to protect the unrestricted user [est. 15,900 m^3 (20,800 yd^3)]		Remove soil to protect the unrestricted user [est. 17,500 m^3 (22,900 yd^3)]		
Groundwater	SWSA 3 Plume	Extract groundwater from 3 wells to minimize impacts to groundwater [est. combined rate of 114 L/min (30 gal/min)]; treat to remove ^{90}Sr	Natural attenuation and monitoring	Extract groundwater from 3 wells to minimize impacts to groundwater [est. combined rate of 114 L/min (30 gal/min)]; treat to remove ^{90}Sr	Natural attenuation and monitoring	Monitoring and land use controls
	Contingency at Northwest Tributary	NA		Interceptor trench to protect Northwest Tributary		
	Contingency at Raccoon Creek	Interceptor trench to protect Raccoon Creek				
Land use controls	Undeveloped areas	Permit program to restrict deep excavation and groundwater well installation; notice on original acquisition records				
	Developed areas	Permit program to restrict deep excavation and groundwater well installation; notice on original acquisition records				
	Buried waste disposal areas	Permit program to restrict deep excavation and groundwater well installation; notice on original acquisition records		Fence; worker training; physical surveillance; permit programs to restrict excavation and groundwater well installation; notice on original acquisition records		Property Record Restrictions, Property Record Notices, Zoning Notices, Permits Program, Access Controls (e.g., fences, gates, portals), Signs, Surveillance Patrols
Estimated waste disposal requirements	ORR EMWMF	67,000 m^3 (88,000 yd^3)	67,000 m^3 (88,000 yd^3)	4.2 m^3 (5.5 yd^3)	NA	NA
	Construction debris landfill	92,000 m^3 (120,000 yd^3)	92,000 m^3 (120,000 yd^3)	NA	NA	NA
	Off-site mixed waste repository	2,400 m^3 (3,200 yd^3)	2,400 m^3 (3,200 yd^3)	NA	NA	NA
	PWTC	12,900,000 L (3,400,000 gal)	12,900,000 L (3,400,000 gal)	6,800,000 L (1,800,000 gal) (Alt. 4a) 170,000 L (45,000 gal) (Alt. 4b)	170,000 L (45,000 gal)	170,000 L (45,000 gal)
		30 gal/min	NA	114 L/min (30 gal/min)	NA	NA

EMWMF = Environmental Management Waste Management Facility
NA = not applicable
ORNL = Oak Ridge National Laboratory
ORR = Oak Ridge Reservation
PWTC = Process Waste Treatment Complex
SWSA = solid waste storage area
WBV = West Bethel Valley

Alternative C-1—No Action. As required by the NCP, the no action alternative provides a comparative baseline against which other alternatives can be evaluated. Under this alternative, all source units, surface water, and groundwater would be left as is without implementing any isolation, removal, treatment, or other mitigating actions. Existing media monitoring, LUCs, groundwater collection programs, and maintenance programs would be discontinued. No other actions would be implemented to reduce existing or potential future unacceptable exposure to human and ecological receptors.

Alternative C-2 (a and b)—Complete Soil Removal with Extensive Groundwater Action. Alternative C-2 is designed to achieve RAO 1 by extensive source removal (Fig. 2.19). This alternative would be implemented in two phases: (1) near-term actions would protect human health of on-site workers until the ORNL operations are terminated at the site, and (2) a future large-scale removal activity would achieve unrestricted industrial use at the site once ORNL site operations are terminated. Under this alternative, all but one of the 54 remaining buildings/facilities designated for D&D would be completely removed from the site. The Graphite Reactor, which is a National Historic Landmark, would be stabilized by grouting the reactor core and would remain on the site. All buried waste would be removed from SWSA 1, the NRWTP Debris Pile, and the FWPA. The interior layer of the Gunite Tank shells would be removed, and then the shells would be grouted in place; grouted steel tank shells would be removed later as part of the large-scale soil removal activity. Inactive LLLW and process waste pipelines and bedding materials would also be grouted (as a near-term action) and later removed as part of the large-scale soil removal activity. In the near-term, contaminated surface soil hot spots would be removed and current LUCs would be continued to protect on-site workers; in the future, contaminated soil would be removed to a depth of 3 m (10 ft) to protect the unrestricted industrial worker. Contaminated sediment would be removed in the near term from White Oak Creek, First Creek, and Fifth Creek to protect the recreational user and aquatic organisms. Groundwater would be extracted from the Core Hole 8 Plume using sumps and extraction wells in the near term. Contaminated groundwater would also be extracted from existing building and tank sumps. At the East Bethel Valley VOC Plume, groundwater would either be extracted (Alternative C-2a) or treated in situ (Alternative C-2b). Groundwater use restrictions would be required.

Alternative C-3 (a and b)—Limited Soil Removal with Extensive Groundwater Action. Alternative C-3 is designed to achieve RAO 2 by a combination of source removal and isolation (Fig. 2.20). Under this alternative, all but one of the 54 remaining buildings/facilities designated for D&D would be completely removed from the site. Below-ground basements would be removed to a depth of 0.6 m (2 ft) below ground surface, and the remainder of the subsurface structure would be decontaminated to protect the groundwater. As with Alternative C-2, the Graphite Reactor would be stabilized and would remain on the site. A multilayer cap would be installed on SWSA 1, and soil covers would be provided at the NRWTP Debris Pile and the FWPA. Gunite and steel tank shells would be grouted in place. Inactive LLLW and process waste pipelines and bedding materials would also be grouted in place. Contaminated surface soil would be removed to protect the controlled industrial worker. Contaminated sediment would be removed from White Oak Creek, First Creek, and Fifth Creek to protect the recreational user and aquatic organisms. Groundwater actions for Alternatives C-3a and C-3b would be the same as for Alternatives C-2a and C-2b, respectively. LUCs, including excavation restrictions and groundwater use restrictions, would restrict access to contamination left in place.

Alternative C-4—Limited Soil Removal and Limited Groundwater Action. Alternative C-4 is designed to achieve RAO 2 by a combination of source removal and isolation (Fig. 2.21). Alternative C-4 differs from Alternative C-3 only in the extent to which the groundwater endpoints are pursued. Inactive LLLW and process waste pipelines and bedding materials would not be grouted in place unless they provide a contamination migration pathway that causes a surface water exceedance. Groundwater extraction from sumps would be the same as for Alternative C-3. However, the deep extraction wells would not be installed at the Core Hole 8 Plume, and the East Bethel Valley VOC Plume would be monitored.

2.9.2 Remedial Alternatives for West Bethel Valley/Raccoon Creek

Five remedial alternatives were developed in the FS for West Bethel Valley/Raccoon Creek, including the no action alternative (DOE 1999a). The four action alternatives rely on removal or isolation of buried waste and contaminated surface soil in West Bethel Valley/Raccoon Creek that contribute to unacceptable risk. These alternatives are presented in Table 2.27 and are summarized here. Partial excavation of the burial grounds to remove those portions posing the greatest risk was not included in any alternative because disposal records have limited data on waste placement. The actions considered for each medium or major component requiring remedial attention under each alternative are presented in the table. The more extensive alternatives (W-2 and W-3) achieve unrestricted use for the waste disposal areas (RAO 1) primarily by relying on source removal, coupled with certain groundwater use controls, to meet risk-based goals and ARARs (Appendix B) for protection of human health and the environment. The less extensive alternatives (W-4 and W-5) achieve restricted access waste disposal use of the waste disposal areas (RAO 2) primarily by source isolation, with more reliance on LUCs. The groundwater actions of Alternatives W-2 and W-4 are more extensive than those of Alternatives W-3 and W-5; Alternatives W-2 and W-4 include groundwater extraction and treatment.

Alternative W-1—No Action. As required by the NCP, the no action alternative provides a comparative baseline against which other alternatives can be evaluated. Under this alternative, all source units, surface water, and groundwater would be left as is without implementing any isolation, removal, treatment, or other mitigating actions. Existing LUCs and maintenance programs would be discontinued. No other actions would be implemented to reduce existing or potential future unacceptable exposure to human and ecological receptors.

Alternative W-2—Buried Waste Removal with Groundwater Extraction. Alternative W-2 is designed to achieve RAO 1 by extensive source removal (Fig. 2.22). Under this alternative, all buried waste would be removed from SWSA 3 and the Contractor's Landfill. Contaminated soil would also be removed to protect the unrestricted user. Extraction wells would be installed at the West Bethel Valley Plume. Groundwater use restrictions would be required.

Alternative W-3—Buried Waste Removal with Groundwater Monitoring. Alternative W-2 is designed to achieve RAO 1 by extensive source removal (Fig. 2.23). Under this alternative, all buried waste would be removed from SWSA 3 and the Contractor's Landfill. Contaminated soil would also be removed to protect the unrestricted user. This alternative differs from Alternative W-2 in that contaminated groundwater would be monitored. As with Alternative W-2, groundwater use restrictions would be required.

Alternative W-4 (a and b)—Buried Waste Isolation with Groundwater Extraction. Alternative W-4 is designed to achieve RAO 2 by a combination of source removal and isolation (Fig. 2.24). Under this alternative, a multilayer cap would be installed on SWSA 3 and a soil cover would be provided for the Contractor's Landfill. Contaminated soil would also be removed to protect the unrestricted user and could be used as contouring fill for the SWSA 3 cap. TDEC and EPA would review and approve plans to use excavated soil as contour fill. An upgradient diversion trench will be installed at SWSA 3 to intercept and divert laterally flowing groundwater and route it around the buried waste. Extraction wells would be installed at the West Bethel Valley Plume. Groundwater use restrictions would be required. Alternative W-4a was developed to consider additional protection to groundwater by grouting the SWSA 3 waste in place; Alternative W-4b does not include in situ grouting.

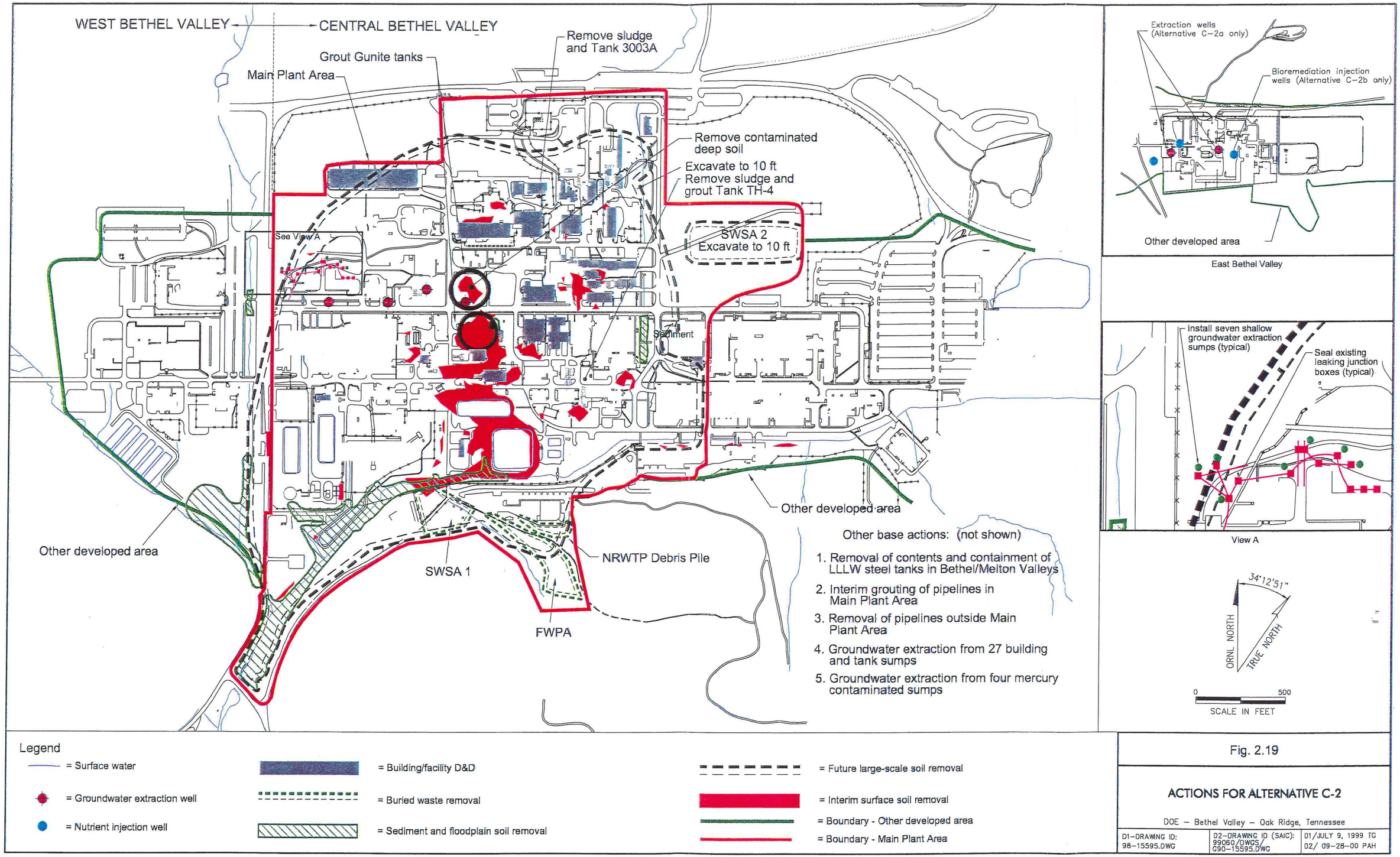


Fig. 2.19. Actions for Alternative C-2.

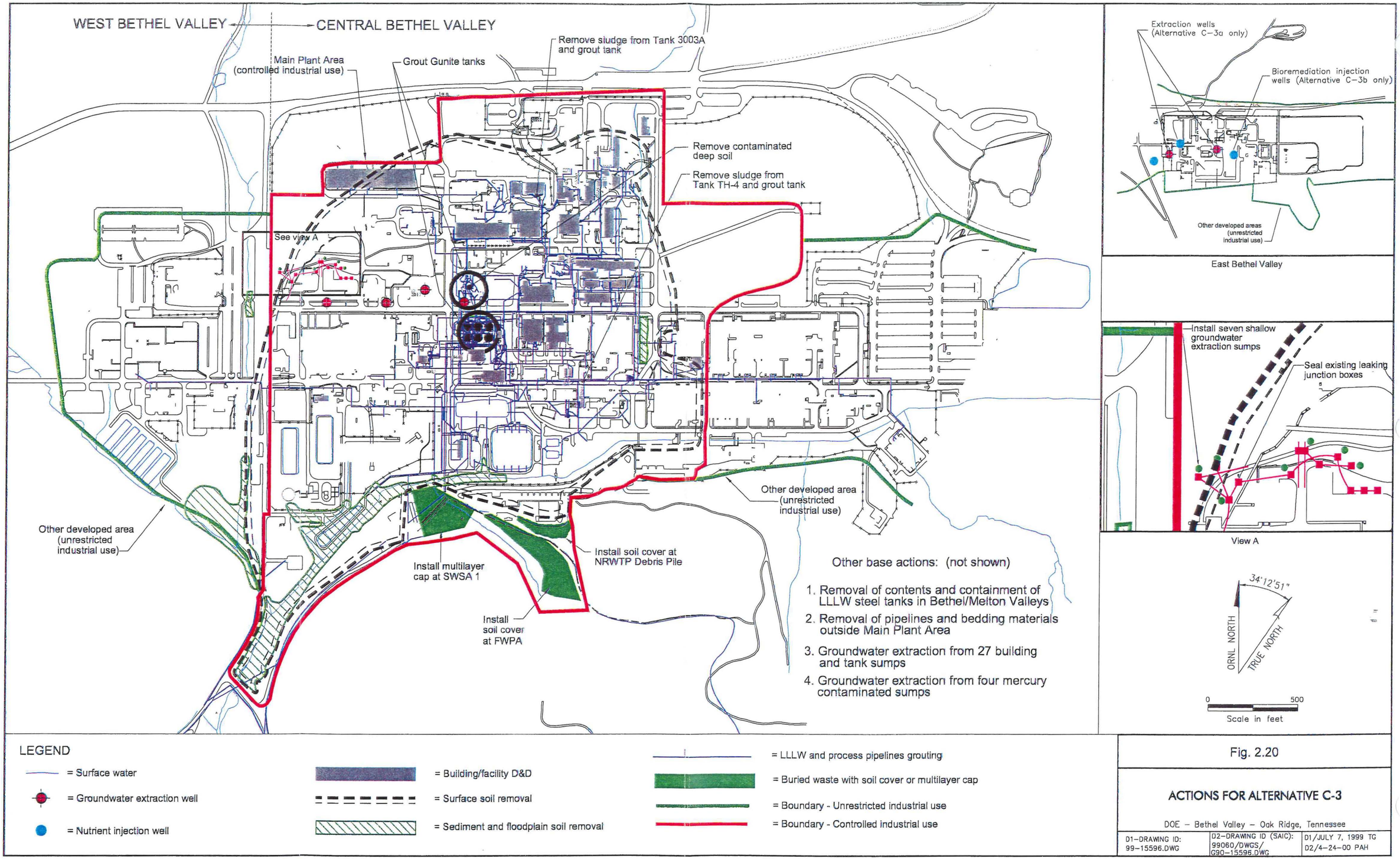


Fig. 2.20. Actions for Alternative C-3.

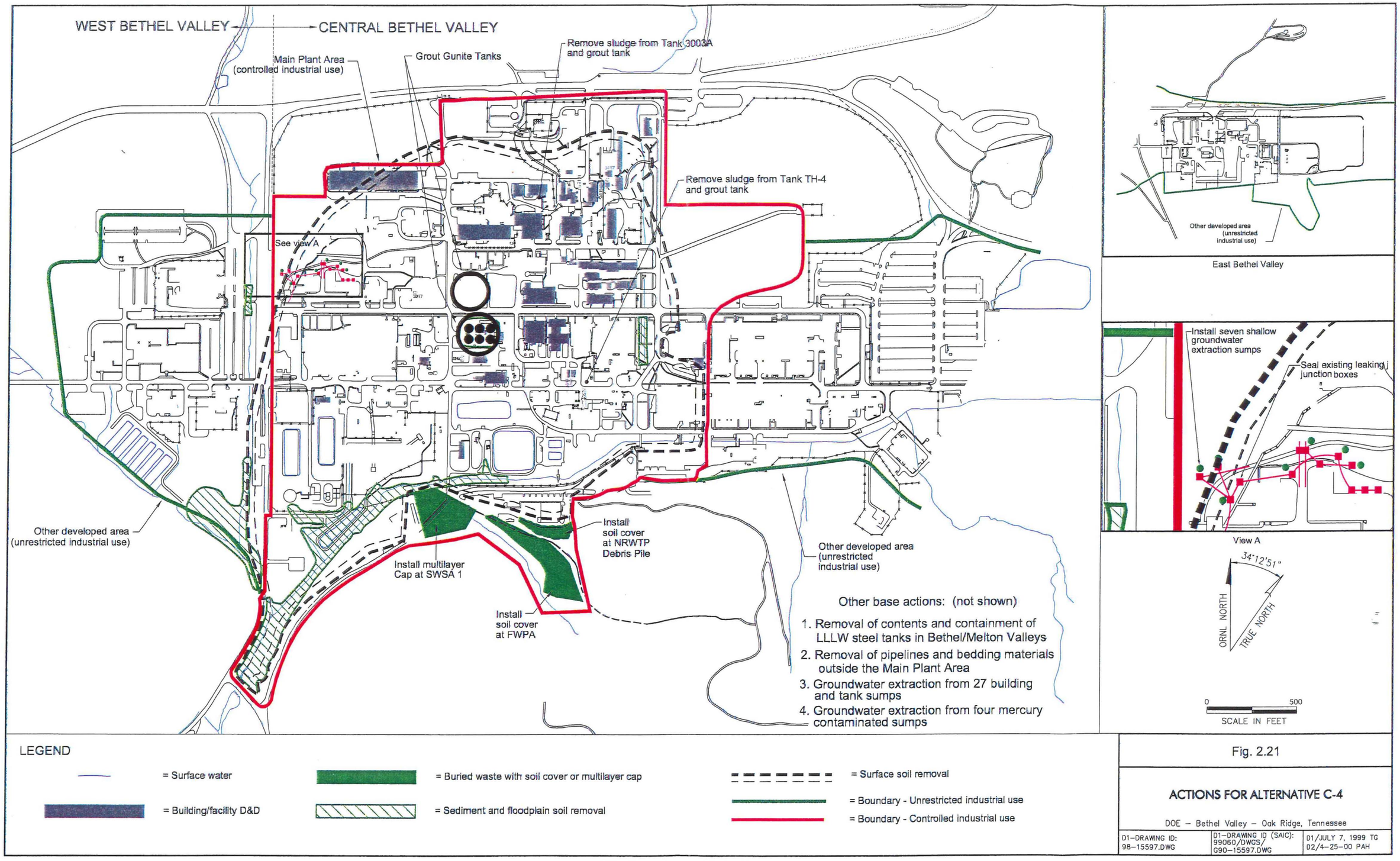


Fig. 2.21. Actions for Alternative C-4.

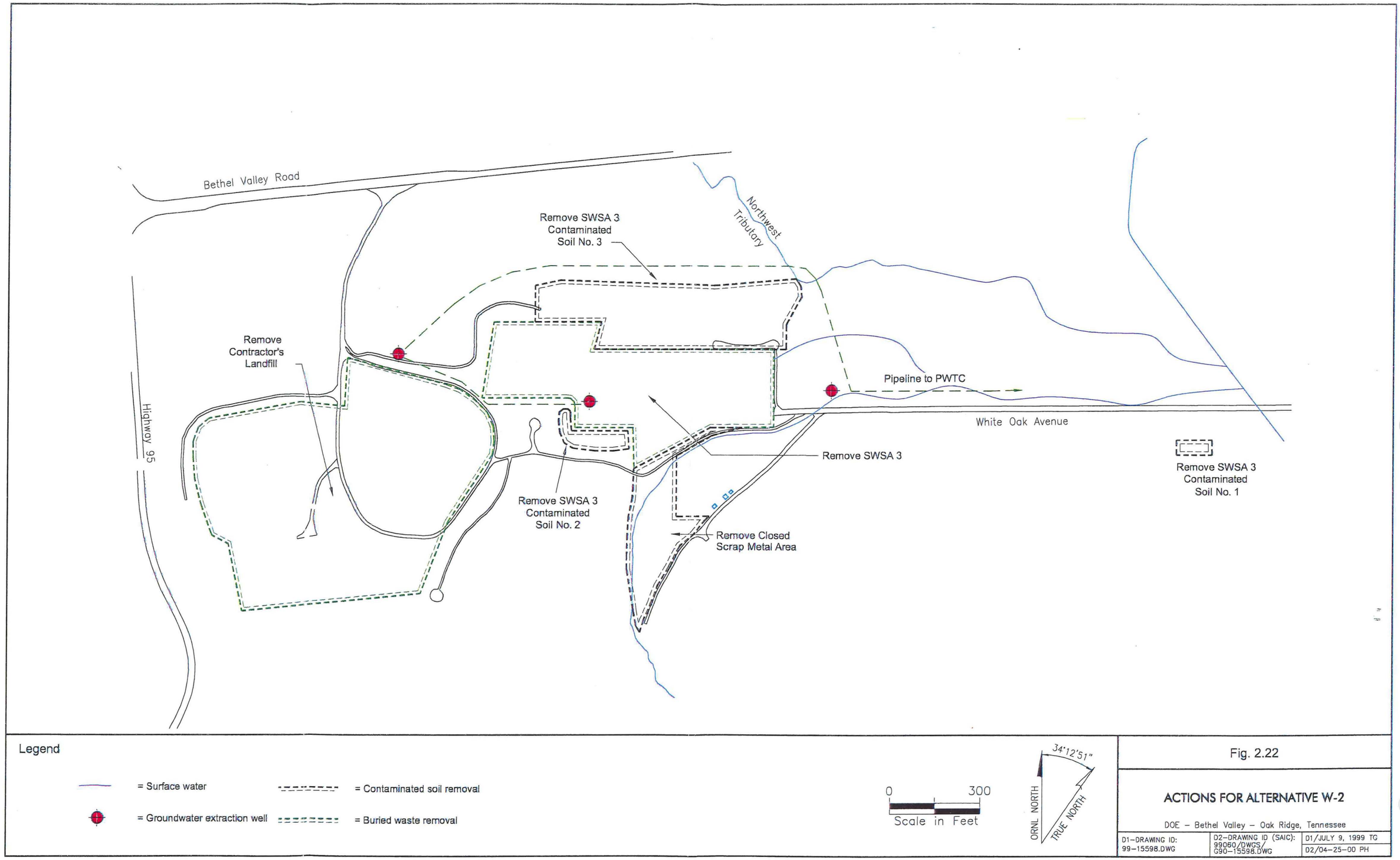


Fig. 2.22. Actions for Alternative W-2.

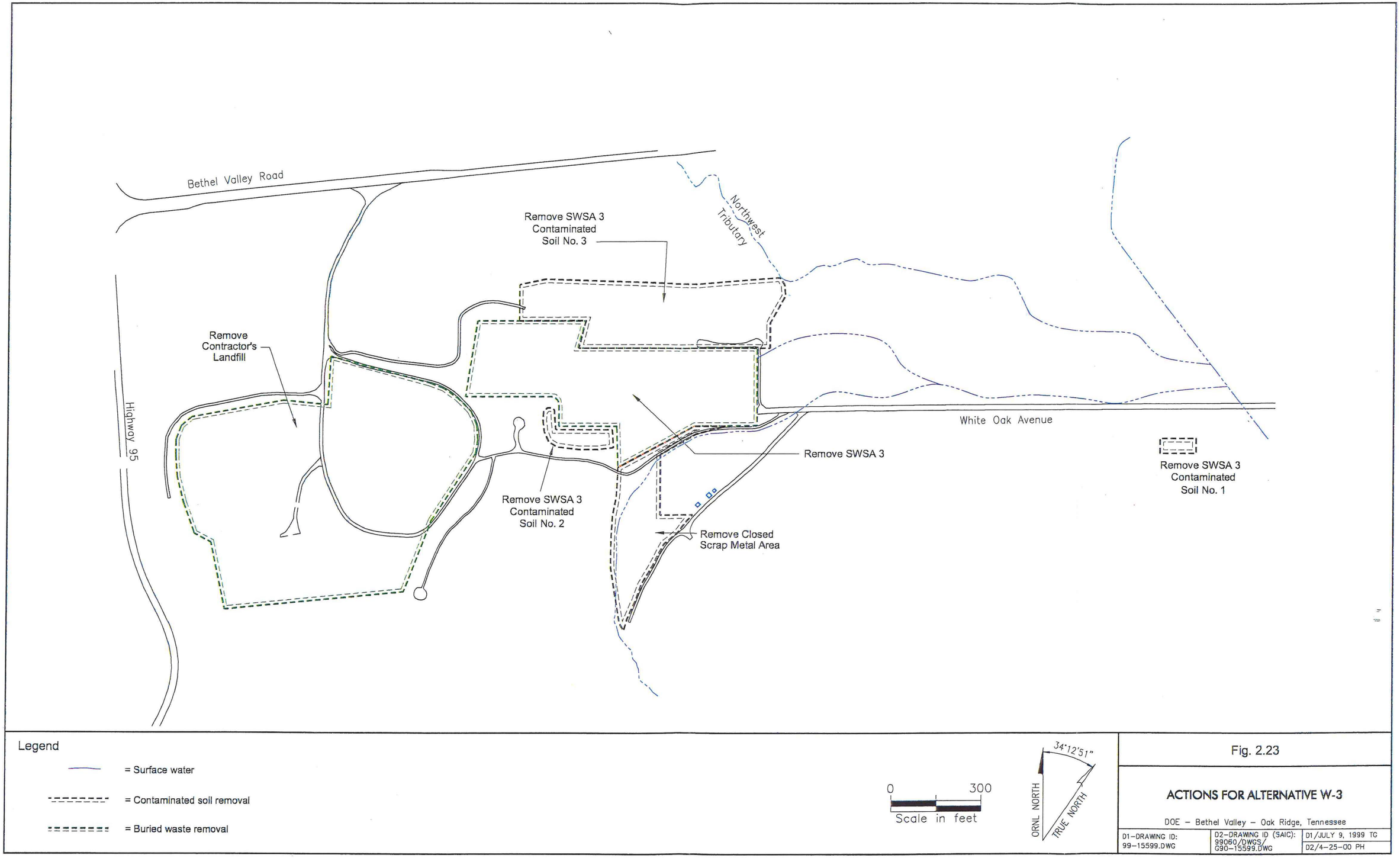


Fig. 2.23. Actions for Alternative W-3.

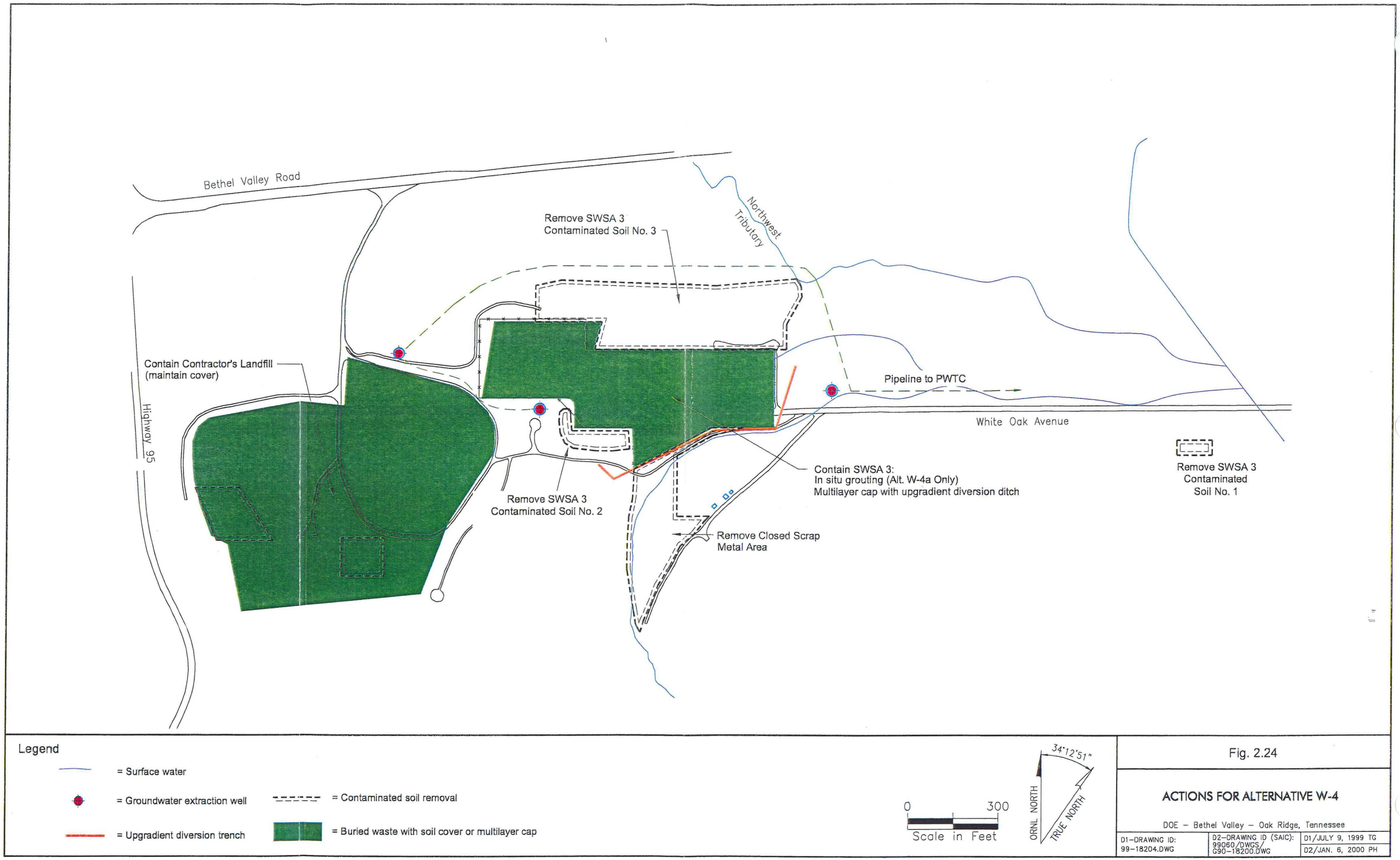


Fig. 2.24. Actions for Alternative W-4.

Alternative W-5—Buried Waste Isolation with Groundwater Monitoring. Alternative W-5 is designed to achieve RAO 2 by a combination of source removal and isolation (Fig. 2.25). Under this alternative, a multilayer cap would be installed on SWSA 3 and a soil cover would be provided for the Contractor's Landfill. Contaminated soil would also be removed to protect the unrestricted user and could be used as contouring fill for the SWSA 3 cap. TDEC and EPA would review and approve plans to use excavated soil as contour fill. An upgradient diversion trench will be installed at SWSA 3 to intercept and divert laterally flowing groundwater and route it around the buried waste. This alternative differs from Alternative W-4 in that the West Bethel Valley Plume would be monitored. As with Alternative W-4, groundwater use restrictions would be required.

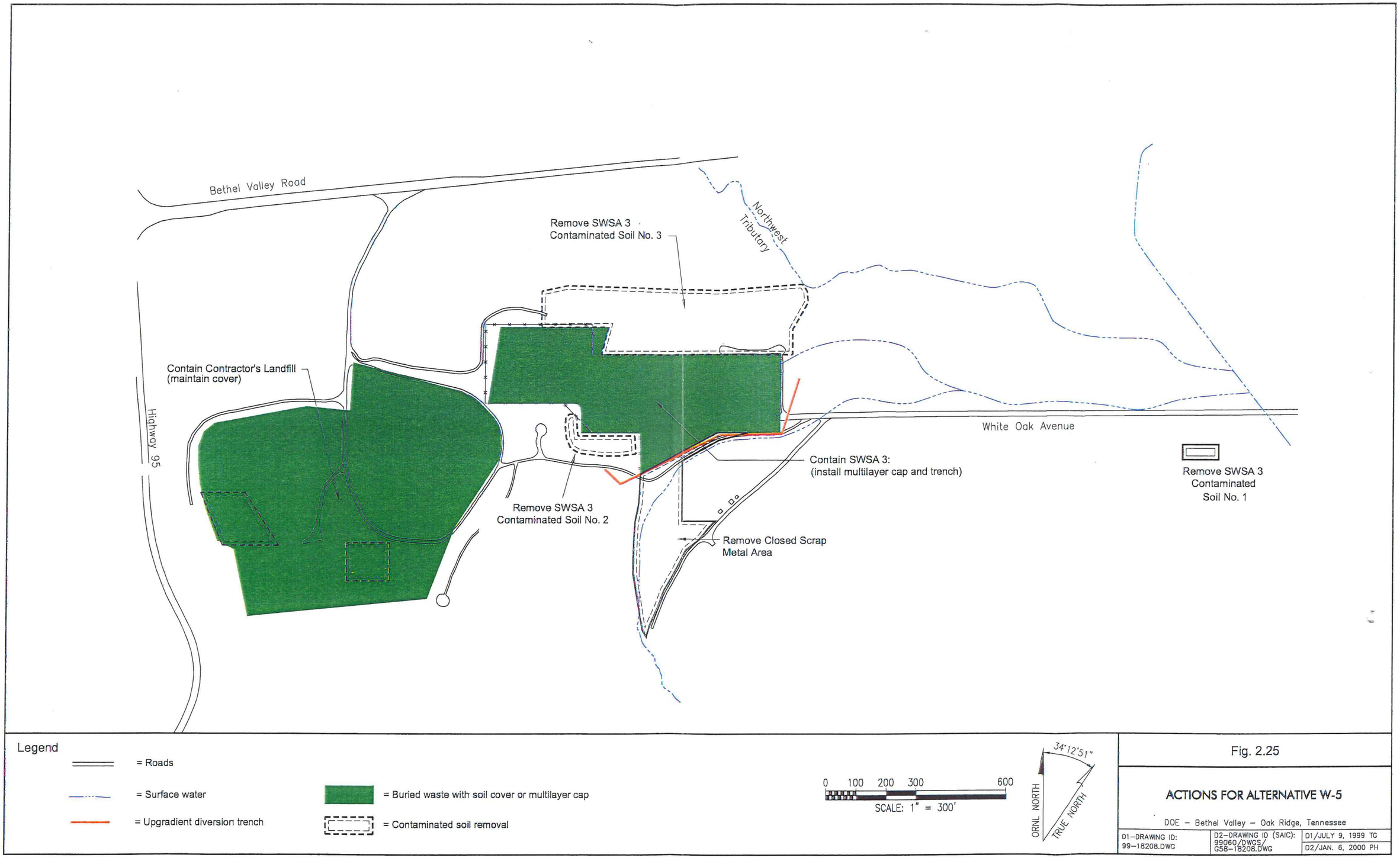


Fig. 2.25. Actions for Alternative W-5.

2.10 SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

All remediation alternatives must be evaluated against the nine CERCLA criteria (see below). The first criterion (overall protection of human health and the environment) must be met by any alternative considered for selection in the ROD. The second criterion (compliance with ARARs) must also be met by any alternative considered for selection unless an ARAR is waived under CERCLA Sect. 121(d)(4). The next five criteria (long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost) are the primary balancing criteria that form the basis of the detailed analysis. The evaluation against the first seven criteria resulted in identification of the preferred alternatives for Central/East Bethel Valley and West Bethel Valley/Raccoon Creek. The final two criteria (state acceptance and community acceptance) are the modifying criteria used in the final balancing of trade-offs between alternatives upon which the final remedy selection is based.

EVALUATION CRITERIA

1. *Overall protection of human health and the environment* addresses whether an alternative eliminates, reduces, or controls threats to public health and the environment.
2. *Compliance with ARARs* addresses whether an alternative meets federal and state environmental laws and regulations.
3. *Long-term effectiveness and permanence* considers the ability of an alternative to protect public health and the environment long after remedial action is complete.
4. *Reduction of toxicity, mobility, or volume through treatment* evaluates an alternative's use of treatment to reduce the harmful nature of contaminants; the contaminants' ability to move in the environment; and the amount, or volume, of contamination present.
5. *Short-term effectiveness* considers the time needed for an alternative to achieve remedial response objectives and the risks posed to workers, residents, and the environment during the remedial action.
6. *Implementability* addresses the feasibility of an alternative from a technical and an administrative standpoint.
7. *Cost* considers the amount of money it will take to design, construct, operate, and maintain the alternative.
8. *State acceptance* addresses TDEC comments concerning the alternatives considered.
9. *Community acceptance* addresses public comments on the alternatives being considered. Public comments are addressed in the Responsiveness Summary section of the ROD.

2.10.1 Evaluation of Alternatives for Central/East Bethel Valley

The comparative analysis of alternatives for Central/East Bethel Valley is presented in Table 2.28 and is summarized here. Consistent with DOE policy, NEPA values are incorporated into this evaluation. A similar comparative analysis, but for each site component (e.g., buildings, buried waste, tanks) is provided in Appendix D.

Table 2.28. Comparative evaluation of Central/East Bethel Valley alternatives, ORNL, Oak Ridge, Tennessee

Criteria		Alternative C-1	Alternative C-2a	Alternative C-2b	Alternative C-3a	Alternative C-3b	Alternative C-4
Overall protection of human health and the environment		Not protective	Protects industrial worker, off-site resident, recreational user of surface water bodies, and aquatic species		Protects controlled industrial worker, off-site resident, recreational user of surface water bodies, and aquatic species. Higher reliance on land use controls		Protects controlled industrial worker, off-site resident, recreational user of surface water bodies, and aquatic species. Higher reliance on land use controls
Compliance with ARARs		NA	Meets all ARARs for actions in scope		Meets all ARARs for actions in scope		Meets all ARARs for actions in scope
Long-term effectiveness and permanence		Unacceptable risk remains	Effective and permanent. More groundwater contaminant removal in future than C-4		Effective as long as land use controls remain in effect and maintenance activities performed as planned. More groundwater contaminant removal in future than C-4		Effective as long as land use controls remain in effect and maintenance activities performed as planned
				Effectiveness of bioremediation of VOC Plume is uncertain		Effectiveness of bioremediation of VOC Plume is uncertain	
Reduction of toxicity, mobility, or volume through treatment		No treatment	Water treatment [760-830 L/min (200–220 gal/min)] provides volume reduction. Grouting of tank shells, pipelines, and bedding materials reduces contaminant mobility		Water treatment [760-830 L/min (200–220 gal/min)] provides volume reduction. Grouting of tank shells, pipelines, and bedding materials reduces contaminant mobility		Less water treatment [610 L/min (160 gal/min)]. Grouting of tank shells reduces contaminant mobility. No grouting of pipelines
				Bioremediation breaks down VOCs permanently		Bioremediation breaks down VOCs permanently	
Short-term effectiveness		No short-term impacts	Most controls required to prevent potential for worker and community exposure		Some controls required to prevent short-term worker and community exposure		Some controls required to prevent short-term worker and community exposure
Implementability		No issues	Most difficult to implement. Largest difference is availability of a future on-site disposal cell and technical challenge of future large-scale soil removal activity		Implementable		Implementable
Base action cost (unescalated)	Capital D&D	NA	$85,000,000		$82,000,000		$81,00,000
	Capital RA	NA	$502,000,000	$502,000,000	$115,000,000	$115,000,000	$97,000,000
	Annual O&M	NA	$13,000,000	$13,000,000	$13,000,000	$13,000,000	$9,000,000

ARAR = applicable or relevant and appropriate requirement
D&D = decontamination and decommissioning
NA = not applicable
O&M = operation and maintenance
ORNL = Oak Ridge National Laboratory
RA = remedial action
VOC = volatile organic compound

Overall Protection of Human Health and the Environment. All action alternatives [Alternatives C-2 (a and b), C-3 (a and b), and C-4] protect the health of the industrial worker. (As explained in Sect. 2.9, the sub-alternatives for C-2 and C-3 differ in approach to treatment of groundwater in East Bethel Valley.) Alternative C-2 (a and b) protects primarily by removal of contaminated media; Alternatives C-3 (a and b) and C-4 protect primarily by removal and isolation of contaminated media, coupled with LUCs that restrict access. All action alternatives reduce the risk of contaminated surface water exiting Bethel Valley by at least 45%, achieve AWQC in all waters of the state, and achieve recreational risk-based goals for surface water and sediment. All action alternatives minimize further impacts to groundwater and prevent groundwater from causing surface water exceedances. All action alternatives protect aquatic populations.

The no action alternative (Alternative C-1) does not meet this threshold criterion and will not be discussed further in the balancing criteria.

Compliance with ARARs. All action alternatives would meet all chemical-specific ARARs for media within the scope of this decision. In particular, all would meet numeric AWQC and narrative criteria in all surface waters of the state and meet recreational risk-based limits in surface water and sediment. All action alternatives would also meet all location-specific and action-specific ARARs. Alternative C-1, the no action alternative, has no ARARs because no remedial actions would be taken; however, surface water currently does not meet AWQC. SDWA MCLs/MCLGs will be used in each alternative as values to assess groundwater quality and to evaluate effectiveness of source-control actions. Final groundwater decisions for Bethel Valley are being deferred to a later decision document. At that time, the final cleanup goal will be determined for groundwater.

Long-Term Effectiveness and Permanence. The long-term effectiveness of all action alternatives is similar, although the reliability of the alternatives differs. Because Alternative C-2 (a and b) relies on source removal and minimal LUCs to protect future users of the site, it is more reliable than Alternatives C-3 (a and b) and C-4. Alternatives C-3 (a and b) and C-4 rely on physical isolation of sources and on more LUCs to prevent access and therefore are considered less reliable. Alternatives C-3 (a and b) and C-4 are effective as long as LUCs remain in effect and maintenance activities are performed as planned. There is some uncertainty regarding the effectiveness of enhanced bioremediation of the East Bethel Valley VOC Plume in Alternatives C-2b and C-3b. This technology is unproven for fractured bedrock/karst applications. The major source of uncertainty is the degree to which nutrients can infiltrate the fractured system. However, since this action represents an interim rather than final groundwater action, issues associated with the ultimate effectiveness of the approach and the final groundwater remedial actions will be addressed under a separate, future discussion.

Reduction of Toxicity, Mobility, or Volume Through Treatment. All alternatives provide treatment for groundwater through groundwater extraction and treatment actions. Enhanced bioremediation (Alternatives C-2b and C-3b) provides in situ degradation of VOCs. Although there is uncertainty about the use of this technology in fractured bedrock, fast degradation rates are possible if nutrients infiltrate successfully. Alternatives C-2 and C-3 provide a reduction in contaminant mobility by grouting pipelines and pipeline trenches.

Short-Term Effectiveness. Short-term impacts require more engineering controls for Alternative C-2, primarily because of the future large scale soil removal activity. The future removal, transportation, and disposal of 656,000 m^3 (858,000 yd^3) of soil would result in greater opportunity for construction-related accidents, transportation-related accidents, and short-term environmental impacts. Because much less soil is excavated in Alternatives C-3 and C-4, these alternatives have less extensive short-term effects. For all action alternatives, removal of contaminated sediment in White Oak Creek will initially destroy aquatic habitat; however, no endangered or threatened species are affected and full recovery is planned.

Implementability. All alternatives are feasible and implementable. Under all alternatives, ORNL site operations could experience significant disruptions during removal of surface soils across the site. This activity could interfere with transportation, utilities, site operations, and other remedial operations. For all alternatives, remedial activities will be performed using standard construction equipment and procedures. With recent approval of the EMWMF ROD (DOE 1999e), very little waste must be disposed of off-ORR. No other administrative issues have been identified that would potentially prohibit or delay implementation. A large, experienced workforce exists to perform the remedial activities included in all of the alternatives.

Cost. Alternative C-2 is the most expensive, with a capital cost of approximately $586 million. Primary cost drivers are the future large-scale soil removal activity ($375 million), building/facility D&D ($85 million), LLLW tank and pipeline actions ($56 million), and removal of stream sediment and floodplain soil ($46 million). Alternative C-2 is nearly three times more expensive than Alternative C-3 ($198 million) and Alternative C-4 ($178 million) because C-2 has a less restrictive final land use. Most of this difference is because of the greater volume of soil removed under Alternative C-2. D&D costs differ very little among alternatives. Operation and maintenance (O&M) elements of Alternatives C-2 and C-3 are slightly greater than those for Alternative C-4 because of the long-term groundwater collection and treatment system for the Core Hole 8 Plume. The enhanced bioremediation alternatives (Alternatives C-2b and C-3b) have slightly lower O&M costs than their pump-and-treat counterparts.

The evaluation of cost estimates of all alternatives is sensitive to the actual volume of soil that exceeds remediation levels. For example, if the actual volumes of soils to be removed were double the current estimates, the total capital costs would increase by 30 to 60%.

Conclusion. All the action alternatives protect human health and the environment. Alternatives C-3 and Alternative C-4 are similar in that both return 147 acres to unrestricted industrial use and 153 acres (the main plant area) to controlled industrial use. Alternative C-2 initially returns 147 acres to unrestricted industrial use and provides interim measures to protect on-site workers in the main plant area until laboratory operations are discontinued, at which time the remaining 153 acres can be returned to unrestricted industrial use by removing a large area of contaminated soil to a depth of 3 m (10 ft). The cost difference of Alternative C-2 over Alternative C-3 is $389 million. Alternative C-3 differs from Alternative C-4 in that Alternative C-3 uses more extensive groundwater actions and grouts the pipelines to control groundwater flow. These actions would cost an additional $20 million in capital cost and $3.4 million/year additional O&M cost at least until the final groundwater decision.

2.10.2 NEPA Values for Central/East Bethel Valley Alternatives

NEPA values are incorporated into the FS (DOE 1999a), consistent with DOE policy. Issues related to the affected environment, including ecological resources, cultural resources, land use, socioeconomics, transportation impacts, and ambient noise, are covered under the "long-term effectiveness and permanence" and/or "short-term effectiveness" sections of the analysis. Important issues are detailed in the FS and are summarized here.

Under Alternative C-1 (the no action alternative), employment, traffic volume, noise levels, and ecological resources in Bethel Valley would remain the same. However, because ongoing groundwater collection would cease, this alternative would result in an increase in the release of contamination to surface water, which could impact drinking water supplies in the Clinch River downstream of ORNL. The large volume of borrow soil required and the volume of waste generated by Alternative C-2 would cause short-term increases in traffic, noise, and potential accidents. Effects of Alternatives C-3 and C-4 on ecological resources, socioeconomics, transportation, land use, etc., would be minimal.

Many of the buildings subject to remedial action (including the Graphite Reactor) are located within the ORNL Historic District and, therefore, adverse effects will be taken into account. Removal of some of these contributing structures could lessen the visibility and, hence, relative historical importance within the district.

Cumulative effects would depend on the timing and location of other activities at ORNL and on the ORR. Impacts could be substantial if remedial activities occur at all ORR facilities simultaneously. Total traffic, noise, fugitive dust, and sediment releases would be noticeably increased. Alternatives C-3 and C-4 and the near-term actions of Alternative C-2 would all have similar contributions to the cumulative effects. The future large-scale soil removal activity of Alternative C-2 would not likely coincide with other remedial activities at the ORR.

No environmental justice communities are impacted as a result of releases and cleanup activities at Central/East Bethel Valley.

2.10.3 Evaluation of Alternatives for West Bethel Valley/Raccoon Creek

The comparative analysis of alternatives for West Bethel Valley/Raccoon Creek is presented in Table 2.29 and is summarized here. Consistent with DOE policy, NEPA values are incorporated into this evaluation.

Overall Protection of Human Health and the Environment. All action alternatives [Alternatives W-2, W-3, W-4 (a and b), and W-5] protect human health. (As explained in Sect. 2.9, the sub-alternatives for W-4 differ in that W-4a includes grouting of SWSA-3 waste in place; W-4b does not include in situ grouting.) Alternatives W-2 and W-3 provide protection primarily by removal of contaminated media; Alternatives W-4 (a and b) and W-5 provide protection by isolation of contaminated media, coupled with LUCs to restrict access. All action alternatives maintain recreational risk-based goals for surface water and sediment. All action alternatives minimize further impacts to groundwater and prevent groundwater from causing surface water exceedences. Alternatives W-2 and W-4 (a and b) remove contaminant mass from the groundwater.

The no action alternative (Alternative W-1) does not meet this threshold criterion and will not be discussed further in the balancing criteria.

Compliance with ARARs. All action alternatives would meet all chemical-specific ARARs for media within the scope of this decision. All alternatives would also meet all location-specific and action-specific ARARs. Alternative W-1, the no action alternative, has no ARARs because no remedial action would be taken. SDWA MCLs/MCLGs will be used in each alternative as values to assess groundwater quality and to evaluate effectiveness of source-control actions. Final groundwater decisions for Bethel Valley are being deferred to a later decision document. At that time, the final cleanup goal will be determined for groundwater.

Long-Term Effectiveness and Permanence. Alternatives W-2 and W-3 rely on removal of contaminated media and minimal LUCs to protect future users of the site, whereas Alternatives W-4 (a and b) and W-5 rely on physical isolation of contaminated media and on more extensive LUCs to

Table 2.29. Comparative evaluation of West Bethel Valley/Raccoon Creek alternatives, ORNL, Oak Ridge, Tennessee

Criteria		Alternative W-1	Alternative W-2	Alternative W-3	Alternative W-4a	Alternative W-4b	Alternative W-5
Overall protection of human health and the environment		Not protective	Protects human health through removal of waste	Protects human health through removal of waste	Protects human health through containment of waste and land use controls		Protects human health through containment of waste and land use controls
Compliance with ARARs		Not applicable	Meets all ARARs for actions in scope	Meets all ARARs for actions in scope	Meets all ARARs for actions in scope		Meets all ARARs for actions in scope
Long-term effectiveness and permanence		Unacceptable risk remains	Effective and permanent	Effective and permanent	Effective as long as land use controls remain in effect and maintenance activities performed as planned		Effective as long as land use controls remain in effect and maintenance activities performed as planned
					Grouting may need replacement after a few decades		
Reduction of toxicity, mobility, or volume through treatment		No treatment	Water treatment provides volume reduction—114 L/min (30 gal/min)	No treatment	Water treatment provides volume reduction—114 L/min (30 gal/min)		No treatment
					In situ waste treatment of SWSA 3 reduces mobility of contaminants		
Short-term effectiveness		No short-term impacts	Greatest controls required for short-term impacts to worker and community because of large volume of waste excavated and transported	Controls required for short-term impacts to workers similar to Alternative W-2	Fewer controls because of lower volume of waste excavated and transported	Controls for short-term impacts to workers somewhat less than for Alternative W-4a	Controls for short-term impacts to workers somewhat less than for Alternative W-4a
Implementability		No issues	Implementable, although the removal of a burial ground includes large uncertainties	Implementable, although the removal of a burial ground includes large uncertainties	Implementable		Implementable
Base action cost (unescalated)	Capital	NA	$101,938,000	$100,989,000	$39,453,000	$8,082,000	$7,133,000
	Annual O&M	NA	$2,798,000	$67,000	$2,883,000	$2,883,000	$152,000

ARAR = applicable or relevant and appropriate requirement
NA = not applicable
O&M = operation and maintenance
ORNL = Oak Ridge National Laboratory
SWSA = solid waste storage area

prevent access. Alternatives W-4 (a and b) and W-5 are effective as long as LUCs remain in effect and maintenance activities are performed as planned. However, the reliability of Alternatives W-2 and W-3 is greater because the material is permanently removed. Alternative W-4a uses a cap plus grouting while Alternative W-4b just has a cap. Grouting may enhance reliability in the short-term interim but is not expected to increase the effectiveness over a cap alone.

Alternatives W-2 and W-4 (a and b) contain groundwater extraction. While these actions would reduce contaminant mass in the groundwater, it is unknown what impact interim extraction may have on times required to reach final cleanup objectives, which will be defined in a future groundwater decision.

Reduction of Toxicity, Mobility, or Volume Through Treatment. Alternative W-4a provides a significant reduction in contaminant mobility by grouting buried waste in SWSA 3. Alternatives W-2 and W-4 (a and b) provide treatment of groundwater through a groundwater extraction and treatment action. Alternatives W-3 and W-5 do not provide reduction of toxicity, mobility, or volume through treatment.

Short-Term Effectiveness. Engineering controls to control short-term worker risks for Alternatives W-2 and W-3 are greater than for the other alternatives because of the volume of material excavated and transported to the EMWMF. For Alternatives W-4 (a and b) and W-5, buried waste will not be exhumed, and only contaminated surface soil will be excavated. With appropriate controls, differences in short-term risks can be minimized.

Implementability. All alternatives are feasible and implementable. Remedial activities will be performed using standard construction equipment and procedures. However, excavation of a burial ground contains numerous significant uncertainties. No administrative issues have been identified that would potentially prohibit or delay implementation. A large experienced workforce exists to perform the remedial activities included in all of the alternatives.

Cost. A comparison of capital costs for the base actions shows that Alternative W-5 is least expensive ($7.1 million), followed by Alternative W-4b ($8.1 million), Alternative W-4a ($39.5 million), Alternative W-3 ($101 million), and Alternative W-2 ($102 million). Alternatives W-2 and W-3 are about 12 times more expensive than Alternative W-4b and W-5 because of more extensive remediation efforts. Removal, transportation, and disposal of buried waste is much more costly than in situ isolation. Alternative W-4a achieves a greater degree of reliability for isolation of SWSA 3 for an additional $31 million over Alternative W-4b. O&M elements for Alternatives W-2 and W-4 (a and b) are an order of magnitude greater than for Alternatives W-3 and W-5 because of the groundwater collection and treatment system. The O&M costs would be required at least until a final groundwater decision is made.

Conclusion. All the action alternatives protect human health and the environment. Alternatives W-2 and W-3 restore the undeveloped portion of the site to unrestricted use by removing all buried waste and contaminated soil. Alternatives W-4 (a and b) and W-5 restore most of the undeveloped area to unrestricted use, with restricted access to about 25 acres of waste management areas. O&M cost for restricted use is $85,000/year versus a capital cost for achieving unrestricted use for these 25 acres of $93.9 million.

The groundwater actions included in Alternatives W-2 and W-4 (a and b) result in an additional cost of $1 million for construction and $2.7 million/year for O&M. While these actions would reduce contaminant mass in the groundwater, it is unknown what impact interim extraction may have on times required to reach final cleanup objectives, which will be defined in a future groundwater decision.

Alternative W-4a includes in situ grouting of SWSA 3 waste and a multilayer cap; this in situ grouting adds $31.4 million to the cost of Alternative W-4 (a and b). However, grouting will not address

contamination that has already leached from the waste; therefore, in situ grouting is not expected to be more effective than capping alone at reducing groundwater contaminant concentrations.

2.10.4 NEPA Values for West Bethel Valley/Raccoon Creek Alternatives

NEPA values are incorporated into the FS (DOE 1999a) consistent with DOE policy. Issues related to the affected environment, including ecological resources, cultural resources, land use, socioeconomics, transportation impacts, and ambient noise, are covered under the "long-term effectiveness and permanence" and/or "short-term effectiveness" sections of the analysis. Important issues are detailed in the FS and are summarized here.

Under Alternative W-1 (the no action alternative), employment, traffic volume, noise levels, and ecological resources in Bethel Valley would remain the same. However, because soil covers over SWSA 3 and the Contractor's Landfill would not be maintained, this alternative would cause a degradation of these covers, resulting in a degradation of surface water quality. The large volume of borrow soil required and the volume of waste generated by Alternatives W-2 and W-3 would cause short-term increases in traffic, noise, and potential accidents. However, by allowing the area to be redeveloped, these alternatives could have a positive effect on socioeconomics and land use. The effects of Alternatives W-4 and W-5 on ecological resources, socioeconomics, transportation, land use, etc., would be minimal.

Cumulative effects would depend on the timing and location of other activities at ORNL and on the ORR. Impacts could be substantial if remedial activities occur at all ORR facilities simultaneously. Total traffic, noise, fugitive dust, and sediment releases would be noticeably increased. Alternatives W-2 and W-3 have similar contributions to the cumulative effects because the excavation activities are identical. The cumulative effects of Alternatives W-4 and W-5 are less because the buried waste sites are capped instead of excavated.

No environmental justice communities are impacted as a result of releases and cleanup activities at West Bethel Valley/Raccoon Creek.

2.11 PRINCIPAL THREAT WASTES

The NCP established an expectation that treatment will be used to address the principal threats posed by a site wherever practicable [40 *CFR* 300.430(a)(1)(iii)(A)]. Identifying principal threat waste combines concepts of both hazard and risk. In general, principal threat wastes are those source materials considered to be highly toxic or highly mobile that generally cannot be contained in a reliable manner or would present a significant risk to human health or the environment should exposure occur.

Most of the principal threat wastes in Bethel Valley have already been remediated through removal, treatment, and final disposal. Through early actions, sludges from the Gunite Tanks have been removed, and ongoing early actions are removing sludges from the FFA steel tanks, sediments from the surface impoundments, and extremely contaminated subsurface soil in the North Tank Farm. These wastes were considered to be both highly mobile and very toxic. Contaminants such as ^{90}Sr are mobile in water and, should a release occur, contamination could migrate large distances from the source. Additionally, radionuclides, such as ^{60}Co, present in these sources, are emitters of gamma radiation, which can penetrate the body from the outside without sufficient shielding such as lead, concrete, or steel. Also, many of these sources contained alpha emitters such as ^{226}Ra that, although lacking the ability to pass through a piece of paper or human skin, are extremely detrimental to human health if ingested or inhaled. Remaining principal threat wastes are the contaminated soil in Central Bethel Valley, currently contributing to groundwater contamination, and buried waste within SWSA 3 in West Bethel Valley.

The soil in Central Bethel Valley may contain contamination at levels similar to that already found in the North Tank Farm. Certain contaminants (e.g., ^{90}Sr) leaching from the soil to the groundwater can migrate into adjacent surface water bodies and be released off the ORR within a day (highly mobile).

It is known that hazardous materials have been placed in SWSA 3, including both long-lived isotopes and short-lived isotopes (highly toxic). There is evidence of substantial releases from SWSA 3 to the underlying groundwater. Ongoing releases from SWSA 3 to the groundwater cause groundwater contamination to slightly exceed the target risk range for industrial use of the groundwater. Releases of this contamination to the surface water have not contaminated adjacent streams above recreational risk-based limits and do not cause consistent exceedance of AWQC. Concentrations in the groundwater underlying SWSA 3 and in the adjacent surface water are either stable or declining. This indicates that most of the releases have already occurred. The age of this burial ground, greater than 50 years, supports this conclusion. Therefore, the primary concern is excavation into the burial ground by a future user.

2.11.1 Soil in Central Bethel Valley Contributing to Groundwater Contamination

Under Alternatives C-2 and C-3, the deep contaminated soil hot spots are removed to reduce the potential for additional releases to groundwater. This activity would be implemented where soil is a continuing source of groundwater contamination. The extent of removal is based on modeling results that indicate the potential to release any contaminant to groundwater at a level that would cause groundwater risk exceedance, based on a 10^{-4} industrial risk.

Because Alternative C-4 adopts a limited approach to groundwater action, deep soil would not be removed.

2.11.2 SWSA 3 in West Bethel Valley

Under Alternatives W-2 and W-3, buried waste within SWSA 3 would be removed to protect the unrestricted user from exposure to radiation and to minimize future impacts to groundwater. This activity

would include removal and disposal of an estimated 96,700 m^3 (126,500 yd^3) of radioactive waste from the 7-acre burial ground.

Under Alternative W-4, buried waste within SWSA 3 would be contained in order to protect the industrial worker from exposure to radiation and to minimize future impacts to groundwater. Under this activity a multi-layer cap and an upgradient shallow groundwater diversion trench would be installed at SWSA 3. The cap and diversion trench would contain the waste in place and substantially reduce the amount of water that migrates through the buried waste, resulting in a reduced flux of contaminants to surface water via groundwater. Alternative W-4a would also include grouting SWSA 3 burial trenches to fill void spaces within the waste and further reduce the amount of water that can migrate through the waste. Alternative W-4b is identical to W-4a, except it would not include grouting SWSA 3 trenches.

Under Alternative W-5, buried waste would be contained in a manner identical to the activities under Alternative W-4b.

2.12 SELECTED REMEDY

2.12.1 Summary of the Rationale for the Selected Remedy

DOE, with the concurrence of EPA and TDEC, has determined that the preferred alternatives (one for each of two subareas in Bethel Valley) presented in the proposed plan (DOE 2000a) are the most appropriate options for remediation in Bethel Valley. These two preferred alternatives were Alternative C-3b for Central/East Bethel Valley and Alternative W-5 for West Bethel Valley/Raccoon Creek, both with some modifications. They have been combined in the ROD to form the selected remedy for Bethel Valley. This remedy protects human health and the environment, complies with ARARs, offers the best balance in satisfying the CERCLA evaluation criteria, and is cost effective. This remedy uses permanent solutions and alternative treatment technologies to the maximum extent practicable. It satisfies the statutory preference for remedial actions that use treatment to reduce toxicity, mobility, or volume.

The selected remedy meets the RAO (Sect. 2.8.2) and achieves the best mix of actions possible, given the relatively large number of units being addressed. The selection of this remedy is based on the comparative analysis of alternatives detailed in the FS (DOE 1999a) and proposed plan (DOE 2000a) and summarized in this ROD.

Alternative C-3b. As mentioned, the selected remedy includes a modified Alternative C-3b, which was presented in the proposed plan (DOE 2000a). The primary mechanism for cleanup in this alternative is isolation of major contaminant sources to protect industrial workers at the site. Principal actions include (1) demolition and removal of buildings; (2) isolation of buried waste and underground pipelines; (3) removal or isolation of contaminated surface soil; (4) removal of contaminated sediment from White Oak Creek, First Creek, and Fifth Creek; (5) bioremediation or extraction and treatment of groundwater to minimize further impacts to groundwater and to protect surface water; and (6) LUCs to control exposure to residual surface soil contamination and prevent contact with contaminated buried waste, tanks, pipelines, subsurface soil, and groundwater.

Four modifications were made to the scope of Alternative C-3b as presented in the RI/FS (DOE 1999a).

(1) The sludge removal and stabilization of only four steel buried tanks (S-424, T-1, T-2, and HFIR) is included in the scope of the selected remedy. All other FFA inactive tanks in the original scope of the RI/FS are undergoing sludge removal and stabilization under separate CERCLA decisions. These tanks will require no further action under this decision.

(2) The selected remedy refines the approach to inactive pipelines and bedding materials from that presented in the RI/FS. The selected remedy does not include the grouting of all bedding material. Pipeline bedding can consist of many different types of materials (e.g., sand, gravel, soil), not all of which are feasible to grout. In addition, some active pipelines are buried next to inactive pipelines. Grouting all the pipeline bedding would therefore encase some active pipelines in grout, thereby hindering access to these pipelines for repair or replacement in the future. Due to these implementability concerns, the selected remedy will add a barrier to flow where bedding materials serve as a preferential flow pathway for contaminated groundwater reaching surface water. Also, LLLW pipelines in the controlled industrial area will be grouted, but not inactive process waste pipelines. Process waste pipelines are expensive to grout, most carried only lightly contaminated material, and many will continue to serve as conductors of collected groundwater to the treatment facility.

(3) The selected remedy has also refined the approach taken to identify areas requiring surface soil excavation to protect the worker. The new approach meets the same risk-based goal that Alternative C-3b

does as presented in the RI/FS. In the FS, a very conservative approach was taken to identify areas requiring remediation. Any area with a risk above the risk goal was assumed excavated. The revised approach recognizes that workers are exposed to an average concentration in the entire area where they work. Therefore, a smaller area requiring excavation was calculated.

(4) A more cost-effective approach to decontaminating subsurface structures has been selected. The FS conservatively assumed intrusive decontamination would be used to minimize impacts to groundwater. The removal of fixed contamination does little to enhance the control of migration of contamination to groundwater yet requires considerable effort and cost. The removal of loose contamination removes the contamination most likely to migrate at a fraction of the effort and cost. Therefore, the preferred alternative defines subsurface decontamination required to minimize impacts to groundwater as removing loose contamination.

The above modifications reduced the capital remedial action costs of Alternative C-3b from $115 million (Table 2.28) to approximately $34 million. Based on available information, DOE, EPA, and TDEC believe that the modified Alternative C-3b provides the best balance of trade-offs among the other alternatives with respect to the evaluation criteria. Additionally, the modified Alternative C-3b is more cost effective than FS Alternatives C-2 (a and b) and C-3 (a and b) because it provides similar protection but at a much lower cost. A major part of FS Alternative C-2 (the large-scale soil removal activity) could not be implemented until ORNL operations at the site are terminated, perhaps several decades into the future. A decision today for an action decades into the future is not practical. Because more surface soil is left in place, the modified Alternative C-3b is less costly than FS Alternatives C-3 (a and b) and C-4, and site operations can continue at a higher level of efficiency. The preferred alternative is considered as protective and reliable as FS Alternatives C-3 (a and b) and C-4 as long as appropriate LUCs are maintained. The modified Alternative C-3b is preferred over Alternative C-4 because the more extensive groundwater actions are anticipated to increase reliability of the alternative. The enhanced in situ treatment is preferred over conventional pump and treat technology at the East Bethel Valley VOC Plume because of its lower O&M cost.

Alternative W-5. The selected remedy also includes Alternative W-5 with minor modifications from that presented in the FS (DOE 1999a). Alternative W-5 has been modified in response to comments from TDEC to allow greater access to the buried waste areas. Under this modified alternative, SWSA 3 and the Contractor's Landfill will meet a recreational land use to allow passive surface use of those areas. The primary component of W-5, the cap, remains unchanged. The cap ensures protection for the recreational user. The existing fence around SWSA 3 is not necessary to ensure protectiveness after construction, and it will be removed. Other controls (Sect. 2.12.4) will take the place of the fence to prevent intrusive activities on the surface of the buried waste areas.

The primary mechanism for cleanup in this alternative is isolation of major contaminant sources to allow passive surface use. Principal actions include isolation of buried waste, removal of contaminated soil, and LUCs to prevent contact with contaminated media. SWSA 3 and the Contractor's Landfill will be maintained as a recreational use area. The 1000 area will support unrestricted industrial use. The remainder of West Bethel Valley/Raccoon Creek will have no land use restrictions. Groundwater use restrictions will be needed.

The technical basis for selecting capping and upgradient water diversion at SWSA 3 instead of excavation includes the status of releases from the buried waste, the nature of waste in the burial ground, and the cost effectiveness of excavation rather than capping. The ^{90}Sr concentrations detected in surface water in the NWT and Raccoon Creek are well below the action level for protection of recreational users of the area. This condition is not expected to change and concentrations of contaminants in surface water have been decreasing and are expected to decrease even further following implementation of the water

diversion and site capping. Much of the waste in SWSA 3 was covered with concrete as part of the burial process. The presence of concrete covering the waste both minimizes the contaminant release and makes excavation of the waste more difficult. The difference in costs between capping and excavation is more than $90 million. Thus, DOE, EPA, and TDEC concluded that excavation of wastes buried in SWSA 3 is not cost effective for reducing human health or environmental risk at this time.

Based on available information, DOE, EPA, and TDEC believe that Alternative W-5 provides the best balance of trade-offs among the alternatives with respect to the evaluation criteria. Alternative W-5 is preferred over Alternatives W-2 and W-3 because it provides more cost-effective protection of human health and the environment. Although the contaminated media are left in place under Alternative W-5, all but 25 acres of West Bethel Valley/Raccoon Creek are restored to unrestricted or unrestricted industrial use. Alternative W-5 is more cost effective than Alternative W-4 because it provides the same level of protection to potential users at considerably less annual O&M cost.

Remedy Summary. The Bethel Valley selected remedy, composed of Alternative C-3b and Alternative W-5 as modified, is summarized in Table 2.30 and Figs. 2.26 and 2.27. Table 2.30 also summarizes the preference for treatment as a principal element of the remedy or indicates why the preference was not satisfied.

State agency and community acceptance of the selected remedy was evaluated in conjunction with review and consideration of comments received. Comments are addressed in Part 3 of this ROD.

Following is a description of the selected remedy that addresses construction activities (and associated decision rules), monitoring, LUCs, uncertainties (and associated contingent actions), cost, NEPA values, and remedy implementation. Implementation issues include sequencing, performance objectives, and remediation levels.

2.12.2 Construction Activities and Decision Rules

Construction activities focus on building/facility D&D, buried waste isolation, tank content removal and shell containment, pipeline containment and removal, soil removal, sediment and floodplain soil removal, and groundwater actions.

Decision rules are provided for buildings/facilities (and associated off-gas systems), pipelines, soil, and sediment under the corresponding construction activity description. These decision rules are general response action (GRA) logic diagrams that indicate the path forward for remediation for active units transferred to inactive status or for newly discovered sources that require integration into the remedy. Establishing these decision protocols allows a remedy to be selected and remedial action to begin even though some uncertainties exist about some site conditions. Actions contemplated as a result of these decision rules that would result in a significant or fundamental change to the selected remedy will be appropriately documented. In some cases, additional public participation could be required.

Buildings and Other Facilities D&D. A total of 58 buildings and other facilities are designated for D&D (Table A.1 and Fig. 2.28). Of the 58 facilities designated for D&D, 3 have already been removed, and another has been stabilized. Under this ROD, the Graphite Reactor, which is a designated National Historic Landmark, will remain on the site and the reactor core will be stabilized; all of the remaining 53 above-ground structures will be removed. Once the above-grade structure has been removed, remaining slabs or subsurface structures will be removed or decontaminated and stabilized, depending on such factors as anticipated land use for the area in which the structure is located, the presence or absence of contaminated soils under the structure that could require removal, and cost effectiveness.

Figure 2.29 is a logic diagram that outlines the general response for inactive buildings or other facilities. As the diagram shows, the above-grade structure is removed. If information such as historical knowledge, process knowledge, or environmental data suggests that soil contamination exists beneath the remaining slab or subsurface structure, the underlying soils are sampled and analyzed. Existing information, and any information acquired during the design investigation, will be evaluated in conjunction with the project-specific Remedial Design Report (RDR)/Remedial Action Work Plan. If the soil underneath a structure exceeds soil remediation levels, the slab or subsurface structure is removed to provide access to those soils. The soil remediation levels are defined in Sect. 2.12.8.3. If the soil underneath a slab or subsurface structure does not exceed remediation levels, the following actions are taken on the slab and/or subsurface structure:

- Slabs are either removed or decontaminated to meet remediation levels for protection of the industrial worker, whichever is more cost effective.

- The top 0.6 m (2 ft) or 3 m (10 ft) (whichever depth is consistent with the required remediation depth for the designated land use) of subsurface structures (e.g., basements) are either removed or decontaminated, whichever is more cost effective.

- Loose contamination is removed from remaining subsurface structures below the remediation depth using noninvasive techniques, such as vacuuming or washing, and are then stabilized in place by backfilling with stabilizing material, such as soil or flowable fill.

- LLLW pipelines and associated equipment located below the remediation depth are left in place and stabilized with the structure.

The remediation approach to be taken for individual structures will be established consistent with the logic described above and will be approved by the regulators in the RDR.

As currently active buildings or other facilities become inactive and require final disposition decisions, the appropriate GRA may be selected using the GRA logic diagram presented in Fig. 2.29. As sections of the ORNL off-gas collection system come off-line, ductwork rendered inactive and located in the controlled industrial area may be addressed using the GRA logic diagram presented in Fig. 2.30. Actions contemplated as a result of these decision rules that would result in a significant or fundamental change to the selected remedy will be appropriately documented. In some cases, additional public participation could be required.

Buried Waste Isolation. A multilayer cap with a barrier and drainage layer will be installed on SWSA 3 to encompass all buried waste and protect workers and future recreational users from unacceptable exposure to radiation and to minimize further impacts to groundwater. Design will meet RCRA closure requirements. During design, the extent of buried waste will be verified to ensure that all waste is contained. An example of a multilayer cap cross section is shown in Fig. 2.31. This figure is an example of typical construction only; the actual capping configuration will be established during detailed design as approved by the regulators in the RDR. The cap will isolate the waste and will substantially reduce the amount of water that migrates through the buried waste, resulting in a reduced flux of contaminants to surface water via groundwater.

An upgradient surface water and groundwater diversion trench will be installed at SWSA 3 to intercept and divert laterally flowing groundwater and route it around the buried waste. The trench will be designed and constructed to minimize surface water from entering. Stormflow and shallow groundwater above the bedrock surface will be collected (surface water will be routed around caps using perimeter ditches). DOE intends to design and construct the upgradient trench in a way that will prevent interception

Table 2.30. Principal actions for the selected remedy for Bethel Valley, ORNL, Oak Ridge, Tennessee

Waste type	Unit	Remedial actions	Preference for treatment
Facilities (buildings and appurtenances)	Multiple structures	Remove inactive buildings/facilities to grade level. Decontaminate and stabilize or remove structures at or below grade, depending on cost effectiveness and extent of contamination. Dispose of debris at EMWMF or other suitable facility.	Size-reduction performed where appropriate; RCRA sludges from the cooling towers treated prior to disposal
	Graphite Reactor building	Stabilize Graphite Reactor core	Grouting eliminates the need for maintaining negative pressure while preserving landmark features
Buried waste	SWSA 1	Install a cap	Only SWSA 3 contains notable levels of contamination. Ex situ treatment not used for SWSA 3 because of significant cost and worker risk; in situ treatment not cost effective as environmental impacts have decreased significantly overtime.
	Former Waste Pile Area	Install and/or maintain soil cover	
	NRWTP Debris Pile	Install and/or maintain soil cover	
	SWSA 3	Install multilayer cap and upgradient diversion trench	
	Contractor's Landfill	Install and maintain soil cover	
Tank sludge and linings	Tank contents	Remove sludge and liquid from S-424, T-1, T-2, and HFIR	Sludge and liquid treated to meet WAC of the appropriate disposal facility
	Tank shells	Fill four tanks with grout	In situ grouting performed to contain residual contamination and stabilize shells
Inactive LLLW pipelines	Inside main plant area	Stabilize pipelines and add trench barriers; D&D associated structures	Grouting performed to contain contaminants
	Outside main plant area	Remove pipelines and contaminated bedding material [estimated at 1000 lin m (4000 lin ft)]; D&D associated structures	Removal preferred because of anticipated future land use
Contaminated soil impacting worker protection	Main plant area	Remove contaminated surface soil [estimated at 9700 m^3 (12,000 yd^3)]. Up to 10% of area may be covered.	Removal generally preferred
	Outside main plant area	Remove contaminated soil to 3m (10 ft) [estimated at 500 m^3 (700 yd^3)]	Removal preferred because of anticipated future land use
	In vicinity of SWSA 3 (multiple contaminated locations)	Remove soil [estimated at 17,500 m^3 (22,900 yd^3)]	Removal preferred because of anticipated future land use
Contaminated soil impacting groundwater	Inside main plant area	Remove contaminated soil [estimated at 1500 m^3 (2000 yd^3)]	Removal preferred over in situ treatment due to multiple contaminants
Sediment and floodplain soils	White Oak Creek, First Creek, and Fifth Creek	Remove sediment and floodplain soils [estimated at 13,500 m^3 (17,600 yd^3)]	Removal preferred over in situ treatment for permanence
Groundwater	Core Hole 8 Plume	Extract groundwater from four wells and from sumps at seven stormwater junction boxes [estimated at combined rate of 380 L/min (100 gal/min)]	Ex situ treatment performed
	^{90}Sr-contaminated sumps	Pump from 27 existing sumps [estimated at combined rate of 306 L/min (81 gal/min)]; continue to treat to remove ^{90}Sr	Ex situ treatment performed

Table 2.30. Principal actions for the selected remedy for Bethel Valley, ORNL, Oak Ridge, Tennessee (continued)

Waste type	Unit	Remedial actions	Preference for treatment
Groundwater (continued)	Mercury-contaminated sumps	Pump from four existing sumps at a combined rate of 34 L/min (9 gal/min); add treatment to remove mercury	Ex situ treatment performed
	VOC Plume	Implement enhanced in situ anaerobic bioremediation	In situ treatment performed
	Well P&A	Grout obsolete or poor quality monitoring wells and piezometers and abandon in place (estimated at 229 wells); in areas designated for unrestricted industrial or unrestricted use, remove to depth of 3 m (10 ft)	Pressure grouting performed to contain contaminants and prevent wellbore migration

Note: See Appendix A for a complete listing of contaminated sites and selected actions.

D&D = decontamination and decommissioning
EMWMF = Environmental Management Waste Management Facility
LLLW = liquid low-level (radioactive) waste
NRWTP = Nonradiological Wastewater Treatment Plant
ORNL = Oak Ridge National Laboratory
P&A = plugging and abandonment
RCRA = Resource Conservation and Recovery Act of 1976
SWSA = solid waste storage area
VOC = volatile organic compound
WAC = waste acceptance criteria

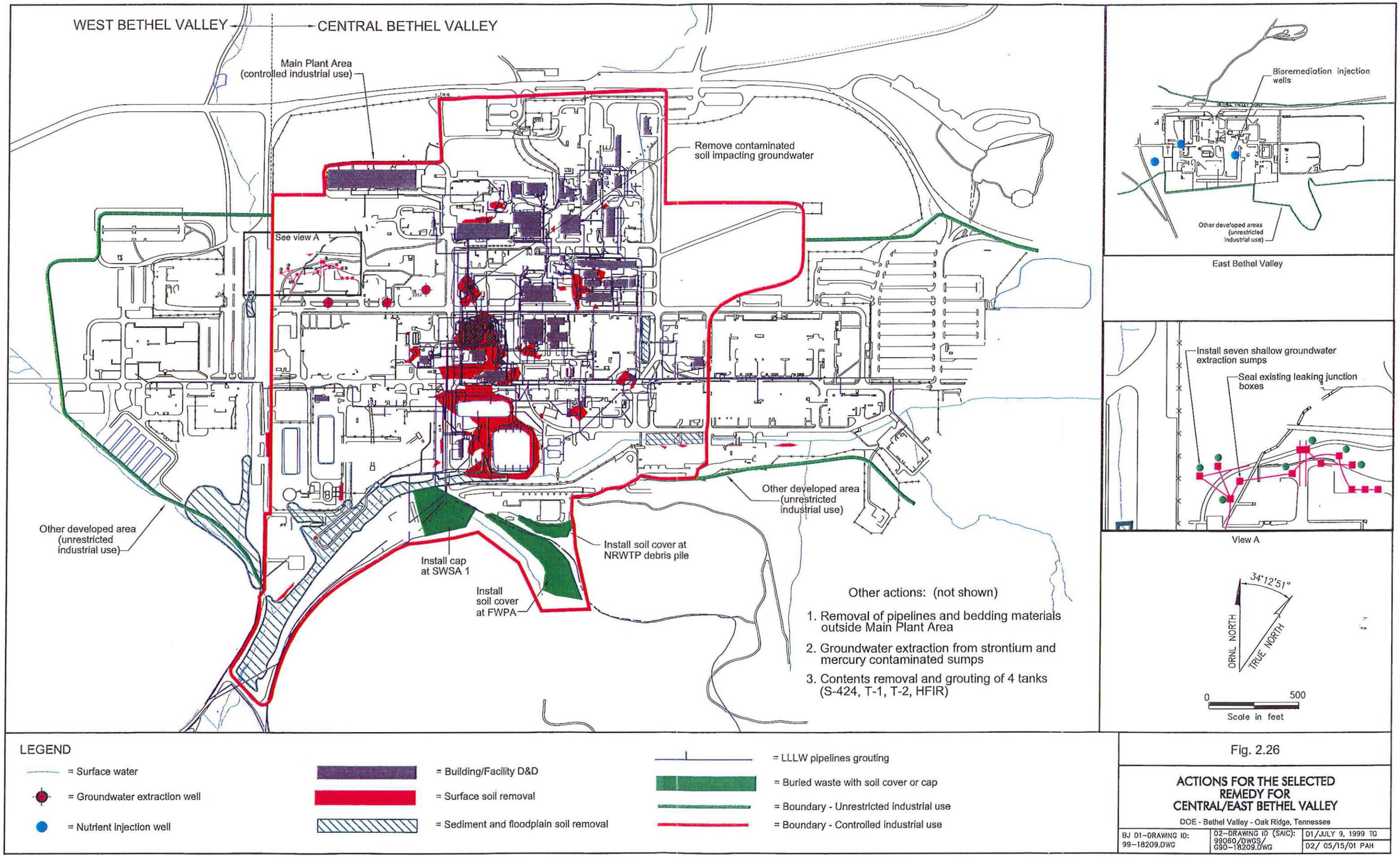


Fig. 2.26. Actions for the selected remedy for Central/East Bethel Valley.

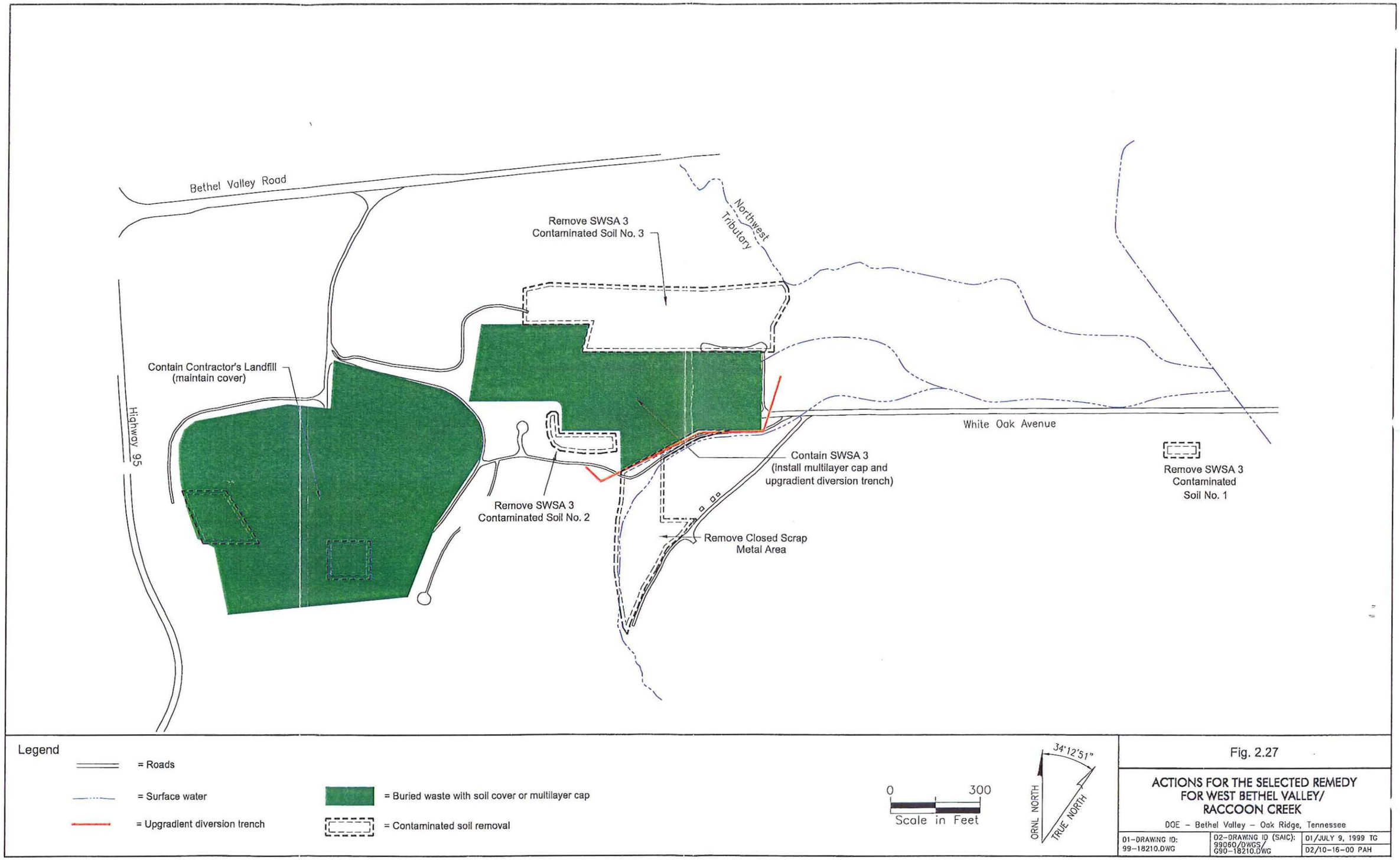


Fig. 2.27. Actions for the selected remedy for West Bethel Valley/Raccoon Creek.

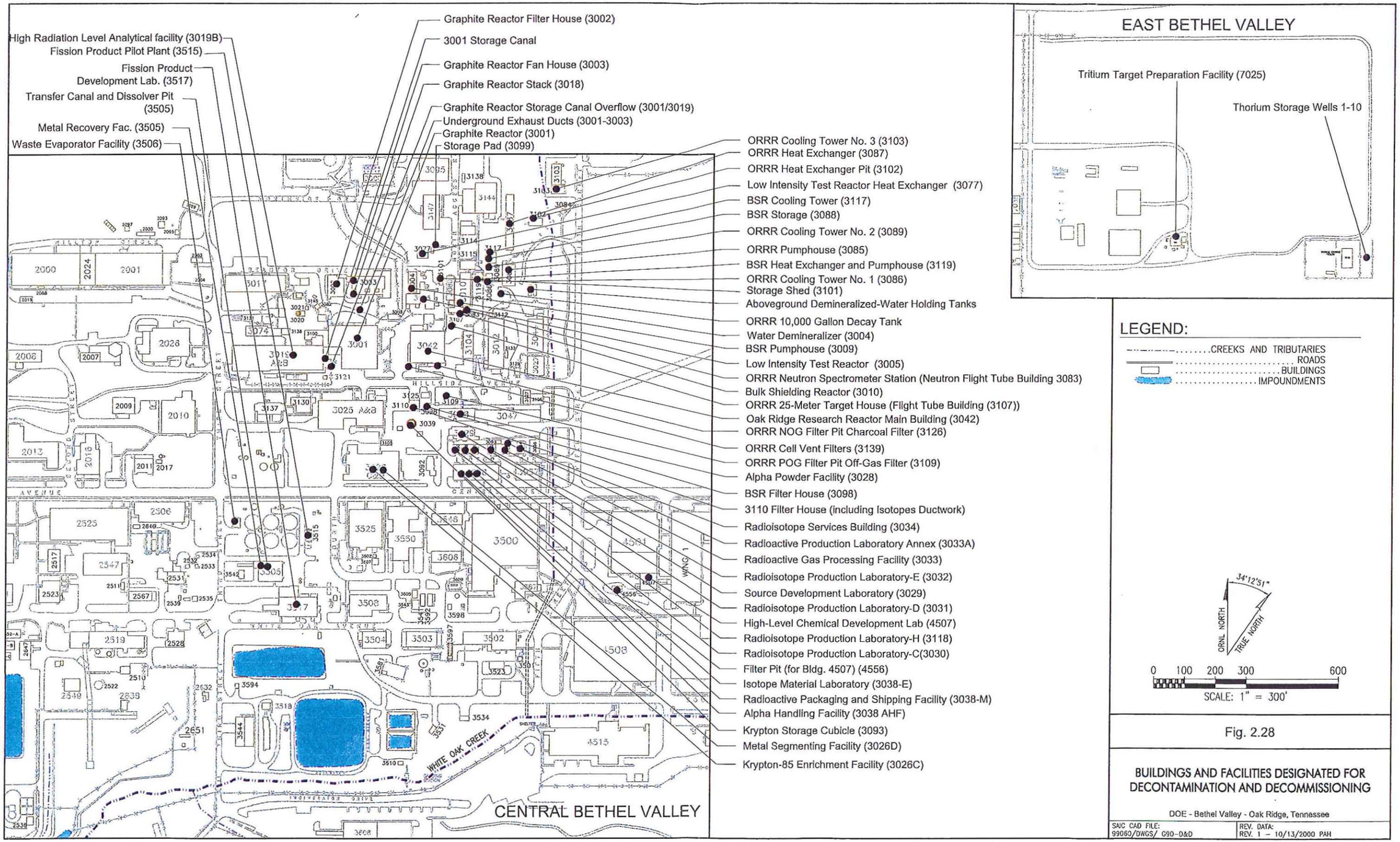


Fig. 2.28. Buildings and facilities designated for decontamination and decommissioning.

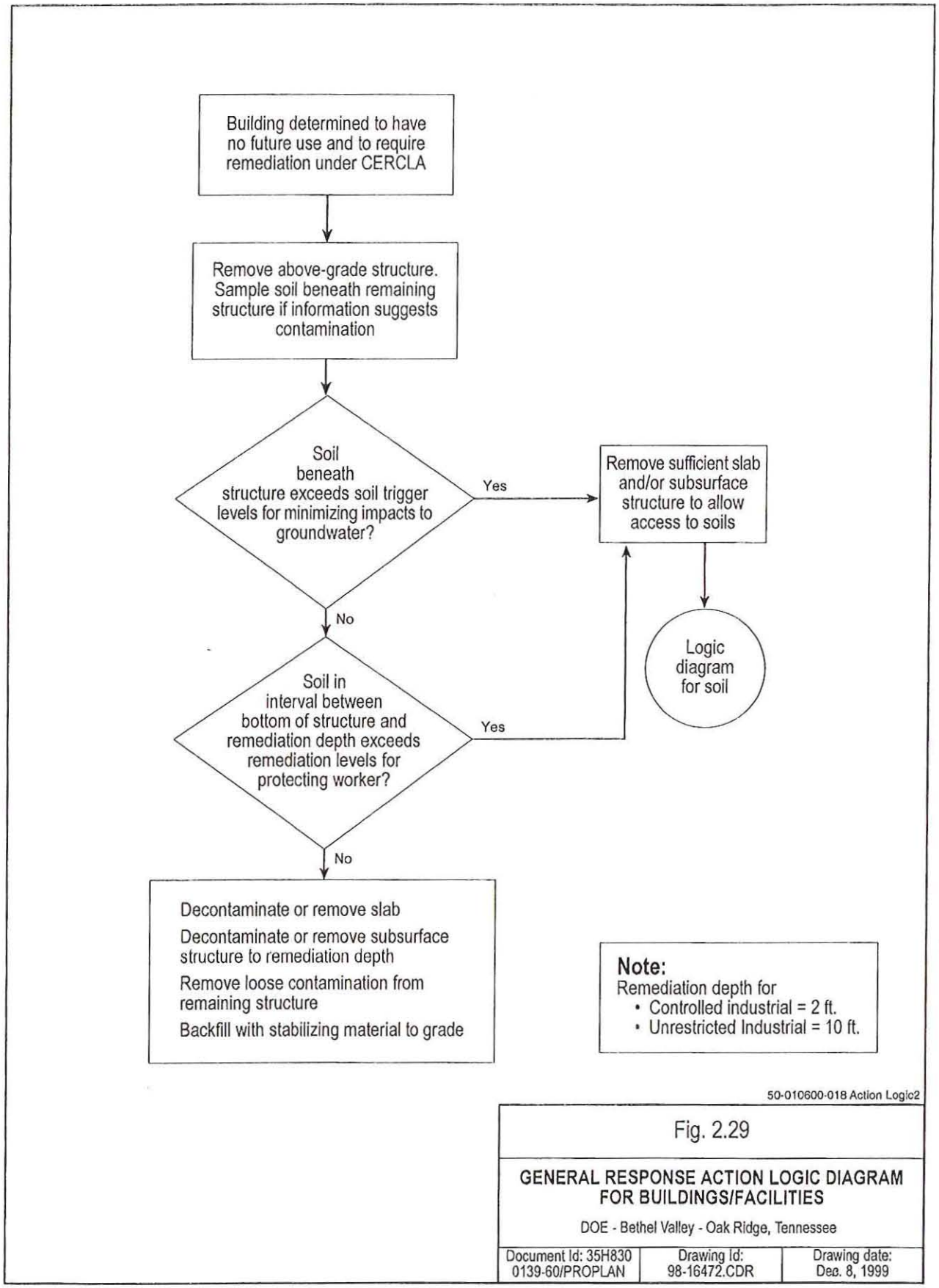
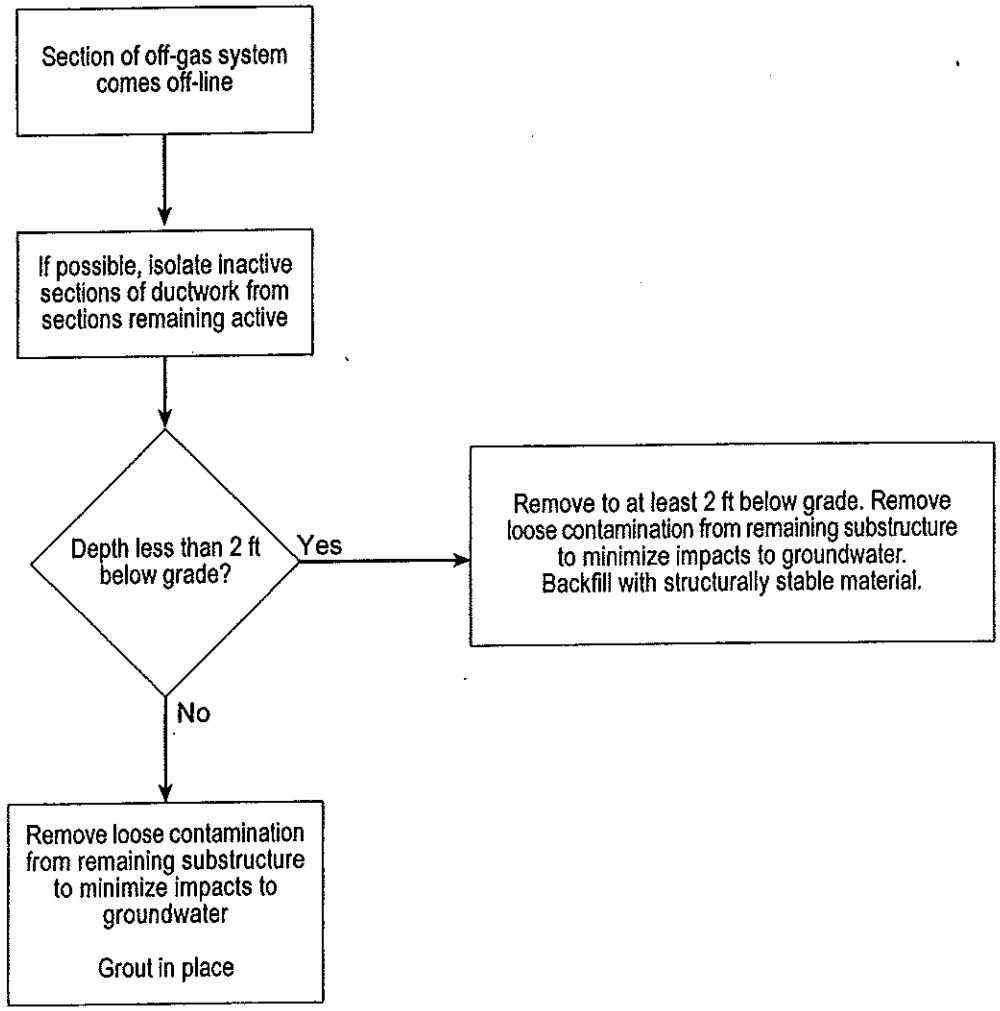


Fig. 2.29. General response action logic diagram for buildings/facilities.



50-010600-018 Fig 3.30

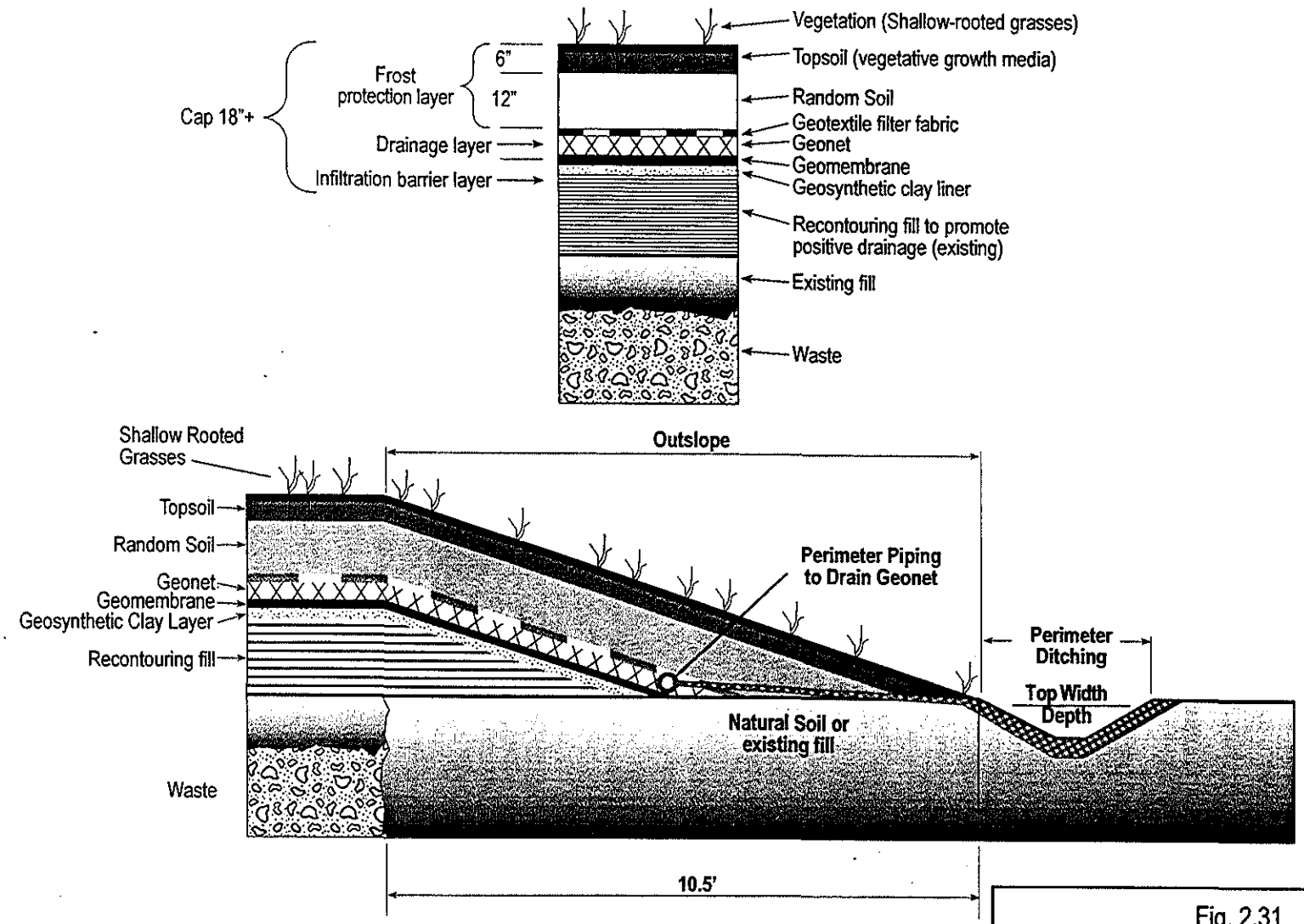
Fig. 2.30

GENERAL RESPONSE ACTION LOGIC DIAGRAM FOR OFF-GAS SYSTEM

DOE - Bethel Valley - Oak Ridge, Tennessee

Document Id: 35H830 0139-60/PROPLAN	Drawing Id: 98-16472.CDR	Drawing date: Dec. 8, 1999

Fig. 2.30. General response action logic diagram for off-gas system.



Conceptual representation. Actual configuration will be established during detailed design.

Fig. 2.31

TYPICAL MULTILAYER CAP WITH GRADUAL OUTSLOPE FOR ALTERNATIVES C-3 AND C-4

DOE - Bethel Valley - Oak Ridge, Tennessee

Document Id: 35H830 0139-60/PROPLAN	Drawing ID: 50-010600-018	Drawing Date: March 15, 2000 DL

Fig. 2.31. Typical multilayer cap with gradual outslope for Alternatives C-3 and C-4.

of contaminated groundwater. An example of an upgradient diversion trench is shown in Fig. 2.32. This figure is an example of typical construction only. The actual upgradient diversion trench configuration will be established during detailed design as approved by the regulators in the RDR. Surface water monitoring for remedial effectiveness will include detection of contaminants that may originate from the diversion trench. If diverted water contributes to surface water exceedances, it will be treated before release.

A simple cap (low permeability cover) will be installed on SWSA 1 to protect workers from unacceptable exposure to radiation and to minimize further impacts to groundwater. The cap will isolate the waste and substantially reduce the amount of water that migrates through the buried waste, thus reducing the potential for SWSA 1 contaminants to reach surface water via groundwater.

A 0.6-m (2-ft) soil cover will be provided at the NRWTP Debris Pile, the FWPA, and the Contractor's Landfill to protect workers from unacceptable exposure to radiation. Additionally, two small areas of the existing cover at the Contractor's Landfill are contaminated and will be removed and backfilled. Predesign sampling will be conducted to determine the extent of surface contamination and thickness of existing soil cover at each area.

The East Melton Valley Borrow Site may be the source of all fill soil required. This site is located in Melton Valley on the east side of Health Physics Research Reactor Access Road. The 25-acre site has been investigated and determined to have at least 17 m (55 ft) of soil suitable for use as fill. The other potential borrow sites evaluated in the FS (DOE 1999a) may also be used.

All surface debris will be removed and sent to the EMWMF or an appropriate off-site facility prior to capping or covering.

Tank Contents Removal and Shell Containment. Liquid and sludge contents will be removed from the remaining inactive LLLW tank in Bethel Valley (Tank S-424), and from the three remaining inactive LLLW tanks in Melton Valley (Tank T-1, Tank T-2, and the HFIR Tank), to minimize impacts to groundwater. The contents will be treated as needed to meet the WAC of the disposal facility. Determination of the appropriate treatment method and disposal facility for the tank contents will be performed during predesign/design of the remedial action. After contents removal, the four tanks will be grouted in place to minimize impacts to groundwater and to structurally stabilize the tanks to keep them from collapsing. FFA inactive tanks that have already been stabilized under early actions will require no further action under this decision. However, soil actions required to minimize further impacts to groundwater may require tank removal for access.

Pipeline Containment. Inactive LLLW pipelines in the controlled industrial area will be grouted to eliminate potential preferential flow paths for contaminated groundwater. Pipelines will be filled with grout to immobilize any residual contamination and to minimize contaminant migration. Pipeline bedding material that is a preferential flow pathway for groundwater reaching surface water may be contained through grouted barriers or other similar containment technologies. This grouting of the pipelines and selected bedding material is used in combination with the ongoing interception and treatment of contaminated groundwater in seepage pathways to minimize impacts to groundwater and to protect surface water. At the time that pipeline bedding materials are contained, an evaluation of the collection system will be made to ensure that contaminated groundwater previously flowing through the bedding material is being collected such that groundwater impacts are minimized and surface water is protected. In the unrestricted industrial or unrestricted areas, inactive LLLW pipelines, contaminated process lines, and contaminated bedding materials will be removed to protect the future user from unacceptable exposure to radiation. Both inactive LLLW and contaminated process lines are included in the scope of this activity.

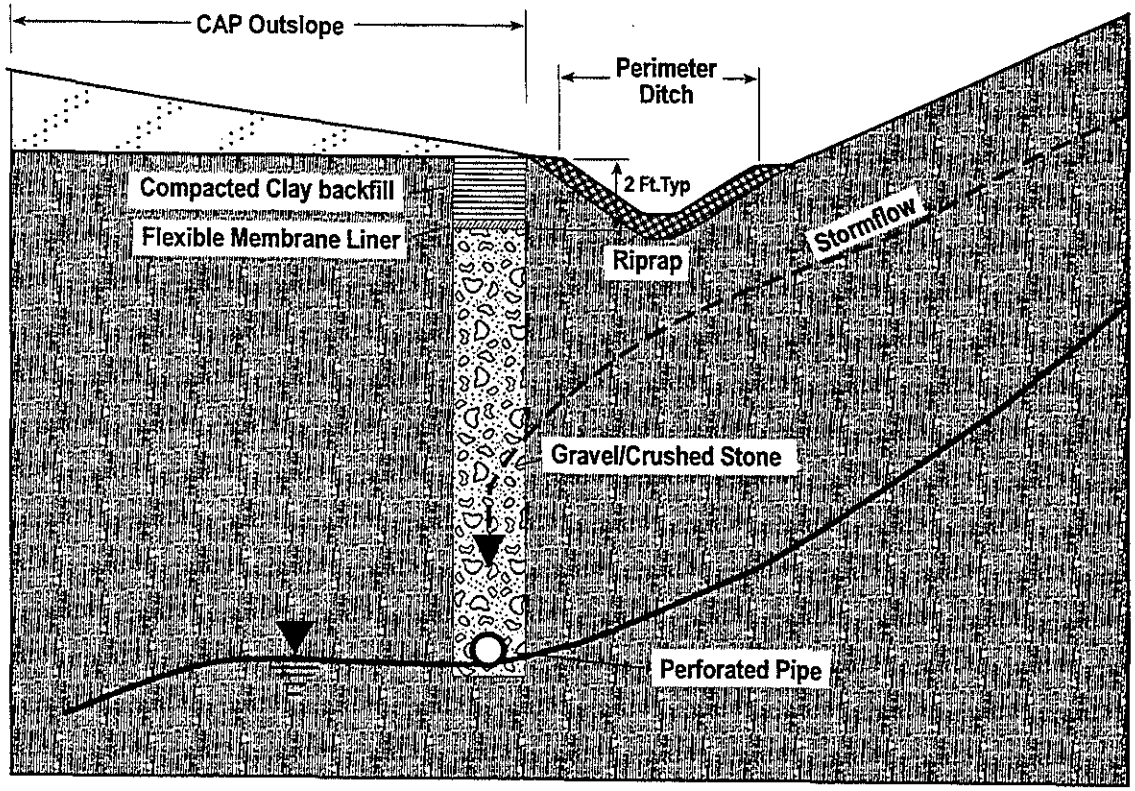


Fig. 2.32

TYPICAL UPGRADIENT DIVERSION TRENCH SCHEMATIC DIAGRAM

DOE - Bethel Valley - Oak Ridge, Tennessee

Document Id: 35H830 0139-60/PROPLAN	Drawing ID: 50-010600-018	Drawing Date: March 15, 2000 DL

Fig. 2.32. Typical upgradient diversion trench schematic diagram.

The GRA logic diagram for pipelines is presented in Fig. 2.33. This logic diagram addresses any pipeline that may be identified in the future as a potential source of unacceptable risk. Depending on pipeline location (i.e., land use area), depth, and migration potential along the bedding material, potential actions would include removal of pipeline and associated bedding material, pipeline grouting, or pipeline grouting with limited plugging of bedding material. Bedding material that exceeds soil trigger levels for minimizing impacts to groundwater is considered contaminated soil and is addressed in Fig. 2.34, General Response Action Logic Diagram for Soil.

Substructures associated with inactive LLLW and contaminated process lines, such as pump pits, valve boxes, manholes, manways, vaults, and dry wells, will undergo D&D similar to that discussed previously for buildings and other facilities. Subsurface structures are either demolished or decontaminated to the appropriate remediation depth, whichever is more cost effective. Any LLLW pipelines and associated equipment located below the remediation depth are left in place and stabilized with the structure. Loose contamination located below the remediation depth is removed using noninvasive techniques such as vacuuming or washing. The substructure or hole is backfilled with stabilizing material such as soil or flowable fill.

Soil Removal. Inside the ORNL main plant area, contaminated surface soil [0 to 0.6 m (0 to 2 ft)] will be preferentially removed and backfilled with clean soil or, as determined on a case-by-case basis during design, covered to protect the industrial worker from unacceptable exposure to radiation. It is estimated that approximately 9000 m^3 (12,000 yd^3) of surface soil will be removed. There may be cases where a soil cover is less disruptive of active plant utilities. However, it is anticipated that these areas will be less than 10% of the total soil area to be remediated. In addition, an estimated total of 500 m^3 (700 yd^3) of contaminated soil will be removed in the vicinity of (1) the Tritium Target Preparation Facility (Bldg. 7025) and the 7078 Area former Dump Site to protect the unrestricted industrial worker, and (2) the Abandoned Burn Pit to achieve unrestricted use.

In the undeveloped areas around ORNL, contaminated soil will be removed and backfilled with clean soil to protect the unrestricted user from unacceptable exposure to radiation. The maximum depth of excavation will be that corresponding to bedrock or the groundwater table, whichever comes first. An estimated 16,700 m^3 (21,900 yd^3) of soil near SWSA 3 will be removed, including approximately 1600 m^3 (2100 yd^3) from the Contractor's Landfill cover. This soil may be used as contouring fill for construction of the SWSA 3 cap. TDEC and EPA will review and approve plans to use excavated soil as contouring fill. If soil contamination adjacent to SWSA 3 extends below 3 m (10 ft) and is contaminated at levels in excess of remediation levels for an unrestricted user, the cap of SWSA 3 may be extended over the area if approved by the FFA parties.

Where soil is a continuing source of groundwater contamination, the contaminated soil will be removed and backfilled with clean soil. To identify these hot spots, a benchmark of groundwater risk greater than 1×10^{-4} (industrial use) was used. Section 2.12.8.3 and Appendix C include information for use in remedial design to determine contaminated soils that require removal to minimize impacts to groundwater. The remedial action selected to address soils impacting groundwater is soil removal/excavation. Selection of the removal/excavation remedial action was based on an assumed work scope of a single "hot spot" containing LLW (e.g., no TRU waste), a total excavation volume of 1500 m^3 (2000 yd^3), and a total cost of approximately $1.1 million. However, it is not yet determined to what extent contaminated subsurface soil is impacting groundwater in Bethel Valley. DOE's estimate of the cost of implementing this part of the remedial actions may increase substantially. Should any of the FFA parties conclude in good faith that such a substantial cost increase appears likely, any of the FFA parties may require DOE, EPA, and TDEC to reconsider the selected alternative in light of the anticipated cost increase. If, as the result of their reconsideration, the three FFA parties agree that, or the dispute

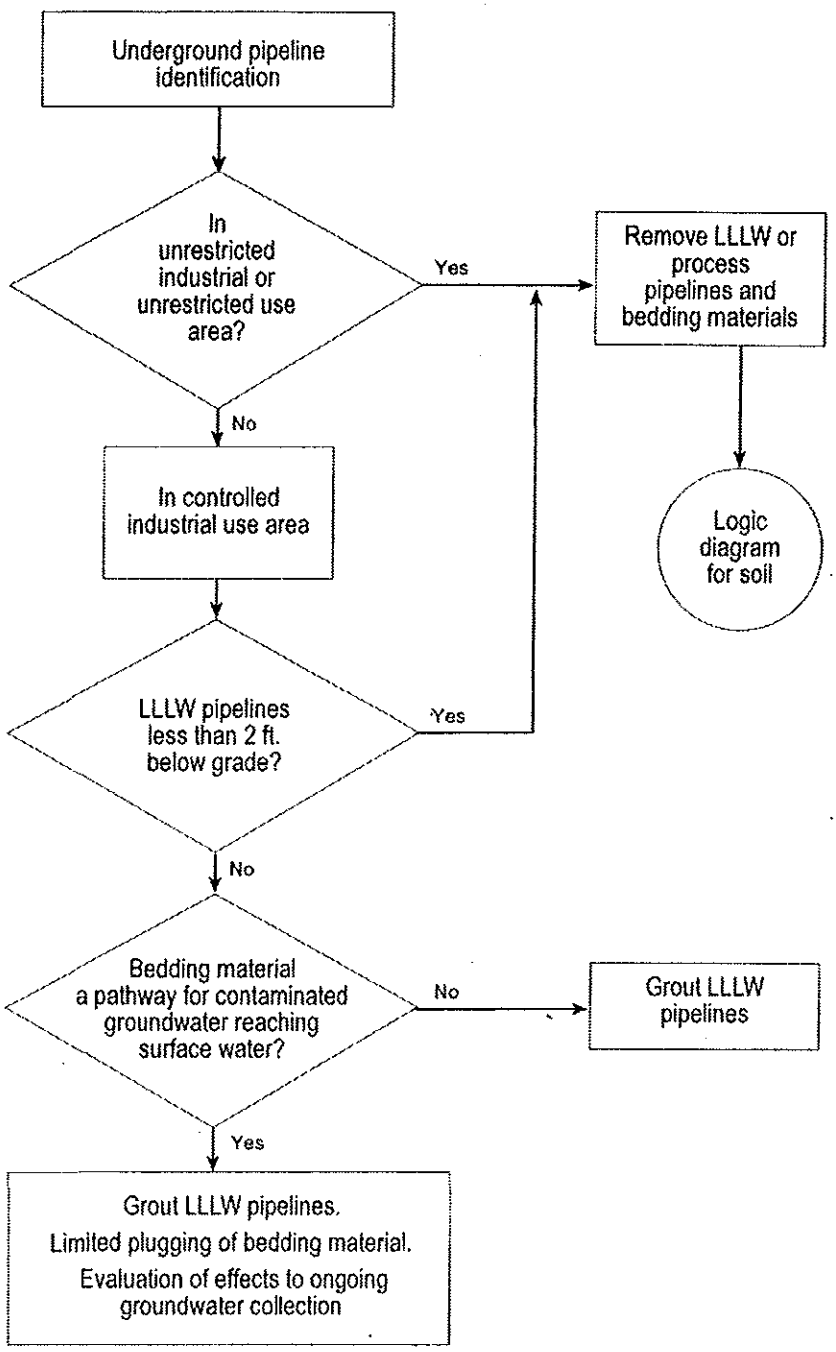


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Fig. 2.33

GENERAL RESPONSE ACTION LOGIC DIAGRAM FOR PIPELINES

DOE - Bethel Valley - Oak Ridge, Tennessee

Document Id: 35H830 0139-60/PROPLAN	Drawing Id: 61-051601-102A	Drawing date: May. 16, 2000

Fig. 2.33. General response action logic diagram for pipelines.

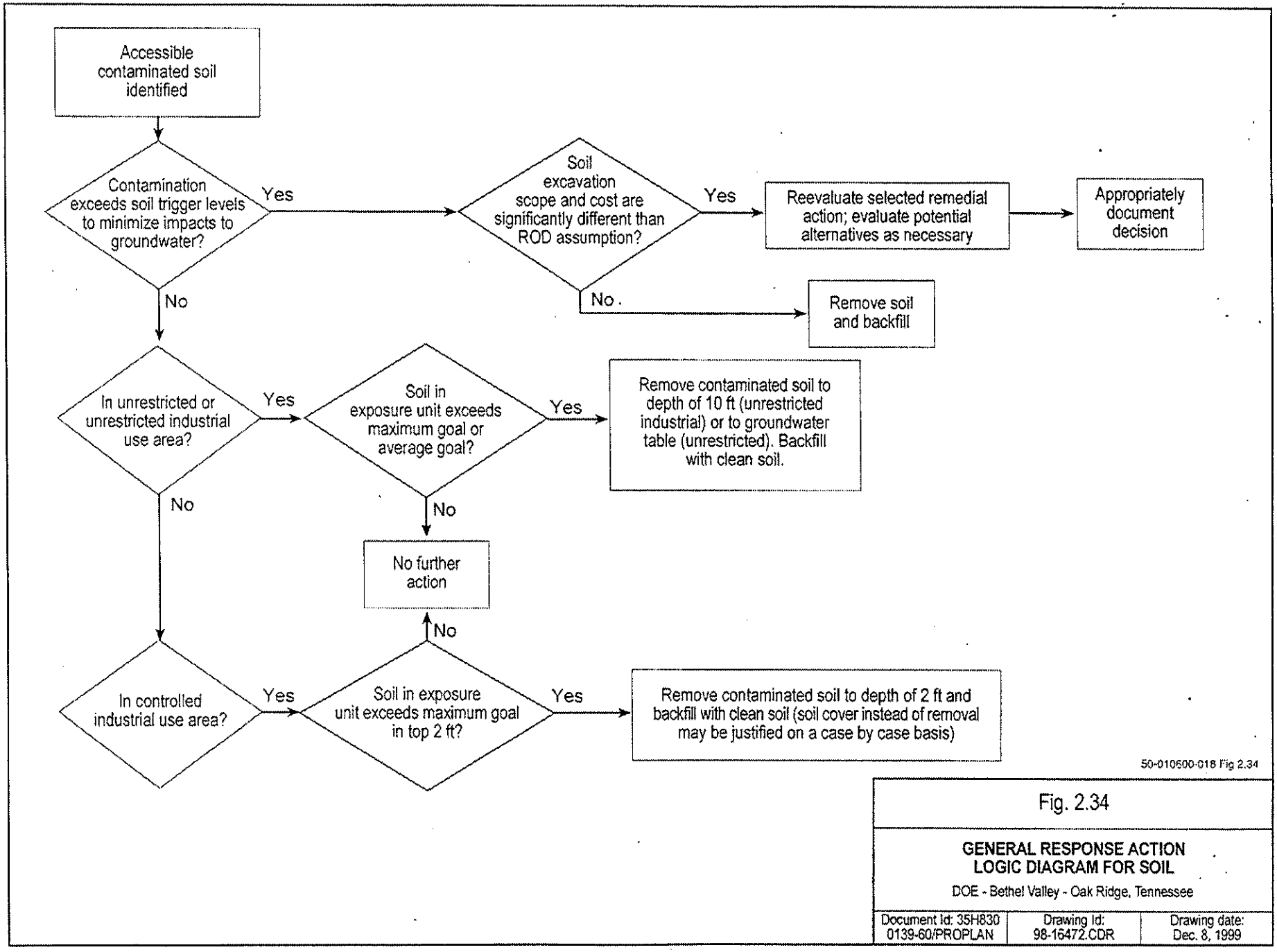


Fig. 2.34. General response action logic diagram for soil.

resolution process under the FFA determines that, significant changes or fundamental alterations should be made to the previously selected action, the proposed changes will be documented in accordance with the National Contingency Plan, using procedures that provide the public with an opportunity to review and comment on the proposed changes prior to any final decision on adopting them.

Other remedial actions in this ROD will continue as the FFA parties work to complete reconsideration of the remedial action selected to address soils impacting groundwater. Additionally, should any party, as contemplated in the above paragraph, require the reconsideration of the selected alternative during implementation of the subsurface soil remediation, all subsurface soil remediation activities will halt (unless the FFA parties agree otherwise) pending the completion of the reconsideration process described above.

Figure 2.34 presents the GRA logic diagram for soils. This logic diagram addresses any soil that may be identified in the future as a potential source of unacceptable risk. Depending on soil location (e.g., land use area), contamination level, depth, and migration potential to groundwater, potential actions would include removal to varying depths or placement of clean cover. The first box in the logic diagram identifies "accessible contaminated soil," indicating that contaminated soil above remediation levels will be removed if the soil is accessible, or as it becomes accessible. This reflects the complexity of performing remedial actions within a research complex with an ongoing mission. In some cases, currently active facilities and infrastructure impede access to contaminated soils that will require remediation to meet the final objectives of this ROD. "Accessible contaminated soil" is soil whose access is not currently impeded. Remediation of soils whose access is impeded may be postponed, with regulatory agency approval, until associated facilities/infrastructure have been deactivated or removed. These soil remediation decisions will be made on a case-by-case basis where the criteria for determining "accessibility" would include 1) extent of disruption to ongoing operations, 2) degree of soil contamination, and 3) logistics or coordination with other remediation or construction activities in the same or nearby area. Eventual remediation of these postponed contaminated soils would follow the same decision logic presented in the diagram once they become accessible.

Sediment and Floodplain Soil Removal. Under this activity, contaminated sediment will be removed to the depth of deposition from Bethel Valley creeks to achieve AWQC for mercury in surface water, achieve risk reduction in surface water at the 7500 Bridge, achieve recreational risk-based limits in sediment, and protect benthic invertebrates in sediment. The GRA logic diagram for sediments is presented in Fig. 2.35. Floodplain soils will be removed from adjacent areas to a maximum depth of 0.6 m (2 ft) and backfilled to protect the industrial worker from unacceptable exposure to radiation and to minimize the migration of contaminants downstream. It is estimated that a total of 13,500 m^3 (17,600 yd^3) of soil and sediment will be removed.

Groundwater Actions. Groundwater extraction will be implemented to minimize further impacts to groundwater and to protect surface water bodies from discharges of strontium and mercury. Four deep extraction wells will be installed at the Core Hole 8 Plume to collect water from bedrock, and seven sumps will be installed near storm drain junction boxes to collect contaminated shallow groundwater. Storm drain junction boxes will be repaired to restrict in-leakage of contaminated shallow groundwater and subsequent discharge to surface water outfalls. These additional sumps will supplement three collection sumps already in place for the Core Hole 8 Plume discharge area. Groundwater collection will continue at existing building and tank sumps throughout the ORNL main plant area (approximately 27 strontium-contaminated sumps and 4 mercury-contaminated sumps). Groundwater will be treated by the existing wastewater treatment system, although some of the water (mercury-contaminated) may require pretreatment. This collection and treatment will continue until a final groundwater decision is made. In addition, DOE will re-evaluate the performance of the collection and treatment system periodically to allow optimization of performance with respect to contaminant mass reduction.

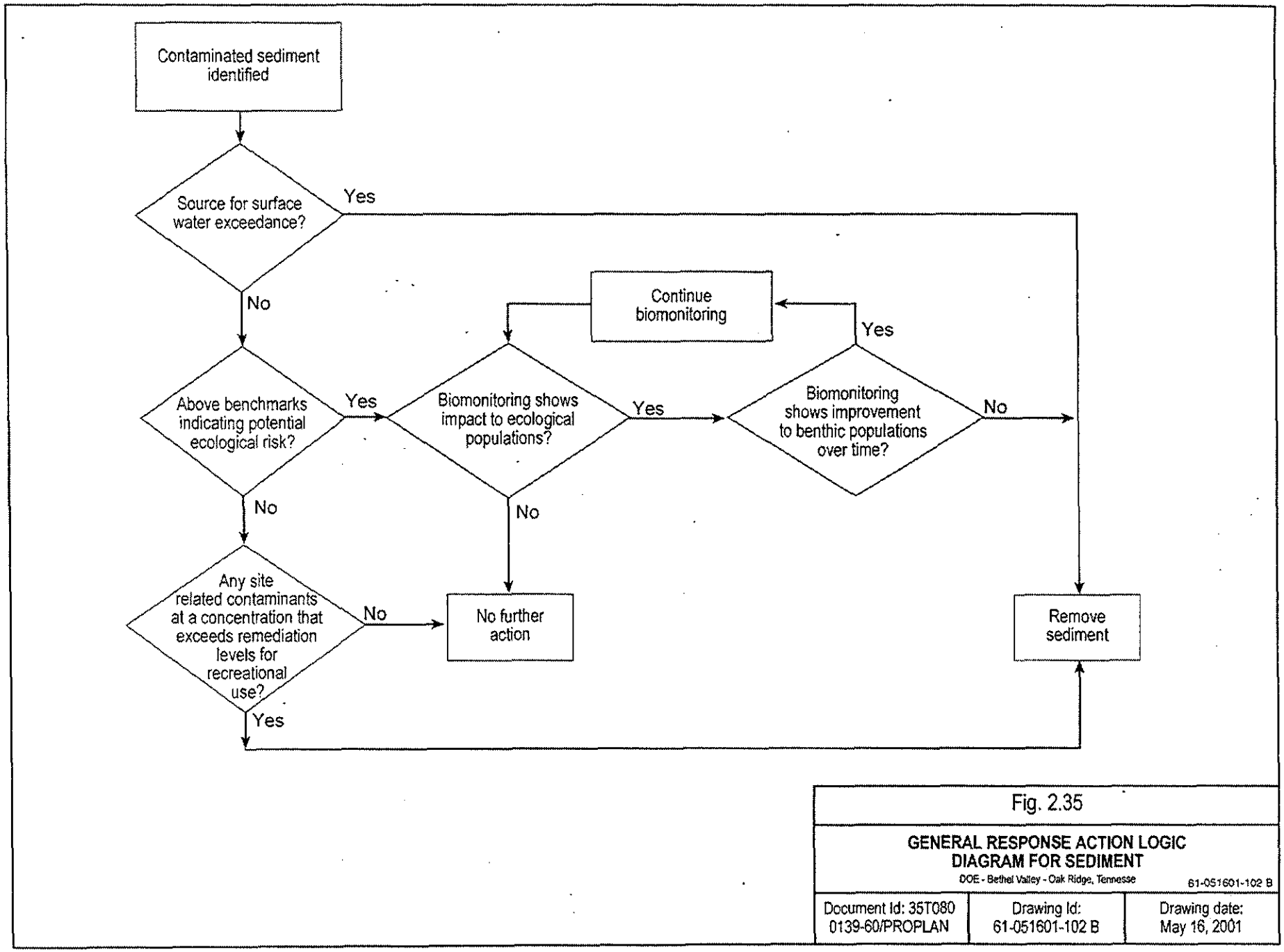


Fig. 2.35. General response action logic diagram for sediment.

At the East Bethel Valley VOC Plume, enhanced in situ biodegradation will be implemented to accelerate microbial degradation of the organic contaminants; groundwater injection wells will be installed for the introduction of food-grade compounds such as lactate, ethanol, or benzoate.

Obsolete or poor quality monitoring wells and piezometers will be grouted and abandoned in place. An estimated 229 such wells throughout Bethel Valley will be affected.

2.12.3 Maintenance Activities and Environmental Monitoring

This section describes both the maintenance activities necessary to ensure that long-term protection is maintained and the environmental monitoring required to evaluate the effectiveness of remedial actions and support future decision making for the deferred areas of Bethel Valley.

Maintenance Activities. Caps, soil covers, and surface drainage will be inspected periodically. Maintenance such as mowing and resodding of eroded areas will be performed as necessary. Groundwater will continue to be collected at extraction wells and from sumps for treatment. Pumps, valves, and piping will be periodically inspected and replaced. Pretreatment system filter media (if required) and collected solids will be periodically removed, filter media will be replaced, and waste will be packaged for disposal. If pretreatment is necessary, performance of the pretreatment system will be monitored to ensure operations are within projected requirements

Surface Water Monitoring. Surface water will be monitored in order to measure the effectiveness of the remedial actions implemented under this decision. Surface water that receives contaminants from surface runoff or groundwater seepage is the only known contaminant release pathway from Bethel Valley, and a system of flow volume and contaminant measurement stations exists within the area. Measurement stations on the main stems of White Oak Creek (e.g., 7500 Bridge), NWT, First Creek, and Raccoon Creek will be maintained and operated to measure concentration and release fluxes of contaminants from Bethel Valley source areas (e.g., SWSA 1, SWSA 3, Corehole 8 Plume sources, South Area Plume sources). Additional established surface water sampling sites are located on White Oak Creek and its tributaries in Bethel Valley, and these sites may be sampled as remedial actions are completed to document contaminant releases from tributary areas. Surface water monitoring will be used to verify compliance with AWQC and to verify reduction of off-site contaminant releases to acceptable levels. Figure 2.36 shows the locations of surface water monitoring stations in the Bethel Valley area that have been used historically to measure contaminant discharges. Continuous measurement of flow volume with flow-proportional sampling for contaminant measurement will occur at the four main stations in Bethel Valley (7500 Bridge Weir, First Creek Weir, NWT Weir, and Raccoon Creek Weir) and other stations dictated by the design of the selected remedial actions. Details of surface water monitoring will be developed and approved during the remedial design process. Results of monitoring will be included in the annual Remediation Effectiveness Report (RER) for the ORR.

Groundwater Monitoring. Groundwater monitoring objectives in Bethel Valley include two aspects of site surveillance:

- Bethel Valley groundwater exit pathway wells will be monitored to verify that contaminants are not leaving the contaminated area.
- Groundwater in the vicinity of contaminant source control areas will be monitored to measure effectiveness of contaminant source control actions.

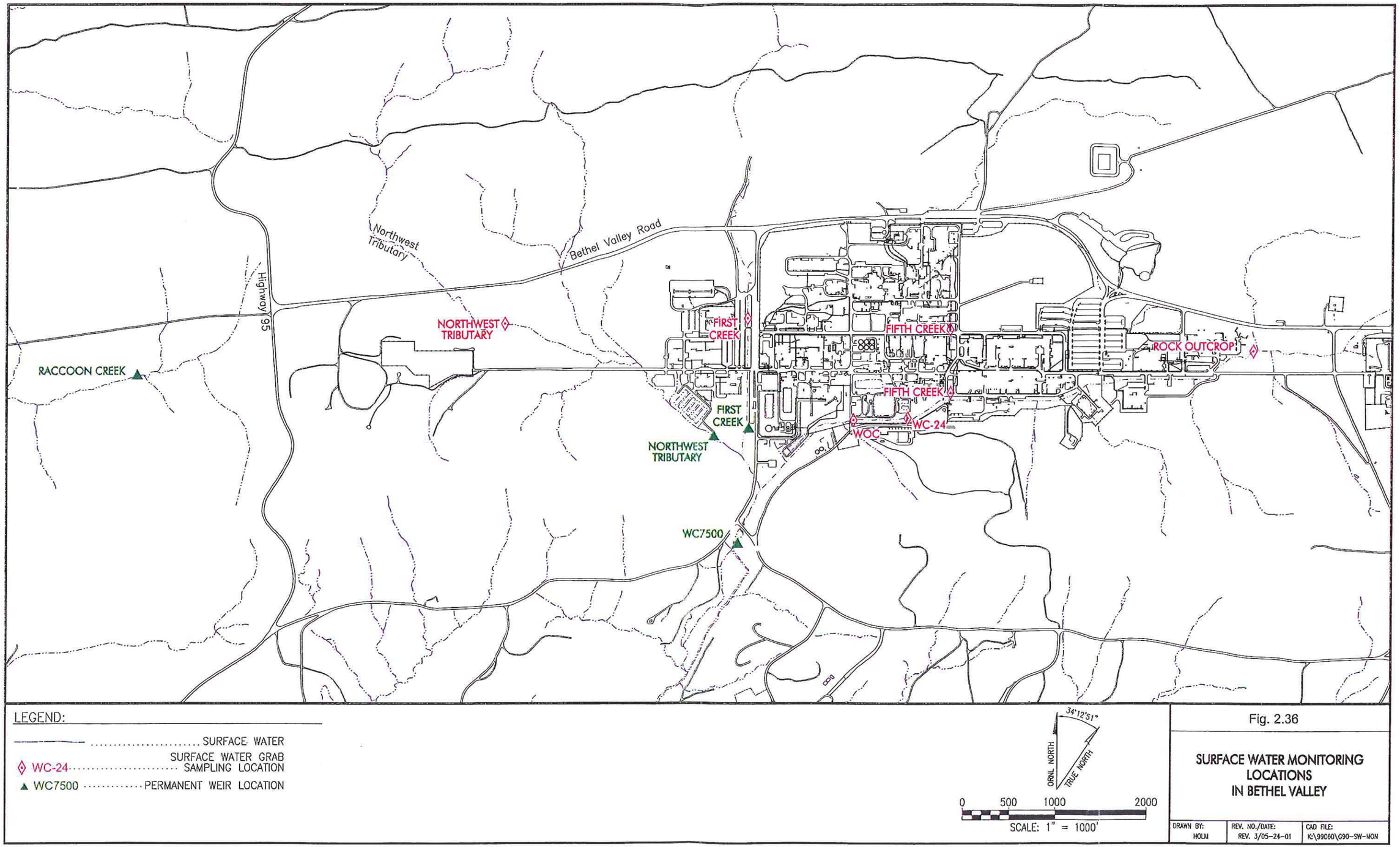


Fig. 2.36. Surface water monitoring locations.

Exit pathway groundwater monitoring will be performed in West Bethel Valley/Raccoon Creek to determine if contaminants are leaving the known contaminated area by groundwater transport and to document the concentrations of any groundwater contaminants at the area boundary. The frequency of groundwater monitoring at the exit pathways will be based on the rates of groundwater movement in shallow versus deep monitoring zones. Groundwater will be analyzed routinely for contaminants known to occur within the Bethel Valley watershed with periodic analysis for a broad spectrum of contaminants.

Groundwater and/or seep monitoring will be used to measure some aspects of remedial action effectiveness in areas where source control actions are implemented. Examples of types of groundwater monitoring that may be used include measurement of water level fluctuations inside and outside hydraulically isolated areas and sampling of monitoring wells to measure contaminant concentrations within and at the edges of existing contaminant plumes. Monitoring of seeps at certain locations is appropriate to sample discharging groundwater to measure changes in contaminants entering the streams. In areas where groundwater is collected for treatment, collected groundwater volumes and contaminant concentrations will be monitored.

As with surface water monitoring, the details of groundwater monitoring will be developed and approved during the remedial design process. Results of monitoring will be included in the annual RER.

Physical Inspections. Physical inspections will be conducted to assess the performance and integrity of remedy components. Remedial components subject to inspection include caps, soil covers, and water treatment facilities. Visual inspections will address issues such as cracks or failures in the caps, erosion of soil covers, and overall condition of the structure or system.

Radiological Surveys. Radiation surveys will be conducted at areas with soil covers to assess the ongoing ability of soil covers to effectively shield on-site workers from sources of radiation and contamination. The frequency of surveys will be determined in a post-ROD monitoring plan.

Sediment Sampling. Sediment samples will be collected in White Oak Creek, First Creek, and Fifth Creek to determine if contaminants are reaccummulating in these streambeds and to help verify whether the goal of reducing risk from contaminated sediment is being met. Results will be reported in the annual RER. The frequency of sampling will be determined in a post-ROD monitoring plan.

Biological Monitoring. Fish and benthic macroinvertebrate surveys will be conducted in White Oak Creek, First Creek, and Fifth Creek to evaluate whether aquatic populations are being protected. Results will be reported in the annual RER. The frequency of monitoring will be determined in a post-ROD monitoring plan.

2.12.4 Land Use Controls

Areas within Bethel Valley cannot support unrestricted use due to hazardous substances remaining in place after implementation of the selected remedy. Land use restrictions are required as part of this CERCLA action and will be achieved through imposition of LUCs that limit the use and/or exposure to those areas of the property, including water resources, that are contaminated. DOE is committed to implementing and maintaining LUCs, including institutional controls, to ensure that the selected remedy remains protective of human health and the environment.

DOE has agreed in an MOU with EPA and TDEC (DOE, EPA, and TDEC 1999) to comply with the ORR LUCAP whenever LUCs, including institutional controls, are selected as part of a remedial action (as in this ROD). The LUCAP, which is attached to the MOU, establishes procedures designed to ensure that each selected LUC will be implemented and properly maintained for as long as the LUC is needed to protect public health and the environment. Included in the LUCAP are requirements for planning

implementation of each selected LUC, regular periodic monitoring of each LUC following its implementation, and annual certification by the manager of DOE–ORO that each LUC continues to be effectively implemented.

Pursuant to the ORR LUCAP, when a remedial action that includes LUCs has been selected, a LUCIP will be developed as a component of the post-ROD documentation. DOE will develop a LUCIP for Bethel Valley that addresses the units covered under the ROD and submit it to EPA and TDEC for approval. The Bethel Valley LUCIP will be submitted and reviewed concurrently with the Bethel Valley Remedial Design Work Plan. The anticipated schedule for the LUCIP is shown in Table 2.31. The LUCIP will specify LUC objectives for Bethel Valley (Sect. 1.2), identify the controls and mechanisms required to achieve each objective, and describe the actions necessary to implement and maintain the LUCs. Upon regulatory approval, the Bethel Valley LUCIP will be added to Appendix B of the ORR LUCAP.

Table 2.31. Schedule for Land Use Control Implementation Plan, Bethel Valley, ORNL, Oak Ridge, Tennessee

Activity	Duration of activity (days)
DOE issues LUCIP (D1 version)	see footnote[a]
EPA and TDEC review D1 LUCIP	90
DOE responds to regulatory comments on the D1 LUCIP and prepares the D2 LUCIP	60
EPA and TDEC review and approve the D2 LUCIP	30

[a]The D1 LUCIP will be submitted concurrently with the Remedial Design Work Plan.
DOE = U.S. Department of Energy
LUCIP = Land Use Control Implementation Plan
EPA = U.S. Environmental Protection Agency
TDEC = Tennessee Department of Environment and Conservation

The Bethel Valley ROD establishes four remediation areas within the watershed with different future land uses and different remediation levels. Each of these land use areas will have one or more controls that are required to ensure the long-term protection of human health and the environment. The seven LUCs that will be used in Bethel Valley are summarized in Table 2.32 and include property record restrictions, property record notices, zoning notices, internal permits program, access controls, signs, and surveillance patrols. For each of these controls, the table specifies the purposes of the controls, duration, implementation, and affected areas. The primary controls that will be used to limit unauthorized activities in the remediation areas includes signs and administration of an excavation/penetration permit program. Use restrictions and information about the residual contamination/waste management areas will also be recorded by DOE along with the original acquisition records (e.g., deeds) for the ORR. Advisories established by the TDEC Division of Water Pollution Control to prohibit fishing or swimming have not been posted in Bethel Valley, in part due to the small size of the streams, and therefore were not included as a LUC for Bethel Valley. Table 2.33 lists the LUCs for the principal waste units or areas to be remediated under the ROD.

The DOE is responsible for implementing, monitoring, maintaining, reporting on, and enforcing the LUCs selected in this ROD in accordance with the requirements in the Bethel Valley LUCIP. The LUCIP will remain in effect until the follow-on or final LUCIP has been approved. The LUCIP may be modified or expanded as needed over the intervening period to address LUCs stipulated in other forthcoming decision documents for Bethel Valley.

Table 2.32. Land use controls for Bethel Valley, ORNL, Oak Ridge, Tennessee

Type of control	Purposes of control	Duration	Implementation	Affected areas[a]
1. Property Record Restrictions[b] A. Land use B. Groundwater	Restrict use of property by imposing limitations Prohibit uses of groundwater	Indefinitely	Drafted and implemented by DOE upon transfer of affected areas. Recorded by DOE in accordance with state law at County Register of Deeds office	All waste management areas and other areas where hazardous substances are left in place at levels requiring land use and/or groundwater restrictions
2. Property Record Notices[c]	Provide notice to anyone searching records about the existence and location of contaminated areas	Indefinitely	Notice recorded by DOE in accordance with state law at County Register of Deeds office: 1) as soon as practicable after signing of the ROD; 2) upon transfer of affected areas; 3) upon completion of all remedial actions	All waste management areas and other areas where hazardous substances are left in place at levels requiring land use and/or groundwater restrictions
3. Zoning Notices[d]	Provide notice to city about the existence and location of waste disposal and residual contamination areas for zoning/planning purposes	Indefinitely	Initial Zoning Notice (same as Property Record Notice) filed with City Planning Commission as soon as practicable after signing of the ROD; final Zoning Notice and survey plat filed with City Planning Commission upon completion of all remedial actions	All waste management areas and other areas where hazardous substances are left in place at levels requiring land use and/or groundwater restrictions
4. Excavation/ Penetration Permit Program[e]	Provide notice to worker/developer (i.e., permit requestor) on extent of contamination and prohibit or limit excavation/penetration activity	As long as property remains under DOE control	• Implemented by DOE and its contractors • Initiated by permit request	Remediation systems, all waste management areas, and areas where hazardous substances are left in place at levels requiring land use and/or groundwater restrictions
5. Access Controls[f] (e.g., fences, gates, portals)	Control and restrict access to workers and the public to prevent unauthorized uses	Indefinitely	Controls maintained by DOE	Specific locations will, if necessary, be determined by each remediation project
6. Signs[g]	Provide notice or warning to prevent unauthorized access	Indefinitely	Signage maintained by DOE	At select locations throughout Bethel Valley
7. Surveillance Patrols	Control and monitor access by workers/public	Indefinitely	• Established and maintained by DOE • Necessity of patrols evaluated upon completion of remedial actions	Patrol of selected areas throughout Bethel Valley, as necessary

[a] Affected areas – Specific locations identified in the Bethel Valley LUCIP or subsequent post-ROD documents.

[b] Property Record Restrictions – Includes conditions and/or covenants that restrict or prohibit certain uses of real property and are recorded along with original property acquisition records of DOE and its predecessor agencies.

[c] Property Record Notices – Refers to any non-enforceable, purely informational document recorded along with the original property acquisition records of DOE and its predecessor agencies that alerts anyone searching property records to important information about residual contamination/waste disposal areas on the property.

[d] Zoning Notices – Includes information on the location of waste disposal areas and residual contamination depicted on a survey plat, which is provided to a zoning authority (i.e., City Planning Commission) for consideration in appropriate zoning decisions for non-DOE property.

[e] Excavation/Penetration Permit Program – Refers to the internal DOE/DOE contractor administrative program(s) that require the permit requestor to obtain authorization, usually in the form of a permit, before beginning any excavation/penetration activity (e.g., well drilling) for the purpose of ensuring that the proposed activity will not affect underground utilities/structures, or in the case of contaminated soil or groundwater, will not disturb the affected area without the appropriate precautions and safeguards.

[f] Access Controls – Physical barriers or restrictions to entry.

[g] Signs – Posted command, warning, or direction.

DOE = U.S. Department of Energy
LUCIP = Land Use Control Implementation Plan
ORNL = Oak Ridge National Laboratory
ROD = record of decision
SWSA = solid waste storage area

Table 2.33. Land use controls for principal waste units or areas to be remediated, Bethel Valley, ORNL, Oak Ridge, Tennessee

Waste type	Unit or area	Land use controls
Facilities (buildings and appurtenances)	Structures at or below grade	1-4
	Graphite Reactor building	1-4,7
Buried waste	SWSA 1	1-4,6,7
	Former Waste Pile Area	1-4,6,7
	NRWTP Debris Pile	1-4,6,7
	SWSA 3	1-7
	Contractor's Landfill	1-7
Tank sludge and linings	Tank contents	1-4 (residuals)
	Tank shells	1-4
Inactive LLLW pipelines	Inside main plant area	1-4
	Outside main plant area	Pipelines removed
Contaminated soil impacting worker protection [top 0.6 m (2 ft)]	Main plant area	Soil Removed
	Outside main plant area	Soil Removed
	In vicinity of SWSA 3	Soil Removed
Contaminated soil impacting groundwater	Inside main plant area	1-4
Sediment and floodplain soils	White Oak Creek, First Creek, and Fifth Creek	1-4
Groundwater	Core Hole 8 Plume	1-4
	^{90}Sr-contaminated sumps	1-4,7
	Mercury-contaminated sumps	1-4,7
	VOC Plume	1-4
	Monitoring wells	1-4

Notes:

(1) This table lists the land use controls that apply to principal waste types or units that will be remediated under the ROD. The numbers in the "Land use controls" column correspond to the numbered land use controls in Table 2.32, "Land use controls for Bethel Valley"; specifically,

1 = Property record restrictions
2 = Property record notices
3 = Zoning notices
4 = Permit program
5 = Access controls
6 = Signs
7 = Surveillance patrols

(2) Details regarding implementation of land use controls are set forth in Table 2.32 and will be further addressed in the land use controls implementation plan.

(3) The indicated land use controls may be applied at the unit or by implementation of the land use control on a Bethel Valley-wide basis. For example, signs may not surround SWSA 1, an individual waste unit in the main plant area, but may be placed at key access points to the main plant area, which contains multiple waste units.

(4) See Appendix A for a complete listing of contaminated sites and selected actions.

LLLW = liquid low-level (radioactive) waste
NRWTP = Nonradiological Wastewater Treatment Plant
ORNL = Oak Ridge National Laboratory
ROD = Record of Decision
SWSA = solid waste storage area
VOC = volatile organic compound

Table 2.34. Management of uncertainties[a], Bethel Valley, ORNL, Oak Ridge, Tennessee

Uncertainty	Expected condition	Potential deviation	Relative probability of deviation	Potential impact of deviation	Action	Contingent action or decision rule
			Buried waste			
Level of contribution to groundwater contamination from SWSA 1	Currently SWSA 1 is not a significant contributor to groundwater contamination	After completion of actions in area, SWSA 1 is a significant contributor to groundwater contamination	Low—existing data show groundwater contamination risk $<10^{-4}$	Low—potential levels would minimally exceed 10^{-4}	Cap SWSA 1	None due to low probability or impact; would be considered in a future decision
			Surface water			
Future contaminant flux in First Creek from Core Hole 8 Plume	Strontium-90 flux decreases markedly with implementation of groundwater removal system	Insufficient flux reduction to meet at least 45% risk reduction at 7500 Bridge and maintain recreational risk-based levels in First Creek and WOC	Low—concentrations have decreased from past actions, flux is directly related	Medium—eventually impacts Clinch River	Source removals; groundwater extraction	Interceptor trench at First Creek
Effectiveness of actions to reduce contaminant flux at 7500 Bridge	Planned actions achieve at least 45% reduction at 7500 Bridge	Insufficient flux reduction to meet at least 45% risk reduction at 7500 Bridge and maintain recreational risk-based levels in WOC	Medium—flux information and source identification both have uncertainties	Medium— eventually impacts Clinch River	Numerous source and groundwater actions	Interceptor trench at South Area Plume
Future contaminant flux from SWSA 3 to Raccoon Creek and Northwest Tributary	Future conditions will not exceed surface water goals	Future recreational or ecological risks will be exceeded. AWQC exceeded	Low—concentrations in Raccoon Creek have decreased significantly. Northwest Tributary concentrations have slowly decreased	High—flux in Raccoon Creek flows off-site	Source containment; sampling	Interceptor trench before affected tributary
Meet AWQC for all site-related contaminants	Planned actions meet AWQC for all site-related contaminants	Planned actions do not meet AWQC	Low—1999 data illustrate AWQC met in Fifth Creek and WOC except for mercury	Low— exceedances most likely to be short-lived as indicated by historical exceedances	Sump collection for mercury. No actions specific to other metals. Sampling	None due to low probability or impact; would be considered in future decision
			Soil			
Extent of contaminated soil impacting worker protection	Process knowledge and existing data are sufficient to determine contaminated soil does not extend outside known or suspected areas of contamination	Contaminated soil extends outside known or suspected areas of contamination	Low—radiological flyover indicates no large, undiscovered sources. Site activity restricted to within secured areas	Medium—cost impact if volumes are significant	Soil removal	Additional soil removal defined by decision rule (Fig. 2.34).

Table 2.34. Management of uncertainties[a], Bethel Valley, ORNL, Oak Ridge, Tennessee (continued)

Uncertainty	Expected condition	Potential deviation	Relative probability of deviation	Potential impact of deviation	Action	Contingent action or decision rule
Nature and extent of contaminated deeper soils impacting groundwater	A single hot spot requiring remediation	The large number of pipeline leak sites and the experience gained from the Core Hole 8 source action suggest the potential for multiple locations of highly contaminated soil impacting groundwater	Medium—a large number of leak/spill sites need additional investigation	Medium—potential worker and cost impacts if nature and extent of subsurface contamination are significantly different than expected	Re-evaluate selected remedy; evaluate potential alternatives as necessary	Additional soil removal defined by decision rule (Fig. 2.34). Deep soil contamination near SWSA 3 may be capped with extension of SWSA 3 cap
Sediment						
Presence/absence of contaminated sediment in areas not planned for remediation	Sediment concentrations are not appreciably different from existing data	Sediment contains unacceptable contamination	Medium—existing data collected far from source; however, the leading contaminant (^{90}Sr) not typically found in sediment	Low—sediment downstream is not contaminated so area is not significant	Sampling	Additional sediment removal defined by decision rule (Fig. 2.35)

[a]Management of groundwater condition uncertainties have been deferred to the final decision

AWQC = ambient water quality criteria
ORNL = Oak Ridge National Laboratory
SWSA = solid waste storage area
WOC = White Oak Creek

2.12.4.1 Uncertainties and Contingent Actions

The decision makers recognize that there are uncertainties associated with site conditions and remedy effectiveness at specific locations. These are documented in Table 2.34. Uncertainties associated with the effectiveness of the selected remedy include (1) whether the actions will sufficiently reduce the flux of Core Hole 8 Plume contaminants reaching First Creek, (2) whether the actions will be sufficient to reduce contaminant flux sufficiently to achieve risk reduction goals at the 7500 Bridge, (3) whether actions will meet AWQC, (4) the extent of soil and sediment contamination requiring removal, and (5) whether SWSA 3 contaminants that have migrated to groundwater will reach NWT or Raccoon Creek in concentrations that exceed remediation levels.

The following contingent actions have been identified to help manage these uncertainties:

- If future surface and groundwater monitoring results indicate that Core Hole 8 Plume contaminants are reaching First Creek at concentrations that cause remediation level exceedances (either exceedance of recreational risk-based levels in First Creek or contribution from First Creek causing the 45% reduction goal at the 7500 Bridge not to be met), a shallow groundwater interception trench will be installed parallel to First Creek.

- If it is determined that the South Area Plume contributes significant ^{90}Sr to surface water, either causing an exceedance of recreational risk in White Oak Creek or prohibiting achievement of the 45% risk reduction at the 7500 Bridge, a shallow groundwater interception trench will be installed parallel to White Oak Creek, just south of the SIOU area.

- If surface and groundwater monitoring results indicate that SWSA 3 contaminants are reaching NWT or Raccoon Creek at concentrations that exceed AWQC or recreational risk-based levels for surface water, shallow groundwater interception trenches will be installed at the appropriate locations downgradient of SWSA 3.

- If the extent of contaminated soil impacting worker protection and contaminated sediment is greater than expected, decision rules will be applied (Figs. 2.34 and 2.35).

- If the scope or cost of the selected remedial action for deep soils impacting groundwater significantly increases, the selected remedial action and, as necessary, potential alternative remedies, will be evaluated and a new response action may be developed to address the deep soils in accordance with CERCLA and the NCP. If deep soil contamination is found adjacent to SWSA 3, then the SWSA 3 cap may be extended to cover the area, if approved by the FFA parties.

Additional surface water monitoring will be performed throughout the implementation of remedial actions to assess surface water quality. No contingent actions have been planned to address the potential failure to meet AWQC. If AWQC are exceeded after all actions are implemented, additional actions will be identified in a future decision for Bethel Valley.

2.12.5 Cost Estimate for the Selected Remedy

The cost estimate for the selected remedy is presented in Table 2.35. The total unescalated capital cost is approximately $126 million. The present worth cost of the selected remedy is $102 million. The present worth cost for 30 years of O&M activities is $128 million. The O&M cost includes such activities as surveillance/inspections, cap maintenance, monitoring, water treatment, and legal costs

Table 2.35. Cost estimate for the selected remedy, Bethel Valley, ORNL, Oak Ridge, Tennessee[a]

Remedial project	Unescalated present day (1998) $ capital cost ($ thousands)			Unescalated present day (1998) $ O&M costs ($ thousands)
	Direct[b]	Indirect[c]	Total	Average annual
Actions				
Demolish hot cells (some below grade to remain in place)	31,289	10,621	41,910	
Demolish NE Corner Buildings	2,138	726	2,864	
Demolish Isotope Area Buildings	6,529	2,216	8,745	
Demolish Reactor Area Buildings (some below grade to remain in place)	15,304	5,195	20,499	
Demolish Tank Area Buildings (some below grade to remain in place)	4,316	1,465	5,781	
Demolish Chemical Development Laboratory Buildings	1,349	458	1,807	
Grout Graphite Reactor (3001)	467	158	625	
Subtotal building/facility D&D:	**61,392**	**20,839**	**82,231**	
Cap SWSA 1 and SWSA 3; add soil cover to FWPA and NRWTP debris pile (associated S&M includes visual inspection, erosion control, mowing, etc.)	3,663	1,222	4,885	108
Remove contents of four tanks and grout tanks; stabilize pipeline and contain bedding materials inside main plant area; remove pipeline and contaminated bedding material outside main plant area	6,971	2,431	9,402	
Excavate contaminated hot spots in Central/East Bethel Valley (applicable S&M includes visual inspection, erosion control, mowing, etc.)	6,044	2,051	8,095	38
Remove sediment and floodplain soil at White Oak Creek, First Creek, and Fifth Creek	10,450	3678	14,128	
Remove contaminated soil hot spots in West Bethel Valley and stockpile	2,248	747	2,995	
Groundwater collection/conveyance system for Core Hole 8 Plume and groundwater collection/conveyance/treatment systems for existing sumps at tanks and buildings; in situ treatment system for the East Bethel Valley VOC Plume; groundwater monitoring wells (treatment facilities include new treatment/pretreatment facilities and PWTC) (associated O&M includes maintenance of facilities and unit treatment costs)	2,118	793	2,861	7,992
Well plugging and abandonment	1,266	430	1,696	
Sitewide monitoring (includes sampling and analysis, biological monitoring, and maintenance of monitoring facilities)	NA	NA	NA	314
Subtotal other remedial actions:	**32,760**	**11,302**	**44,062**	**8,452**
Actions: unescalated total cost:	**94,152**	**32,141**	**126,293**	**8,452**
Actions: present worth:	**NA**	**NA**	**102,211**	**128,427**
Contingent actions				
Install groundwater recovery /conveyance/treatment from trenches at Core Hole 8 Plume and South Area Plume	445	157	602	3,114
Groundwater recovery trench and treatment system at Raccoon Creek; groundwater recovery trench at SWSA 3; and conveyance to PWTC (associated O&M includes maintenance of facilities and unit treatment costs)	1,699	598	2,297	2,378
Contingent action totals:	**2,144**	**755**	**2,899**	**5,492**

Table 2.35. Cost estimate for the selected remedy, Bethel Valley, ORNL, Oak Ridge, Tennessee[a] (continued)

[a]The information in this cost estimate summary table is based on the best available information regarding the anticipated scope of the selected remedy. Changes in the cost estimates are likely to occur as a result of new information and data collection during the engineering design of the selected remedy. This is an order-of-magnitude engineering cost estimate that is expected to be within +50 to –30% of the actual project cost.

[b]Direct cost includes FPSC field activities, general requirements, waste transportation and disposal, overhead, profit, bond, sales tax, and a 17% site overhead.

[c]Indirect cost includes design engineering, project integration, M&I contract management, predesign sampling and analysis on building D&D and buried waste, and a 17% site overhead on indirects.

[d]This is the present worth of total O&M assuming 30-year evaluation period.

D&D = decontamination and decommissioning
FPSC = fixed-price subcontractor
FWPA = Former Waste Pile Area
M&I = management and integration
NA = not applicable
NE = northeast
NRWTP = Nonradiological Wastewater Treatment Plant
O&M = operations and maintenance
ORNL = Oak Ridge National Laboratory
PWTC = Process Waste Treatment Complex
S&M = surveillance and maintenance
SWSA = solid waste storage area
VOC = volatile organic compound

(e.g., deed notices, deed restrictions, and zoning notices). The O&M cost does not include landlord activities (e.g., road maintenance), maintenance of information systems (e.g., databases, reports, maps), security (e.g., guard patrols), and other land use-related activities that currently exist or will be created for reasons unrelated to this remedy.

The information in the cost estimate summary table, Table 2.35, is generated from cost estimates produced during the FS process for Alternatives C-3b and W-5, modified to match the scope of the selected remedy and the anticipated duration of construction. The cost estimates were based on the best available information at the time of estimate development regarding the anticipated scope of the selected remedy. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design of the selected remedy. Final costs will depend on actual labor and material cost, actual site conditions, productivity, competitive market conditions, action sequencing, final scope, final engineering design, and other variables. Accordingly, final costs could vary significantly from the estimates presented. This is an order-of-magnitude engineering cost estimate that is expected to be within +50% to –30% of the actual project cost.

2.12.6 NEPA Values

In accordance with DOE Secretarial Policy on NEPA (DOE 1994a), DOE evaluations under CERCLA and associated documents incorporate NEPA values to the extent practicable. These NEPA values include physical values of air quality, water quality, groundwater quality, and ecological resources; human-related values of cultural and historical resources, visual and aesthetic effects, socioeconomics, environmental justice, and transportation; and the overall cumulative and indirect impacts anticipated. This summary addresses NEPA values during and following remedial action (Table 2.36). Another important consideration under NEPA is public participation in the decision-making process. The public has been involved throughout the CERCLA process for Bethel Valley, as detailed in Sect. 2.3.

Short-term impacts on the human environment will include minor visual impacts, some increase in road traffic, and minor local employment impacts. Long-term impacts will include reduction in off-site contaminant releases and eventual lessening of access restrictions required to prevent contact with radioactive contaminants. Permanent adverse impacts on the use of the site and surrounding area can be expected from leaving wastes and residual contamination in place.

Cumulative impacts will depend on the extent of other actions on the ORR and the development of future land use plans for the ORR. If other sites manage waste in place, the presence of waste in place in Bethel Valley will represent only one of a number of contributors to future impacts. If other sites on the ORR remove waste rather than managing it in place, the relative impact of Bethel Valley on future development of the ORR may be more significant. Fuel, borrow soil, and other materials will be used directly during remedial action and will constitute an irreversible and irretrievable commitment of resources.

Many of the buildings to be removed under the remedy are within the ORNL Historic District, which has been recommended for inclusion in the National Register of Historic Places under the National Historic Preservation Act (NHPA). The Graphite Reactor is a National Historic Landmark. Adverse effects on historic properties will be taken into account, and measures to minimize or mitigate them will be evaluated per applicable NHPA requirements. An architectural/historical assessment was performed for ORNL in 1993. The results of this assessment were submitted to the Tennessee State Historic Preservation Officer (SHPO). If any of the buildings to be demolished are listed as historical properties, approval is required from the SHPO. The SHPO must also be consulted regarding measures to mitigate adverse effects to historical properties.

2.12.7 Remedy Implementation

2.12.7.1 Sequencing and milestones

The actual schedule of activities will depend on numerous factors including, funding, logistics, and availability of resources. Most importantly, activities must be coordinated with the laboratory. Regardless, there are relationships that are important between activities in the selected alternative. These relationships or logic connections are illustrated in Fig. 2.37, along with how the work could be grouped into projects. The sequence of actions shown in Fig. 2.37 is intended only to show that some actions are precursors to other projects and to convey a general activity sequence for major activities. This figure does not attempt to show all aspects of remedial actions in Bethel Valley. Several of the actions are dependent on the availability of an on-site disposal facility. Significant demolition and soil removal activities will be more cost-effectively implemented once the EMWMF is constructed.

In addition, some of the activities, such as the installation of groundwater extraction wells and the excavation of deep soils to minimize impacts to groundwater, are dependent on the collection of additional information. A post-ROD groundwater engineering design study will be conducted to collect information and satisfy data needs associated with the implementation of several remedial actions related to groundwater, including: (1) the deep groundwater extraction at the Core Hole 8 Plume, (2) the in situ biodegration at the East End VOC Plume, (3) the groundwater monitoring in West Bethel Valley, and (4) the deep soil excavation at known leak sites to minimize impacts to groundwater. Data collected from this investigation will supplement data from former groundwater and soil characterization efforts and will provide the basis for the groundwater and deep soil remedial actions.

Before contaminated soil can be effectively excavated, the buildings should be demolished. To minimize the potential for recontamination of sediments, the sediment and floodplain soils should be removed after the mercury-contaminated sumps have been addressed and after the disposal areas near White Oak Creek (SWSA 1, etc.) are capped and covered.

In West Bethel Valley, contaminated surface soil will be excavated and may be used as contouring fill for the cap on SWSA 3. Then the cap will be constructed along with the upgradient diversion trench. Concurrent with these tasks, the soil cover on the Contractor's Landfill will be upgraded. Groundwater monitoring needs to begin before the cap is constructed in order to measure the impacts the actions have on the groundwater. This information supports the final groundwater decision.

Activities such as T1, T2, and HFIR tanks contents removal and tank grouting and grouting of the pipelines are fairly independent of other activities. More predesign work is needed prior to initiating these activities.

Figure 2.37 also shows the currently anticipated fiscal year dates for completion of selected major activities. All remedial actions included in this ROD currently are projected to be completed by fiscal year (FY) 2014. The exception is remediation of inaccessible soil (defined under "Soil Removal" in Sect. 2.12.2); removal of the contaminated soil would be delayed until the active structures blocking access have become inactive and are removed. Pursuant to Sect. XXXVIII of the FFA, DOE shall take all necessary steps to obtain sufficient funding for activities required by this ROD. This is to be accomplished, as set forth in that section of the FFA, through consultation with EPA and TDEC and the submission of timely budget requests. However, schedules for completion of projects, as set forth in Fig. 2.37, are planning dates only and are not considered to be enforceable elements of the selected remedy. The enforceable milestones and nonenforceable FY+3 milestones for performance of remedial

Table 2.36. NEPA values, Bethel Valley, ORNL, Oak Ridge, Tennessee

NEPA value	Definition	Impacts associated with selected remedy
Air quality	Cleanliness of air measured by pollutant level relative to regulatory standards or guidelines	Standard dust-control practices will prevent significant releases of airborne contaminants during action. Minor emissions from equipment used for construction and transportation can be expected. No potential exists for any long-term impacts on air quality.
Surface water quality	Condition of surface waters of the state relative to AWQC. Residual risk from contaminated media associated with surface water	Current exceedences of AWQC area anticipated to cease in a reasonable amount of time. Minor impacts to surface water may occur during remedial action. Some floodplain media will continue to remain radioactive and will present risk to a recreational user for approximately 170 years.
Groundwater quality	Condition of groundwater relative to EPA-specified maximum contaminant levels	Source control actions will mitigate further adverse impacts to groundwater in the general extent of contamination in Bethel Valley.
Ecological impacts	Ecological health measured by reduction in populations of indicator species, impacts on an individual[a] level to indicator or specially designated species, and by general biodiversity	In the short term, actions at the site will destroy some terrestrial, floodplain, and aquatic habitat and disturb adjacent areas. In the long term, health of ecological receptors on a population level will improve.
Cultural and historical resources	Impacts to materials of special cultural interest, graveyards, or structures eligible for listing on the National Register of Historic Places	Many of the buildings (including the Graphite Reactor) subject to remedial action are located within the ORNL Historic District and, therefore, adverse effects will be taken into account. Removal of some of these contributing structures could lessen the visibility and, hence, relative historical importance within the district.
Visual and aesthetic effects	Changes in the skyline or appearance of an area, especially with regard to the aesthetics of the area	The area is currently visible mainly from access roads and adjacent ridges. Short-term visual impacts will be minor. In the long term, should areas adjacent to the controlled area be opened for public use, the controlled and maintained waste areas will represent a continuing visual impact. Removal of old facilities and capping with grass cover will enhance visual effects.
Socioeconomic impacts	Changes in the employment profile, population, total wage base or other economic elements of work and life in the affected area	Remediation workers will likely be drawn from the local work force, generating a minor positive impact in the short term. Negligible long-term employment may result from monitoring and implementing long-term land use controls.
Environmental justice impacts	The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies (see EO 12898)	No specific low-income or minority population as defined under EO 12898 exists in the vicinity of Bethel Valley. Action is expected to reduce releases to the environment on-site and environmental justice concerns are not likely.
Transportation impacts	Potential impacts include road damage, disruption of current and future transportation, emissions of dust and exhaust, and injuries or death from accidents	Estimates based on state road accident statistics indicate that <1 accident should occur during remedial action. No long-term impacts are anticipated.
Irreversible and irretrievable commitment of resources	Some resources, such as fuel or soil, cannot be replaced once used in an action or committed to a permanent use	The resource represented by the waste sites in Bethel Valley will continue to be committed to waste disposal and will not be useful for other purposes. Fuel, borrow soil, and other materials will be directly used during remedial action.
Cumulative impacts	Impacts that result from the incremental impact of a proposed action added to other present, past, and reasonably foreseeable future actions	The overall cumulative impact during and after remedial action will depend on other actions that may occur at the same time. Action at Bethel Valley will contribute to transportation and socioeconomic impacts in the short term. Excavations at the borrow area will contribute to overall loss of habitat. Remediation of Bethel Valley should contribute to the overall desirability of ORNL for redevelopment.
Indirect impacts	Impacts that accrue as a peripheral result of direct actions but are reasonably foreseeable	The primary indirect impact could be changes to land use on the ORR as a result of redevelopment.

[a]The specific indicator species to be used to monitor the health of ecological species are dependent upon the location to be addressed and the remedy selected. Therefore, the specific species cannot be listed here. However, these species may include aquatic and/or terrestrial species such as benthic organisms, fish, soil invertebrates, and wildlife (e.g., shrew, mouse, otter, mink, etc.).

AWQC = ambient water quality criteria
EO = Executive Order
EPA = U.S. Environmental Protection Agency
NEPA = National Environmental Policy Act of 1969
ORNL = Oak Ridge National Laboratory
ORR = Oak Ridge Reservation

actions for sites included in this ROD are set forth in Appendix E and Appendix J of the FFA, respectively. Any additional milestones, timetables, or deadlines for sites included in this ROD will be identified and established independent of this ROD, in accordance with the existing FFA protocols.

2.12.7.2 Performance objectives

The selected remedy for Bethel Valley was summarized earlier in Figs. 2.26 and 2.27. Each component action in the selected remedy contributes in some way to meeting the RAO for Bethel Valley. The roles of each major action in fulfilling the RAO and required performance of the major actions are outlined in Table 2.37. Performance requirements included for the major actions show the level of protectiveness required for the actions to meet the overall RAO and protection goals.

2.12.7.3 Remediation levels

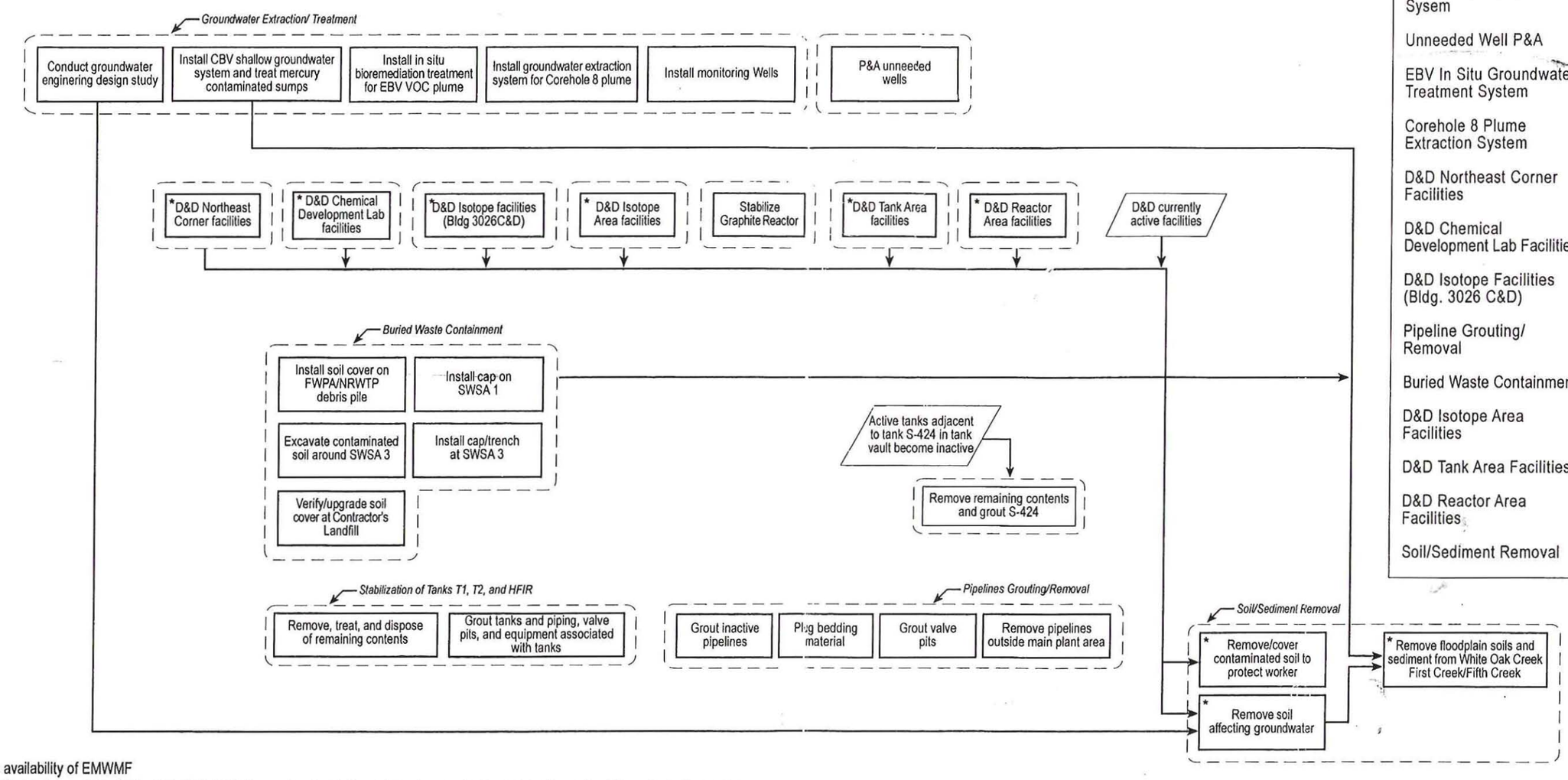
General

Remediation levels establish the permissible risk, concentration, or exposure level of contaminants at a site that must be achieved by the completed remedy. Remediation levels for remedial actions under CERCLA are developed principally using site-specific risk assessments and ARARs/To Be Considereds, but may also consider any of the nine CERCLA criteria specified in the NCP. All remedial actions at CERCLA sites must be protective of human health and the environment and comply with ARARs unless a waiver is justified. ARARs are often the determining factor in establishing remediation levels at CERCLA sites. However, where ARARs are not available or are not sufficiently protective, site-specific risk assessments are used to develop remediation levels for (1) carcinogens at a level that represents an ELCR to an individual of between 10^{-4} and 10^{-6}; and (2) noncarcinogens such that the cumulative risks from exposure will not result in adverse effects to human populations, incorporating an adequate margin of safety.

During and/or at the end of remedy implementation, data are collected and analyzed to measure whether the remedy has attained the remediation levels in the ROD with an acceptable level of confidence. Documentation of remediation level attainment for Bethel Valley will use statistical methods to provide a quantitative estimate of the probability that the residual risk or exposure in an area does not exceed the respective remediation level. Statistical methods also provide for specifying (controlling) the probability of making decision errors.

To estimate risk or exposure in a particular area, an estimate is needed of the concentration of the substance that is present. Under current EPA guidance for risk assessment, the average concentration is the value to be used in such estimation. Because only a finite number of samples can be taken, the average concentration cannot be determined precisely. For this reason, EPA requires that a 95% upper confidence limit (UCL_{95}) on the arithmetic average concentration be calculated to estimate concentrations used in risk assessments. The UCL_{95} of the average concentration is the value that, when calculated repeatedly for randomly drawn subsets of area data, will equal or exceed the true average 95% of the time. An exception to the general guideline for using a UCL_{95} for the average concentration is when multiple surface water samples are taken from a continuous sampler. In this case, the continuous sampler adequately averages the concentration over the sampling period; therefore, an arithmetic average of the concentrations measured in the multiple samples is acceptable.

The remediation levels for (1) surface water, (2) soils and sediment, and (3) structure surfaces in Bethel Valley are discussed in the following subsections.



Activity Description	** Anticipated Completion
CBV Shallow Groundwater Collection/Treatment Sysem	1/05
Unneeded Well P&A	5/04
EBV In Situ Groundwater Treatment System	2/06
Corehole 8 Plume Extraction System	3/06
D&D Northeast Corner Facilities	3/07
D&D Chemical Development Lab Facilities	8/07
D&D Isotope Facilities (Bldg. 3026 C&D)	12/07
Pipeline Grouting/ Removal	2/08
Buried Waste Containment	7/08
D&D Isotope Area Facilities	9/08
D&D Tank Area Facilities	12/08
D&D Reactor Area Facilities	7/09
Soil/Sediment Removal	9/14***

* Assumes availability of EMWMF

** Anticipated completion dates (submittal of D1 PCCR) are planning dates only and are not enforceable elements of the selected remedy

*** Completion date is for accessible soil; inaccessible soil will be remediated when active structures have been removed.

Legend

- Remedial project
- Remedial task
- Logic connection
- Activity not in scope of decision

Notes:
(1) Length of activity box does not imply duration of activity
(2) All activities must be coordinated with plant operations

Fig. 2.37

CONSTRUCTION LOGIC FOR SELECTED REMEDY*

DOE - Bethel Valley - Oak Ridge, Tennessee 61-051601-102 C

Document Id: 35H830 0139-40/FS	Drawing Id: 61-051601-102 C	Drawing date: May 16, 2001

Fig. 2.37. Construction logic for selected remedy.

Table 2.37. Performance measures for major actions in Bethel Valley, ORNL, Oak Ridge, Tennessee

Waste type	Unit	Remedial actions	Performance objective (protection goals)	Performance measure (demonstration of effectiveness)
Facilities (buildings and appurtenances)	Multiple structures	Remove facilities to grade. Remaining structures at or below grade will undergo decontamination and stabilization or removal depending on cost effectiveness and underlying soil contamination	Protect human health for industrial use; minimize further impacts to groundwater	Contamination removed to protect industrial worker to 0.6 m (2 ft) or 3 m (10 ft). Loose contamination in subsurface removed to the extent practicable
	Graphite Reactor building	Stabilize Graphite Reactor core	Protect human health for industrial use and visitors	Negative pressure in building interior no longer needed
Buried waste	SWSA 1	Install a cap	Protect human health for controlled industrial use; minimize further impacts to groundwater	Entire area of buried waste covered by cap; infiltration limited by cap
	Former Waste Pile Area	Install and/or maintain soil cover	Protect human health for controlled industrial use	All debris and contamination above remediation levels covered
	NRWTP Debris Pile	Install and/or maintain soil cover	Protect human health for controlled industrial use	All debris and contamination above remediation levels covered
	SWSA 3	Install multilayer cap and upgradient surface water and groundwater diversion trench	Protect human health through access controls; minimize further impacts to groundwater	Entire area of buried waste covered by cap designed to meet relevant RCRA landfill cover requirements; stable or decreasing surface water concentrations; stable groundwater concentrations
	Contractor's Landfill	Install and maintain soil cover	Protect human health through access controls	All contamination above remediation levels covered
Tank sludge and linings	Tank contents	Remove sludge and liquid from S-424, T-1, T-2, and HFIR	Minimize further impact to groundwater	Sludge removed to the extent practicable
	Tank shells	Fill the four tanks with grout	Minimize further impacts to groundwater	Tanks filled to the extent practicable
Inactive LLLW pipelines	Inside main plant area	Stabilize pipelines and add trench barriers	Maintain surface water recreational risk-based limits; achieve at least 45% risk reduction at 7500 Bridge; minimize further impacts to groundwater	Surface water goals met. Pipelines filled to the extent practicable
	Outside main plant area	Remove pipelines and contaminated bedding material [estimated at 1000 lin m (4000 lin ft)	Protect human health for unrestricted industrial use	Meets remediation levels to 3 m (10 ft)
Contaminated soil impacting worker protection	Main plant area	Remove contaminated surface soil [estimated at 9000 m^3 (12,000 yd^3)]. Up to 10% of area may be covered.	Protect human health for controlled industrial use	Meets remediation levels to 0.6 m (2 ft). Substitutions of covers for removal determined on a case-by-case analysis during design
	Outside main plant area	Remove contaminated soil to 3 m (10 ft) [estimated at 500 m^3 (700 yd^3)]	Protect human health for unrestricted industrial use	Meets remediation levels to 3 m (10 ft)
	Vicinity of SWSA 3 (multiple contaminated locations)	Remove soil [estimated at 17,500 m^3 (22,900 yd^3)]	Protect human health for unrestricted use	Meets remediation levels

Table 2.37. Performance measures for major actions in Bethel Valley, ORNL, Oak Ridge, Tennessee (continued)

Waste type	Unit	Remedial actions	Performance objective (protection goals)	Performance measure (demonstration of effectiveness)
Contaminated soil impacting groundwater	Bethel Valley	Remove contaminated soil [estimated at 1500 m^3 (2000 yd^3)]	Minimize further impacts to groundwater	No soil above trigger levels and not contributing above 10^{-4} industrial risk from groundwater
Sediment and floodplain soils	White Oak Creek, First Creek, and Fifth Creek	Remove contaminated sediment to depth of deposition and floodplain soils to a maximum depth of 0.6 m (2 ft) [estimated at 13,500 m^3 (17,600 yd^3)]	Achieve recreational risk-based limits in sediment, achieve at least 45% risk reduction at 7500 Bridge (primarily ^{137}Cs); protect human health for controlled industrial use; protect reach-level benthic invertebrate populations	Meets remediation levels and results in healthy benthic invertebrate populations. Meets surface water goals of at least 45% risk reduction at 7500 Bridge
Groundwater	Core Hole 8 Plume	Extract groundwater from four wells and from sumps at seven stormwater junction boxes [estimated at combined rate of 380 L/min (100 gal/min)]	Prevent groundwater from causing surface water exceedances (at least 45% risk reduction at 7500 Bridge); minimize further impacts to groundwater	Controls plume growth; collect highly contaminated groundwater to extent practicable; effluent meets surface water goals and plant NPDES permit
	^{90}Sr-contaminated sumps	Pump from 27 existing sumps [estimated at combined rate of 306 L/min (81 gal/min)]; continue to treat to remove ^{90}Sr	Prevent groundwater from causing surface water exceedances (recreational risk-based levels and at least 45% risk reduction at 7500 Bridge)	Streams meet surface water goals (recreational risk and at least 45% risk reduction at 7500 Bridge); effluent meets surface water goals and plant NPDES permit
	Mercury-contaminated sumps	Pump from four existing sumps at a combined rate of 34 L/min (9 gal/min); add treatment to remove mercury	Prevent groundwater from causing surface water exceedances (meet AWQC)	Streams meet AWQC in surface water; effluent meets surface water goals and plant NPDES permit
	VOC Plume	Implement enhanced in situ anaerobic bioremediation	Minimize further impacts to groundwater	Biodegradation occurs and reduces VOC mass and concentration
	Well P&A	Grout obsolete or poor quality monitoring wells and piezometers and abandon in place (estimated at 229 wells); in areas designated for unrestricted industrial or unrestricted use, remove to depth of 3 m (10 ft)	Protect human health for the specified industrial use; minimize further impacts to groundwater	No unacceptable risk to workers. Consistent with TDEC plugging and abandonment standards [1200-4-6-.09(6)]

AWQC = ambient water quality criteria
LLLW = liquid low-level (radioactive) waste
NPDES = National Pollutant Discharge Elimination System
NRWTP = Nonradiological Wastewater Treatment Plant
ORNL = Oak Ridge National Laboratory
P&A = plugging and abandonment
RCRA = Resource Conservation and Recovery Act of 1976
Sr = strontium
SWSA = solid waste storage area
VOC = volatile organic compound

Remediation levels for surface water

Remediation levels for surface water are established for each of the three surface water protection or remediation goals stated in the RAO (Sect. 2.8.2). These three goals and a brief explanation of their origin are given below:

1. *Achieve AWQC for designated stream uses in all waters of the state.* White Oak Creek is classified for *Fish and Aquatic Life*, *Recreation*, and *Livestock Watering and Wildlife* uses, but not for *Domestic* or *Industrial Water Supply* or *Irrigation*. All other named and unnamed surface waters in the valley are also classified for *Irrigation* by default under the Rules of the TDEC Chap. 1200-4-4. Both numeric AWQC and narrative criteria for the protection of human health and aquatic organisms will be met. Numeric AWQC exist for selected compounds under the *Recreation* and *Fish and Aquatic Life* use classifications. Consistent with EPA guidance, compliance with numeric AWQC for *Recreation* and *Fish and Aquatic Life* classifications is sufficiently stringent to ensure protection of other uses for which there are narrative, but not numeric, criteria (i.e., *Irrigation* or *Livestock Watering and Wildlife*).

2. *Maintain surface water risk below the recreational risk-based limit of 1×10^{-4}.* This goal is a more explicit statement on how the narrative criteria portion of the AWQC goal described above will be achieved for Bethel Valley. The CERCLA risk assessment process is used for quantifying remediation levels to address the narrative AWQC for recreational use.

3. *Achieve at least 45% risk reduction in surface water exiting Bethel Valley.* This goal is a direct corollary of a goal in the Melton Valley watershed ROD (DOE 2000c) to protect an off-site resident user of surface water within 10 years from completion of actions in Melton Valley and Bethel Valley. To protect the off-site resident, the Melton Valley watershed ROD established remediation levels at the confluence of White Oak Creek with the Clinch River to achieve an annual average ELCR of 1×10^{-4} and an HI of 1 for a residential exposure scenario (i.e., general household use). The Melton Valley watershed FS (DOE 1998c) estimated that the risk at White Oak Dam was 6.4×10^{-4} ELCR under a hypothetical residential scenario and 1994 baseline conditions. Of this total risk, Bethel Valley contributed approximately 20% (1.3×10^{-4} ELCR), primarily in the form of ^{90}Sr and ^{137}Cs. Assuming the Melton Valley remedy achieves at least an 82% reduction of the Melton Valley contribution to the risk at White Oak Dam, then Bethel Valley must achieve at least a 45% risk reduction in surface water exiting Bethel Valley to meet the Melton Valley watershed ROD goal of protecting the off-site resident.

Remediation levels for the three goals are summarized in Table 2.38 and explained in more detail in the following three subsections: Numeric AWQC, Narrative Criteria, and Risk Reduction for Off-Site Releases. The surface water remediation levels will be met within 10 years from completion of source actions in Bethel Valley.

Numeric AWQC. The Bethel Valley RI/FS noted numeric AWQC exceedances for cadmium, chromium, copper, iron, and mercury in White Oak Creek, First Creek, and Fifth Creek (DOE 1999a). However, AWQC will be met for all site-related contaminants in all waters of the state. The numeric AWQC for (1) *Fish and Aquatic Life* and (2) *Recreation* (organisms only) use classifications are tabulated in Rules of the TDEC Chap. 1200-4-3.03. Compliance will be based on statistically valid data assessments. The initial sampling locations proposed for determining compliance were shown previously in Fig. 2.36; these sampling locations will be finalized in a post-ROD sampling plan. The locations are generally at the downstream end of individual reaches but before any confluence with other major streams. Samples taken from such locations would essentially integrate contamination entering the reach from any sources upstream of the sampling location.

Table 2.38. Surface water remediation levels for Bethel Valley, ORNL, Oak Ridge, Tennessee

Bethel Valley	Numeric AWQC	Narrative criteria[a]	Risk reduction for off-site releases
Receptor	Hypothetical recreational user; fish and aquatic life	Hypothetical recreational user	Hypothetical off-site resident
Areas affected	All waters of the state	All waters of the state	Confluence of WOC with the Clinch River
Anticipated compliance locations	See Fig. 2.36	See Fig. 2.36 (remediation levels are applied to selected reaches[b])	7500 Bridge or equivalent integration point
Remediation level	Levels established in Rules of the TDEC Chap. 1200-4-3-.03	Annual average ELCR $< 1 \times 10^{-4}$ and HI<1	Surface water risk (based on ^{90}Sr and ^{137}Cs only) will be at least 45% less than the 1994 baseline
Exposure scenarios	NA (numeric criteria tabulated in regulation; no separate calculation using exposure scenarios needed)	Hypothetical recreational wading for waters of the state (the exposure scenario does not include fish ingestion)	Hypothetical residential (i.e., general household use) scenario at confluence of WOC with the Clinch River translated to a risk reduction of at least 45 percent in surface water exiting Bethel Valley (i.e., 7500 Bridge) from a 1994 baseline

[a] Unacceptable risks in surface water do not exist in Bethel Valley based on the RI/FS analysis. If unacceptable risks are encountered in the future, then the narrative criteria will be achieved by developing remediation levels based on a hypothetical recreational receptor.

[b] Surface water reaches: First Creek, Fifth Creek, Northwest Tributary, Raccoon Creek, WOC between 7500 Bridge and First Creek, WOC between First Creek and Fifth Creek, and WOC above Fifth Creek.

AWQC = ambient water quality criteria
ELCR = excess lifetime cancer risk
FS = feasibility study
HI = hazard index
NA = not applicable
RI = remedial investigation
TDEC = Tennessee Department of Environment and Conservation
WOC = White Oak Creek

Narrative Criteria. The CERCLA risk assessment process is used to address the narrative criteria for waters of the state. A recreational risk scenario considered representative of the surface water use classifications is used to calculate cumulative risk from measured concentrations of surface water contaminants or, conversely, to derive allowable concentrations from risk-based limits.

Based on the human health risk assessment in the Bethel Valley RI/FS (DOE 1999a), no waters of the state exceeded recreational risk-based limits. Therefore, no surface water risk-based COCs were identified for which allowable concentrations need to be derived at this time. However, if in the course of periodic surface water monitoring, consistently unacceptable recreational risks are found and new significant COCs are identified, then the risk assessment process will be used to derive allowable concentrations for the new surface water COCs.

Waters of the state must achieve an annual average ELCR less than 1×10^{-4} and an HI less than 1 for a recreational exposure scenario. This goal applies only to surface water and only to those COCs, such as radionuclides, that do not have numeric AWQC. The numeric AWQC for individual contaminants is generally equivalent to risk levels ranging up to 10^{-5}. The annual average risk goal of 1×10^{-4} meets the intent of the AWQC because, when multiple contaminants are present in the surface water, their individual risk levels would be roughly equivalent to the AWQC-equivalent risk of 10^{-5}. A lower risk goal could require individual contaminant risks to be below the AWQC-equivalent risk of 10^{-5}.

Under this ROD, the recreational scenario is defined as a wading scenario in the streams. It does not include fishing because the streams are too small to support fishable fish. The initial sampling locations

proposed for determining conformity with these levels are shown in Fig. 2.36; these sampling locations will be finalized in a post-ROD sampling plan. The locations are at the downstream end of individual reaches (i.e., First Creek, Fifth Creek, NWT, Raccoon Creek, White Oak Creek between 7500 Bridge and First Creek, White Oak Creek between First Creek and Fifth Creek, and White Oak Creek above Fifth Creek) but before any confluence with other major streams. Samples taken from such locations would essentially integrate contamination entering the reach from any sources upstream of the sampling location.

Risk Reduction for Off-Site Releases. Surface water exiting Bethel Valley must achieve at least 45% risk reduction from a 1994 baseline. This 45% risk reduction will be based on the combined risk from ^{90}Sr and ^{137}Cs, the two principal risk contributors, and is in addition to that reduction attributable to radioactive decay from 1994. The 45% reduction in total residential ELCR must be achieved within 10 years from completion of source actions selected in this ROD in Bethel Valley.

Samples to demonstrate compliance with the 45% risk reduction will be taken at the 7500 Bridge or equivalent integration point. If the continuous samplers are used at the 7500 Bridge, as expected, averages of the measured concentrations rather than the UCL_{95} will be used for the average concentration parameter in the risk calculation.

Remediation levels for soil and sediment

The soil and sediment remediation goals stated in the RAO (Sect. 2.8.2) are as follows:

1. *Protect human health for (a) controlled industrial use in ORNL's main plant area, (b) unrestricted industrial use in the remainder of the ORNL developed areas, (c) recreational use in SWSA 3 and the Contractor's Landfill area, and (d) unrestricted use in the undeveloped areas; all to a risk level of* 1×10^{-4}.

2. *Achieve the sediment recreational risk-based limit of* 1×10^{-4}.

3. *Protect reach-level populations of aquatic organisms.*

4. *Control releases from contaminated soil to minimize further impacts to groundwater.*

To accomplish these goals, both average remediation levels and maximum remediation levels for soil and sediment are established for specific exposure units. The terms "exposure unit," "average remediation level," and "maximum remediation level" are defined below:

- Exposure unit—an area over which compliance with the remediation levels would be demonstrated or verified after remediation has been completed. An exposure unit is the geographical area (e.g., surface water reach or land area) in which an anticipated receptor may move about and be exposed to a contaminated medium during the period of the exposure duration. Receptors are typically assumed to exhibit random movement such that there is an equal probability of contacting any area within the exposure unit. The size of the exposure unit is appropriate for the receptor being considered.

- Average remediation level—a risk (or equivalent) limit not to be exceeded by the residual risk calculated for the exposure unit. The risk limit would lie within EPA's acceptable risk range of 10^{-6} to 10^{-4}. The residual risk calculated for the exposure unit would be based on appropriate data and statistical principles.

- Maximum remediation level—a risk (or equivalent) limit not to be exceeded by the risk determined for any particular location or hot spot (e.g., small contaminated surface area) within the exposure unit.

Contaminated sediment or soil within an exposure unit will be remediated such that the residual risk within that exposure unit is at or below the corresponding average remediation level, and the maximum hot spot risk is at or below the corresponding maximum remediation level. The soil and sediment remediation levels will be achieved upon completion of all accessible remediation identified in this ROD. Given that the principal COCs are gamma emitters, characterization and verification protocols will maximize use of direct-reading field instruments (e.g., radiation walkover surveys, in situ gamma measurements) and limit sampling to the extent practicable.

Derivation of radionuclide concentrations to meet a specified risk limit in sediment or soil will consider both radioactive decay and ingrowth of daughter radionuclides over the exposure duration. The rate of radioactive decay is a fixed physical characteristic of each radionuclide. The simplistic assumption in risk calculations that the receptor is always exposed to a constant radionuclide concentration in the sediment or soil over the entire exposure duration would be excessively conservative and, depending on the half-life of the radionuclide, could result in a derived concentration that corresponds to a risk level far below the risk limit. Therefore, decay will be included in the risk calculations. Similarly, any ingrowth of radioactive decay products over time will be included, particularly for cases where radioactive daughter products are more radiotoxic than the parent radionuclide, to ensure that the receptor would be protected to the selected risk limit.

Remediation levels were determined for each of several Bethel Valley remediation areas: the industrial areas (both controlled industrial and unrestricted industrial), the recreational (streambed sediment) area, and the unrestricted (undeveloped) area. These remediation levels are summarized by remediation area in Table 2.39 and discussed in more detail in the subsections below. Soil trigger levels for reducing impacts to groundwater are also discussed in this section. Remediation levels were not determined for the passive recreational area encompassing SWSA 3 and the Contractor's Landfill because these waste units will be capped or covered over with clean fill material.

Controlled and Unrestricted Industrial Areas. The intent of remediation in these areas is to protect the industrial worker (exposure frequency of 2000 hours/year and exposure duration of 25 years). The remediation levels for the controlled and unrestricted industrial areas are identical except for the prescribed depth of cleanup addressed later in this section.

As shown in Fig. 2.38, the controlled industrial area is composed of four exposure units located in the main plant area: the 2000 North Area, the 2000 South Area, the 3000 North Area combined with the northwest corner of the 4000 Area, and the 3000 South Area combined with the western portion of the 4000 Area. These exposure units range in size from approximately 19 to 43 acres (or 9 to 25 acres excluding building and pavement footprints). The unrestricted industrial area is composed of five exposure units: one exposure unit encompassing the 1000 Area on the west side of the main plant, and four units encompassing the 4000 through 7000 areas in the eastern portion of the plant. These exposure units range in size from approximately 32 to 50 acres (or 13 to 22 acres excluding building and pavement footprints).

The residual cumulative (aggregate) risk within an exposure unit in the industrial area will not exceed the average remediation level of 1×10^{-4} ELCR and an HI of 1. The risk will generally be based on direct contact routes of exposure: incidental ingestion, inhalation of particulates (and/or vapors), dermal contact, and external exposure. The exposure unit risk limit of 1×10^{-4} ELCR was established at a level incrementally higher than the estimated background risk of approximately 1×10^{-5} ELCR, the lowest risk level technically feasible. The maximum remediation level for any individual location within the exposure unit is based on an exposure of 200 hours/year, one-tenth the exposure frequency of the average remediation level.

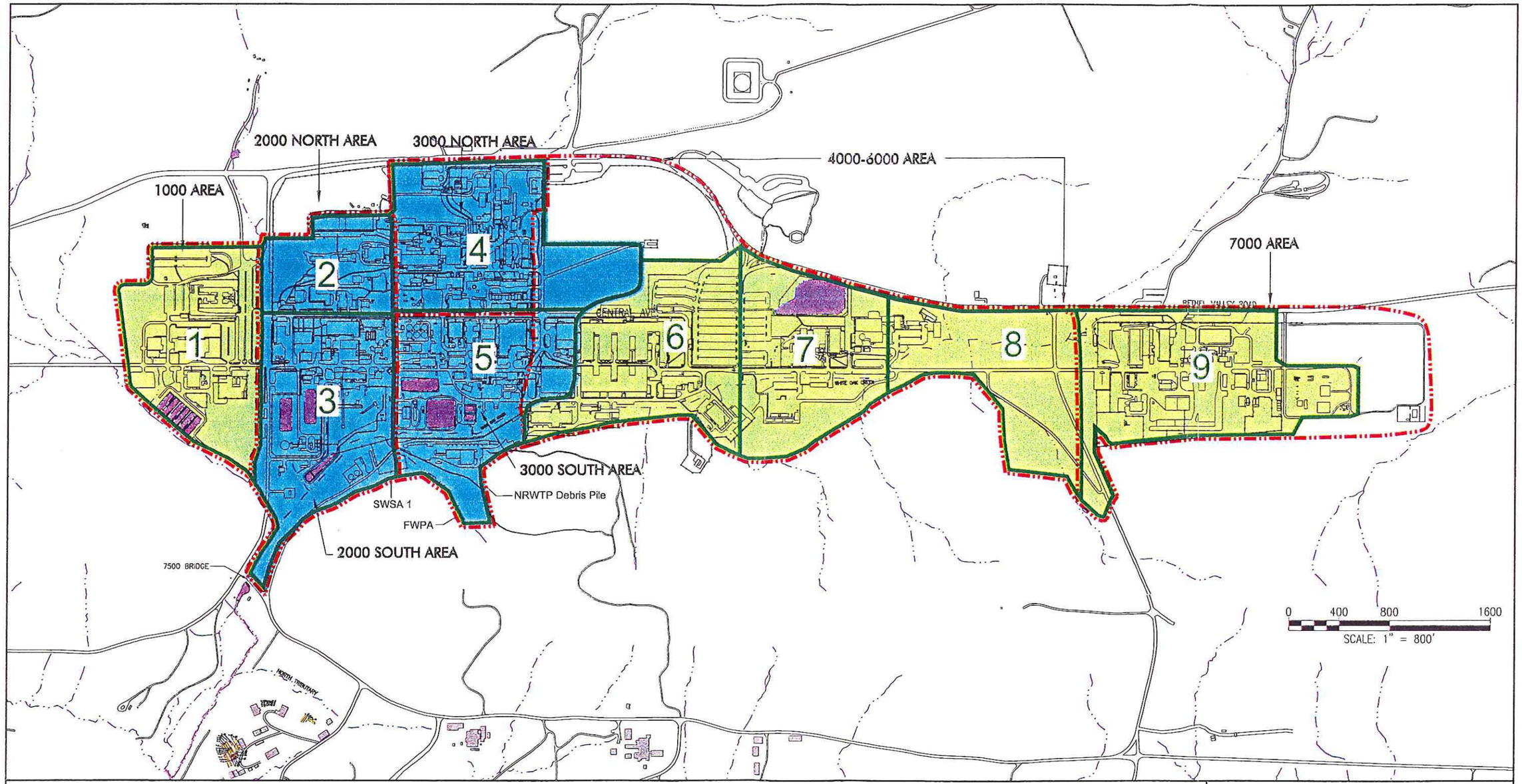
Table 2.39. Soil and sediment remediation levels for Bethel Valley, ORNL, Oak Ridge, Tennessee

Bethel Valley area	Controlled and unrestricted industrial areas (ORNL main plant area)	Recreational area (streambed sediments)	Unrestricted area (undeveloped areas)
Number of exposure units	Controlled industrial: 4 units; unrestricted industrial: 5 units (see Fig. 2.38)	7 units[a]	NA. One-acre exposure units used where contamination above remediation levels is discovered
Receptors	Industrial worker	Hypothetical recreational receptor; aquatic life	Hypothetical residential receptor
Exposure frequency	2000 hours/year	75 hours/year for recreational receptor	8760 hours/year
Target contaminants	All significant COCs (predominantly ^{137}Cs and ^{60}Co)	Human health COCs: all significant COCs (predominantly ^{137}Cs) Ecological COCs: Hg, Ag, Zn, Cd, PCBs, PAHs	All significant COCs (predominantly ^{137}Cs and ^{60}Co)
Average remediation level not to be exceeded for the exposure unit	ELCR = 1×10^{-4}, HI = 1	For multiple human health COCs: ELCR = 1×10^{-4}, HI = 1; for the principle COC (^{137}Cs): ELCR = 1×10^{-5}. For COECs: selected ecological benchmarks	ELCR = 1×10^{-4}, HI = 1
Concentrations corresponding to average remediation level	See Table 2.40 for concentrations	Human health COCs: see Table 2.41 for concentrations Ecological COCs[b]: Hg at 0.7 mg/kg (PEL) Ag at 1.8 mg/kg (PEL) Zn at 270 mg/kg (PEL) Cd at 4.2 mg/kg (PEL) PCBs at 0.18 mg/kg (PEL) PAHs at 4 mg/kg (ER-L)	See Table 2.42 for concentrations
Maximum remediation level not to be exceeded at individual locations	Ten times the average remediation concentration (assumes an acute exposure to a receptor of 200 hours/year)	Ten times the average remediation concentration (assumes an acute exposure to a receptor of 7.5 hours/year)	Ten times the average remediation concentration (assumes an acute exposure to a receptor of 876 hours/year)
Maximum depth of remediation	Controlled industrial: 0.6 m (2 ft) Unrestricted industrial: 3 m (10 ft)	Depth of deposited sediments	Bedrock or the groundwater table, whichever is reached first

[a] Exposure units for streambed sediments are defined in terms of the following stream reaches: First Creek, Fifth Creek, Northwest Tributary, Raccoon Creek, WOC between 7500 Bridge and First Creek, WOC between First Creek and Fifth Creek, and WOC above Fifth Creek.

[b] The ecological COCs and the relevance of their ecological benchmarks to cleanup will be substantiated by biomonitoring.

COC = contaminant of concern
COEC = contaminant of ecological concern
EDE = effective dose equivalent
ELCR = excess lifetime cancer risk
ER-L = effect range - low
HI = hazard index
NA = not applicable
ORNL = Oak Ridge National Laboratory
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
PEL = probable effects level



LEGEND:

- CREEKS AND TRIBUTARIES
- ROADS
- BUILDINGS
- IMPOUNDMENTS
- SUBAREA BOUNDARY
- EXPOSURE UNITS
- CONTROLLED INDUSTRIAL
- UNRESTRICTED INDUSTRIAL

EU	1	2	3	4	5	6	7	8	9
Total Area (acres)	36	19	42	43	39	39	36	32	50
Open Area (acres)	20	9	25	21	15	13	22	22	21
Building & Pavement (acres)	16	10	17	22	24	26	14	10	29

34°12'51"
ORNL NORTH
TRUE NORTH

Fig. 2.38

EXPOSURE UNITS FOR CONTROLLED INDUSTRIAL AND UNRESTRICTED INDUSTRIAL AREAS

DOE - Bethel Valley - Oak Ridge, Tennessee

SAIC CAD FILE: 99060/DWGS/ H28-PARCEL

REV. DATA: REV. 1 - 10/13/2000 PAH

Fig. 2.38. Exposure units for controlled and unrestricted industrial areas.

Soil remediation concentrations that correspond to the average remediation level for the industrial areas in Bethel Valley are shown in Table 2.40 for individual COCs. For example, soil remediation levels for ^{137}Cs and ^{60}Co are 14 pCi/g and 7.1 pCi/g, respectively. (These soil concentrations can be correlated with an area-averaged external exposure rate measurement of approximately 5 to 13 μR/hour, depending on the relative concentration of ^{137}Cs and ^{60}Co.) These values apply to single contaminants only. To account for the total risk or dose from multiple contaminants, sum-of-ratios calculations may be applied to all significant site-related contaminants that are present above background. Actual remediation concentrations will, therefore, likely be lower than the concentrations listed in the table.

In Table 2.40, the radium and thorium isotopes are exceptions to the general risk- or dose-based approach because they have alternate concentration-based remediation levels of 3 pCi/g each. In practice, the 3 pCi/g concentration limit would apply to the average concentration of ^{226}Ra or ^{230}Th (whichever is greater) and also to the average concentration of ^{232}Th, ^{228}Ra, or ^{228}Th (whichever is greater), averaged over the exposure unit. These alternative concentration limits, which are set as low as reasonably achievable, are used because setting a risk-based cleanup that attains a 1×10^{-4} risk-based goal is not attainable due to the risk associated with natural background concentrations, which alone exceed the desired risk goal of 1×10^{-4} ELCR. For example, the residual risk associated with remediation of soils to 3 pCi/g is estimated at approximately 5×10^{-4} for ^{226}Ra and 2×10^{-4} for ^{232}Th. Because site-specific background concentrations of these radionuclides are outside the target risk range, residual concentrations of these radionuclides and their decay series will not be considered in the estimates of residual risk following completion of these actions.

The goal for the controlled industrial area is to have soils clean to a depth of 0.6 m (2 ft). The goal for the unrestricted industrial area is to have vadose-zone soils clean to 3 m (10 ft) depth. Areas suspected of being uncontaminated (based on available data or process knowledge) will at a minimum be verified as such through use of walkover surveys. These areas may be assumed to be clean if no surface debris or contamination above the remediation levels is found from the walkover surveys. The need for any further verification (e.g., sampling and analysis) will be established during design and evaluated through review of the walkover surveys augmented by available information. The three FFA parties must concur on the designation of areas as being "clean" within the context of meeting industrial remediation levels.

The average remediation level will be assessed against the residual exposure unit risk (or equivalent) for both (1) the uppermost 15-cm (6-in.) layer of soil and (2) all soil to the prescribed cleanup depth [0 to 0.6 m (0 to 2 ft) for controlled industrial and 0 to 3 m (0 to 10 ft) for unrestricted industrial]. The maximum remediation level will be assessed against the residual risk (or equivalent) for (1) contaminated surface soils having an area greater than 1 m^2 (11 ft^2) and a depth of 0 to 15 cm (0 to 6 in.), (2) subsurface soil over the depth interval of 15 cm to 0.6 m (6 in. to 2 ft) (controlled and unrestricted industrial), and (3) subsurface soil over the depth interval of 0.6 to 3 m (2 to 10 ft) (unrestricted industrial only). To facilitate these assessments, soil sampling to verify cleanup will be based on composites over the following depth intervals: 0 to 15 cm (0 to 6 in.), 15 cm to 0.6 m (6 in. to 2 ft), and 0.6 to 3 m (2 to 10 ft). The basis for selecting the latter two intervals are hypothetical construction scenarios where 0.6-m (2-ft) or 3-m (10-ft) excavations are performed and the excavated material is spread over the ground surface.

The number and grid spacing of samples to verify that the average remediation level has been met in disturbed areas will be determined using the approach by Gilbert (1987), with $\beta = 0.1$ and $L = 30$ m (100 ft), or other appropriate statistical method approved by the three FFA parties. Sample results used for verification of the average remediation level will also be assessed against the maximum remediation level. However, verification of the maximum remediation level will be based primarily on risk-to-exposure correlations with the walkover or other radiological surveys, to the extent practicable. Detection of contaminated soils that exceed the remediation levels at the verification stage will trigger additional cleanup and verification.

Table 2.40. Soil remediation concentrations that correspond to the average remediation level for the industrial areas in Bethel Valley, ORNL, Oak Ridge, Tennessee

Principal soil COCs [a]	Units	Reference concentration[b]	Minimum detection limit[c]	Risk-based remediation concentration[d] (1×10^{-4} ELCR)
Arsenic	mg/kg	7.3	0.5	330
Benz(a)anthracene	mg/kg	ND	0.66	260
Benzo(a)pyrene	mg/kg	ND	0.66	26
Benzo(b)fluoranthene	mg/kg	ND	0.66	250
Dibenz(a,h)anthracene	mg/kg	ND	0.66	26
Americium-241	pCi/g	ND	1.0	450[e]
Cesium-137+D	pCi/g	0.9	1.0	14
Cobalt-60	pCi/g	ND	1.0	7.4
Europium-152	pCi/g	ND	5.0	9.5
Europium-154	pCi/g	ND	1.0	11
Europium-155	pCi/g	ND	5.0	710[e]
Iodine-129	pCi/g	ND	5.0	1400
Lead-210+D	pCi/g	ND	1.0	270[e]
Plutonium-240	pCi/g	ND	1.0	540[e]
Radium-226+D	pCi/g	0.86	0.5	3[f]
Radium-228+D	pCi/g	ND	0.5	3[f]
Thorium-228+D	pCi/g	0.94	1.0	3[f]
Thorium-232	pCi/g	0.97	1.0	3[f]
Uranium-238+D	pCi/g	1.7	1.0	310

Note: These values apply to single contaminants only. To account for the total risk or dose from multiple contaminants, sum-of-ratios calculations may be applied to all significant site-related contaminants that are present above background. Actual remediation concentrations will therefore likely be lower than the concentrations listed in the table. Concentrations for other contaminants not listed in the table will be determined as necessary and in a manner similar to that followed above. Exceptions are contaminants such as radium and thorium that have alternate remediation concentrations; these are not included in the sum-of-ratios calculations.

[a] COCs identified in the RI but not listed here include beryllium, beryllium-7, cerium-144, cesium-134, cobalt-57, cobalt-58, nickel-63, potassium-40, promethium-147, ruthenium-106, sodium-22, yttrium-91, and zirconium-95. (These analytes also were not included in the background risk estimate of 1.5×10^{-5} ELCR.) Beryllium was excluded from the table because EPA has re-evaluated its carcinogenicity and eliminated its slope factor for ingestion. Potassium-40 was excluded because it is considered to be naturally occurring (the maximum value detected was within the concentration range for the country). Nickel-63 was excluded because it is an innocuous material (weak beta emitter) that has a very high remediation concentration and is unlikely to pose any health risk. The other radionuclides were excluded because they have half-lives of 2.6 years or less.

[b] The reference concentration is the 95th tolerance limit of the background or the maximum background value, whichever is less.

[c] The laboratory standard minimum detection limits are based on existing regulatory methodology and current laboratory instrument capabilities. The detection limits can be lowered by concentrating the sample, increasing the count times, or modifying/changing the analytical method.

[d] The risk-based remediation levels for the nonradionuclides are calculated at 1×10^{-4} ELCR using standard risk assessment protocols for an industrial scenario: a 70-kg adult receptor, an exposure frequency of 250 days/year, an exposure duration of 25 years, an ingestion rate of 0.00005 kg/day, an inhalation rate of 20 m^3/day, and a skin surface area of 0.316 m^2. The risk-based remediation levels for the radionuclides are calculated at 1×10^{-4} ELCR using the RESRAD computer code. RESRAD used input parameters constrained to mimic the standard risk assessment algorithms and parameters with the addition of radioactive decay and ingrowth.

[e] The remediation concentrations for americium-241, europium-155, lead-210+D, and plutonium-240 are calculated using the RESRAD computer code to attain 25 mrem/year under an industrial land scenario. The 25 mrem/year dose-based standard required by DOE Orders results in a lower remediation concentration (i.e., a higher degree of cleanup) for these four radionuclides than the risk-based standard of 1×10^{-4}.

[f] The alternate concentration limit of 3 pCi/g for the radium and thorium isotopes is applied over the exposure unit and to the established depth of remediation. The radium and thorium isotopes are not included with the other COCs in the aggregate risk calculation for the exposure unit to meet the desired risk goal of 1×10^{-4} ELCR.

Table 2.40. Soil remediation concentrations that correspond to the average remediation level for the industrial areas in Bethel Valley, ORNL, Oak Ridge, Tennessee (continued)

COC = contaminant of concern
D = radioactive decay daughter
DOE = U.S. Department of Energy
ELCR = excess lifetime cancer risk
EPA = U.S. Environmental Protection Agency
ND = not detected or analyzed
ORNL = Oak Ridge National Laboratory
RI = remedial investigation
RESRAD = the name of the computer program used to perform analysis of dose and risk received from exposure to ionizing radiation emitted by environmental media (i.e., residual radiation).

Recreational Area (Streambed Sediment Area). The intent of remediation in the streambed sediment area is to protect the hypothetical recreational user (exposure frequency of 75 hours/year and exposure duration of 30 years), protect aquatic life, and generally improve surface water quality. Access to most of the streambed sediments will continue to be restricted, and exposures for workers will continue to be controlled through a radiological exposure protection program.

Seven exposure units have been defined for the recreational area. These exposure units equate to the following stream reaches: Raccoon Creek, NWT, First Creek, Fifth Creek, White Oak Creek between 7500 Bridge and First Creek, White Oak Creek between First Creek and Fifth Creek, and White Oak Creek above Fifth Creek.

For sediment, two average remediation levels for human health are established: one for the principal COC and one for all the significant COCs combined. The primary sediment COC identified in the RI/FS for the recreational user is ^{137}Cs (DOE 1999a). At the completion of all accessible remediation identified in this ROD, the residual cumulative (aggregate) risk for ^{137}Cs within each exposure unit will not exceed 1×10^{-5} ELCR. The remediation level for ^{137}Cs was set at 1×10^{-5} recreational risk so as to reduce the potential for recontamination of the adjacent floodplain soil above its remediation level of 1×10^{-4} industrial risk, which is comparable to the 1×10^{-5} recreational risk. The residual cumulative risk for multiple COCs present within each exposure unit will not exceed the average remediation level of 1×10^{-4} ELCR and an HI of 1. Sediment remediation concentrations that correspond to the average remediation levels for the recreational (streambed) areas in Bethel Valley are shown in Table 2.41 for individual human health COCs. The ecological COCs and their potential average levels, subject to further biomonitoring, are listed in Table 2.39.

The maximum remediation level for any individual sediment location or hot spot within a reach is set at 10 times the average remediation concentration (assuming an exposure frequency of 7.5 hours/year). Sediment will be removed to the depth of deposition.

Areas suspected of being uncontaminated (based on available data or process knowledge) will at a minimum be verified as such through use of walkover surveys. These areas will be assumed to be clean if no surface debris or contamination above the remediation levels is found from the walkover surveys. The need for further verification (e.g., sampling and analysis) will be established during design and evaluated through review of the walkover surveys.

Unrestricted Area. The remediation area designated as unrestricted includes those areas outside of the ORNL main plant area, SWSA 3, and the Contractor's Landfill. There are several known contaminated areas next to or associated with SWSA 3 that are in the unrestricted area. These will be removed under the

Table 2.41. Sediment remediation concentrations that correspond to the average remediation level for the recreational areas in Bethel Valley, ORNL, Oak Ridge, Tennessee

Principal sediment COCs [a]	Units	Reference concentration[b]	Minimum detection limit[c]	Risk-based remediation concentration[d] (1×10^{-4} ELCR or HI=1)
Aroclor-1254	mg/kg	ND	2.0	110
Aroclor-1260	mg/kg	ND	2.0	110
Benzo(a)pyrene	mg/kg	ND	0.66	62
Hexachlorodibenzofuran	mg/kg	ND	0.001	4.8
Cesium-137+D	pCi/g	0.9	1.0	32[e]
Cobalt-60	pCi/g	ND	1.0	200
Europium-152	pCi/g	ND	5.0	230
Europium-154	pCi/g	ND	1.0	270

Note: These values apply to single contaminants only. To account for the total risk or dose from multiple contaminants, sum-of-ratios calculations may be applied to all significant site-related contaminants that are present above background. Actual remediation concentrations will therefore likely be lower than the concentrations listed in the table. Concentrations for other contaminants not listed in the table will be determined as necessary and in a manner similar to that followed above. The 25 mrem/year dose-based standard required by DOE Orders may result in a lower remediation concentration (i.e., a higher degree of cleanup) for some radionuclides than the risk-based standard of 1×10^{-4}.

[a] Na-22 was identified as a COC in the RI but is not listed here because of its short half-life of 2.6 years.

[b] The reference concentration is the 95th tolerance limit of the background or the maximum background value, whichever is less.

[c] The laboratory standard minimum detection limits are based on existing regulatory methodology and current laboratory instrument capabilities. The detection limits can be lowered by concentrating the sample, increasing the count times, or modifying/changing the analytical method.

[d] The risk-based remediation levels for the nonradionuclides are calculated at 1×10^{-4} ELCR or HQ=1 using standard risk assessment protocols for an industrial scenario: a 70-kg adult receptor, an exposure frequency of 75 days/year, an exposure duration of 30 years, an ingestion rate of 0.0001 kg/day, an inhalation rate of 20 m^3/day, and a skin surface area of 0.316 m^2. The risk-based remediation levels for the radionuclides are calculated at 1×10^{-4} ELCR using the RESRAD computer code. RESRAD used input parameters constrained to mimic the standard risk assessment algorithms and parameters with the addition of radioactive decay and ingrowth.

[e] An alternate remediation level for the primary COC in sediment, cesium-137, is set at 1×10^{-5} ELCR.

ARAR = applicable or relevant and appropriate requirement
COC = contaminant of concern
ELCR = excess lifetime cancer risk
D = radioactive decay daughter
ND = not detected or analyzed
RI = remedial investigation
RESRAD = the name of the computer program used to perform analysis of dose and risk received from exposure to ionizing radiation emitted by environmental media (i.e., residual radiation)

remedy, but, in general, the unrestricted area consists of undeveloped areas that have not yet been fully characterized. These areas are assumed to be generally uncontaminated because of their lack of use for known historical ORNL activities. If contamination is present, it would likely be in isolated areas (e.g., small dump sites rather than widespread or diffuse sources) at relatively low contamination levels. However, the lack or presence of contamination in the unrestricted area will be verified in post-ROD activities. Where contamination is found, the intent of remediation in this area will be to protect the residential user.

The goal for the unrestricted area is to have soil clean to bedrock or the groundwater table, whichever is nearer the surface. Walkover surveys will be performed in the unrestricted area. These areas may be assumed to be clean if no surface debris or contamination above residential levels is found from the walkover surveys, and if available information (e.g., federal government records, historical documents, interviews with site personnel, historical aerial photographs, existing remote sensing data) do not indicate anomalies. The need for any further verification (e.g., sampling and analysis) will be established during design and evaluated through a review of the walkover surveys augmented by available information. The

three FFA parties must concur on the designation of areas as being "clean" within the context of meeting unrestricted levels.

Where a contaminated area requiring cleanup exists or is found, an exposure unit will be situated to encompass the contaminated area. Exposure units will be sized as needed on a case-by-case basis but will not exceed 1 acre in size.

At the completion of all accessible remediation identified in this ROD, the residual aggregate risk within an exposure unit in the unrestricted area will not exceed the average remediation level of 1×10^{-4} ELCR and an HI of 1, based on a residential scenario for direct contact exposures only. The maximum remediation level for any individual location within the exposure unit is based on an exposure frequency of 876 hours/year, one-tenth the exposure frequency of the average remediation level.

Soil remediation concentrations that correspond to the average remediation level for the unrestricted area in Bethel Valley are shown in Table 2.42 for individual COCs. These values apply to single contaminants only. To account for the total risk or dose from multiple contaminants, sum-of-ratios calculations may be applied to all significant site-related contaminants that are present above background. In Table 2.42, the radium and thorium isotopes are exceptions to the general risk- or dose-based approach in that they have alternate concentration-based remediation levels of 3 pCi/g. These alternate concentration limits are set as low as reasonably achievable due to the risk associated with natural background concentrations of radium and thorium.

The average and maximum remediation levels will be assessed against the residual exposure unit risk (or equivalent) for both (1) the uppermost 6-in. layer of soil and (2) all soil to the cleanup depth. The number and grid spacing of samples to verify that the average remediation level has been met in disturbed areas will be determined using the approach by Gilbert (1987), with $\beta = 0.1$ and $L = 15$ m (50 ft), or other appropriate statistical method approved by the FFA parties. Sample results used for verification of the average remediation level will also be assessed against the maximum remediation level. However, verification of the maximum remediation level will be based primarily on risk-to-exposure correlations with the walkover or other radiological surveys, to the extent practicable. Detection of contaminated soils that exceed the remediation levels at the verification stage will trigger additional cleanup and verification.

Soil remediation levels to reduce groundwater impact

Soils that contain sufficiently high levels of soluble contaminants can be sources of contamination to groundwater. One of the remediation goals for soil in Bethel Valley is to minimize further contamination of groundwater by removing accessible soils that contribute significantly to groundwater contamination at an ELCR $> 1 \times 10^{-4}$ or HI > 1 for industrial use of the groundwater. Industrial use of groundwater is assumed only for the purpose of back-calculating soil remediation levels and does not imply an anticipated future use or final groundwater goal for this ROD. The groundwater will not have an anticipated future use until DOE goes through the state's procedure for classifying groundwater on the ORR and/or until the final groundwater decision is made for Bethel Valley. Furthermore, because a final groundwater decision is not being made at this time, these soil remediation levels will need to be revisited at the time a future decision is made to ensure consistency with that decision. The intent of this section is to guide remediation of the worst soil contributors to groundwater contamination and not to achieve a specific groundwater cleanup level.

Table 2.42. Soil remediation concentrations that correspond to the average remediation level for the unrestricted areas in Bethel Valley, ORNL, Oak Ridge, Tennessee

Principal soil COCs [a]	Units	Reference concentration[b]	Minimum detection limit[c]	Risk-based remediation concentration[d] (1×10^{-4} ELCR)
Benz(a)anthracene	mg/kg	ND	0.66	86
Benzo(a)pyrene	mg/kg	ND	0.66	8.6
Benzo(b)fluoranthene	mg/kg	ND	0.66	86
Dibenz(a,h)anthracene	mg/kg	ND	0.66	8.6
N-nitroso-di-n-propylamine	mg/kg	ND	0.66	7.8
Cesium-137+D	pCi/g	0.9	1.0	7
Cobalt-60	pCi/g	ND	1.0	4
Europium-152	pCi/g	ND	5.0	5
Europium-154	pCi/g	ND	1.0	6
Radium-226+D	pCi/g	0.86	0.5	3[e]
Thorium-232+D	pCi/g	0.97	1.0	3[e]
Uranium-235+D	pCi/g	0.12	1.0	37
Uranium-238+D	pCi/g	1.7	1.0	91

Note: These values apply to single contaminants only. To account for the total risk or dose from multiple contaminants, sum-of-ratios calculations may be applied to all significant site-related contaminants that are present above background. Actual remediation concentrations will therefore likely be lower than the concentrations listed in the table. Concentrations for other contaminants not listed in the table will be determined as necessary and in a manner similar to that followed above. Exceptions are contaminants such as radium and thorium that have alternate remediation concentrations; these are not included in the sum-of-ratios calculations. Also, the 25 mrem/year dose-based standard required by DOE Orders may result in a lower remediation concentration (i.e., a higher degree of cleanup) for some radionuclides than the risk-based standard of 1×10^{-4}.

[a] COCs identified in the RI (for West Bethel Valley) but not listed here include beryllium, cesium-134, and potassium-40. Beryllium was excluded from the table because EPA has re-evaluated its carcinogenicity and eliminated its slope factor for ingestion. Potassium-40 was excluded because it is considered to be naturally occurring (the maximum value detected was within the concentration range for the country). The other radionuclides were excluded because they have half-lives of 2.6 years or less.

[b] The reference concentration is the 95th tolerance limit of the background or the maximum background value, whichever is less.

[c] The laboratory standard minimum detection limits are based on existing regulatory methodology and current laboratory instrument capabilities. The detection limits can be lowered by concentrating the sample, increasing the count times, or modifying/changing the analytical method.

[d] The risk-based remediation levels for the nonradionuclides are calculated at 1×10^{-4} ELCR using standard risk assessment protocols for a residential scenario: a 70-kg adult receptor, an exposure frequency of 350 days/year, an exposure duration of 30 years, an age-averaged ingestion rate of 0.000114 kg/day, an inhalation rate of 20 m^3/day, and a skin surface area of 0.316 m^2. The risk-based remediation levels for the radionuclides are calculated at 1×10^{-4} ELCR using the RESRAD computer code. RESRAD used input parameters constrained to mimic the standard risk assessment algorithms and parameters with the addition of radioactive decay and ingrowth and consideration of indoor and outdoor occupancy.

[e] The alternate concentration limit of 3 pCi/g for the radium and thorium isotopes is applied over the exposure unit and to the established depth of remediation. The radium and thorium isotopes are not included with the other COCs in the aggregate risk calculation for the exposure unit to meet the desired risk goal of 1×10^{-4} ELCR.

ARAR = applicable or relevant and appropriate requirement
COC = contaminant of concern
DOE = U.S. Department of Energy
ELCR = excess lifetime cancer risk
EPA = U.S. Environmental Protection Agency
ND = not detected or analyzed
RI = remedial investigation
RESRAD = the name of the computer program used to perform analysis of dose and risk received from exposure to ionizing radiation emitted by environmental media (i.e., residual radiation)

Some of the major variables that determine whether specific contaminant concentrations in soil will cause risk or hazard above the threshold values include contaminant solubility, adsorption coefficient, contaminant concentration versus soil volume, volume of water that seeps through the soil, and distance of the well intake from the contaminated soil mass.

A process, described in Appendix C, has been developed to determine whether contaminated soil has the potential to contaminate groundwater above the decision thresholds stated above and, if so, what the soil remediation (trigger) levels should be. The process includes simple contaminant transport model estimates of contaminant concentrations in a hypothetical on-site groundwater well that could result from leaching of contaminated soil.

The process will be utilized to determine soil remediation levels on a case-by-case basis for known subsurface contaminated soil masses (i.e., the LLLW Lines and Leak Sites in Table A.1) and for previously unidentified subsurface contaminated soils that are encountered during site remediation. Also, soil remediation levels are established only for 12 target soil contaminants that have been identified as primary groundwater COCs and have been detected at multiple groundwater locations. Primary groundwater COCs are those COCs that individually contribute risk > 1×10^{-4} or HI > 1 under the industrial scenario. (These COCs are a subset of the contaminants evaluated in Appendix C.) The target soil contaminants are arsenic, ^{14}C, ^{137}Cs, ^{244}Cu, ^{228}Ra, ^{90}Sr, ^{3}H, ^{234}U, ^{238}U, 1,2-dichloroethene, trichloroethene, and vinyl chloride.

Structure surfaces

Some building slabs may remain in place after completion of building D&D. These surfaces will be decontaminated to meet industrial surface criteria derived to achieve the same average risk level (ELCR of 1×10^{-4}) and maximum risk level (ten times the average) specified for the industrial area soils (see Table 2.39). The industrial surface criteria will be applied to the entire exposed surface of the slab.

Subsurface structures will meet the same industrial surface criteria to the required remediation depth [e.g., 0.6 m or 3 m (2 ft or 10 ft)] for the anticipated land use in which they are located.

Surface criteria for residual building surfaces (building slabs and below-grade structures) in Bethel Valley have been derived based on American National Standard ANSI/Health Physics Society HPS N13.12-1999 (HPS 1999). This standard specifies screening levels for clearance of surfaces containing residual radioactive materials, based on a dose limit of 1 mrem/year, for several groups of radionuclides. Clearance is defined as "the removal of items or materials that contain residual levels of radioactive materials within authorized practices from any further control of any kind." The primary radionuclides of concern for remaining building surfaces in Bethel Valley are classified in Group 2 of Standard N13.12-1999, "Uranium and Selected High Dose Beta-Gamma Emitters." The surface activity screening level for Group 2 radionuclides is specified at 6000 disintegrations per minute per 100 cm^2 (6000 dpm/100 cm^2). This screening level has been used to derive a risk-based surface concentration limit as follows

$$
\begin{aligned}
RL_{surf} &= TR / [\, DL/SL \times R \times ED \,] \\
&= 1\times10^{-4}\ \text{ELCR} / [(1\ \text{mrem/yr})/(6000\ \text{dpm}/100\ \text{cm}^2) \times 6\times10^{-7}\ \text{ELCR/mrem} \times 25\ \text{years}] \\
&= 40{,}000\ \text{dpm}/100\ \text{cm}^2\,,
\end{aligned}
$$

where

RL_{surf} = remediation levels for residual building surfaces,
TR = target risk level = 1×10^{-4} ELCR,
DL = dose limit used to derive surface screening level = 1 mrem/year (HPS 1999),
SL = surface activity screening level for Group 2 radionuclides
= 6000 dpm/100 cm^2 (HPS 1999),
R = cancer risk per unit dose for surface-deposited radioactivity (conservatively based on radionuclide-specific slope factor and external dose coefficient for ^{137}Cs+D)
= 6×10^{-7} ELCR/mrem
ED = exposure duration = 25 years for industrial scenario (EPA 1991).

The derived RL_{surf} value is based on the assumption that a worker could potentially be located directly above the building surfaces for 2000 hours per year. Since it is unlikely that any worker would actually occupy this location for such an extended period of time, this estimate is considered conservative and any actual risk may be well below the target level of 1×10^{-4} ELCR. Additional conservative assumptions are the absence of any consideration of (1) the decreasing concentrations of radionuclides on the building surfaces due to radioactive decay, and (2) shielding effects from backfill of basements and other subsurface structures.

2.13 STATUTORY DETERMINATIONS

Under CERCLA, Sect. 121, selected remedies must protect human health and the environment, comply with ARARs (unless a statutory waiver is justified and granted), be cost effective, and use permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practical. In addition, CERCLA includes a preference for remedies that, as their principal element, use treatment that significantly and permanently reduces the volume, toxicity, or mobility of hazardous wastes. The following sections discuss how the selected remedy meets those statutory requirements.

2.13.1 Overall Protection of Human Health and the Environment

The selected remedy will protect human health under expected land use scenarios through a combination of waste removal, treatment, containment, and LUC activities. Exposure levels will be reduced to protective ARAR levels or to within EPA's generally acceptable risk ranges for risks from carcinogens and noncarcinogens. Because significant inventories of contaminated materials would remain in Bethel Valley, this approach requires LUCs to ensure protection of current and potential receptors. Until final decisions are made concerning remediation of the remaining contamination in Bethel Valley, LUCs will be used to preclude access that may result in unacceptable exposures.

The selected remedy will reduce contaminant contributions to groundwater in Bethel Valley. Both the removal of sources of groundwater contamination, such as contaminated soil, and the control of groundwater migration through sump collection and pipeline grouting will control the size and concentration of groundwater plumes in Central Bethel Valley. In situ biodegradation activities in East Bethel Valley and groundwater extraction in Central Bethel Valley will reduce the mass of the plume, thereby containing its future growth. The cap and upgradient diversion trench at SWSA 3 will control future contributions to groundwater contamination in West Bethel Valley.

Reduced contributions to groundwater, plus collection and treatment of shallow groundwater in Central Bethel Valley, will reduce the Bethel Valley contributions to surface water contamination migrating off-site. With effective implementation of the selected remedy, risk at the 7500 Bridge will be reduced by at least 45%. That risk reduction, combined with actions selected for Melton Valley, will allow residential risk levels to be met at the confluence of White Oak Creek and the Clinch River.

The selected remedy provides overall protection of reach-level populations of aquatic species, valleywide populations of wide-ranging ecological species, and areawide populations of terrestrial populations in West Bethel Valley, the only area with sufficient habitat. Groundwater treatment actions for mercury and removal of contaminated sediments in the streams will allow AWQC to be met and will protect the aquatic species in those streams. Soil removal actions in West Bethel Valley will remove a threat to individuals of terrestrial species (populations are already protected). These actions, especially the sediment removal actions, will have some short-term effects on the ecological populations, but it is planned to restore these habitats quickly.

2.13.2 Compliance with ARARs

The selected remedy meets all ARARs for the scope of remedial actions encompassed in this ROD, as listed and described in Appendix B. No waiver of an ARAR under CERCLA 121(d)(4) will be required.

Groundwater actions would minimize further impacts to groundwater. Contaminant plumes are not expected to appreciably migrate beyond current boundaries. Final groundwater decisions for Bethel Valley are being deferred to a later decision document.

2.13.3 Cost Effectiveness

The selected remedy is cost effective because it meets the following definition: "A remedy shall be cost-effective if its costs are proportional to its overall effectiveness" [40 *CFR* 300.430(f)(1)(ii)(D)]. In evaluating the remedial alternatives from the FS (DOE 1999a), DOE followed additional guidance found in the preamble to the NCP, which states that decision makers should compare "the cost of effectiveness of each alternative individually and the cost and effectiveness of alternatives in relation to one another" (55 *FR* 8728). The more aggressive alternatives evaluated in the FS cost substantially more than the selected remedy, yet provide little additional risk reduction.

Specific differences between alternatives include the extent of groundwater collection and treatment, excavation, or containment of SWSA 3. The extent of groundwater collection is the basis of distinction between several alternatives. For East Bethel Valley, in situ biodegradation is the selected remedy as compared to monitoring or extraction and ex situ treatment. In situ treatment was selected over monitoring because of the potential that the plume could be migrating. There is insufficient information about the plume to understand its growth potential fully. It is prudent to reduce the mass in the plume, in the event the plume is growing, while gathering information to support the final decision. In situ treatment was selected over ex situ treatment for two reasons. First, the annual O&M costs are roughly $150,000 a year less for in situ treatment. Second, the process of implementing an in situ treatment system will allow additional information to be collected about biodegradation conditions in this plume. The mass reduction amount to be realized by either in situ treatment or ex situ treatment is unknown. However, the investment in capital and O&M costs is much less in the period of time required to collect the information needed to make a final decision. If the final decision is made in roughly 10 years, ex situ treatment would cost roughly $1.5 million more than in situ treatment in today's dollars. Both systems have the same level of effectiveness, although there is more uncertainty regarding the reliability of the in situ system.

For Central Bethel Valley, groundwater collection was determined to be necessary because contaminants are currently migrating from the groundwater to the surface water and leaving Bethel Valley at levels causing a risk at White Oak Dam. In addition to the shallow groundwater collection system, FS Alternatives C-2 and C-3 and the selected remedy include the installation of four deep groundwater extraction wells for an incremental capital cost of approximately $300,000. The benefits provided by the deep well extraction is control over the plume if it is slipping below First Creek (more robust alternative) and less reliance on the shallow groundwater collection. The shallow groundwater collection system alone is effective only if placed at the point of discharge. As the point of discharge moves through any number of factors, the effectiveness of the shallow system alone is jeopardized. Failure of the system results in off-site releases within 24 hours. The deep extraction system is effective regardless of where the plume is discharging. In fact, over time, some of the shallow collection systems may be taken off line.

The selected interim groundwater action does not treat the plume in West Bethel Valley. Concentrations in the groundwater and associated surface water are decreasing. There is no evidence that the plume is increasing in size or concentrations. Capital cost increases are roughly $1 million and annual O&M increases are $2.7 million. If 10 years are required to make a final decision, roughly $16 million would have been spent. Mass would have been removed from the groundwater, but there would be no increased effectiveness or reliability in the meantime. The selected action of monitoring while making the final decision is the most cost effective.

SWSA 3 and the Contractor's Landfill were considered as candidates for excavation or for containment. Containment is the preferred alternative for several reasons. It is considered protective. The level of releases from SWSA 3 is decreasing, as evidenced by decreasing nearby surface water concentrations and decreasing groundwater concentrations in some wells. The proposed cap and upgradient diversion

trench would enhance a future decrease in releases. However, it is unlikely that a cap to control releases would be required past 30 years, when concentrations in the groundwater are predicted to be below industrial drinking water levels. MCLs would be achieved in roughly 200 years. Institutional controls would be needed for a very long time unless the final decision changes this action. The costs associated with excavating these landfills is roughly $100 million, vs $7 million for containment. The annual O&M costs associated with capping are $85,000 for the first few years, dropping off quickly as the need to maintain the cap for infiltration control is no longer needed. If the average O&M costs over 100 years is closer to $10,000 for inspection and institutional controls, the costs in today's dollars of the containment alternative would be $8 million. Use of institutional controls in West Bethel Valley are considered nearly as effective in the long term as institutional controls applied both at Chestnut Ridge (disposal site for the Contractor's Landfill) and in Bear Creek Valley (disposal site for SWSA 3). The great cost increase and potential worker risk increase from removal of SWSA 3 is not worth the limited additional protectiveness.

2.13.4 Use of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable

The selected remedy provides the best balance of trade-offs among the alternatives with respect to the evaluation criteria, such that it represents the maximum extent to which permanent solutions can be practically used for the Bethel Valley area. Of the remediation alternatives considered, the selected remedy provides the best balance of trade-offs in terms of long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost.

Although the selected remedy is considered interim, it does include certain components that DOE believes will become elements of a permanent solution for the Bethel Valley area. Removal of soils and sediments is considered a permanent solution. A primary component of the selected remedy that has a relatively low degree of permanence is hydraulic isolation, with its associated cap maintenance and institutional controls. It was deemed impracticable to remove or permanently treat these waste areas.

2.13.5 Preference for Treatment as a Principal Element

CERCLA, Sect. 121, establishes a preference for alternatives that use treatment to permanently reduce the toxicity, mobility, or volume of hazardous substances.

Treatment of underground pipelines will be effected by grouting in place. Grouting will isolate and immobilize residual wastes left in pipelines and those tanks already grouted; therefore, mobility, but not toxicity or volume of contamination, will be reduced. This remedy will also treat extracted groundwater, reducing the volume of contaminants in water, but not the toxicity or mobility. Biodegradation of the East Bethel Valley VOC Plume results in the destruction of contaminants to nontoxic compounds.

As explained in Section 2.11, most of the principal threat wastes in Bethel Valley have already been remediated through removal, treatment, and final disposal. Through early actions, sludges from the Gunite Tanks, sludges from the FFA steel tanks, sediments from the surface impoundments, and extremely contaminated subsurface soil in the North Tank Farm have been removed from Bethel Valley. These wastes were considered to be both highly mobile and very toxic. Remaining principal threat wastes are the contaminated soil in Central Bethel Valley, currently contributing to groundwater contamination, and buried waste within SWSA 3 in West Bethel Valley, for which the primary concern is excavation into the burial ground by a future user. The selected remedy does not satisfy the statutory preference for treatment of these principal threat wastes. An explanation of why it does not do so is provided below.

The selected remedy removes the highly mobile soil contamination in Central Bethel Valley that is a primary contributor to groundwater contamination. Removal of this principal threat waste is preferred over treatment because removal is more cost effective for small volumes in an active facility. Sufficient contact between deep soils and treatment chemicals in situ in an active plant can be very difficult. There can be significant questions about the effectiveness of this method in the long term. Multiple contaminants lessens the ability of a single treatment technology to be effective, and many of the soil sites have radionuclides that are of concern other than just strontium. Ex situ treatment is not necessary prior to disposal of any excavated material and, therefore, would not be cost effective either.

Containment of buried waste within SWSA 3 is preferred over treatment for two reasons. First, the cost of excavating the waste material within SWSA 3 for subsequent ex situ treatment is significant. Additionally, worker risk from excavating SWSA 3, although difficult to quantify because of the great uncertainty of what is buried there, would also be significant. Secondly, in situ treatment of the buried waste in SWSA 3 (grouting of trenches) is not considered cost effective since grouting of the trenches does not address contamination that has already leached from the waste. Concentrations in the subsurface groundwater appear to have stabilized or are decreasing, indicating that the most significant mass of contamination has already escaped the burial ground. Therefore, in situ grouting is not expected to be more effective than capping alone at reducing groundwater contaminant concentrations.

2.13.6 Five-Year Review Requirements

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure, the statutory CERCLA reviews will be scheduled, conducted, and reported in the ORR-wide RER/Five-Year Review Reports following initiation of remedial action to ensure the remedy is, or will be, protective of human health and the environment.

2.14 DOCUMENTATION OF SIGNIFICANT CHANGES

The proposed plan (DOE 2000a) was released for public comment on June 26, 2000. Since that time, changes have been made to the preferred alternative (now the selected remedy).

The preferred remedial action for buildings and other facilities in the proposed plan specified removal of contaminated slabs or subsurface structures to the depth of remediation [e.g., 0.6 m (2 ft) in the controlled industrial area]. This section was modified under the selected remedy to include the option of decontamination instead of removal where equal protectiveness can be achieved at a lower cost. Remediation levels for structure surfaces were added to the selected remedy.

The preferred remedial action for sediments in the proposed plan was removal to a maximum depth of 0.6 m (2 ft). This depth limit was modified to depth of sediment deposition for the selected remedy because the sediment layer is anticipated to be relatively shallow and located directly on top of bedrock.

The construction logic for the preferred alternative was presented in Fig. 7 of the proposed plan. This construction logic has been modified slightly in the ROD (see "Sequencing and Milestones," Sect. 2.12.8.1) to better reflect the latest organization and sequencing of work under the ORNL Project life cycle baseline.

In the FS for Bethel Valley (DOE 1999a), it was assumed that water from both Core Hole 8 wells and sumps adjacent to seven storm drain junction boxes would require pretreatment to remove U, Sr, Cs, and organics before being sent to the PWTC for discharge. Unit processes including equalization, filtration, ion exchange, zeolite, and liquid-phase carbon adsorption comprised a process train capable of operating at 510 L/min (135 gal/min). Based on the results from the Well 4411 pumping test, pretreatment is not required; thus, the pretreatment system has been eliminated from the ROD scope. This reduced the capital cost of the selected remedy by approximately $1.5 million and reduced associated average annual O&M costs by $4.4 million.

Costs for D&D of pump pits/valve boxes have been incorporated into the estimated costs for stabilizing pipelines inside the main plant area. This increased the capital cost of the selected remedy by approximately $0.8 million.

The scope of the preferred remedy in the proposed plan included stabilization of eight Gunite Tanks in Bethel Valley. Stabilization of these tanks has been removed from the scope of the remedy and placed in a non-time-critical removal action where its implementation schedule will be accelerated. Concerns associated with tank shell integrity precluded postponement of the stabilization until after ROD approval. Removal of the stabilization of the eight Gunite Tanks from the scope of the ROD reduced the capital cost of the selected remedy by approximately $3.7 million.

Contents removal and stabilization of three inactive Melton Valley tanks (Tank T-1, Tank T-2, and the HFIR Tank) were previously to be performed under an action memorandum for inactive steel tanks. Remediation of these tanks has now been incorporated into the selected remedy because the ion exchange resins found in the tank sludges are incompatible with the final processing anticipated under the action memorandum. Further evaluation of the treatment for the tank sludges will need to be performed during post-ROD design. Addition of contents removal and stabilization of the three Melton Valley tanks to the scope of the ROD increased the total capital cost of the selected remedy by approximately $6.4 million.

The Proposed Plan identified 10 *CFR* 20.1402 and 10 *CFR* 20.1403(a) and (b) as ARARs that require a soil cleanup level of 25 mrem/year. While the 25 mrem/year standard is relevant, EPA has determined that it is not appropriate in the context of this particular remedial action because, in some cases, the residual concentrations of radionuclides that would remain in soil following remediation based solely on this dose limit would not achieve the risk goal of 1×10^{-4} selected in this ROD. Accordingly, for the purposes of this ROD, these two regulations have been deleted from the ARAR list, and cleanup levels for all radionuclides of concern have been developed to achieve the risk goal of 1×10^{-4}. Those cleanup levels are set forth in Tables 2.40 through 2.42. For certain radionuclides (i.e., ^{241}Am, ^{155}Eu, ^{210}Pb + D, and ^{240}Pu), cleaning up to the dose-based 25 mrem/year constraint as required by DOE Orders will result in a higher degree of cleanup than simply attaining risk-based (1×10^{-4}) cleanup levels for those radionuclides. The actual relationship between radiation dose and risk for any individual radionuclide is dependent on many factors (e.g., radioactive decay characteristics, exposure pathways, metabolic properties), such that the dose limit may be more limiting in some cases. Thus, as indicated in Table 2.40, DOE will remediate those radionuclides to levels that will attain the dose constraint of 25 mrem/year where, in DOE's opinion, such action is necessary to achieve compliance with DOE Orders as well as the risk limit of 1×10^{-4}.

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PART 3. RESPONSIVENESS SUMMARY

RESPONSIVENESS SUMMARY

Comments have been consolidated to enhance readability of this section. Comments include those received in writing and those questions and comments received at the public meeting held on July 27, 2000.

General

- In general, most reviewers from the Site Specific Advisory Board (SSAB) found that the Proposed Plan (PP) adequately describes the strategic decisions required as remediation proceeds. When used in conjunction with the remedial investigation/feasibility study (RI/FS), it explains the alternatives well enough to allow thoughtful decisions and it reflects input received from the public at meetings and from informal reviews of preceding documents.

DOE Response: Comment noted.

- The PP reflects the considerable careful work expended to develop it and, I believe, the input received from the public through previous interactions. In most cases the PP illuminates clearly the strategic decisions required as remediation proceeds, and explains the alternatives well enough to allow thoughtful broad decisions.

DOE Response: Comment noted.

- Discussions at the public hearing showed that DOE and contractor staff in some cases had a good approach in mind that had not been reflected clearly in the written PP. The Record of Decision (ROD) needs to carefully include the plan actually developed, because staff changes prior to the field work can cause good ideas to be lost if they are not contained in the ROD.

DOE Response: DOE agrees that there is more information about the selected remedy than reflected in the PP. Much of the information reflected in the FS or in work conducted to specifically address this comment has been added throughout the ROD to improve understanding of the basics of the selected actions.

- The preferred remedial alternatives support appropriate Remedial Action Objectives. Except as noted below, I see no reason they would not be effective with modest likelihood of requiring the indicated contingencies.

DOE Response: Comment noted.

- The preferred alternatives outlined in the PP represent a reasonable overall approach to remediation in Bethel Valley. However, we have questions and concerns about some elements of the proposal.

DOE Response: DOE appreciates the comment. Please see the comments and responses below responding to the questions and concerns.

- U.S. Fish and Wildlife Service (Service) personnel have reviewed the *Proposed Plan for Interim Actions in Bethel Valley, Oak Ridge, Tennessee* (DOE/ORO1-1795&D3). While the Service remains concerned over the considerable uncertainty regarding the nature and extent of contamination and the ecological health of the terrestrial and aquatic biological communities in the Bethel Valley

watershed, we fully support the preferred alternatives for interim remedial actions in Central Bethel Valley, East Bethel Valley, West Bethel Valley, and Raccoon Creek.

DOE Response: The uncertainties associated with nature and extent of contamination along with ecological risk are being managed as indicated in Sect. 2.12.5 of the ROD. Additionally, necessary predesign sampling (for nature and extent) and biological studies as indicated in the GRA Logic Diagram for Sediment (for aquatic ecological risk uncertainties) are planned. Due to the limited terrestrial ecological habitat, DOE does not feel there are uncertainties with the results of the terrestrial risk assessment.

- The Citizens' Advisory Panel (CAP) initially had some difficulty accepting the proposed remediation for Solid Waste Storage Area (SWSA) 3, as the original plan was to excavate the site, leaving it available for unrestricted use. Considering, however, the overall cost and extent of remediation, the CAP accepts the final solutions offered in the PP. The CAP is especially pleased that DOE believes the groundwater problem is abating and that the protection goal is for recreational use, which exceeds the protectiveness of the End Use Working Group recommendation.

DOE Response: Comment noted.

<u>Soil Remediation Approach</u>

- Fifty years from now, the Oak Ridge National Laboratory (ORNL) soil surface under the preferred alternative would be rather usable, with 50 old buildings buried a couple of feet, and surface "warm" spots ten times more radioactive than the average. While it is true that workers usually move around and tend to receive an average exposure, how does DOE plan to keep track of the location of these "warm spots," so workers will not loiter there? Signage for these spots would be a problem for generations. We think the maximum ratio of surface radioactivity in warm areas to average should be much smaller. The savings in the present proposal would be only in the short term.

  We suggest that the average contamination be figured over regions no larger than an acre, so one may be confident that a worker would rarely spend his day in an area that retains a higher specific activity than the selected objectives. We also suggest that square-yard areas with above-average radioactivity exhibit an intensity no more than four times the average stated as the objective, so that even the maximum value would still be within the range of standards presently being proposed.

  While the above suggestion would increase the initial remediation cost, we believe the Remedial Action Objective would then be met during practical future use of the site. With the preferred alternative interpreted as in the PP, we doubt the "clean surface" objective would be satisfied.

DOE Response: An exposure unit is a geographical area about which a receptor moves and can potentially contact contaminated soil during a certain period of time. It is assumed that the receptor can access any area within the exposure unit with equal probability. The size of the exposure unit is set by considering the future use of the land. For the industrial areas in Bethel Valley, the individual who is outside the greatest amount of time with the greatest chance for exposure to contaminated soil is currently, and is envisioned in the future, to be a maintenance-type worker who stays outdoors 2000 hours/year, for 25 years, performing ORNL S&M activities. Based on discussions with current S&M supervisors, current field personnel are generally assigned work that takes them throughout Melton and Bethel Valleys (up to 2000 acres). To be conservative, the exposure units were made much smaller than the size of the valleys. The developed portion of Bethel Valley was divided into nine exposure units ranging in size from 19 to 50 acres (average of 37 acres) of

land. If building and pavement footprints are subtracted from these total acreages, the size of the exposure unit soil area ranges from 9 to 25 acres (average of 19 acres).

A laboratory worker who spends most of his or her time indoors, but then spends 200 hours/year outdoors near or on a hot spot either through walking or through spending small amounts of time outside, is the receptor protected by a maximum level. This level is based on the assumption that a receptor is exposed to a certain small contaminated soil area (1 m^2 or greater) for 200 hours/year, for 25 years. This receptor would incur no more risk than the industrial worker spending 2000 hours/year outdoors over a larger area. All accessible hot spots with contamination above the maximum remediation level will be removed under the selected remedy.

The details of the remediation level approach were not presented in the PP in order to maximize the readability of the document. The details mentioned above are presented in the ROD. DOE believes that the removal of soils above a maximum remediation level, essentially regardless of size, will protect the worker from small areas of contamination. No access controls would be required.

- Is DOE aiming primarily at soils down to 10^{-2} risk or 10^{-3}?

DOE Response: DOE's objective is to not leave soil in place that could allow for greater than an average of 10^{-4} ELCR for industrial land use. Material more dangerous than that would be removed or, in limited cases, covered.

- I have two questions: (1) How do you know what is underneath the buildings? and, (2) obviously, you can't remove (contaminated soil) from underneath a building that's an operational building.

DOE Response: One of the biggest challenges associated with remediating ORNL is conducting that remediation while it remains a viable national laboratory. In most cases DOE does not have a complete data set underneath the buildings; therefore, there is incomplete information as to the extent of soil remediation that may be required under the buildings. In general, soil remediation will wait until buildings are removed (demolished). Once contaminated soil becomes accessible, the soil will be sampled before design of the remediation in that area. The amount of soil requiring remediation will be determined consistent with the remediation levels and the GRA logic diagram for soil.

- Under the PP, all areas in Bethel Valley that are currently developed but are not contaminated (such as land under office buildings and parking lots) would be designated for "unrestricted industrial use." This is the same designation as would be applied to many contaminated areas, and it is assumed to allow no excavation deeper than 3 m (10 ft). We understand that this is an assumption made for purposes of risk assessment, but we are concerned that the analytical assumption will become a permanent designation. Broad application of the "unrestricted industrial" designation is misleading, in that it suggests that there is much more contaminated land than is actually the case. Also, it may lead to misallocation of future stewardship effort, as this designation makes it appear that these areas are known to be contaminated and must be restricted to industrial use. Designations should be explicitly tied to the nature and extent of residual contamination. Can the "unrestricted industrial use" designation be subdivided into "unrestricted industrial–with residual contamination" and "unrestricted industrial use assumed–no known contamination?"

DOE Response: The more contaminated areas of ORNL have been designated for controlled industrial use and use access controls below 0.6 m (2 ft). This decision was made because of the potential costs associated with remediation to 3 m (10 ft). Other areas that are more lightly contaminated have been designated for more aggressive action, to 3 m (10 ft), because this objective

can be achieved economically. However, these unrestricted industrial areas are not necessarily clean. Therefore, some type of remediation levels needs to be assigned. Once industrial remediation levels are assigned instead of residential remediation levels, some type of institutional controls will be needed to prevent residential use. Because ORNL is an active national laboratory, the controls necessary to prevent residential use are minimal, and their application to truly clean areas does not require any additional effort or cost. Once the laboratory is no longer operational, another set of remediation levels can be selected in another decision. DOE believes further delineation of "unrestricted industrial" into contaminated and uncontaminated areas is not needed.

- Is DOE's proposed soil removal consistent with the higher risk soils shown in that drawing with all the red and orange and yellow on it [commenter is referring to the soil risk map shown in Chap. 6 of the RI/FS and shown again in the public meeting].

DOE Response: The referenced figure illustrates risk at individual points. The remediation levels are averaged over the exposure unit. Therefore, the areas requiring remediation are represented on the referenced figure by somewhere between the 10^{-4} and 10^{-3} risk contour. However, the residual risk will be averaged over the exposure unit and will be less than 10^{-4} ELCR and, for a receptor present for 200 hours at a single point, also less than 10^{-4} ELCR.

<u>Clarification on the plan to grout the pipe bedding material</u>

- Earlier versions of the PP had grouting the bedding material because it is a marvelous conduit for groundwater, which is contaminated, hence enhancing the spread of contamination. The current plan is to plug those channels here and there, but only where it affects surface water. This is puzzling because it is true that all the groundwater becomes surface water someplace. It seems like those channels are facilitating the spread of groundwater that is contaminated. If DOE wants to hold the line on the question of the groundwater contamination being spread, it seems like the bedding material should be plugged comprehensively. Additionally, plugging only portions of the trench may cause groundwater to move in unanticipated directions. How will the remedial design decide whether or not to plug the media channel around a certain pipeline? The preferred alternative for bedding around waste lines needs a clearer explanation. The ideas conveyed in the public meeting need to be stated in the ROD to indicate the planned criteria for various remedial actions related to these trenches.

DOE Response: The approach to grouting bedding materials did change between versions of the PP. This change was made because of two implementability concerns. First, many of the LLLW lines are in the same trench with active utilities. Grouting the bedding material would render those active lines inaccessible. Second, in some cases the bedding materials are gravel (and can be grouted) and in some cases there are no bedding materials present that can be grouted; therefore, complete grouting is not viable. Instead, DOE proposed combining trench grouting with shallow groundwater collection. In areas where plugging of a trench is proposed, the area hydraulics will be evaluated to determine if the water will be collected by an existing sump or if enhancements of the shallow groundwater collection system are required to prevent unexpected movement of the groundwater. In other areas with notable groundwater movement, additional groundwater collection is planned to control groundwater migration, and less reliance is needed on complete trench grouting. The explanation of this interconnection between trench plugging and shallow groundwater collection has been enhanced in the ROD.

Subsurface "fixed" contamination

- Perhaps some "fixed" contamination under paint should be removed during decontamination and decommissioning (D&D) before backfilling. Currently, building basements are to have loose contamination removed. Contamination under paint would be considered "fixed" under the preferred alternative. We assume buried basements will lose their paint after a few years, freeing some of the contamination. Portions of some buildings probably have walls that have been given many coats of surface treatment to "hide" alpha-particle emitting contaminants. For such buildings, we believe it would be appropriate to grind these surfaces while they are accessible. This would require sampling walls and floor of at least one radiochemical laboratory that was in a basement to determine any need to remove fixed contaminants.

DOE Response: The purpose of removing (via wiping, pressure washing, or vacuuming) the loose contamination during D&D is primarily to remove the potential for airborne contamination during construction activities and as a "best management practice." A best management practice is an activity that does not contribute toward an RAO but is done because the additional effort is minimal (pennies per square foot and low worker risk due to potential to operate at a distance). Neither the loose contamination nor the fixed contamination under the paint is contributing to an industrial risk (too deep) or a groundwater impact (insufficient volume). The fixed contamination does not contribute to the potential of airborne contamination during backfilling. The fixed contamination would require considerable effort (dollars per square foot through scabbling) to remove and would result in greater potential exposure to remediation workers. Therefore, there is insufficient justification to completely remove the material as a best management practice.

SWSA 3 Decision

- The rationale for capping SWSA 3 in West Bethel Valley, rather than excavating the waste, is neither evident nor fully explained. This site appears to have a smaller inventory than other contaminated areas and is isolated from other waste areas, so the continued presence of waste at this location would have a disproportionate impact on the cost and complexity of future stewardship. The community needs more specific information on the technical rationale for recommending that waste be left in place in this area, including some reassurance of the technical effectiveness of the proposal to intercept upgradient groundwater.

DOE Response: The technical basis for selecting capping and upgradient water diversion at SWSA 3 instead of excavation includes the status of releases from the buried waste, the nature of waste in the burial ground, and the cost effectiveness of excavation rather than capping. The ^{90}Sr concentrations detected in surface water in the NWT and Raccoon Creek are well below the action level for protection of recreational users of the area. This condition is not expected to change, and concentrations of contaminants in surface water have been decreasing and are expected to decrease even further following implementation of the water diversion and site capping. Much of the waste in SWSA 3 was covered with concrete as part of the burial process. The presence of concrete covering the waste both minimizes the contaminant release and makes excavation of the waste more difficult. The difference in costs between capping and excavation is more than $90 million. Assuming that the maintenance of the cap and groundwater monitoring requirements will decrease over time as the strontium activity decays, DOE estimated that nearly 2000 years of O&M would be required before capping became as expensive as excavation. In addition, the risk to excavation workers will be difficult to control due to the uncertainty of the material placed in SWSA 3. Thus DOE, EPA, and TDEC concluded that excavation of wastes buried in SWSA 3 is not cost effective for reducing human health or environmental risk. The explanation of this rationale has been expanded in Sect. 2.12.

- It is recognized that the manner of waste burial in WAG 3, with some concrete caps, discourages excavation. If the portions of the waste most apt to trouble future use of the site could be identified, a partial excavation would be warranted. Consideration should be given to adding a discussion of this issue to the ROD.

DOE Response: Partial excavation was not considered during alternative development or remedy selection because the WAG 3 records are not sufficiently detailed to identify the worst problem areas of WAG 3. DOE does not have a basis on which to consider partial excavation and, therefore, has not added this issue to the ROD.

- If the current preferred alternative is maintained, the planned water diversion trench should be cut deeply enough to intercept all upgradient groundwater that could reach the difficult waste.

DOE Response: The upgradient diversion channel must function both as a surface water and shallow groundwater diversion structure. There is a swale that comes off Haw Ridge to the south, and the diversion trench will need to convey the seasonal surface water flows and route the water around to the east to NWT. The trench is planned to be excavated to bedrock to capture as much groundwater as reasonably possible. Complete dewatering of the buried material may not occur but is not required because the future release potential of the burial ground is decreasing without any action.

- Several questions were received during the public meeting seeking clarification on the actions proposed in West Bethel Valley.

DOE Response: There are two major burial areas associated with West Bethel Valley: the Contractor's Landfill and SWSA 3. The proposed action caps SWSA 3. The Contractor's Landfill currently has a 0.6-m (2-ft) soil cover over it. Portions of the cover are contaminated (identified on Fig. 8 of the PP). These contaminated areas along with all contaminated soil in the area above unrestricted remediation levels would be removed. The soil cover would then be repaired. One of the contaminated soil areas is called the Closed Scrap Metal Area. Miscellaneous debris located there would also be removed.

- How did that soil become contaminated? In other words, is it a sign of there being leaching and water flow from the burial grounds in those directions? Does that suggest additional details that need to go into DOE's planning?

DOE Response: The Closed Scrap Metal Area did have some waste stored on the surface. The surface contamination inside the SWSA 3 fenced area is derived from contaminated equipment stored on the ground surface. Contaminated soil areas adjacent to the burial ground are presumed to have been created by seepage of contaminants out of the SWSA 3 waste burial trenches. This shallow groundwater seepage is expected to be controlled through diverting surface water and groundwater flows on the upslope side of the burial ground and capping to stop the infiltration of water into the waste.

<u>Project duration and cost/funding</u>

- How long does DOE estimate the whole project will take? How will DOE obtain the money for this project?

DOE Response: DOE estimates that the project will require through 2014 to complete remediation of accessible contamination, assuming that the funding allocations to Oak Ridge for cleanup are similar to this last year. Funding is obtained through annual appropriations from Congress.

- If DOE is going to be spreading the project over approximately 10 + years, during each year as much will be spent on O&M as on capital cost, and then the O&M continues on even after completion.

DOE Response: The annual O&M costs presented in the PP are quite high and are a notable portion of the selected remedy. As time proceeds, these costs will decrease as conditions stabilize and less monitoring is required. A tradeoff between high capital expenditures for a more complete cleanup had to be balanced against greater O&M costs.

- With respect to the contaminated buildings, if DOE is able to get the funding and either clean up the loose contamination and perhaps even remove them within say the 10- or 12-year timeframe referenced, it is fine to ignore my comment. But some of those buildings, especially in Isotope Circle, contain very high levels of loose contamination in the hot cells. I say this having been one of the people who worked on the isotope program shutdown plan and knowing they did not get the funding to do hot cell wash downs. I am not talking about stuff that is embedded in the concrete; I'm talking about loose stuff. The ventilation systems, the off gas systems for those hot cells, run on the roofs of the buildings. The HEPA filters are on the roofs of the buildings and experience, at least in other places, is that particles tend to settle out in various beds. There are particulates in the filters, which as far as I know have not been changed to put clean ones in. If we're talking 10 to 12 years, I think the important thing is to spend the money on moving forward with the cleanup. But when DOE starts talking about 20 years one begins to get concerned. What happens if a tornado comes through? What happens if a high wind comes through? The monitoring instruments in those buildings are old; they're vacuum tube technology, and one cannot buy replacement parts for them. At the time I worked on the shutdown plan, the roofs were in poor condition. They were barely able to meet containment with respect to the ventilation air pressure, so there are a lot of problems there. I understand perfectly well that tanks and pipelines are the first priority. But let's please not forget the buildings and not put them off too long. Either that or come in and do a quick clean-up of the sort that takes care of the loose stuff, so if something goes wrong DOE is not sucking a lot of stuff out of the building.

DOE Response: DOE understands the request not to delay demolition of the buildings too far into the future. DOE intends to maintain the buildings in a safe condition until the demolition can proceed. There is currently a sitewide HEPA filter system, and HEPA filters are replaced on a 7-year cycle. The S&M program is currently maintaining negative pressures on the hot cells. All remediation activities planned for Bethel Valley are important. DOE prioritized as high filling the Gunite Tanks and pipelines to limit S&M dollars associated with treatment of water collecting in the tanks and because of concerns associated with Gunite Tank shell integrity. DOE also prioritized groundwater actions high to limit the spread of contamination.

- Is any thought being given to looking at the processes proposed to see if they can be made cheaper or doing any research investigation because, obviously, the stewardship business, as it goes down through the years, is going to be pretty hard to keep coming up with money for.

DOE Response: The selected remedy does have higher O&M expenses than some of the other options, because this option involves long-term management of large volumes of water. There are two mechanisms by which more inexpensive technologies may be identified. First, the project will be bid competitively, rewarding vendors for innovative, less expensive solutions to all of the efforts. Secondly, long-term water treatment has been identified as an expensive component of stewardship activities at the ORR, and the draft Stewardship Management Plan has emphasized the need to continue technology development activities for this problem. This need has been sent to DOE's technology development program for consideration with future research opportunities. This need identification allows the entire DOE complex to consider reasonable solutions.

- Clarify that there is a difference between the PP costs for the preferred alternative for Central Bethel Valley ($116 million) and the FS costs for Alternative C-3 for Central Bethel Valley ($197 million).

DOE Response: The differences in costs are as a result of changes in the preferred alternative after further evaluation and negotiations between the FFA parties. These differences were highlighted on p. 25 of the PP. The key differences were a reduction in the volumes of soil removed ($50 million reduction) and the reduction in pipeline bedding material and process waste line grouting ($20 million reduction). Both costs are in 1998 dollars.

- Page 36. In Table 8, the discount or interest rate assumed for the present worth calculation is not apparent.

DOE Response: The discount rate of 7% and an escalation range of 2.5 to 2.7% were used in the present worth calculations. More information can be found in Sect. 10.1.7 of the RI/FS.

Commitment to Stewardship

- While the DOE presentation at the public hearing indicated that stewardship issues would not be covered in the current interim ROD, the PP does include sections directly relevant to stewardship, including those on long-term effectiveness of the remedies, land use controls (LUCs), and the federal commitment to stewardship of the site. Since it is not really known that a Final ROD will occur, and the preferred alternatives will often require ongoing stewardship activities, the ORSSAB believes the Bethel Valley interim ROD should cover the general principles that guarantee effective stewardship. The following paragraphs provide some detail for this request.

  (a) Clarity is needed that maintenance of remedial structures and LUC activities are included at least for the period until a final ROD is adopted.

  (b) Maintenance of caps, trenches, and treatment facilities is described as a "continuing" activity, with no indications of criteria for adequacy or what the word "continuing" means in context. The ROD must be explicit on this matter.

  (c) LUCs are briefly listed, with reference to the Land Use Control Assurance Plan (LUCAP). (Paragraph 2.5 of that LUCAP states that the PP and ROD must contain an adequate description of the land use controls along with conditions for their use "to allow evaluation of each land use control under remedy selection criteria contained in CERCLA and the NCP.") The various types of LUC are listed only by title in the PP. The ROD should at least meet the requirements of the LUCAP in this matter.

DOE Response: (1) Sect. 2.12.3 of the ROD describes the maintenance and monitoring that will be required after completion of the selected remedy. Sect. 2.12.4 describes the LUCs required by this selected remedy. (2) Continuing maintenance is required as long as residual waste is a risk or until a final decision is made. (3) The intent of Sects. 2.12.2–2.12.4 is to provide the necessary information about the selected remedy that was used to support the evaluation during the remedy selection process. This process was conducted in the FS and the maintenance, monitoring, and LUCs required by each alternative were identified and evaluated along with the other elements of the alternatives.

As provided in the LUCAP, details for implementing and maintaining all LUCs included in the remedy encompassed by this ROD will be specified by DOE in a LUCIP submitted to EPA and TDEC for approval. The Bethel Valley LUCIP will be submitted and reviewed concurrently with the Bethel Valley RDWP.

- Other essential stewardship activities that will need to be carried out during the interim remediation should be listed in the ROD. The important record keeping, public education, and surveillance functions should be listed in the ROD. There is concern that ongoing activities not specifically mentioned in a ROD will not endure, and this PP would be the public's only opportunity to comment on the remediation program for Bethel Valley. At a minimum, we believe the following points should be included in the ROD:

  (a) The essential classes of records to be maintained should be listed.

  (b) A public education program should be specified to include at least a public annual progress meeting (that could also include other areas of the Reservation).

  (c) The aspects of Bethel Valley remediation that will require routine surveillance should be listed.

DOE Response: The Bethel Valley ROD indicates that DOE and the other FFA parties are committed to ensuring that LUCs included under the selected remedy will be implemented and maintained for as long as they remain necessary to protect public health and the environment. The interim remedy will undergo routine S&M as illustrated in Sects 2.12.2 and 2.12.3 in the ROD to ensure that the remedial actions meet their individual performance measures. Some essential stewardship activities, such as listing classes of records or providing public education opportunities, are beyond the scope of the Bethel Valley ROD, and will be addressed in DOE's Stewardship Management Plan currently under development. In addition, DOE is planning the revision to the Public Involvement Plan, and these types of issues will be addressed with the public during the development of that plan.

- The CAP recommends that, in addition to the stewardship activities for remedies to be implemented, a standard paragraph be inserted into the Interim ROD to capture the principles guaranteeing effective stewardship. The CAP challenges DOE, Oak Ridge Operations, and Environmental Management (EM) to consider the following as an example, if not the actual paragraph:

  "Contamination will remain in the Bethel Valley Watershed after the remedial actions described. These residuals will require monitoring, maintenance of containment structures, and restrictions of access for the foreseeable future to protect the public's health and environment. The implementation and funding of these activities is acknowledged to be the responsibility of government of the United States of America, through its designated agents or contractors, until the hazards become negligible. The local public will be involved in the oversight of these stewardship activities, by support of a citizens' group and by ensuring public input in CERCLA five-year reviews."

  Please comment by adopting this or similar wording this ROD and future RODs, or justify why such a statement is omitted.

DOE Response: Similar wording has been adopted in the Declaration of the Bethel Valley ROD. The example paragraph provided speaks to the commitment of DOE to stewardship and the involvement of the public in that stewardship. Requirements for surveillance, maintenance, monitoring, operation, and control of facilities constructed as part of the interim remedy are addressed in this ROD. DOE has adopted a policy of public involvement and intends to continue pursuing public involvement. Funding commitments are not made in this ROD; DOE receives funding through annual appropriations from Congress.

- The CAP understands the LUCAP for the Oak Ridge Reservation but is concerned with the lack of information on the planned content of the Land Use Controls Implementation Plan (LUCIP), as this

document will not be developed until the RDWP is written. Will the public be invited to review the LUCIP for this Interim ROD as it is developed for the RDWP, a post-ROD document? Because the Administrative Record ends with the ROD, the CAP is concerned about the lack of requirement for further public involvement.

DOE Response: The LUCIP submittals will be placed in the Post-Decision File where they will be accessible to the public. The LUCIP will also be incorporated into Appendix B of the LUCAP and will be revised, as necessary, to reflect approved changes to any LUCs.

- The Federal Facility Agreement for the ORR does not address public involvement in the 5-year reviews required at sites where remedial actions result in contaminants remaining above levels that allow for unlimited use. Thus, we recommend the ROD include the following provisions for public involvement:

  (a) Public notice of forthcoming 5-year reviews and invitations to participate extended to interested citizens, community groups, and local government.

  (b) Public meetings to provide stakeholders with information about remedial activities subject to the 5-year reviews, to explain the 5-year review process, and to gather community issues and concerns related to forthcoming 5-year reviews.

  (c) Site visits.

  (d) Public review and comment periods for draft 5-year review reports.

  (e) Public notice of final 5-year review reports and the location of their availability.

  (f) Distribution of summary fact sheets to all individuals and groups who participate in the 5-year review process.

DOE Response: DOE is planning the revision to the Public Involvement Plan, and these types of issues will be addressed with the public during the development of that plan.

- All alternatives considered would leave hazardous substances in place, which would require land use restrictions for hundreds of years or more. As the municipality with local jurisdiction over this area, the City of Oak Ridge will inevitably need to play a major role in assuring long-term stewardship. The City, therefore, needs to be a participant in developing and negotiating the LUCAP for the Oak Ridge Reservation (this plan was already agreed upon by DOE, EPA, and TDEC, without local government participation) and related plans for long-term controls.

DOE Response: DOE intends to keep the City of Oak Ridge informed of the long-term stewardship program. The LUCAP was prepared in response to EPA Region 4 requirements, and agreed upon by EPA, TDEC, and DOE. The LUCIP submittals will be placed in the post-decision file where they will be accessible to the public.

- The preferred alternatives are predicated on a long-term stewardship program that would include active control measures such as security patrols, as well as passive control measures such as placing notices on property records. We are concerned about whether it will be practicable to maintain useable records and other controls as long as they are needed, and about how the community will be assured that maintenance of these control measures, particularly the active controls, will not someday

become a financial burden on the local community. If it is difficult now for DOE to obtain sufficient federal funding to pay for remediation, it will be more difficult in the future to obtain funds for long-term stewardship. Would the less intensive remediation efforts included in the preferred alternatives be attractive financially if the true costs of long-term stewardship (including contingencies for future uncertainties) were factored into the cost analysis?

DOE Response: It is important to note that this ROD is for interim actions only and should not be construed to reflect the final actions for this site. The costs presented in this ROD include the following interim actions: maintenance, monitoring, documentation of activities, institutional controls, and water treatment. The cost estimates were prepared in accordance with CERCLA guidelines. A cost analysis was then conducted (also in accordance with CERCLA guidelines) to determine the cost-effectiveness of each alternative individually and compare the cost and effectiveness of alternatives in relation to each other.

For West Bethel Valley, DOE completed a separate analysis that considered long-term costs of cap maintenance and monitoring. The analysis concluded that a more expensive but more aggressive excavation alternative was not more cost effective. (This analysis is presented in the ROD.) For Central Bethel Valley, the alternative selection was less dependent on capital costs vs long-term costs and more dependent on what was technically feasible while keeping the laboratory operational; therefore, no separate analysis was conducted.

- Page 11, second column, Lines 21-24. While surface waters are classified by the State for the listed uses, text could be added to the ROD describing the existing restrictions on such uses on the ORR (e.g., access, fencing, guards, signs).

DOE Response: The ROD does not require implementation of restrictions on surface water use in Bethel Valley and therefore text describing the existing restrictions will not be part of the selected remedy. Remediation will be sufficient to meet the classified use of the streams. Although there may be restrictions to accessing the streams that may be in place after the remedies are implemented, they will be for security reasons and are not required by CERCLA to protect against residual contamination.

<u>NEPA</u>

- SSAB reviewers recognize that DOE 0451.1A (National Environmental Policy Act Compliance Program; approved 06/05/97) requires only that certain NEPA "values" (i.e., analysis of cumulative, off-site ecological and socioeconomic impacts) be incorporated, to the extent practicable, in DOE CERCLA documents. These NEPA values are meant to supplement the required CERCLA evaluation criteria. We find the PP discussion of the issues and concerns previously identified in the RI/FS as NEPA values to be consistent with the findings stated in the RI/FS.

DOE Response: Comment noted.

- Preservation of physical evidence of Oak Ridge's atomic history—and the associated potential for heritage tourism—is important to our community. Therefore, we note with concern that all of the remedial alternatives considered for Central/East Bethel Valley would include the removal of 53 buildings (not specifically identified in the PP), apparently including all Manhattan Project and early Atomic Energy Commission (AEC) structures other than the Graphite Reactor. Although the Graphite Reactor is the one building that is designated a National Historic Landmark, there are other nearby structures of historic significance that probably could be listed on the National Register of

Historic Places and that contribute to Graphite Reactor visitors' appreciation for the history of this site. Have the Tennessee Historic Commission and the Advisory Council on Historic Preservation provided opinions on the proposal to remove all of these structures (as required under the National Historic Preservation Act)? What evaluation has been done to determine whether it would be feasible to decontaminate and preserve some additional structures that have historic significance or contribute to the historic setting of the Graphite Reactor? The topics of historic preservation and cultural resource impacts (which are addressed in all NEPA documents) are missing from this PP, including the NEPA Values section, where we expected to find them.

DOE Response: Many of the buildings/structures to be removed during building remediation activities are within the ORNL Historic District, which encompasses the 2000–4000 areas of Central Bethel Valley. This ORNL Historic District has been recommended for inclusion in the National Register of Historic Places under the NHPA (see ARARs in Appendix B). Additionally, the Graphite Reactor is a National Historic Landmark. Adverse effects on historic properties will be taken into account, and measures to minimize or mitigate them will be evaluated per applicable NHPA requirements.

An architectural/historical assessment was performed for ORNL in 1993. The results of this assessment were submitted to the Tennessee SHPO. If any of the buildings to be demolished are listed as historical properties, approval is required from the SHPO. The SHPO must also be consulted regarding measures to mitigate adverse effects to historical properties. This consultation will occur during the design of each project.

The topics of historic preservation and cultural resource impacts are included in the NEPA analysis for the selected remedy in this ROD.

- There is no NEPA Values section in this PP, although some of the values in Appendix E, Applicable or Relevant and Appropriate Requirements (ARARs), and others are interspersed throughout the text. In the opinion of the CAP, the criteria discussed are inadequate in scope. This does not meet the spirit of Hazel O'Leary's *Secretarial Policy on the National Environmental Policy Act (June 13, 1994),* which clearly states that "Department of Energy CERCLA documents will incorporate NEPA values, such as analysis of cumulative, off-site, ecological, and socioeconomic impacts, to the extent practicable."

DOE Response: Highlights of NEPA Values are provided on pages 37 and 44 of the PP. The associated text explains that a more detailed analysis can be found in the FS. The DOE is committed to complying with the Secretarial Policy and has incorporated NEPA Values into the Bethel Valley ROD. For instance, the ROD (Sect. 2.12.7) includes a table that addresses each NEPA Value as applied to the selected remedy as well as some discussion in the main text.

<u>Maps</u>

- The CAP is concerned that DOE continues to include poorly thought-out and executed maps in these important CERCLA documents. In the Bethel Valley Proposed Plan, "the" incorrect map has returned to page 3 after the public has repeatedly corrected it in past documents. The ORR is entirely within the City of Oak Ridge boundaries with the exception of approximately 806 acres in the northwest corner adjacent to East Tennessee Technology Park. Please use a map that represents the facts. The CAP also suggests that the DOE spend some time comparing the various maps in the proposed plan against the text. Some maps do not show all of the information given by the text, which results in confusion on the part of the reviewer.

DOE Response: The City of Oak Ridge boundaries shown on the PP map referred to the metropolitan or residential/commercial area of Oak Ridge and not to the City's corporate limits. The PP map allowed the reader to see at a glance that residential/commercial areas are not adjacent to contaminated areas on the ORR. However, the corresponding map for this ROD has been modified to show the City of Oak Ridge corporate limits rather than the metropolitan area. Other maps within the ROD have been updated to include locations of facilities or waste units mentioned in the text.

- The CAP also recommends that the DOE research a better way to include maps in CERCLA and other documents. Not all members of the public have access to documents with color maps, and the black and white copies provided by the Information Resource Center do not adequately differentiate between different-colored areas on the maps. As this information is often only presented on the map, DOE must find a better way to communicate it. Either provide all documents with color maps, or use some form of shading or pattern in black and white to allow all readers to understand the information presented.

DOE Response: Comment noted. DOE is taking the comment under advisement.

- Page 4, Figure 2. Recommend that the 1000 area be shown on the map.

DOE Response: Central Bethel Valley maps containing the 1000 Area have been modified to indicate that the 1000 Area is actually in West Bethel Valley.

- Pages 4 and 7. Recommend that First Creek and Fifth Creek be shown on Figure 2 and also on Figure 3. The Core Hole 8 plume should also be included on Figure 3. A heavy line similar to the gunite tanks line would be appropriate.

DOE Response: First and Fifth Creek have been added to the ROD figures. However, the Core Hole 8 plume was not added. Although DOE understands that this plume is mentioned in the documents, to ensure readability of the figures, the level of detail on groundwater contamination was not modified.

- Line 51. The "7500 Bridge" on Figure 3 should be identified or, if not possible on Figure 3, then on Figure 2.

DOE Response: The 7500 Bridge has been added, where appropriate, to figures in the ROD.

<u>Natural Resources</u>

- While many decisions on the Oak Ridge Reservation are implemented due to regulatory commitments associated with the Federal Facilities Agreement, the DOE, acting as a natural resource trustee, must also ensure that its actions are fully protective of the response it is entrusted to protect.

  Since land use controls are ineffective in reducing exposure of site-related contaminants to ecological receptors, remedial actions must reduce ecological risks to levels that will result in the recovery and maintenance of healthy local populations and communities of biota.

DOE Response: The selected remedy is protective of the ecological receptors, reduces risks, and allows for recovery and maintenance of healthy local populations and communities. The impacted species identified in the baseline ecological risk assessment were the aquatic species in the local creeks. As noted in Sect. 2.13.1, Overall Protection of Human Health and the Environment,

"Groundwater treatment actions for mercury and removal of contaminated sediments in the streams will allow AWQC to be met and will protect the aquatic species in those streams."

- For the Oak Ridge Reservation, a streamlined process should be developed to address natural resource trustee concerns concurrently with CERCLA investigations, documentation, and remedial action implementation. We do not believe that the watershed approach, utilized in recent years by DOE at Oak Ridge, has been effective in reducing CERCLA documentation requirements, managing uncertainty associated with remedial action decisions, and, most importantly from our perspective, ensuring ecologically safe clean-up levels or that potential exposure pathways to ecological receptors have been removed.

DOE Response: General comments on the strategy of addressing natural resource considerations as part of the existing CERCLA process should be directed to the ORR Natural Resource Trustee Council (NRTC). Comments and recommendations received on specific ORR CERCLA documents from members of the ORR NRTC are taken into consideration during finalization of these documents. Although NRTC members do not have the same role as the parties to the FFA in reviewing and concurring on documents, please be assured that the integration of NRDA into the CERCLA process is an ongoing process.

- We are pleased that the DOE recognized the Endangered Species Act as a location-specific ARAR in Appendix E; however, the absence of a specific monitoring plan to fully address the potential for remaining impacts does not ensure full compliance with the Endangered Species Act or other ARARs. The Migratory Bird Treaty Act is also a location-specific ARAR for planned remedial actions/decisions implemented on the Oak Ridge Reservation.

DOE Response: Surveys by DOE in 1994 (DOE/OR/01-1302/V1) and 1996 (ES/ER/TM-188/R1) indicated there were no threatened or endangered species or designated critical habitat identified in the Bethel Valley watershed. Therefore, a specific monitoring plan for the Endangered Species Act is not required.

The DOE will conduct post-remediation monitoring to evaluate compliance with RAOs, as specified in Sect. 2.12.3 of the ROD, to ensure that protection of human health and the environment is achieved. The monitoring includes evaluation of residual contamination levels related to ecological protection in surface water, soils, and sediments. Additionally, DOE will carefully evaluate its remediation activities to ensure full compliance with the Endangered Species Act and other ARARs in the ROD.

The DOE believes that the Migratory Bird Treaty Act (MBTA), in particular Sect. 703, taking, killing, or possessing migratory birds unlawful, is not an ARAR for actions in Bethel Valley. The MBTA Sect. 703 generally prohibits taking (e.g., killing, capturing, possessing, offering for sale, export, etc.) of migratory birds or their nests except as prescribed in hunting regulations and is not really an environmental protection statute but rather has been dubbed by legal commentators as a "hunting law." This act has not been cited as an ARAR in other RODs on the ORR.

Miscellaneous

- Page 19 (Alternative C-1-No Action) and page 20 (Alternative W-1-No Action). The no-action alternative seems ambiguous in DOE CERCLA documents. Does it mean cessation of existing protective procedures as suggested in this document? Or does it mean not proceeding with any of the

other alternatives? If the former, chances are it would not be allowed by the regulators. For purposes of comparison of alternatives, the current status should be the baseline.

DOE Response: The no action alternative is cessation of existing protective procedures in both alternatives. It matches the conditions of the baseline risk assessments. This definition is necessary to demonstrate that the current protective procedures are necessary. The no action alternatives are not intended to be viable alternatives, they are developed to be a basis for comparison with other alternatives and to illustrate that basic institutional controls are needed. The alternative that is described above as not adding more actions is considered a limited action alternative. It was not evaluated for Bethel Valley.

- On December 2, 1999, U.S. Fish and Wildlife Service (Service) personnel participated in a conference call with DOE representatives regarding our comments on the *Remedial Investigation/Feasibility Study for Bethel Valley Watershed, Oak Ridge, Tennessee* (DOE/OR/01-1748/V2&D2). We expressed numerous concerns about the need for a complete characterization of the nature and extent of contamination present in the Bethel Valley watershed, and about the specific assumptions made in the ecological risk assessment. We were assured that "although the scope of additional data collection and evaluation for design purposes for ecological protection is not yet defined, input from the Service will be used and incorporated as appropriate." Unfortunately, the subject proposal is very general in terms of a post-interim remedial action-monitoring plan to address remaining uncertainties.

DOE Response: Development of the monitoring plans has not yet begun. The Service will have the opportunity to provide input in the development of a more comprehensive monitoring plan after the BV ROD has been signed and during subsequent updates of the monitoring plan.

- With this PP the DOE has abandoned the *Annotated Outlines for Documents required by the Federal Facility Agreement and CERCLA for Oak Ridge Reservation Sites, January 1993.* The FFA Project Manager's Office assures the CAP that new versions of the Annotated Outlines are out for DOE review and will soon be in place. The Annotated Outlines provide both a set of tools and a quantitative measure for ORR CERCLA documents. The CAP reserves the right to comment on the revised and updated Annotated Outlines when they are released to the public.

DOE Response: The existing annotated outline was not used for this PP as noted by the commenter. The outline is considered out of date. New versions of all annotated outlines are being generated. The new versions of the Annotated Outlines for the PP and ROD will take into account the July 1999 guidance from EPA on preparing proposed plans, records of decision, and other remedy selection decision documents. Although there is no specific requirement for public involvement with the Annotated Outlines, DOE would welcome review of the Outlines by the public.

- The CAP found it difficult to discover the documentation for the decisions reached between parties for the Federal Facility Agreement (FFA) for this PP. The Administrative Record File is deficient in this respect. The *Procedure for Environmental Restoration Administrative Records Management - 1991* states that the following should be included: DOE and regular signature correspondence, approved/signed regulator meeting minutes, regulator telephone conversations, telephone conversations (contractor level), and internal communications (contractor level). When the Administrative Record File becomes the Administrative Record (at the point the ROD is signed), DOE and the regulators must ensure that the Administrative Record is complete as specified in the cited procedure.

DOE Response: Prior to signature of the ROD, the Administrative Record was reviewed to ensure inclusion of all appropriate documents.

- DOE's follow-up action will be the groundwater ROD; it was mentioned earlier in the presentation that DOE will evaluate the effects of source removal on the groundwater. How long will it take to evaluate the effects? What kind of response do you expect to see?

DOE Response: DOE is currently anticipating developing an additional ROD for East and West Bethel Valley groundwater after 3 to 5 years of monitoring has occurred on the groundwater following implementation of the interim actions. Source control actions in the main portion of ORNL are not anticipated to be completed until the facility is no longer operational in the current 3000 Area. Therefore, the groundwater decision on this portion of the plant is delayed past 2010. It is anticipated that in all cases, the interim actions should result in a decrease in nearby groundwater concentrations within a few years. This strategy for further decision making is still under negotiation with EPA and TDEC.

- What is the estimate of the average flow in White Oak Creek?

DOE Response: In 1994, the mean flow measured at the 7500 Bridge was 20,800 L/min (5500 gal/min). However, the flow volume can normally vary from 3,800 to 38,000 L/min (1000 to 10,000 gal/min) depending on rainfall.

- How many buildings will be left at ORNL after completion of the D&D work?

DOE Response: Upon completion of the D&D activities outlined in this ROD, more than 100 buildings including wastewater treatment plants, operational laboratories, and office spaces, will remain.

- Are any of the hot cell facilities active today?

DOE Response: None of the hot cells covered by this ROD are being used. There are a number of active hot cells at the ORNL site that UT-Battelle is maintaining.

- Page 2: Recommend the addition of the "Feasibility Study DOE/OR/01-1748/V1&V2&D2" to the list of references of the PP.

DOE Response: Although the PP will not be revised, the RI/FS for Bethel Valley Watershed is included in the list of references for this ROD.

- Recommend that the LUCAP be added to the list of references of the PP.

DOE Response: Although the PP will not be revised, the 1999 MOU between DOE, EPA, and TDEC (which includes the LUCAP) is included in the References section of this ROD.

- Recommend that the following be added to the Glossary: Land Use Control (LUC), Land Use Control Assurance Plan (LUCAP), and Land Use Control Implementation Plan (LUCIP).

DOE Response: The PP will not be revised.

- Page 19 (top of 2nd column). Suggest that "Table B.3." be added to "a and b" (a and b; Table B.3) also on pages 20 and 21. Readers need to know where "a and b" can be found.

DOE Response: The PP will not be revised.

- Several reviewers suggested that a basic flow chart of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process would assist in understanding the schedule and sequence of activities and decisions for the watershed approach to decision making.

DOE Response: Although the PP will not be revised, this comment will be taken into.consideration for future PPs.

APPENDIX A

SELECTED REMEDIES FOR INDIVIDUAL POTENTIAL SOURCE UNITS

Table A.1. Selected remedy for individual potential source units in Bethel Valley, ORNL, Oak Ridge, Tennessee

Waste type	FFA or FS unit name (Bldg. No.)	SWMU number	Selected remedy
Facilities	Low Intensity Test Reactor Heat Exchanger (3077)		No further action. Facility has been completely removed.
	Thorium Storage Wells 1–10		No further action. Thorium storage wells removed in earlier maintenance action.
	Graphite Reactor (Bldg. 3001)		Contain reactor core.
	3001 Storage Canal (Graphite Reactor)	1.79	No further remedial action. Land use controls.
	High Radiation Level Analytical Facility (3019B) Transfer Canal and Dissolver Pit (3505) Metal Recovery Facility (3505) Fission Product Development Laboratory (3517) Fission Product Pilot Plant (3515) Graphite Reactor Storage Canal Overflow (3001/3019) Graphite Reactor Filter House (3002) Underground Exhaust Ducts 3001–3003 Graphite Reactor Stack (3018) Krypton-85 Enrichment Facility (3026C) Graphite Reactor Fan House (3003) Metal Segmenting Hot Cell Facility (3026D) 3110 Filter House (including isotopes ductwork) ORRR Cell Vent Filters (3139) Low Intensity Test Reactor (3005) Oak Ridge Research Reactor (3042) ORRR NOG Filter Pit Charcoal Filter (3126) ORRR 25-Meter Target House [Flight Tube Building (3107)] Alpha Powder Facility (3028) Radioisotope Production Laboratory-C (3030) Bulk Shielding Reactor (3010) Source Development Laboratory (3029) ORRR Neutron Spectrometer Station (Neutron Flight Tube Bldg. 3083) Radioisotope Production Laboratory-H (3118) Radioisotope Production Laboratory-D (3031) Radioactive Packaging and Handling Facility (3038-M) Alpha Handling Facility (3038 AHF) Isotope Material Laboratory (3038-E) ORRR A/C Cooling Tower (3089) Pool-water Cooling Tower (3086) Radioisotope Production Laboratory-E (3032)	1.62 1.8	Remove inactive buildings/facilities to grade level. Decontaminate and stabilize or remove structures at or below grade, depending on cost effectiveness and extent of soil contamination. Dispose of debris at EMWMF or other suitable facility.

Table A.1. Selected remedy for individual potential source units in Bethel Valley, ORNL, Oak Ridge, Tennessee (continued)

Waste type	FFA or FS unit name (Bldg. No.)	SWMU number	Selected remedy
Facilities (continued)	ORRR POG Filter Pit Off-Gas Filter (3109) Storage Pad (3099) Krypton Storage Cubicle (3093) ORRR 10,000-Gallon Decay Tank Radioactive Gas Processing Facility (3033) ORRR Pumphouse (3085) ORRR Heat Exchanger (3087) Radioactive Production Laboratory Annex (3033A) Radioisotope Services Building (3034) Aboveground Demineralized-Water Holding Tanks ORRR Heat Exchanger Pit (3102) ORRR Cooling Tower No. 3 (3103) High-Level Chemical Development Lab Filter Pit (4556) High-Level Chemical Development Laboratory (4507) Water Demineralizer (3004) BSR Pumphouse (3009) BSR Storage (3088) BSR Filter House (3098) Storage Shed (3101) BSR Cooling Tower (3117) BSR Heat Exchanger and Pumphouse (3119)		Remove inactive buildings/facilities to grade level. Decontaminate and stabilize or remove structures at or below grade, depending on cost effectiveness and extent of soil contamination. Dispose of debris at EMWMF or other suitable facility.
	Tritium Target Preparation Facility (7025)		Demolish surface facilities to 3 m (10 ft) below grade and dispose of debris in ORR EMWMF or other suitable facility. Remove loose contamination from remaining substructures and backfill with soil or flowable fill.
	Waste Evaporator Facility (3506)	1.62	Facility demolished and basement filled. No further action. Land use controls.
Buried waste	SWSA 3	3.1	Install a multilayer cap to protect the maintenance worker and recreational user and to minimize impacts to groundwater; install upgradient diversion trench to minimize impacts to groundwater.
	SWSA 1 (2624)	1.46	Install a cap. Land use controls.
	NRWTP Debris Pile Former Waste Pile Area (south of NRWTP)	1.58	Install/maintain 0.6 m (2 ft) of soil cover. Land use controls.
	Contractor's Landfill (1554)	3.3	Maintain soil cover to protect the maintenance worker and recreational user.
Gunite and concrete tank shells	Inactive LLLW Tank W-1 Inactive LLLW Tank W-2 Inactive LLLW Tank W-11	1.23A 1.23B 1.27	Grouted in early action. No further remedial action. Land use controls.
	Inactive LLLW Tank W-3 Inactive LLLW Tank W-4	1.24A 1.24B	Grouting of tank shells to occur under planned non-time-critical removal action. Land use controls.

Table A.1. Selected remedy for individual potential source units in Bethel Valley, ORNL, Oak Ridge, Tennessee (continued)

Waste type	FFA or FS unit name (Bldg. No.)	SWMU number	Selected remedy
Gunite and concrete tank shells (continued)	Inactive LLLW Tank W-5	1.26A	Grouting of tank shells to occur under planned non-time-critical removal action. Land use controls.
	Inactive LLLW Tank W-6	1.26B	
	Inactive LLLW Tank W-7	1.26C	
	Inactive LLLW Tank W-8	1.26D	
	Inactive LLLW Tank W-9	1.26E	
	Inactive LLLW Tank W-10	1.26F	
	Inactive LLLW Tank TH-4	1.32	Grouted in early action. No further remedial action. Land use controls.
	Inactive LLLW Tank 3003-A	1.74	
Steel tanks	Inactive LLLW Tank W-1A	1.28	To be addressed as part of source removal for the Core Hole 8 Plume.
	Inactive LLLW Tank W-20	1.56B	Tanks grouted in early action. No further remedial action. Land use controls.
	Inactive LLLW Tank W-19	1.56A	
	Inactive LLLW Tank W-17	1.42B	
	Inactive LLLW Tank W-16		
	Inactive LLLW Tank W-18	1.42C	
	Inactive LLLW Tank WC-4	1.36	
	Inactive LLLW Tank WC-3	1.35	
	Inactive LLLW Tank WC-9	1.37D	
	Inactive LLLW Tank W-11	1.66	
	Inactive LLLW Tank WC-10	1.39A	
	Inactive LLLW Tank WC-11	1.39B	
	Inactive LLLW Tank WC-1 (and Valve Pit)	1.29	
	Inactive LLLW Tank WC-12	1.39C	
	Inactive LLLW Tank WC-13	1.39D	
	Inactive LLLW Tank WC-15	1.30A	
	Inactive LLLW Tank WC-17	1.30B	
	Inactive LLLW Tank W-13	1.25A	
	Inactive LLLW Tank W-14	1.25B	
	Inactive LLLW Tank W-15	1.25C	
	Inactive LLLW Tank H-209	1.71	
	Inactive LLLW Tank 3013	1.76	
	Inactive LLLW Tank W-12	1.41	
	Inactive LLLW Tank WC-7	1.38	
	Inactive LLLW Tank TH-1	1.31A	
	Inactive LLLW Tank TH-2	1.31B	
	Inactive LLLW Tank WC-8	1.37C	
	Inactive LLLW Tank WC-6	1.37B	
	Inactive LLLW Tank WC-5	1.37A	
	Inactive LLLW Tank TH-3	1.31C	
	Inactive LLLW Tank WC-2	1.34	
	Inactive LLLW Tank WC-19	1.40	
	Inactive LLLW Tank WC-14	1.39E	
	Inactive LLLW Tank 2026A	1.33	Tanks grouted in early action. Remove vaults to 0.6 m (2 ft) below grade if contaminated and backfill. Land use controls.
	Inactive LLLW Tank F-501	1.65B	
	Inactive LLLW Tank S-424	1.64C	Remove tank contents, grout tank in place. Remove vaults to 0.6 m (2 ft) below grade if contaminated and backfill.

Table A.1. Selected remedy for individual potential source units in Bethel Valley, ORNL, Oak Ridge, Tennessee (continued)

Waste type	FFA or FS unit name (Bldg. No.)	SWMU number	Selected remedy
Steel tanks (continued)	Inactive Filter House Seal Tank 3002-A Inactive LLLW Tank 4501-P Inactive LLLW Tank T-30 Inactive LLLW Tank 3001-B Inactive LLLW Tank 3004-B Inactive LLLW Tank F-201	1.68 1.67C 1.78 1.73 1.75 1.65A	Tanks grouted in early action. Remove vaults to 0.6 m (2 ft) below grade if contaminated and backfill. Land use controls.
	Inactive LLLW Tank LA-104 (F-104)	1.70	Tank removed in earlier action. Address vault as part of Bldg. 3047 D&D.
Melton Valley steel tanks	Inactive HFIR Complex LLLW Tank T-1 Inactive HFIR Complex LLLW Tank T-2 Inactive HFIR Complex LLLW Tank	8.7A 8.7B 8.6	Remove tank contents, grout tanks in place.
	Inactive Tank T-14	5.16	Tank grouted in early action. No further remedial action. Land use controls.
	Inactive Tank WC-20	8.5	Tank grouted in early action. Remove vaults to 0.6 m (2 ft) below grade if contaminated and backfill. Land use controls.
Mercury-contaminated soil	Mercury-Contaminated Soil (Bldg. 3592) Mercury-Contaminated Soil (Bldg. 3503) Mercury-Contaminated Soil (Bldg. 4508) Mercury-Contaminated Soil (Bldg. 4501)	1.2 1.1 1.4 1.3	Conduct design investigation. See Fig. 2.34 to determine if excavation is required. Land use controls.
Radioactively contaminated soil	Contaminated Surfaces and Soil from 1959 Explosion in Bldg. 3019 Cell Contaminated soil detected through radiological walkover		Excavate contaminated soil above remediation levels to up to 0.6 m (2 ft) and backfill with clean soil. Dispose at the ORR EMWMF or other suitable facility.
	7078 Area Former Construction Dump Site Abandoned Burn Pit C-14 Allocation in Woody Biomass Plantation Species	0.11 0.1	Conduct design investigation. See Fig. 2.34 to determine if excavation of contaminated soil to depth of 3 m (10 ft) is required.
	West End Dump Site	0.61	Conduct design investigation. See Fig. 2.34 to determine if excavation of contaminated soil is required.
	SWSA 3 Contaminated Soil No. 1 Soil No. 2 Soil No. 3 Closed Scrap Metal Area (1562)	 3.2	Excavate contaminated soil above remediation levels. Use as below-cap fill.
	ORRR Decay Tank Rupture Site (3087) Decommissioned Waste Holding Basin (3512) (soils) 3517 Filter Pit Contaminated Soil (Fission Product Development Laboratory) LLLW Lines and Leak Sites—Northwest of SWSA 1 LLLW Lines and Leak Sites—East of Bldg. 2531	 1.11 1.20 1.5V 1.5N	Conduct design investigation. See Fig. 2.34 to determine if excavation of contaminated soil to minimize impacts to groundwater is required. Surface soil will undergo evaluation per Fig. 2.34.

Table A.1. Selected remedy for individual potential source units in Bethel Valley, ORNL, Oak Ridge, Tennessee (continued)

Waste type	FFA or FS unit name (Bldg. No.)	SWMU number	Selected remedy
Radioactively contaminated soil (continued)	LLLW Lines and Leak Sites—Southwest Corner of Bldg. 3019	1.5E	Conduct design investigation. See Fig. 2.34 to determine if excavation of contaminated soil to minimize impacts to groundwater is required. Surface soil will undergo evaluation per Fig. 2.34.
	Fission Product Development Laboratory LLLW Transfer Line	1.21	
	LLLW Lines and Leak Sites—Bldg. 3518, West Contamination at Base of 3019 Stack	1.5U	
	LLLW Lines and Leak Sites—North of Bldg. 3019 WC-10 LLLW Line Leak Site	1.5D	
	LLLW Lines and Leak Sites—West of Bldg. 3082	1.5C	
	LLLW Lines and Leak Sites—South of Bldg. 3020	1.5A	
	LLLW Lines and Leak Sites—East of Bldg. 3020 Stack Fission Product Pilot Plant Contaminated Soil	1.5B	
	LLLW Lines and Leak Sites—Under Bldg. 3515	1.5O	
	LLLW Lines and Leak Sites—Bldg. 3525 to a Sump	1.5P	Conduct design investigation. See Fig. 2.34 to determine if excavation of contaminated soil to minimize impacts to groundwater is required. Land use controls. Maintain minimum 0.6-m (2-ft) soil cover.
	LLLW Lines and Leak Sites—Under Bldg. 3026	1.5J	
	LLLW Lines and Leak Sites—Abandoned Line Central Avenue Area	1.5S	
	LLLW Lines and Leak Sites—Under Bldg. 3550	1.5Q	
	LLLW Lines and Leak Sites—Between W-5 and WC-19	1.5F	
	LLLW Lines and Leak Sites—Bldg. 3092 Area	1.5I	
	LLLW Lines and Leak Sites—Bldg. 3503 Ground Contamination	1.5W	
	LLLW Lines and Leak Sites—Sewer Near Bldg. 3500	1.5R	
	LLLW Lines and Leak Sites—Bldg. 3028	1.5M	
	LLLW Lines and Leak Sites—Between WC-1 and W-5	1.5K	
	LLLW Lines and Leak Sites—ORRR Water Line (Bldg. 3085)	1.5L	
	LLLW Lines and Leak Sites—Under Bldg. 3047	1.5G	
	LLLW Lines and Leak Sites—General Isotopes Area (3037, 3038, 3034) Low Intensity Test Reactor Ponds (3085W)	1.5H	
	LLLW Lines and Leak Sites—Bldg. 4508, North	1.5T	

Table A.1. Selected remedy for individual potential source units in Bethel Valley, ORNL, Oak Ridge, Tennessee (continued)

Waste type	FFA or FS unit name (Bldg. No.)	SWMU number	Selected remedy
Radioactively contaminated soil (continued)	North and South Tank Farm Contaminated Soil (includes Tank W-1A Contaminated Soil)		Conduct design investigation to determine if all source removed. See Fig. 2.34 to determine if more excavation to minimize impacts to groundwater is required.
	SWSA 2 (4003)	1.47	Land use controls. Maintain minimum 0.6-m (2-ft) soil cover.
	Equalization Basin (3524) Waste Holding Basin (3513) Process Waste Pond (3540) Process Waste Pond (3539)	1.13 1.12 1.15 1.14	Sediment removed under SIOU. No further remedial action.
	Abandoned Underground Waste Oil Storage Tank 7002A (soils)		Conduct design investigation. See Fig. 2.34 to determine if excavation of contaminated soil to a depth of 3 m (10 ft) is required.
Pipelines	Inactive LLLW pipelines in the controlled industrial area		Grout LLLW pipelines. Contain bedding material allowing discharge of contaminated groundwater to surface water using grouted trench barriers or equivalent. D&D associated structures. Dispose of at the EMWMF or other suitable facility.
	Inactive LLLW pipelines and contaminated process lines outside the controlled industrial area		Remove pipelines and contaminated bedding material. D&D associated structures. Dispose of at the EMWMF or other suitable facility.
Sediment	White Oak Creek, First Creek, and Fifth Creek soil/sediment		Remove sediment to depth of deposition. Dispose of at the EMWMF or other suitable facility.
Groundwater	Core Hole 8 Plume/WAG 1 Groundwater (Storm Flow)		Install groundwater extraction wells and sumps in existing junction boxes. Treat water at PWTC.
	Core Hole 33 Plume		Controlled through existing sumps
	South Area Plume West Bethel Valley Plume		Monitoring
	Contaminated sumps/WAG 1 Groundwater (Storm Flow)		Collect and treat water from sumps
	East Bethel Valley VOC Plume		In situ bioremediation
	Bethel Valley Unneeded Wells		Grout poor-quality or obsolete monitoring wells and piezometers and abandon in place (est. 229 wells)
Land parcels available for transfer to non-federal ownership (Appendix E)	6.6-acre area, predominantly an asphalt-paved parking lot east of Bldg. 4500 North		No further action for soil; land use controls
	1.7-acre parking lot area northeast of Bldg. 5002		
	1-acre parking lot area northwest of Bldg. 1505		

Table A.1. Selected remedy for individual potential source units in Bethel Valley, ORNL, Oak Ridge, Tennessee (continued)

A/C = Air-conditioning
BSR = Bulk Shielding Reactor
D&D = decontamination and demolition
EMWMF = Environmental Management Waste Management Facility
est = estimated
FWPA = Former Waste Pile Area
HFIR = High Flux Isotope Reactor
LLLW = liquid low-level (radioactive) waste
LLW = low-level (radioactive) waste
NOG = normal off-gas
NRWTP = Nonradiological Wastewater Treatment Plant
ORNL = Oak Ridge National Laboratory
ORR = Oak Ridge Reservation
ORRR = Oak Ridge Research Reactor
POG = pressurized off-gas
PWTC = Process Waste Treatment Complex
ROD = record of decision
SIOU = Surface Impoundments Operable Unit
SWMU = Solid Waste Management Unit
SWSA = solid waste storage area
VOC = volatile organic compound
WAG = waste area grouping

APPENDIX B

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Section 121(d) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) specifies, in part, that remedial actions for cleanup of hazardous substances must comply with requirements and standards under federal or more stringent state environmental laws and regulations that are applicable or relevant and appropriate (ARAR) to the hazardous substances or particular circumstances at a site or obtain a waiver [see also 40 Code of Federal Regulations (*CFR*) 300.430(f)(1)(ii)(B)]. ARARs include only federal and state environmental or facility siting laws/regulations and do not include occupational safety or worker radiation protection requirements. In addition, per 40 *CFR* 300.400(g)(3), other advisories, criteria, or guidance may be considered in determining remedies [the so-called to be considered (TBC) guidance category]. In accordance with 40 *CFR* 300.400(g), the U.S. Department of Energy (DOE), the Tennessee Department of Environment and Conservation (TDEC), and the U.S. Environmental Protection Agency (EPA) have identified the specific ARARs and TBCs for the specified actions. The selected remedy complies with all ARARs/TBCs related directly to implementing the selected actions and does not require an ARAR waiver(s). Tables B.1, B.2, and B.3, respectively list the chemical-, location-, and action-specific ARARs/TBCs for component actions in the selected remedy. A brief description of key ARAR/TBC issues follows.

CHEMICAL-SPECIFIC ARARs/TBC

Chemical-specific ARARs provide health- or risk-based concentration limits or discharge limitations in various environmental media (i.e., surface water, groundwater, soil, air) for specific hazardous substances, pollutants, or contaminants and are listed on Table B.1 and discussed below.

Surface Water. White Oak Creek is designated for *Fish and Aquatic Life*, *Recreation*, and *Livestock Watering and Wildlife* uses, but not for *Domestic* or *Industrial Water Supply* or for *Irrigation*. All other named and unnamed surface waters in the watershed, including Raccoon Creek and the Northwest Tributary, are also classified for *Irrigation* by default under Rules of the TDEC Chapter 1200-4-4. Treatment of mercury-contaminated groundwater collected from building sumps before discharge to White Oak Creek is planned. On completion of the source control actions in Bethel Valley, numeric ambient water quality criteria (AWQC) and narrative criteria for the protection of human health and aquatic organisms for site-related contaminants will be met in all surface waters located in Bethel Valley in a reasonable timeframe per 40 *CFR* 300.435(f)(3). Consistent with EPA guidance (EPA-823-B-94-005A, 1994), compliance with numeric AWQC for *Recreation* and *Fish and Aquatic Life* use classifications is sufficiently stringent to ensure protection of other uses for which there are narrative, but not numeric, criteria (i.e., *Irrigation* or *Livestock Watering and Wildlife*).

Groundwater. Extraction and treatment of the Core Hole 8 Plume and bioremediation of the East Bethel Valley volatile organic compound (VOC) Plume will minimize further impacts to groundwater by minimizing further growth of the plumes. Safe Drinking Water Act of 1974 (SDWA) maximum contaminant levels (MCLs)/maximum contaminant level goals (MCLGs) will be used during this action as values to assess groundwater quality and to evaluate effectiveness of source-control actions. Final groundwater decisions for Bethel Valley are being deferred to a later decision document. At that time, a decision will be made as to whether the SDWA MCLs/MCLGs are ARAR for groundwater cleanup. Depending on the classification of the groundwater, remediation goals may include restoring groundwater to meet any corresponding criteria (both numeric and narrative) that are ARAR. Following completion of all source actions in Bethel Valley, a final groundwater decision will be made.

Radiation Protection. Relevant and appropriate U.S. Nuclear Regulatory Commission (NRC) radiation protection requirements include (1) an exposure limit for individual members of the public of 100 mrem/year total effective dose equivalent (EDE) from all sources excluding dose contributions from background radiation, medical exposures, or voluntary participation in medical/research programs [10 *CFR* 20.1301(a)(1)]; and (2) the need to further reduce exposures to as low as reasonably achievable (ALARA) levels [10 *CFR* 20.1101(b)]. Notwithstanding these ARARs, proposed actions (e.g., removing or covering contaminated soils) will limit exposures to radioactive contaminants and protect all users to a risk level within the target risk range, consistent with the EPA guidance on CERCLA risk levels for radionuclides (EPA Office of Solid Waste and Emergency Response Directive 9200.4-18) and DOE Order 5400.5 TBC requirements for residual radioactivity in soils.

LOCATION-SPECIFIC ARARs/TBC

Location-specific requirements establish restrictions on permissible concentrations of hazardous substances or establish requirements for how activities will be conducted because they are in special locations (e.g., wetlands, floodplains, critical habitats, historic districts, streams). Table B.2 lists federal and state location-specific ARARs for protection of cultural or sensitive resources.

Cultural Resources. Many of the buildings/structures to be removed during building remediation activities are within the Oak Ridge National Laboratory (ORNL) Historic District, which encompasses the 2000–4000 areas of Central Bethel Valley. This ORNL Historic District has been recommended for inclusion in the National Register of Historic Places under the National Historic Preservation Act (NHPA). Additionally, the Graphite Reactor is a registered National Historic Landmark. Adverse effects on historic properties will be taken into account, and measures to minimize or mitigate them will be evaluated per applicable NHPA requirements.

Aquatic Resources. Removal of contaminated sediment and floodplain soils may involve diversion of stream flow, bank stabilization, removal of riparian vegetation, and dredging. All land-disturbing construction activities (e.g., excavation, trenching, capping, soil covers, etc.) with the potential to impact surface waters from storm water runoff will be designed and implemented using best management practices as well as erosion and sedimentation controls to comply with storm water control and aquatic resource alteration requirements. Additionally, the Clean Water Act of 1972, as amended (CWA) Section 404 requirements for protection of aquatic resources at 40 *CFR* 230.10 must be met if the action involves any discharges of dredged or fill material into aquatic ecosystems. Applicable requirements to protect aquatic resources during land-disturbing construction operations are listed in Table B.2.

Wetlands/Floodplains. The selected remedy includes excavation of contaminated floodplain soils and sediments to minimize contaminant levels to acceptable risk-based cleanup levels. Actions must avoid, to the extent possible, adverse impacts to wetlands and floodplains, in accordance with Executive Order 11990 and 10 *CFR* 1022. Nonetheless, there will be some adverse effects on wetlands adjacent to White Oak Creek, First Creek, and Fifth Creek. Mitigation measures listed in 10 *CFR* 1022.12, which include minimum grading requirements, runoff controls, and design and construction constraints, would be implemented. Mitigation strategies for destroyed or disturbed wetlands include restoration, enhancement, or creation of wetlands in the Bethel Valley area at a 1:1 replacement ratio. These strategies will be detailed in the Remedial Design Report/Remedial Action Work Plan. ARARs for protection of aquatic resources, including wetlands and floodplains, will be met during these activities and are listed in Table B.2.

Threatened or Endangered Species. The federally endangered gray bat (*myotis grisescens*) and pink mucket (*hampsilis abrupta*) have been seen in the vicinity of Bethel Valley; however, there are no designated critical habitats located in the valley. Nevertheless, precautions will be taken such that any

state or federally endangered species will not be adversely affected by actions included as part of the selected remedy.

ACTION-SPECIFIC ARARs/TBCs

Action-specific ARARs include operation, performance, and design requirements or limitations based on the waste types, media, and remedial activities. Component actions include capping, upgradient stormflow diversion, sludge removal, water treatment, groundwater extraction/treatment, contaminated surface soil removal actions, grouting and/or removal of inactive pipelines, decontamination and decommissioning (D&D), groundwater well construction and plugging and abandonment (P&A), institutional controls, waste management, and transportation. ARARs for each component action are listed in Table B.3 and briefly discussed below.

General Construction Activities. Requirements for the control of fugitive dust and storm water runoff are listed in Table B.3 and potentially provide ARARs for all construction, demolition, excavation, trenching and site preparation activities. Reasonable precautions will be taken and include the use of best management practices for erosion control to prevent runoff, and application of water on exposed soil/debris surfaces to prevent particulate matter from becoming airborne. In addition, diffuse or fugitive emissions of radionuclides to the ambient air from the remediation activities, which are only one of potentially many sources of radionuclide emissions at a DOE facility, must comply with the Clean Air Act of 1970, as amended (CAA) requirements in 40 *CFR* 61.92.

Capping. Containment is proposed for Solid Waste Storage Area (SWSA) 1, SWSA 3, the Former Waste Pile Area (FWPA), the Contractors Landfill, and the Nonradiological Wastewater Treatment Plant (NRWTP) Debris Pile. Historic disposal records indicate the potential for wastes containing Resource Conservation and Recovery Act of 1976 (RCRA) hazardous constituents at levels that would render it characteristic if generated as well as solid low-level (radioactive) waste (LLW) in SWSA 3; therefore, RCRA and TDEC/NRC requirements for closure with waste in place are relevant and appropriate for capping SWSA 3. Specifically, an impermeable cap will be designed to meet all relevant and appropriate RCRA performance-based criteria for final covers, thus ensuring compliance with TDEC/NRC closure requirements. SWSA 1 contains both solid and low-level radioactive wastes. The NRC/TDEC requirements for disposal of radioactive waste are relevant and appropriate for capping SWSA 1.

The FWPA, Contractors Landfill, and NRWTP Debris Pile are inactive disposal areas containing buried solid wastes, including construction/demolition debris. For closure with waste in place, the TDEC solid waste landfill closure performance standard under Rules of the TDEC Chap. 1200-1-7-.04(8)(a) is relevant and appropriate. Soil covers and vegetation would be applied to meet the closure standard for these units, as well as DOE Order 5400.5 requirements (TBC) for residual radioactivity left in place. Any surface debris would be removed prior to capping, characterized, and then sent to the Environmental Management Waste Management Facility (EMWMF) for disposal (see Waste Management subsection below).

Upgradient Diversion Ditches/Downgradient Collection Ditches. Construction of an upgradient diversion ditch at SWSA 3 is proposed. Construction of an upgradient diversion ditch, storm water collection trenches, and any other methods to collect and/or redistribute surface or groundwater may trigger aquatic resource alteration requirements (see Table B.2). Additionally, runoff from a diversion trench, which may be considered a wet weather conveyance, must not degrade or adversely affect the quality of downstream waters. There are no other ARARs for these actions other than general construction requirements described above.

Sludge Removal. Sludge removed from the T1, T2, S-424, and HFIR tanks will be characterized and then transferred to the Melton Valley Storage Tanks (MVST) if the waste meets the waste acceptance criteria (WAC). Temporary staging and management must meet requirements of DOE O 435.1 and DOE M 435.1-1 (TBC) for LLW and, depending on the type and activity of the radionuclides, for transuranic (TRU) waste management. TRU waste that does not meet the WAC for the MVST will be stored on-site for subsequent treatment and disposal and will meet DOE M 435.1-1(Chap. III) requirements as well as relevant EPA requirements at 40 *CFR* 191.03(a) for interim management of TRU waste. LLW sludge that does not meet the WAC for MVST will be disposed at an appropriate off-site facility (e.g., Nevada Test Site) or the on-site cell (i.e., EMWMF). All LLW or TRU liquids (i.e., supernatant) meeting the WAC will be transferred into the liquid low-level (radioactive) waste (LLLW) system for treatment before transfer to MVST. TRU wastes at MVST will be treated and eventually transferred to the Waste Isolation Pilot Plant in accordance with DOE M 435.1-1(III) requirements (TBC).

Removal of Contaminated Media. Removal of contaminated surface and/or floodplain soil is designed to protect ecological and human receptors. Soils removed as part of these actions may be considered Toxic Substances Control Act of 1976 (TSCA) PCBs, LLW, RCRA, solid, hazardous, or mixed waste depending on the extent of contamination and will be disposed of either at the EMWMF or an appropriate off-site facility. Excavated soils/sediments contaminated with PCBs is considered Bulk PCB remediation waste and must be managed accordingly. Any RCRA hazardous soils removed from the areal extent of contamination for subsequent disposal in a land-based unit must meet the pertinent RCRA land disposal restrictions treatment standards for hazardous waste at 40 *CFR* 268.40 or 40 *CFR* 268.49. In the unlikely event these treatment standards cannot be met, a site-specific treatment variance under 40 *CFR* 268.44(h) may be obtained with concurrence of the Federal Facility Agreement parties. See waste generation, characterization, management, treatment, and disposal requirements listed in Table B.3.

There are no action-specific ARARs for these actions other than the general requirements to control fugitive dust emissions and storm water runoff (discussed above). However, chemical-specific ARARs for these actions include radiation protection requirements for the public and for unrestricted or restricted use of sites with residual radioactivity (see Table B.1). Risk-based remediation levels for PCB-contaminated sediments remaining in situ will satisfy risk-based disposal requirements of 40 *CFR* 761.61(c). Also, depending on the location of the soil removal, location-specific ARARs to protect sensitive resources, such as threatened and endangered plants or wildlife, wetlands, and floodplains (listed in Table B.2) may be triggered. All removal actions will be designed to protect the appropriate human receptor and to meet DOE Order 5400.5 TBC guidelines for residual radioactivity left in soil (see Table B.3).

In Situ Grouting. Inactive pipelines that are not removed and any empty tank shells will be stabilized (e.g., grouted) to reduce contaminant releases and minimize impacts to groundwater. There are no specific ARARs for in situ grouting other than the general construction requirements for control of emissions and runoff. Appropriate engineering controls will be implemented if necessary to ensure compliance with air emission standards for fugitive and radionuclide emissions (listed in Table B.3) during grouting of pipelines and tank shells.

Groundwater Treatment/Extraction. Contaminated groundwater will be extracted and treated to minimize further impacts to groundwater and to attain AWQC for protection of aquatic organisms in surface water. Mercury-contaminated groundwater will be piped from sumps to a National Pollutant Discharge Elimination System-permitted wastewater treatment system [i.e., the Process Waste Treatment Complex (PWTC)] before discharge via a permitted outfall into White Oak Creek. The sump-water treatment plant is expected to remove mercury to below required detection levels and meet the WAC for the PWTC. Further treatment at the PWTC will ensure compliance both with effluent limits set at Outfall X12 and compliance with the AWQC for mercury at the 7500 Bridge. Pretreatment for other identified contaminants

will be employed, if necessary, to ensure compliance with the WAC. In addition, four deep extraction wells would be installed at the Core Hole 8 Plume to collect groundwater in bedrock, and seven sumps would be installed in storm drain junction boxes to collect shallow groundwater. These additional sumps would supplement two existing sumps associated with the earlier removal and maintenance actions of the Core Hole 8 Plume. The contaminated groundwater will be collected and transferred to the PWTC.

Also, in situ treatment of the East End VOC plume will be implemented to accelerate degradation of the organic contaminants. There are no ARARs for this activity other than the requirements associated with construction of the injection wells (see discussion below).

Water Treatment. Other wastewaters collected during construction, well drilling, dewatering, or decontamination activities will, if necessary, be transported to the PWTC for treatment and subsequently discharged via a permitted outfall. Wastewaters that are hazardous only because they exhibit a hazardous characteristic, and which are otherwise restricted from land disposal, are not prohibited if such wastes are managed in a treatment system that subsequently discharges to waters of the United States pursuant to a permit issued under Section 402 of the CWA [40 *CFR* 268.1(c)(4)(i); Rules of the TDEC Chap. 1200-1-11-.10(1)(a)(30(iv)(I)].

Well Construction and P&A. Construction of groundwater extraction or monitoring wells and P&A of groundwater monitoring wells will meet relevant and appropriate TDEC requirements listed in Table B.3. Installation of new groundwater monitoring wells will meet relevant and appropriate RCRA well construction requirements. Well P&A will be accomplished in accordance with relevant and appropriate TDEC regulations in a manner to prevent contamination of groundwater. Wells used for injection of nutrients for bioremediation of the East Bethel Valley VOC Plume will meet applicable requirements for construction and operation of a Class V underground injection well.

Building Remediation. A total of 54 facilities in the Bethel Valley area are slated for D&D. All but one of the above-ground structures will be demolished; the Graphite Reactor, which is a National Historic Landmark, will remain on the site and the reactor core stabilized. Once the above-ground structure has been removed, remaining slabs or subsurface structures will be removed, decontaminated, or stabilized, or undergo a combination of these three actions, as appropriate. Requirements under the CAA for control of asbestos, Class I/II refrigerant and/or radionuclide emissions included in Table B.3 will be met during demolition.

Building remediation activities may result in generation of RCRA solid or hazardous waste (e.g., hazardous debris containing lead paint), LLW, mixed waste, asbestos, TSCA PCBs in fluorescent light ballasts or drained equipment, PCB bulk product waste (e.g., demolition debris having surfaces coated with paint containing PCBs greater than 50 ppm), or lead wastes (e.g., lead shielding). Characterization, treatment, storage, and disposal of these wastes must meet the ARARs for waste management listed in Table B.3. Any scrap metal that otherwise is considered RCRA hazardous is not subject to RCRA Subtitle C requirements if it is intended for recycle or reuse. Materials for unrestricted release must meet DOE Order 5400.5 TBC requirements listed in Table B.3 for residual surface radioactive contamination. Decommissioned sites will meet the radiation protection requirements listed in Table B.1 for either restricted or unrestricted use, as appropriate (see chemical-specific ARARs section above).

Land Use Controls. Per Rules of the TDEC Chap. 1200-1-13-.08(10), institutional controls such as water use and deed restrictions/notices are required under this remedy to supplement engineering controls as appropriate to prevent or limit exposure to hazardous substances left in place that may pose an unreasonable threat to public health, safety, or the environment. Such controls will apply after completion of the remedial actions and will be described in the Land Use Control Implementation Plan. These controls may include

land and groundwater use restrictions, as well as deed notices designed to warn and restrict potential users of the contaminated property throughout the valley. Deed restrictions will be recorded in accordance with state law on the original property acquisition records of DOE (and its predecessor agencies) that will notify anyone searching Oak Ridge Reservation property records that certain areas of Bethel Valley are contaminated. In accordance with DOE Order 5400.5(IV)(6)(c), controls including signs to prevent access and appropriate radiological safety measures will be used to prevent disturbance of the residual radioactive material where necessary. An existing program for excavation/penetration permits will be utilized to limit or prohibit such activities in all waste disposal units, remediation systems, and contamination areas. Information on the extent of site contamination will be available to permit requestors.

Waste Management. All primary wastes (soil, D&D debris, sludge) and secondary wastes (contaminated personal protective equipment, decontamination wastewaters) generated during remedial activities will be appropriately characterized as either solid, hazardous, asbestos, PCB, radioactive waste(s), and/or mixed wastes and, respectively, managed in accordance with appropriate RCRA, CAA, TSCA, or DOE Order/Manual requirements. Table B.3 lists the requirements associated with the characterization, storage, treatment, and disposal of the aforementioned waste types.

Transportation. Any wastes that are transferred off-site or transported in commerce along public rights-of-way must meet the U.S. Department of Transportation requirements summarized in Table B.3, for hazardous materials as well as the specific requirements for the type of waste (e.g., RCRA, PCB, TRU, LLW, or mixed). These include packaging, labeling, marking, manifesting, and placarding requirements for the specific waste type. In addition, CERCLA Sect. 121(d)(3) provides that the off-site transfer of any hazardous substance, pollutant, or contaminant generated during CERCLA response actions be sent to a treatment, storage, or disposal facility that is in compliance with applicable federal and state laws and has been approved by EPA for acceptance of CERCLA waste [see also the "Off-Site Rule" at 40 *CFR* 300.440 *et seq.*]. Accordingly, DOE will verify with the appropriate EPA regional contact that any needed off-site facility is acceptable for receipt of CERCLA wastes prior to transfer.

Table B.1. Chemical-specific ARARs and TBC guidance for the selected remedy, Bethel Valley area, ORNL, Oak Ridge, Tennessee

Action/medium	Requirements	Citation(s)
Restoration of surface water(s) classified for *Fish and Aquatic Life* use	Waters shall not contain toxic substances or a combination of substances including disease-causing agents that, by way of either direct or indirect exposure through food chains, may cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions, physical deformations, or restrict or impair growth in fish or aquatic life or their offspring—**applicable or relevant and appropriate**	Rules of the TDEC Chap. 1200-4-3-.03(3)(g)
	May not exceed numeric AWQC in surface water(s) —**applicable or relevant and appropriate**	Rules of the TDEC Chap. 1200-4-3-.03(3)(g)
	Waters shall not contain other pollutants that will be detrimental to fish or aquatic life —**applicable or relevant and appropriate**	Rules of the TDEC Chap. 1200-4-3-.03(3)(h)
Restoration of surface water(s) classified for *Recreation* use	Waters shall not contain toxic substances, whether alone or in combination with other substances, that will render the water unsafe or unsuitable for water contact activities including the capture and subsequent consumption of fish and shellfish, or will propose toxic conditions that will adversely affect man, animal, aquatic life, or wildlife—**applicable or relevant and appropriate**	Rules of the TDEC Chap. 1200-4-3-.03(4)(h)
	May not exceed numeric AWQC in surface water(s)—**applicable or relevant and appropriate**	Rules of the TDEC Chap. 1200-4-3-.03(4)(h)
	Waters shall not contain other pollutants in quantities that may have a detrimental effect on recreation—**applicable or relevant and appropriate**	Rules of the TDEC Chap. 1200-4-3-.03(4)(i)
Restoration of surface water(s) classified for *Irrigation* and/or *Livestock Watering and Wildlife* uses	Waters shall not contain toxic substances, whether alone or in combination with other substances, that will produce toxic conditions that adversely affect the quality of the waters for irrigation and/or livestock watering and wildlife—**applicable or relevant and appropriate**	Rules of the TDEC Chap. 1200-4-3-.03(5)(f) and (6)(f)
	Waters shall not contain other pollutants in quantities that may be detrimental to the waters used for irrigation and/or for livestock watering and wildlife—**applicable or relevant and appropriate**	Rules of the TDEC Chap. 1200-4-3-.03(5)(g) and (6)(g)

Table B.1. Chemical-specific ARARs and TBC guidance for the selected remedy, Bethel Valley area, ORNL, Oak Ridge, Tennessee (continued)

Action/medium	Requirements	Citation(s)
Release of radionuclides into the environment	Exposure to individual members of the public from radiation shall not exceed a total EDE of 0.1 rem/year (100 mrem/year), exclusive of the dose contributions from background radiation, any medical administration the individual has received, or voluntary participation in medical/research programs—**relevant and appropriate**	10 *CFR* 20.1301(a)(1)
	Shall use, to the extent practicable, procedures and engineering controls based on sound radiation protection principles to achieve doses to members of the public that are ALARA—**relevant and appropriate**	10 *CFR* 20.1101(b)

ALARA = as low as reasonably achievable
ARAR = applicable or relevant and appropriate requirement
AWQC = ambient water quality criteria
CFR = *Code of Federal Regulations*
EDE = effective dose equivalent
ORNL = Oak Ridge National Laboratory
TBC = to be considered
TDEC = Tennessee Department of Environment and Conservation

Table B.2. Location-specific ARARs and TBC guidance for the selected remedy, Bethel Valley area, ORNL, Oak Ridge, Tennessee

Location characteristic(s)	Requirement(s)	Prerequisite	Citation(s)
	Wetlands		
Presence of wetlands as defined in 10 *CFR* 1022.4(v)	Avoid, to the extent possible, the long- and short-term adverse effects associated with destruction, occupancy, and modification of wetlands. Measures to mitigate adverse effects of actions in a wetlands include, but are not limited to, minimum grading requirements, runoff controls, design and construction constraints, and protection of ecology-sensitive areas as provided in 10 *CFR* 1022.12(a)(3)	Federal actions that involve potential impacts to, or take place within, wetlands—**applicable**	10 *CFR* 1022.3(a)
	Take action, to the extent practicable, to minimize destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands		10 *CFR* 1022.3(b)(5) and (6)
	Potential effects of any new construction in wetlands shall be evaluated. Identify, evaluate, and, as appropriate, implement alternative actions that may avoid or mitigate adverse impacts on wetlands		10 *CFR* 1022.3(c) and (d)
	Floodplains		
Presence of floodplain as defined in 10 *CFR* 1022.4(i)	Avoid, to the extent possible, the long- and short-term adverse effects associated with occupancy and modification of floodplains. Measures to mitigate adverse effects of actions in a floodplain include, but are not limited to, minimum grading requirements, runoff controls, design and construction constraints, and protection of ecology-sensitive areas as provided in 10 *CFR* 1022.12(a)(3)	Federal actions that involve potential impacts to, or take place within, floodplains—**applicable**	10 *CFR* 1022.3(a)
	Potential effects of any action taken in a floodplain shall be evaluated. Identify, evaluate, and implement alternative actions that may avoid or mitigate adverse impacts on floodplains		10 *CFR* 1022.3(c) and (d)
	Design or modify selected alternatives to minimize harm to or within floodplains and restore and preserve floodplain values		10 *CFR* 1022.5(b)

Table B.2. Location-specific ARARs and TBC guidance for the selected remedy, Bethel Valley area, ORNL, Oak Ridge, Tennessee (continued)

Location characteristic(s)	Requirement(s)	Prerequisite	Citation(s)
	Aquatic resources		
Within an area potentially impacting waters of the state as defined in *TCA* 69-3-103(33)	Must comply with the substantive requirements of the ARAP for erosion and sediment control to prevent pollution	Action potentially altering the properties of any waters of the state — **applicable**	*TCA* 69-3-108(b)(1)(j)
	Erosion and sediment control requirements include, but are not limited to • Limit clearing, grubbing, and other disturbances in areas in or immediately adjacent to waters of the state to the minimum necessary to accomplish the proposed activity; • Unnecessary vegetation removal is prohibited, and all disturbed areas must be properly stabilized and revegetated as soon as practicable; • Limit excavation, dredging, bank reshaping, or grading to the minimum necessary to install authorized structures, accommodate stabilization, or prepare banks for revegetation; • Maintain the erosion and sedimentation control measures throughout construction period; and • Upon achievement of a final grade, stabilize and revegetate, within 30 days, all disturbed areas by sodding, seeding, or mulching, or using appropriate native riparian species	Action potentially altering the properties of any waters of the state —**TBC**	TDEC ARAP Program General Requirements
Location encompassing aquatic ecosystem as defined in 40 *CFR* 230.3(c)	No discharge of dredged or fill material into an aquatic ecosystem is permitted if there is a practicable alternative that would have less adverse impact No discharge of dredged or fill material shall be permitted unless appropriate and practicable steps in accordance with 40 *CFR* 230.70 *et seq.* have been taken that will minimize potential adverse impacts of the discharge on the aquatic ecosystem	Action that involves the discharge of dredged or fill material into waters of the United States, including jurisdictional wetlands—**applicable**	40 *CFR* 230.10(a) 40 *CFR* 230.10(d)

Table B.2. Location-specific ARARs and TBC guidance for the selected remedy, Bethel Valley area, ORNL, Oak Ridge, Tennessee (continued)

Location characteristic(s)	Requirement(s)	Prerequisite	Citation(s)
	Endangered, threatened, or rare species		
Presence of federally endangered or threatened species, as designated in 50 *CFR* 17.11 and 17.12, or critical habitat of such species	Actions that jeopardize the existence of a listed species or results in the destruction or adverse modification of critical habitat must be avoided or reasonable and prudent mitigation measures taken	Action that is likely to jeopardize fish, wildlife, or plant species or destroy or adversely modify critical habitat—**applicable**	16 *USC* 1531 *et. seq.*, Sect. 7(a)(2)
Presence of Tennessee non-game species as defined in *TCA* 70-8-103	May not take (e.g., harass, hunt, capture, kill or attempt to kill), possess, transport, export, or process such wildlife species	Action impacting Tennessee non-game species, including wildlife species that are threatened and endangered or "in need of management" (as listed in TWRCP 94-16 and 94-17) — **applicable**	*TCA* 70-8-104(c)
	May not knowingly destroy the habitat of such wildlife species		TWRCP 94-16(II)(1)(a) and TWRCP 94-17(II)
	Upon good cause shown and where necessary to protect human health or safety, endangered or threatened species may be removed, captured, or destroyed		*TCA* 70-8-106(e) TWRCP 94-16(II)(1)(c)
Presence of Tennessee-listed endangered or rare plant species as listed in Rules of the TDEC Chap. 0400-6-2.04	May not knowingly uproot, dig, take, remove, damage or destroy, possess, or otherwise disturb for any purpose any endangered species	Action impacting rare plant species including but not limited to federally listed endangered species—**applicable**	*TCA* 70-8-309
	Cultural resources		
Presence of historic properties (including artifacts, records, or remains located within such properties)	Must take into account the adverse effects on historic properties per Sect. 106 of the NHPA	Undertaking [as defined in 36 *CFR* 800.16(y)] that has the potential to cause effects on historic property on or eligible for inclusion on the National Register of Historic Places—**applicable**	36 *CFR* 800.1(a) 36 *CFR* 800.3
	Determine adverse effects per 36 *CFR* 800.5(a)(1) and, if found, evaluate alternatives or modifications to the undertaking to avoid, minimize, or mitigate the adverse effects on the property		36 *CFR* 800.5(a) and (d) 36 *CFR* 800.6

ARAP = Aquatic Resource Alteration Permit
ARAR = applicable or relevant and appropriate requirement
CFR = *Code of Federal Regulations*
NHPA = National Historic Preservation Act
ORNL = Oak Ridge National Laboratory
TBC = to be considered
TCA = *Tennessee Code Annotated*
TDEC = Tennessee Department of Environment and Conservation
TWRCP = Tennessee Wildlife Resources Commission Proclamation
USC = *United States Code*

Table B.3. Action-specific ARARs and TBC guidance for the selected remedy, Bethel Valley area, ORNL, Oak Ridge, Tennessee

Action	Requirements	Prerequisite	Citation(s)
	General construction standards—site preparation, excavation, drilling, trenching, etc., activities		
Activities causing fugitive dust emissions	Shall take reasonable precautions to prevent particulate matter from becoming airborne; reasonable precautions shall include, but are not limited to, the following:	Fugitive emissions from demolition of existing buildings or structures, construction operations, grading of roads, or the clearing of land—**applicable**	Rules of the TDEC Chap. 1200-3-8-.01(1)
	• use, where possible, of water or chemicals for control of dust, and • application of asphalt, oil, water, or suitable chemicals on dirt roads, materials stock piles, and other surfaces which can create airborne dusts;		Rules of the TDEC Chap. 1200-3-8-.01(1)(a) Rules of the TDEC Chap. 1200-3-8-.01(1)(b)
	Shall not cause or allow fugitive dust to be emitted in such a manner as to exceed 5 min/h or 20 min/d beyond property boundary lines on which emission originates		Rules of the TDEC Chap. 1200-3-8-.01(2)
Activities causing radionuclide emissions	Shall not exceed those amounts that would cause any member of the public to receive an EDE of 10 mrem per year	Radionuclide emissions from point sources, as well as diffuse or fugitive emissions, at a DOE facility—**applicable**	40 *CFR* 61.92 Rules of the TDEC Chap. 1200-3-11-.08(6)
Activities causing storm water runoff (e.g., clearing, grading, excavation)	Implement good construction management techniques (including sediment and erosion controls, vegetative controls, and structural controls) in accordance with the substantive requirements of *General Permit No. TNR10-0000 Appendix F*, to ensure that storm water discharge	Dewatering or storm water runoff discharges from land disturbed by construction activity— disturbance of ≥5 acres total—**applicable**; < 5 acres—**relevant and appropriate**	*TCA* 69-3-108(j) Rules of the TDEC Chap. 1200-4-10-.03(2)
	• does not violate water quality criteria as stated in TDEC 1200-4-3-.03 including but not limited to prevention of discharges that cause a condition in which visible solids, bottom deposits, or turbidity impair the usefulness of waters of the state for any of the designated uses for that water body by TDEC 1200-4-4	Storm water discharges from construction activities – **TBC**	*General Permit No. TNR10-0000* Part III D.2.a

Table B.3. Action-specific ARARs and TBC guidance for the selected remedy, Bethel Valley area, ORNL, Oak Ridge, Tennessee (continued)

Action	Requirements	Prerequisite	Citation(s)
	• does not contain distinctly visible floating scum, oil, or other matter;		*General Permit No. TNR10-0000* Part III D.2.b
	• does not cause an objectionable color contrast in the receiving stream; and		*General Permit No. TNR10-0000* Part III D.2.c
	• results in no materials in concentrations sufficient to be hazardous or otherwise detrimental to humans, livestock, wildlife, plant life, or fish and aquatic life in the receiving stream		*General Permit No. TNR10-0000* Part III D.2.d
	Capping—SWSA 1, SWSA 3, FWPA, NRWTP Pile, and Contractors Landfill		
Closure of SWSA 3	Must close the unit in a manner that:	Closure of a RCRA hazardous waste management facility—**relevant and appropriate**	40 *CFR* 265.111(a) Rules of the TDEC Chap. 1200-1-11-.05(7)(b)(1)
	• minimizes the need for further maintenance;		
	• controls, minimizes, or eliminates to the extent necessary to protect human health and the environment, postclosure escape of hazardous waste, hazardous constituents, leachate, contaminated runoff, or hazardous waste decomposition products to ground or surface waters or to the atmosphere; and		40 *CFR* 265.111(b) Rules of the TDEC Chap. 1200-1-11-.05(7)(b)(2)
	• complies with the relevant closure requirements of 40 *CFR* 265.310		40 *CFR* 265.111(c) Rules of the TDEC Chap. 1200-1-11-.05(7)(b)(3)
Capping of SWSA 3	Must cover the landfill or cell with a final cover designed and constructed to	Closure of a RCRA hazardous waste management facility—**relevant and appropriate**	40 *CFR* 265.310(a) Rules of the TDEC Chap. 1200-1-11-.05(14)(k)(1)
	• provide long-term minimization of migration of liquids through the closed landfill;		40 *CFR* 265.310(a)(1) Rules of the TDEC Chap. 1200-1-11-.05(14)(k)(1)(i)
	• function with minimum maintenance;		40 *CFR* 265.310(a)(2) Rules of the TDEC Chap. 1200-1-11-.05(14)(k)(1)(ii)
	• promote drainage and minimize erosion or abrasion of the cover;		40 *CFR* 265.310(a)(3) Rules of the TDEC Chap. 1200-1-11-.05(14)(k)(1)(iii)
	• accommodate settling and subsidence so that the cover's integrity is maintained; and		40 *CFR* 265.310(a)(4) Rules of the TDEC Chap. 1200-1-11-.05(14)(k)(1)(iv)

Table B.3. Action-specific ARARs and TBC guidance for the selected remedy, Bethel Valley area, ORNL, Oak Ridge, Tennessee (continued)

Action	Requirements	Prerequisite	Citation(s)
	• have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present		40 *CFR* 265.310(a)(5) Rules of the TDEC Chap. 1200-1-11-.05(k)(1)(v)
Protection of capped SWSA 3	Postclosure use of property must never be allowed to disturb the integrity of the final cover, liners, or any other components of the containment system or the facility's monitoring system unless necessary to reduce a threat to human health or the environment.	Closure of a RCRA landfill—**relevant and appropriate**	40 *CFR* 265.117(c) Rules of the TDEC Chap. 1200-1-11-.05(7)(h)(3)
General postclosure care of capped SWSA 3	Owner or operator must • maintain the effectiveness and integrity of the final cover, including making repairs to the cap as necessary to correct effects of settling, subsidence, erosion, and other events; and • prevent run-on and runoff from eroding or otherwise damaging final cover	Closure of a RCRA landfill—**relevant and appropriate**	40 *CFR* 265.310(b) 40 *CFR* 265.310(b)(1) Rules of the TDEC Chap. 1200-1-11-.06(14)(k)(2) Rules of the TDEC Chap. 1200-1-11-.06(14)(k)(2)(i) 40 *CFR* 265.310(b)(4) Rules of the TDEC Chap. 1200-1-11-.05(14)(k)(2) (iv)
Closure of LLW burial grounds (SWSA 1 and SWSA 3)	Covers must be designed to minimize, to the extent practicable, water infiltration, to direct percolating or surface water away from the disposed waste, and to resist degradation by surface geologic processes and biotic activity	Land disposal of LLW—**relevant and appropriate**	Rules of the TDEC Chap.1200-2-11-.17(2)(d)
	Concentrations of radioactive material which may be released to the general environment in groundwater, surface water, air, soil, plants, or animals must not result in an annual dose exceeding an equivalent of 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ; a reasonable effort shall be made to maintain releases of radioactivity in effluents to the general environment to ALARA		Rules of the TDEC Chap. 1200-2-11-.16(2)

Table B.3. Action-specific ARARs and TBC guidance for the selected remedy, Bethel Valley area, ORNL, Oak Ridge, Tennessee (continued)

Action	Requirements	Prerequisite	Citation(s)
Corrective Measures for SWSA 1 and SWSA 3	Must have plans for taking corrective measures if migration of radionuclides would indicate that the performance objectives of Rules of the TDEC Chap. 1200-2-11-.16 may not be met	Closure of a LLW disposal facility—**relevant and appropriate**	Rules of the TDEC Chap. 1200-2-11-.17(4)(b)
Closure of solid waste disposal units (FWPA, NRWTP Pile, Contractors Landfill)	Must be closed in a manner that minimizes the need for further maintenance and controls, and minimizes, or eliminates, to the extent necessary to protect human health and the environment, postclosure escape of solid waste, solid waste constituents, leachate, contaminated rainfall, or waste decomposition products to the ground or surface waters or to the atmosphere	Closure of a Class I-IV solid waste landfill—**relevant and appropriate**	Rules of the TDEC Chap. 1200-1-7-.04(8)(a)
Sludge removal—TRU waste from tanks (S-424, T1, T2, and HFIR)			
Characterization of TRU waste	Shall be characterized using direct or indirect methods and the characterization documented in sufficient detail to ensure safe management and compliance with the WAC of the receiving facility	Generation TRU waste for management and storage at a DOE facility—**TBC**	DOE M 435.1-1(III)(I)
	Characterization data shall, at a minimum, include the following information relevant to the management of the waste:		DOE M 435.1-1(III)(I)(2)
	• physical and chemical;		DOE M 435.1-1 (III)(I)(2)(a)
	• volume, including the waste and any stabilization or absorbent media;		DOE M 435.1-1(III)(I)(2)(b)
	• weight of the container and contents;		DOE M 435.1-1(III)(I)(2)(c)
	• identities, activities, and concentrations of major radionuclides;		DOE M 435.1-1(III)(I)(2)(d)
	• characterization date;		DOE M 435.1-1(III)(I)(2)(e)
	• generating source;		DOE M 435.1-1(III)(I)(2)(f)
	• packaging date; and		DOE M 435.1-1(III)(I)(2)(g)
	• any other information that may be needed to prepare and maintain the disposal facility performance assessment or demonstrate compliance with the applicable performance objectives		DOE M 435.1-1(III)(I)(2)(h)

Table B.3. Action-specific ARARs and TBC guidance for the selected remedy, Bethel Valley area, ORNL, Oak Ridge, Tennessee (continued)

Action	Requirements	Prerequisite	Citation(s)
Packaging of TRU waste	Shall be packaged in a manner that provides containment and protection for the duration of the anticipated storage period and until disposal is achieved or until the waste is removed from the container	Generation of TRU waste for management and storage at a DOE facility—**TBC**	DOE M 435.1-1(III)(L)(1)(a)
	Vents or other mechanisms to prevent pressurization of containers or generation of flammable or explosive concentration of gases shall be installed on containers of newly generated waste at the time the waste is packaged		DOE M 435.1-1(III)(L)(1)(b)
	Containers of TRU waste shall be marked such that their contents can be identified		DOE M 435.1-1(III)(L)(1)(d)
Temporary storage of TRU waste	Shall be conducted in a manner as to provide reasonable assurance that the combined annual dose equivalent to any member of the general public in the general environment resulting from discharges of radioactive material and direct radiation shall not exceed 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other critical organ	Management and storage of TRU waste at a DOE facility—**relevant and appropriate**	40 *CFR* 191.03(a)
	Shall not be readily capable of detonation, explosive decomposition, reaction at anticipated pressures and temperatures, or explosive reaction with water	Management and storage of TRU waste at a DOE facility—**TBC**	DOE M 435.1-1(III)(N)(1)
	Shall be stored in a location and manner that protects the integrity of waste for the expected time of storage and minimizes worker exposure		DOE M 435.1-1(III)(N)(2)
	Shall be monitored, as prescribed by the appropriate facility safety analysis, to ensure the wastes are maintained in a safe condition		DOE M 435.1-1(III)(Q)(2)
Treatment of TRU waste	Shall be treated as necessary to meet the WAC of the facility receiving the waste for storage or disposal	Generation of TRU waste for storage at a DOE facility and disposal at WIPP—**TBC**	DOE M 435.1-1(III)(O)

Table B.3. Action-specific ARARs and TBC guidance for the selected remedy, Bethel Valley area, ORNL, Oak Ridge, Tennessee (continued)

Action	Requirements	Prerequisite	Citation(s)
	Shall be treated, prepared and packaged to be nonflammable	Generation of pyrophoric TRU waste at a DOE facility—**TBC**	DOE M 435.1-1(III)(N)(1)
Disposal of TRU waste at WIPP	Shall be disposed in accordance with the requirements of 40 *CFR* Part 191	Generation of TRU waste at a DOE facility for disposal at WIPP—**TBC**	DOE M 435.1-1(III)(P)
Removal of contaminated media—White Oak Creek and tributary sediment and floodplain soils; contaminated soil hotspots			
Risk-based disposal of PCB remediation waste	May be disposed of in a manner other than prescribed in 40 *CFR* 761.61(a) or (b) if approved in writing by EPA and method will not pose an unreasonable risk of injury to human health or the environment	Disposal of PCB remediation waste— **applicable**	40 *CFR* 761.61(c)
Remediation of radionuclide-contaminated soil	Guidelines for residual concentrations of radionuclides in soil shall be derived from the basic dose limit using an environmental pathway analysis	Residual radioactive material in soil—**TBC**	DOE Order 5400.5(IV)(4)(a)
D&D activities—inactive facilities in the main plant area			
Decontamination of radioactively contaminated equipment and building structure	Must meet surface contamination guidelines for residual activity provided in Fig. IV-1 of the Order for specified radionuclides	Residual radioactive material on equipment and building structures for unrestricted use—**TBC**	DOE Order 5400.5(IV)(4)(d) and Fig. IV-1
Removal of refrigeration equipment	Disposal of any such appliances, which may vent or otherwise release to the environment any Class I or II substances as a refrigerant is prohibited	Appliances that contain Class I or II substances used as a refrigerant—**applicable**	40 *CFR* 82.154(a)
	No person may dispose of such appliances, with certain exceptions, without • observing the required practices set forth in 40 *CFR* 82.156, and • using equipment that is certified for that type of appliance pursuant to 40 *CFR* 82.158		40 *CFR* 82.154(b)
Removal of RACM from a facility	Procedures for asbestos emission control per 40 *CFR* 61.145(c)(1-10) shall be followed, as appropriate	Demolition of a facility containing RACM exceeding the volume requirements of 40 *CFR* 61.145(a)(1) — **applicable**	40 *CFR* 61.145(c) Rules of the TDEC Chap. 1200-3-11-.02(2)(d)(3)

Table B.3. Action-specific ARARs and TBC guidance for the selected remedy, Bethel Valley area, ORNL, Oak Ridge, Tennessee (continued)

Action	Requirements	Prerequisite	Citation(s)
	Water treatment—on-site treatment and discharge of groundwater, transfer of collected dewatering, decontamination, etc. water		
Transport to ORNL NPDES wastewater treatment facility	All tank systems, conveyance systems, and ancillary equipment used to store or transport waste to an on-site NPDES-permitted wastewater treatment facility are exempt from the requirements of RCRA Subtitle C standards	On-site wastewater treatment units that are subject to regulation under Sect. 402 or Sect. 307(b) of CWA (NPDES permitted)—**applicable**	40 *CFR* 270.1(c)(2)(v) Rules of the TDEC Chap. 1200-1-11-.07(1)(b)(4)(iv)
Discharge of treated groundwater	Shall receive the degree of treatment or effluent reduction necessary to comply with water quality standards and, where appropriate, will comply with the standard of performance as required by the Tennessee Water Quality Control Act of 1977 at *TCA* 69-3-103(30)	Point source discharge(s) of pollutants into surface water—**applicable**	Rules of the TDEC Chap. 1200-4-3-.05(6)
	Are not prohibited from land disposal if such wastes are managed in a treatment system that subsequently discharges to waters of the United States pursuant to a permit issued under Sect. 402 of the CWA, unless the wastes are subject to a specified method of treatment other than DEACT in 40 *CFR* 268.40 or are D003 reactive cyanide	Restricted RCRA characteristically hazardous waste intended for disposal—**applicable**	40 *CFR* 268.1(c)(4)(i) Rules of the TDEC Chap. 1200-1-11-.10(1)(a)(3)(iv)(I)
	Absorbed dose to native animal aquatic organisms must not exceed 1 rad/day	Discharge of radioactive materials in liquid waste to surface water at a DOE facility—**TBC**	DOE Order 5400.5(II)(3)(a)(5)
	In situ grouting—empty tank shells and inactive pipelines		
Emissions from air filter system	Discharge of air contaminants must be in accordance with the appropriate provisions of Rules of the TDEC 1200-3 et seq., any applicable measures of control strategy, and all provisions of the Tennessee Pollution Control Act	Emissions of air pollutants from new air contaminant sources—**applicable**	Rules of the TDEC Chap. 1200-3-9-.01(1)(d)

Table B.3. Action-specific ARARs and TBC guidance for the selected remedy, Bethel Valley area, ORNL, Oak Ridge, Tennessee (continued)

Action	Requirements	Prerequisite	Citation(s)
	Emission measurements in conformance with 40 *CFR* 61.93(b) shall be made	Release points that have the potential to discharge radionuclides into the air in quantities that could cause an EDE in excess of 1% of	40 *CFR* 61.93(b)(4)(i)
	Shall measure all radionuclides that could contribute greater than 10% of the potential EDE for a release point	10 mrem/year to any member of the public —**applicable**	Rules of the TDEC Chap. 1200-3-11-.08(6)
	Periodic confirmatory measurements shall be made to verify low emissions	Other release points that have the potential to release radionuclides into the air—**applicable**	
	Well P&A—all inactive monitoring wells		
Closure of groundwater monitoring well(s)	Well shall be completely filled and sealed in such a manner that vertical movement of fluid either into or between formation(s) containing groundwater classified pursuant to Rules of the TDEC Chap. 1200-4-6-.05(1) through the borehole is not allowed.	Permanent plugging and abandonment of a well—**relevant and appropriate**	Rules of the TDEC Chap. 1200-4-6-.09(6)(d)
	Shall be performed in accordance with the provisions for Seals at Rules of the TDEC 1200-4-6-.09(6)(e), (f), and (g); for Fill Materials at Rules of the TDEC 1200-4-6-.09(6)(h) and (i); for Temporary Bridges at Rules of the TDEC 1200-4-6-.09(6)(j); for Placement of Sealing Materials at Rules of the TDEC 1200-4-6-.09(7)(a) and (b); and for Special Conditions at Rules of the TDEC 1200-4-6-.09(8)(a) and (b), as appropriate		
	Well construction—all new groundwater monitoring wells and extraction wells		
Construction of extraction wells for groundwater treatment	Shall construct, reconstruct, or repair wells in accordance with provisions at Rules of the TDEC Chap. 1200-4-9-.10(4) through (11), as appropriate	Construction, reconstruction, or repair of any water well constructed for the production of water from underground sources—**relevant and appropriate**	Rules of the TDEC Chap. 1200-4-9-.10(1)(a)
	When strict compliance with these standards is impractical, may obtain TDEC approval of equivalent standards (a variance) prior to work being performed		Rules of the TDEC Chap. 1200-4-9-.10(1)(d)

Table B.3. Action-specific ARARs and TBC guidance for the selected remedy, Bethel Valley area, ORNL, Oak Ridge, Tennessee (continued)

Action	Requirements	Prerequisite	Citation(s)
	Shall install any pump, filter, and water treatment units in accordance with provisions at Rules of the TDEC Chap. 1200-4-9-.11		Rules of the TDEC Chap. 1200-4-9-.10(1)(a)
Construction of groundwater monitoring well(s)	All monitoring wells must be cased in a manner that maintains the integrity of the monitoring well bore hole; this casing must be screened or perforated and packed with gravel or sand, where necessary, to enable collection of groundwater samples; the annular space above the sampling depth must be sealed to prevent contamination of groundwater and samples	Construction of RCRA groundwater monitoring well—**relevant and appropriate**	40 *CFR* 264.97(c) Rules of the TDEC Chap. 1200-1-11-.06(6)(h)(3)
	Underground Injection Well Construction and Operation		
Injection of nutrients (or other treatments) into groundwater	Wells shall be designed, constructed, and operated in such a manner that does not present a hazard to existing or future use of groundwater and may not cause a violation of water quality standards	Class V injection well for innovative or experimental technologies—**relevant and appropriate**	TDEC 1200-4-6-.14(1)(b) TDEC 1200-4-6-.14(7)(b) and (8)(a)
	Institutional control—all waste left in place (SWSAs), pipelines, D&D facilities, contaminated soil or sediment		
Waste left in place	Institutional controls are required and shall include, at a minimum, deed restrictions for sale and use of property and securing area to prevent human contact with hazardous substances	Hazardous substances left in place that may pose an unreasonable threat to public health, safety, or the environment—**relevant and appropriate**	Rules of the TDEC Chap. 1200-1-13-.08(10)
Radioactive material left in place	A property may be maintained under interim management provided administrative controls are established to protect members of the public	Residual radioactive material above guidelines in inaccessible locations that would be unreasonably costly to remove—**TBC**	DOE Order 5400.5(IV)(6)(c)(1)
	Controls include, but are not limited to, periodic monitoring as appropriate, appropriate shielding, physical barriers (i.e., fences, warning signs) to prevent access, appropriate radiological safety measures during maintenance, renovation, demolition, or other activities that might disturb the residual radioactive material or cause it to migrate		DOE Order 5400.5(IV)(6)(c)(2)

Table B.3. Action-specific ARARs and TBC guidance for the selected remedy, Bethel Valley area, ORNL, Oak Ridge, Tennessee (continued)

Action	Requirements	Prerequisite	Citation(s)
Waste generation, characterization, segregation, and storage—excavated soils, sludge, sediments, building debris, secondary wastes			
Characterization of solid waste ***(all primary and secondary wastes)***	Must determine if solid waste is hazardous waste or if waste is excluded under 40 *CFR* 261.4(b); and	Generation of solid waste as defined in 40 *CFR* 261.2 and that is not excluded under 40 *CFR* 261.4(a)—**applicable**	40 *CFR* 262.11(a) Rules of the TDEC Chap. 1200-1-11-.03(1)(b)(1)
	Must determine if waste is listed under 40 *CFR* Part 261; or		40 *CFR* 262.11(b) Rules of the TDEC Chap. 1200-1-11-.03(1)(b)(2)
	Must characterize waste by using prescribed testing methods or applying generator knowledge based on information regarding material or processes used		40 *CFR* 262.11(c) Rules of the TDEC Chap. 1200-1-11-.03(1)(b)(3)
	Must refer to Parts 261, 262, 264, 265, 266, 268, and 273 of Chap. 40 for possible exclusions or restrictions pertaining to management of the specific waste	Generation of solid waste that is determined to be hazardous – **applicable**	40 *CFR* 262.11(d); Rules of the TDEC Chap. 1200-1-11-.03(1)(b)(4)
Characterization of hazardous waste (***all primary and secondary wastes***)	Must obtain a detailed chemical and physical analysis on a representative sample of the waste(s), which at a minimum contains all the information that must be known to treat, store, or dispose of the waste in accordance with pertinent sections of 40 *CFR* 264 and 268	Generation of RCRA-hazardous waste for storage, treatment, or disposal—**applicable**	40 *CFR* 264.13(a)(1) Rules of the TDEC Chap. 1200-1-11-.06(2)(d)(1)
	Must determine the underlying hazardous constituents [as defined in 40 *CFR* 268.2(i)] in the waste	Generation of RCRA characteristic hazardous waste (and is not D001 non-wastewaters treated by CMBST, RORGS, or POLYM of Sect. 268.42 Table 1) for storage, treatment or disposal – **applicable**	40 *CFR* 268.9(a) Rules of the TDEC Chap. 1200-1-11-.10(1)(i)(1)
	Must determine if the waste is restricted from land disposal under 40 *CFR* 268 *et seq.* by testing in accordance with prescribed methods or use of generator knowledge of waste		40 *CFR* 268.7 Rules of the TDEC Chap. 1200-1-11-.10(1)(g)(1)(i)

Table B.3. Action-specific ARARs and TBC guidance for the selected remedy, Bethel Valley area, ORNL, Oak Ridge, Tennessee (continued)

Action	Requirements	Prerequisite	Citation(s)
	Must determine each EPA Hazardous Waste Number (Waste Code) to determine the applicable treatment standards under 40 *CFR* 268.40 et. seq.		40 *CFR* 268.9(a) Rules of the TDEC Chap. 1200-1-11-.10(1)(i)(1)
Temporary storage of hazardous waste in containers *(e.g., PPE, D&D demolition debris)*	A generator may accumulate hazardous waste at the facility provided that:	Accumulation of RCRA hazardous waste on site as defined in 40 *CFR* 260.10—**applicable**	40 *CFR* 262.34(a) TDEC 1200-1-11-.03(4)(e)
	• waste is placed in containers that comply with 40 *CFR* 265.171-173; and		40 *CFR* 262.34(a)(1)(i) Rules of the TDEC Chap. 1200-1-11-.03(4)(e)(2)(i)(I)
	• the date upon which accumulation begins is clearly marked and visible for inspection on each container,		40 *CFR* 262.34(a)(2) Rules of the TDEC Chap. 1200-1-11-.03(4)(e)(2)(ii)
	• container is marked with the words "hazardous waste," or		40 *CFR* 262.34(a)(3) Rules of the TDEC Chap. 1200-1-11-.03(4)(e)(2)(iv)
	• container may be marked with other words that identify the contents	Accumulation of 208 L (55 gal) or less of RCRA hazardous waste at or near any point of generation—**applicable**	40 *CFR* 262.34(c)(1) Rules of the TDEC Chap. 1200-1-11-.03(4)(e)(5)(i)(II)
Use and management of hazardous waste in containers	If container is not in good condition (e.g., severe rusting, structural defects), or if it begins to leak, must transfer waste into container in good condition	Storage of RCRA hazardous waste in containers—**applicable**	40 *CFR* 265.171 Rules of the TDEC Chap. 1200-1-11-.05(9)(b)
	Use container made or lined with materials compatible with waste to be stored so that the ability of the container is not impaired		40 *CFR* 265.172 Rules of the TDEC Chap. 1200-1-11-.05(9)(c)
	Keep containers closed during storage, except to add/remove waste		40 *CFR* 265.173(a) Rules of the TDEC Chap. 1200-1-11-.05(9)(d)(1)
	Open, handle, and store containers in a manner that will not cause containers to rupture or leak		40 *CFR* 265.173(b) Rules of the TDEC Chap. 1200-1-11-.05(9)(d)(2)

Table B.3. Action-specific ARARs and TBC guidance for the selected remedy, Bethel Valley area, ORNL, Oak Ridge, Tennessee (continued)

Action	Requirements	Prerequisite	Citation(s)
Storage of hazardous waste in container area	Area must have a containment system designed and operated in accordance with 40 *CFR* 264.175(b)	Storage of RCRA-hazardous waste in containers with free liquids—**applicable**	40 *CFR* 264.175(a) Rules of the TDEC Chap. 1200-1-11-.06(9)(f)(1)
	Area must be sloped or otherwise designed and operated to drain liquid from precipitation, or Containers must be elevated or otherwise protected from contact with accumulated liquid	Storage of RCRA-hazardous waste in containers that do not contain free liquids —**applicable**	40 *CFR* 264.175(c) Rules of the TDEC Chap. 1200-1-11-.06(9)(f)(3)
Characterization of LLW (*e.g., contaminated PPE, equipment, D&D demolition debris)*	Shall be characterized using direct or indirect methods and the characterization documented in sufficient detail to ensure safe management and compliance with the WAC of the receiving facility	Generation of LLW for storage or disposal at a DOE facility—**TBC**	DOE M 435.1-1(IV)(I)
	Characterization data shall, at a minimum, include the following information relevant to the management of the waste:		DOE M 435.1-1(IV)(I)(2)(a)
	• physical and chemical characteristics;		DOE M 435.1-1(IV)(I)(2)(a)
	• volume, including the waste and any stabilization or absorbent media;		DOE M 435.1-1(IV)(I)(2)(b)
	• weight of the container and contents;		DOE M 435.1-1(IV)(I)(2)(c)
	• identities, activities, and concentration of major radionuclides;		DOE M 435.1-1(IV)(I)(2)(d)
	• characterization date;		DOE M 435.1-1(IV)(I)(2)(e)
	• generating source; and		DOE M 435.1-1(IV)(I)(2)(f)
	• any other information that may be needed to prepare and maintain the disposal facility performance assessment, or demonstrate compliance with performance objectives		DOE M 435.1-1(IV)(I)(2)(g)
Temporary storage of LLW *(e.g., contaminated PPE, D&D demolition debris)*	Shall not be readily capable of detonation, explosive decomposition, reaction at anticipated pressures and temperatures, or explosive reaction with water	Management of LLW at a DOE facility—**TBC**	DOE M 435.1-1 (IV)(N)(1)

Table B.3. Action-specific ARARs and TBC guidance for the selected remedy, Bethel Valley area, ORNL, Oak Ridge, Tennessee (continued)

Action	Requirements	Prerequisite	Citation(s)
	Shall be stored in a location and manner that protects the integrity of waste for the expected time of storage		DOE M 435.1-1 (IV)(N)(3)
	Shall be managed to identify and segregate LLW from mixed waste		DOE M 435.1-1 (IV)(N)(6)
Packaging of solid LLW (*e.g., contaminated PPE, equipment, D&D demolition debris*)	Shall be packaged in a manner that provides containment and protection for the duration of the anticipated storage period and until disposal is achieved or until the waste has been removed from the container	Storage of LLW in containers at a DOE facility—**TBC**	DOE M 435.1-1(IV)(L)(1)(a)
	Vents or other measures shall be provided if the potential exists for pressurizing or generating flammable or explosive concentrations of gases within the waste container		DOE M 435.1-1(IV)(L)(1)(b)
	Containers shall be marked such that their contents can be identified		DOE M 435.1-1(IV)(L)(1)(c)
Segregation of scrap metal for recycle	Material is not subject to RCRA requirements for generators, transporters, and storage facilities under 40 *CFR* Parts 262 through 266, 268, 270, or 124	Scrap metal, as defined in 40 *CFR* 261.1(c)(6) intended for recycle—**applicable**	40 *CFR* 261.6(a)(3)(ii) Rules of the TDEC Chap. 1200-1-11-.02(1)(f)(1)(iii)(II)
Release of scrap metal (*lead bricks, lead shielding, etc.*)	Before being released, items shall be surveyed to determine whether both removable and total surface contamination (including contamination present on or under any coating) is greater than the levels given in Fig. IV-1 of the Order and that the contamination has been subjected to the ALARA process	Radionuclide-contaminated scrap materials and equipment intended for recycle or reuse—**TBC**	DOE Order 5400.5(II)(5)(c)(1)
Management of asbestos-containing waste prior to disposal (*e.g., D&D demolition debris*)	Discharge no visible emissions to the outside air, or use one of the emission control and waste treatment methods specified in paragraphs (a)(1) through (a)(4) of 40 *CFR* 61.150	Collection, processing, packaging or transporting of any asbestos-containing waste material generated by demolition activities—**applicable**	40 *CFR* 61.150(a) Rules of the TDEC Chap. 1200-3-11-.02(2)(j)(1)

Table B.3. Action-specific ARARs and TBC guidance for the selected remedy, Bethel Valley area, ORNL, Oak Ridge, Tennessee (continued)

Action	Requirements	Prerequisite	Citation(s)
Management of PCB waste *(e.g., contaminated PPE, demolition debris, sludges)*	Any person storing or disposing of PCB waste must do so in accordance with 40 *CFR* 761, Subpart D	Generation of waste containing PCBs at concentrations ≥ 50 ppm—**applicable**	40 *CFR* 761.50(a)
	Any person cleaning up and disposing of PCBs shall do so based on the concentration at which the PCBs are found	Generation of PCB remediation waste as defined in 40 *CFR* 761.3—**applicable**	40 *CFR* 761.61
Management of PCB/radioactive waste (*e.g., oils drained from pumps, equipment, D&D demolition debris, etc.*)	Any person storing such waste must do so taking into account both its PCB concentration and radioactive properties, except as provided in 40 *CFR* 761.65(a)(1), (b)(1)(ii) and (c)(6)(i)	Generation for disposal of PCB/ radioactive waste with ≥ 50 ppm PCBs—**applicable**	40 *CFR* 761.50(b)(7)(i)
	Any person disposing of such waste must do so taking into account both its PCB concentration and its radioactive properties		40 *CFR* 761.50(b)(7)(ii)
	If, after taking into account only the PCB properties in the waste, the waste meets the requirements for disposal in a facility permitted, licensed, or registered by a state as a municipal or nonmunicipal nonhazardous waste landfill [e.g., PCB bulk product waste under 40 *CFR* 761.62(b)(1)], the person may dispose of such waste without regard to the PCBs, based on its radioactive properties alone in accordance with applicable requirements		
Temporary storage of PCB waste *(e.g., contaminated PPE, D&D demolition debris, sludges)*	Container(s) shall be marked as illustrated in 40 *CFR* 761.45(a)	Storage of PCBs and PCB items at concentrations of 50 ppm for disposal — **applicable**	40 *CFR* 761.65(a)(1)
	Storage area must be properly marked as required by 40 *CFR* 761.40(a)(10)		40 *CFR* 761.65(c)(3)
	Any leaking PCB Items and their contents shall be transferred immediately to a properly marked nonleaking container(s).		40 *CFR* 761.65(c)(5)

Table B.3. Action-specific ARARs and TBC guidance for the selected remedy, Bethel Valley area, ORNL, Oak Ridge, Tennessee (continued)

Action	Requirements	Prerequisite	Citation(s)
	Container(s) shall be in accordance with requirements set forth in DOT HMR at 49 *CFR* 171-180		40 *CFR* 761.65(c)(6)
	The date shall be recorded when PCB items are removed from service, and the storage shall be managed such that PCB items can be located by this date. (Note: Date should be marked on the container.)	PCB items (includes PCB wastes) removed from service for disposal—**applicable**	40 *CFR* 761.65(c)(8)
Storage of PCB/radioactive waste in containers *(e.g., contaminated PPE, demolition debris, sludges)*	For liquid wastes, containers must be nonleaking.	Storage of PCB/radioactive waste in containers other than those meeting DOT HMR performance standards— **applicable**	40 *CFR* 761.65(c)(6)(i)(A)
	For nonliquid wastes, containers must be designed to prevent buildup of liquids if such containers are stored in an area meeting the containment requirements of 40 *CFR* 761.65(b)(1)(ii)		40 *CFR* 761.65(c)(6(i)(B)
	For both liquid and nonliquid wastes, containers must meet all regulations and requirements pertaining to nuclear criticality safety		40 *CFR* 761.65(c)(6)(i)(C)
Storage of PCB waste and/or PCB/radioactive waste in a RCRA-regulated container storage area	Does not have to meet storage unit requirements in 40 *CFR* 761.65(b)(1) provided unit	Storage of PCBs and PCB items designated for disposal—**applicable**	40 *CFR* 761.65(b)(2)
	• is permitted by EPA under RCRA Sect. 3004, or		40 *CFR* 761.65(b)(2)(i)
	• qualifies for interim status under RCRA Sect. 3005, or		40 *CFR* 761.65(b)(2)(ii)
	• is permitted by an authorized state under RCRA Sect. 3006, and		40 *CFR* 761.65(b)(2)(iii)
	• PCB spills cleaned up in accordance with Subpart G of 40 *CFR* 761		40 *CFR* 761.65(c)(1)(iv)
Treatment/disposal of waste—excavated sediment/soils, sludge, building debris, secondary wastes			
Disposal of RCRA-hazardous waste in a land-based unit (*debris with lead paint, lead shielding, sludge, etc.*)	May be land disposed if it meets the requirements in the table "Treatment Standards for Hazardous Waste" at 40 *CFR* 268.40 before land disposal	Land disposal, as defined in 40 *CFR* 268.2, of restricted RCRA waste—**applicable**	40 *CFR* 268.40(a) Rules of the TDEC Chap. 1200-1-11-.10(3)(a)

Table B.3. Action-specific ARARs and TBC guidance for the selected remedy, Bethel Valley area, ORNL, Oak Ridge, Tennessee (continued)

Action	Requirements	Prerequisite	Citation(s)
	May be land disposed if it meets the requirements in the table "Alternative Treatment Standards for Hazardous Debris" at 40 *CFR* 268.45 before land disposal or the debris is treated to the waste-specific treatment standard provided in 40 *CFR* 268.40 for the waste contaminating the debris	Land disposal, as defined in 40 *CFR* 268.2, of restricted RCRA-hazardous debris—**applicable**	40 *CFR* 268.45(a) Rules of the TDEC Chap. 1200-1-11-.10(3) (f)(1)
	Must be treated according to the alternative treatment standards of 40 *CFR* 268.49(c) or according to the UTSs specified in 40 *CFR* 268.48 applicable to the listed and/or characteristic waste contaminating the soil prior to land disposal	Land disposal, as defined in 40 *CFR* 268.2, of restricted hazardous soils—**applicable**	40 *CFR* 268.49(b) Rules of the TDEC Chap. 1200-1-11-10(3)(J)(2)
	Are not prohibited if the wastes no longer exhibit a characteristic at the point of land disposal, unless the wastes are subject to a specified method of treatment other than DEACT in 40 *CFR* 268.40, or are D003 reactive cyanide	Land disposal of restricted RCRA characteristically hazardous wastes—**applicable**	40 *CFR* 268.1(c)(4)(iv) Rules of the TDEC Chap. 1200-1-11-.10(1) (a)(3)(iv)(IV)
Packaging of LLW for disposal *(e.g., contaminated PPE, D&D demolition debris)*	Must have structural stability either by processing the waste or placing the waste in a container or structure that provides stability after disposal	Generation of LLW for disposal at a LLW disposal facility— **relevant and appropriate**	Rules of the TDEC Chap. 1200-2-11-.17(7)(b)(1)
	Void spaces within the waste and between the waste, and its package must be reduced to the extent practicable		Rules of the TDEC Chap. 1200-2-11-.17(7)(b)(3)
Treatment of LLW	Treatment to provide more stable waste forms and to improve the long-term performance of a LLW disposal facility shall be implemented as necessary to meet the performance objectives of the disposal facility	Generation of LLW for disposal at a LLW disposal facility—**TBC**	DOE M 435.1-1(IV)(O)
Disposal of solid LLW *(D&D demolition debris, pipelines, equipment, soil, sediment)*	LLW shall be certified as meeting waste acceptance requirements before it is transferred to the receiving facility	Generation of LLW for disposal at a DOE facility—**TBC**	DOE M 435.1-1(IV)(J)(2)

Table B.3. Action-specific ARARs and TBC guidance for the selected remedy, Bethel Valley area, ORNL, Oak Ridge, Tennessee (continued)

Action	Requirements	Prerequisite	Citation(s)
Disposal of asbestos-containing waste material *(D&D demolition debris)*	Shall be deposited as soon as practicable at • an approved waste disposal site operated in accordance with Sect. 61.154 or • an EPA-approved site that converts RACM and asbestos-containing waste material into nonasbestos (asbestos-free) material according to the provisions of 40 *CFR* 61.155	Asbestos-containing waste material or RACM (except Category I nonfriable asbestos-containing material) from demolition activities—**applicable**	40 *CFR* 61.150(b) Rules of the TDEC Chap. 1200-3-11-.02(2)(j)(2) 40 *CFR* 61.150(b)(1) Rules of the TDEC Chap. 1200-3-11-.02(2)(j)(2)(i) 40 *CFR* 61.150(b)(2) Rules of the TDEC Chap. 1200-3-11-.02(2)(j)(2)(ii)
Disposal of fluorescent light ballasts (e.g., *from D&D wastes*)	Must be disposed of in a TSCA-approved disposal facility, as bulk product waste under 40 *CFR* 761.62, or in accordance with the decontamination provisions of 40 *CFR* 761.79	Generation for disposal of fluorescent light ballasts containing PCBs in the potting material—**applicable**	40 *CFR* 761.60(b)(6)(iii)
	May dispose of in a municipal solid waste landfill	Generation for disposal of intact, nonleaking PCB Small Capacitors (as defined in 40 *CFR* 761.3) — **applicable**	40 *CFR* 761.60(b)(2)(ii)
Disposal of PCB-contaminated articles (e.g., *hydraulic machines, pumps, electrical equipment, etc.*)	Must remove all free-flowing liquid from the article, disposing of the liquid in compliance with the requirements of 40 *CFR* 761.60(a)(2) or (a)(3); and	Generation for disposal of PCB-Contaminated Articles (as defined in 40 *CFR* 761.3)—**applicable**	40 *CFR* 761.60(b)(6)(ii)
	Dispose by one of the following methods:	Disposal of PCB-Contaminated Articles with no free-flowing liquid—**applicable**	40 *CFR* 761.60(b)(6)(ii)
	• in accordance with the decontamination provisions at 40 *CFR* 761.79;		40 *CFR* 761.60(b)(6)(ii)(A)
	• in a facility permitted, licensed, or registered by a state to manage municipal solid waste or nonmunicipal nonhazardous waste;		40 *CFR* 761.60(b)(6)(ii)(B)
	• in an industrial furnace operating in compliance with 40 *CFR* 761.72; or		40 *CFR* 761.60(b)(6)(ii)(C)
	• in a disposal facility approved under this part		40 *CFR* 761.60(b)(6)(ii)(D)

Table B.3. Action-specific ARARs and TBC guidance for the selected remedy, Bethel Valley area, ORNL, Oak Ridge, Tennessee (continued)

Action	Requirements	Prerequisite	Citation(s)
Disposal of PCB liquids (*e.g., from drained electrical equipment*)	Must be disposed of in an incinerator that complies with 40 *CFR* 761.70, except	PCB liquids at concentrations ≥ 50 ppm —**applicable**	40 *CFR* 761.60(a)
	• for mineral oil dielectric fluid, may be disposed of in a high-efficiency boiler according to 40 *CFR* 761.71(a), and	PCB liquids at concentrations ≥ 50 ppm and < 500 ppm—**applicable**	40 *CFR* 761.60(a)(1)
	• for liquids other than mineral oil dielectric fluid, may be disposed of in a high-efficiency boiler according to 40 *CFR* 761.71(b)		40 *CFR* 761.60(a)(2)
Disposal of PCB cleanup wastes *(e.g., contaminated PPE, nonliquid cleaning materials)*	Shall be disposed of either • in a facility permitted, licensed, or registered by a state to manage municipal solid waste under 40 *CFR* 258 or nonmunicipal, nonhazardous waste subject to 40 *CFR* 257.5 thru 257.30; or • in a RCRA Subtitle C landfill permitted by a state to accept PCB waste; or • in an approved PCB disposal facility; or • through decontamination under 40 *CFR* 761.79(b) or (c).	Generation of nonliquid PCBs at any concentration during and from the cleanup of PCB remediation waste—**applicable**	40 *CFR* 761.61(a)(5)(v)(A)
Disposal of PCB cleaning solvents, abrasives, and equipment	May be reused after decontamination in accordance with 40 *CFR* 761.79	Generation of PCB wastes from the cleanup of PCB remediation waste— **applicable**	40 *CFR* 761.61(a)(5)(v)(B)
Performance-based disposal of PCB remediation waste *(e.g., soils, sediments, sludges)*	May dispose by one of the following methods:	Disposal of nonliquid PCB remediation waste as defined in 40 *CFR* 761.3—**applicable**	
	• in a high-temperature incinerator approved under 40 *CFR* 761.70(b),		40 *CFR* 761.61(b)(2)
	• by an alternate disposal method approved under 40 *CFR* 761.60(e),		40 *CFR* 761.61(b)(2)(i)
	• in a chemical waste landfill approved under 40 *CFR* 761.75,		
	• in a facility with a coordinated approval issued under 40 *CFR* 761.77, or		40 *CFR* 761.61(b)(2)(ii)
	• through decontamination in accordance with under 40 *CFR* 761.79		

Table B.3. Action-specific ARARs and TBC guidance for the selected remedy, Bethel Valley area, ORNL, Oak Ridge, Tennessee (continued)

Action	Requirements	Prerequisite	Citation(s)
Performance-based disposal of PCB bulk product waste *(e.g., D&D demolition debris with PCB painted surfaces)*	May dispose of by one of the following:	Disposal of PCB bulk product waste as defined in 40 *CFR* 761.3—**applicable**	40 *CFR* 761.62(a)
	• in an incinerator approved under 40 *CFR* 761.70,		40 *CFR* 761.62(a)(1)
	• in a chemical waste landfill approved under 40 *CFR* 761.75,		40 *CFR* 761.62(a)(2)
	• in a hazardous waste landfill permitted by EPA under Sect. 3004 of RCRA or by authorized state under Sect. 3006 of RCRA,		40 *CFR* 761.62(a)(3)
	• under alternate disposal approved under 40 *CFR* 761.60(e),		40 *CFR* 761.62(a)(4)
	• in accordance with decontamination provisions of 40 *CFR* 761.79, or		40 *CFR* 761.62(a)(5)
	• in accordance with thermal decontamination provisions of 40 *CFR* 761.79(e)(6) for metal surfaces in contact with PCBs		40 *CFR* 761.62(a)(6)
Risk-based disposal of PCB bulk product waste	May dispose of in a manner other than prescribed in 40 CFR 761.62(a) or (b) if receive approval in writing from EPA and the method (based on technical, environmental or waste-specific characteristics) will not pose an unreasonable risk of injury to human health or the environment.	Disposal of PCB bulk product waste—**applicable**	40 *CFR* 761.62(c)
		Transportation	
Transportation of hazardous materials	Shall be subject to and must comply with all applicable provisions of the HMTA and HMR at 49 *CFR* 171-180	Any person who, under contract with a department or agency of the federal government, transports "in commerce," or causes to be transported or shipped, a hazardous material—**applicable**	49 *CFR* 171.1(c)
Transportation of radioactive waste	Shall be packaged and transported in accordance with DOE Order 460.1A and DOE Order 460.2	Shipment of LLW and/or TRU waste off-site—**TBC**	DOE M435.1-(I)(1)(E)(11)
Transportation of LLW and/or TRU waste	To the extent practical, the volume of the waste and the number of the shipments shall be minimized	Shipment of LLW and/or TRU waste off-site—**TBC**	DOE M 435.1-1(IV)(L)(2) DOE M 435.1-1(III)(L)(2)

Table B.3. Action-specific ARARs and TBC guidance for the selected remedy, Bethel Valley area, ORNL, Oak Ridge, Tennessee (continued)

Action	Requirements	Prerequisite	Citation(s)
Transportation of PCB wastes	Must comply with the manifesting provisions at 40 *CFR* 761.207 through 40 *CFR* 761.218	Relinquishment of control over PCB wastes by transporting, or offering for transport—**applicable**	40 *CFR* 761.207 (a)
Transportation of hazardous waste off-site	Must comply with the generator requirements of 40 *CFR* 262.20–23 for manifesting, Sect. 262.30 for packaging, Sect. 262.31 for labeling, Sect. 262.32 for marking, Sect. 262.33 for placarding, Sect. 262.40, 262.41(a) for record keeping requirements, and Sect. 262.12 to obtain EPA ID number	Off-site transportation of RCRA hazardous waste—**applicable**	40 *CFR* 262.10(h) Rules of the TDEC Chap. 1200-1-11-.03(1)(a)(8)
	Must comply with the requirements of 40 *CFR* 263.11–263.31	Transportation of hazardous waste within the United States requiring a manifest—**applicable**	40 *CFR* 263.10(a) Rules of the TDEC Chap. 1200-1-11-.04(1)(a)(1)
	A transporter who meets all applicable requirements of 49 *CFR* 171–179 and the requirements of 40 *CFR* 263.11 and 263.31 will be deemed in compliance with 40 *CFR* 263		
Transportation of hazardous waste on-site	The generator manifesting requirements of 40 *CFR* 262.20–262.32(b) do not apply. Generator or transporter must comply with the requirements set forth in 40 *CFR* 263.30 and 263.31 in the event of a discharge of hazardous waste on a private or public right-of-way	Transportation of hazardous wastes on a public or private right-of-way within or along the border of contiguous property under the control of the same person, even if such contiguous property is divided by a public or private right-of-way—**applicable**	40 *CFR* 262.20(f) Rules of the TDEC Chap. 1200-1-11-.03(3)(a)(6)

ALARA = as low as reasonably achievable
ARAR = applicable or relevant and appropriate requirement
CFR = *Code of Federal Regulations*
CWA = Clean Water Act of 1972
D&D = decontamination and decommissioning
DEACT = deactivation
DOE = U.S. Department of Energy
DOE M = *Radioactive Waste Management Manual*
DOT = U.S. Department of Transportation
EDE = effective dose equivalent
EPA = U.S. Environmental Protection Agency
FWPA = Former Waste Pile Area
HMR = Hazardous Materials Regulations
HMTA = Hazardous Materials Transportation Act
ID = identification
LLW = low-level (radioactive) waste
NPDES = National Pollutant Discharge Elimination System
NRWTP = Nonradiological Wastewater Treatment Plant
ORNL = Oak Ridge National Laboratory
P&A = plugging and abandonment
PCB = polychlorinated biphenyl
PPE = personal protective equipment
RACM = regulated asbestos-containing material
RCRA = Resource Conservation and Recovery Act of 1976
SWSA = solid waste storage area
TBC = to be considered
TCA = *Tennessee Code Annotated*
TDEC = Tennessee Department of Environment and Conservation
TRU = transuranic
TSCA = Toxic Substances Control Act of 1976
UTS = universal treatment standard
WAC = waste acceptance criteria
WIPP = Waste Isolation Pilot Plant

APPENDIX C

PROCESS TO DETERMINE SUBSURFACE SOIL CLEANUP FOR MINIMIZING IMPACTS TO GROUNDWATER IN BETHEL VALLEY

PROCESS TO DETERMINE SUBSURFACE SOIL CLEANUP FOR MINIMIZING IMPACTS TO GROUNDWATER IN BETHEL VALLEY

C.1 INTRODUCTION

A goal has been established to excavate accessible contaminated subsurface soils at leak and spill sites that have the potential to cause groundwater contamination at levels that would exceed a 1×10^{-4} risk for carcinogenic contaminants of concern (COCs) or a hazard quotient (HQ) of 1.0 for noncarcinogens, under an industrial scenario. The intent of this cleanup is to conduct initial removal of the most contaminated deeper soils that pose an immediate threat of causing continued or further spread of groundwater contamination. Additional soil cleanup may be required under a future final ROD for the site.

The approach to determining required subsurface soil removal uses simple mathematical models to estimate the amount of contaminant release from soils, their attenuation during migration, and the concentration that would occur in water withdrawn from a groundwater well positioned within the lateral boundary of the contaminated area and withdrawing groundwater from beneath the contaminated soil mass. This appendix outlines the process that will be used in order to determine how much contaminated soil must be removed to minimize impacts to groundwater under the industrial use scenario. The process was developed and applied to a representative contaminated soil area [the Tank W-1A leak site in Central Bethel Valley (CBV)] for the purpose of method demonstration.

C.2 SUBSURFACE SOIL CLEANUP DECISION MODEL

Each liquid low-level (radioactive) waste (LLLW) leak or spill site will be evaluated at the time of remediation to determine the amount of soil removal required for minimizing impacts to groundwater.

The process of determining concentrations of site-related COCs in soil that may require removal involves several steps as shown schematically in Fig. C.1. The first step is to establish a first approximation of soil contaminant trigger level concentrations for each area of deep soil contamination in order to determine the amount of soil that must be removed. The first approximation of soil trigger levels uses the Summers Model to estimate contaminant concentrations in groundwater from leaching of contaminated soil and uses rough estimates of the contamination soil dimensions [i.e., site footprint dimensions such as 6×9 m (20×29 ft)]. Screening of soil contaminant concentrations against the first approximation trigger levels includes computing a sum of fractions to determine if the total contaminant inventory for a site has the potential to contaminate groundwater above the industrial use limits. If the first approximation site assessment indicates that subsurface soils may contaminate groundwater above the industrial use limits, a refined assessment is performed using the Seasonal Soil compartment model (SESOIL) and the Analytical Transient 1-, 2-, 3-Dimensional Model (AT123D) to calculate contaminant concentrations in a hypothetical groundwater well that would be located at the downgradient edge of the contaminated soil mass. The refined assessment is used to provide the limiting concentration in soil for each COC to minimize impacts to groundwater withdrawn from the hypothetical on-site well. A sum-of-fractions approach is used to include all relevant site-specific COCs. Limiting COC concentrations in soil are used to generate contours that are subsequently used to compute the volume of soil that must be removed at each site.

The general process outlined above is described in more detail in the next two subsections.

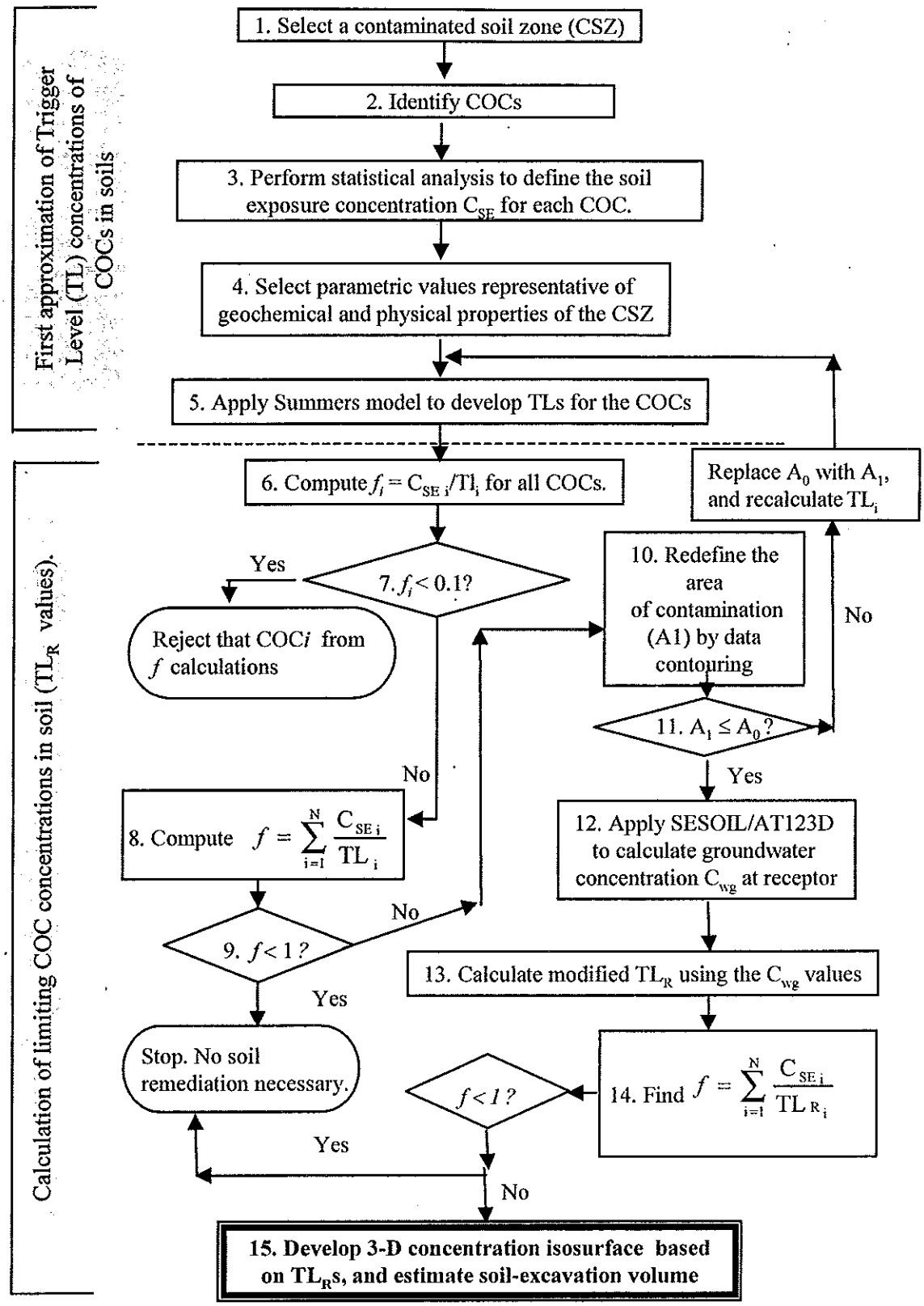

Fig. C.1. Bethel Valley subsurface soil cleanup decision process

C.2.1 First Approximation of Trigger Level Concentrations of COCs in Soil

1. The first step in determining the requirements for subsurface soil cleanup to minimize the impacts to groundwater is to identify the contaminated soil site (i.e., known leakage or spill location or other subsurface contaminated soil mass). A site conceptual model is prepared to define the basis of input parameters required for the contaminant transport modeling. An example of a conceptual model for subsurface soil contamination and transportation of COCs for Central Bethel Valley (CBV) is portrayed in Fig. C.2.

2. Site-related COCs (in soil and groundwater) described in the Bethel Valley Watershed Remedial Investigation/Feasibility Study (RI/FS) (DOE 1999) (Table 6.2) for areas of concern in CBV are quantified for each contaminated site. COCs listed below include groundwater COCs in addition to certain soil COCs considered to be potential groundwater COCs because of their geochemical behavior. Trichloroethene (TCE) and dichloroethene (DCE) are also included because the concentration of vinyl chloride (a daughter product of these chemicals) in groundwater was observed to exceed groundwater criteria. The COCs selected for this analysis include metals (antimony, arsenic, mercury, and zinc), radionuclides (^{228}Ac, ^{241}Am, ^{14}C, ^{134}Cs, ^{137}Cs, ^{60}Co, ^{244}Cm, ^{152}Eu, ^{154}Eu, ^{210}Pb, ^{40}K, ^{147}Pm, ^{226}Ra, ^{228}Ra, ^{90}Sr, ^{208}Tl, ^{228}Th, ^{3}H, ^{232}U, ^{234}U, ^{235}U, ^{238}U, and ^{95}Zr), and volatile organic compounds (DCE, TCE, vinyl chloride).

3. The laboratory analytical data obtained for the COCs are used in statistical analysis to define the 95% Upper Confidence Limit of the mean (UCL) for each contaminant. The UCL_{95} represents the concentration of a COC such that it can be said with 95% confidence that the mean value will not exceed this concentration. The UCL_{95} is compared against the maximum observed concentration, and the lesser of these two values is defined as the soil exposure concentration (C_{SE}).

4. Certain hydrogeologic parameters are required to estimate the impact of soil COCs on groundwater quality. Parametric values representative of Bethel Valley hydrogeologic conditions have been used in the sample calculations presented in this appendix. Site-specific parameters may be required during soil cleanup in Bethel Valley to modify the site conceptual model. Hydrogeologic parameters include (a) planar area of soil contamination A_o, (b) percolation rate q_p, (c) saturated hydraulic conductivity K_s, (d) horizontal hydraulic gradient I, (e) area perpendicular to groundwater flow A_A, (f) depth of contamination h, (g) depth to the water table from ground surface, (h) moisture content in the saturated zone, (i) effective porosity of the unsaturated zone, (j) distance traveled by the contaminant, (k) organic fraction f_{oc}, etc. The parametric values used for this assessment are shown in Table C.1. Chemical parameters included target groundwater concentration (C_w), soil-water distribution coefficient (K_d), and organic-carbon partition coefficient (K_{oc}). The values for these parameters are shown in Table C.2. Target groundwater concentrations are based on a preliminary remediation goal (PRG) at a carcinogenic risk level of 1×10^{-4} for groundwater use under an industrial exposure scenario. However, if a PRG based on cancer risk was not available, a value based on HQ = 1.0 was used. The parametric values are based on findings from previous investigations and published literature. In selecting literature values, a conservative approach was taken, and emphasis was placed on values representative of site-specific conditions. A detailed description of the parameters and the justification of the selected values are discussed in subsection C.3.

5. The trigger level concentration of each COC is estimated using the analytical transport model developed by Summers et al. (1980). The concentration of any given COC, leached from the soil into the groundwater, is a function of the amount of the solute percolating through a theoretical soil column of negligible thickness, the amount of the chemical already present in the aquifer (if any), and the volume of water available for dissolution. The mathematical expression is as follows:

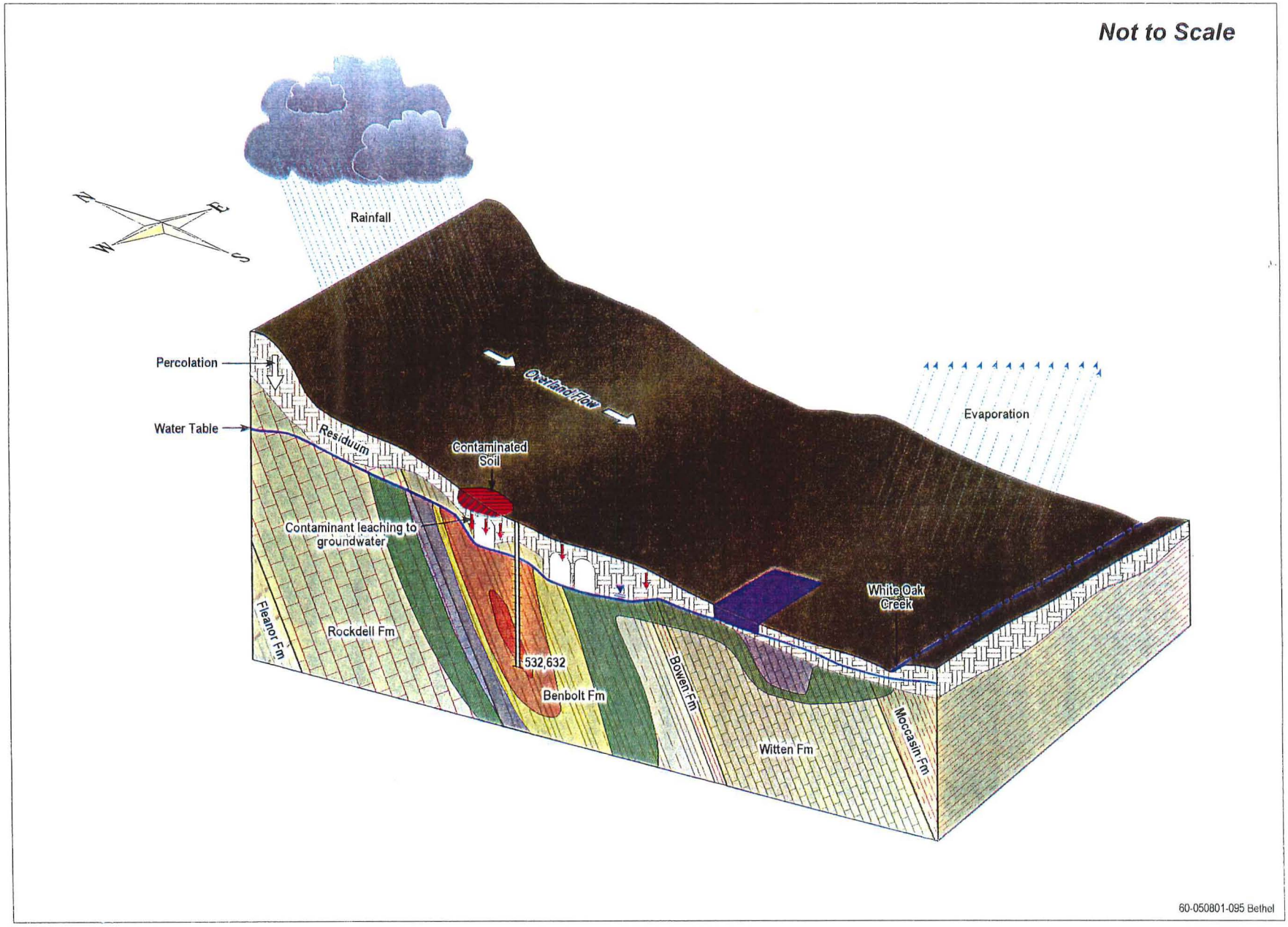

Fig. C.2. Conceptual diagram of contaminant transport in Central Bethel Valley.

$$TL = C_w \times K_d \left\{ \frac{(Q_P + Q_A)}{Q_P} \right\}$$

where

TL = trigger level concentration for soil cleanup (mg/kg or pCi/g)
C_w = target groundwater concentration based on 10^{-4} cancer risk, if available; otherwise 1.0 hazard quotient (mg/L or pCi/L)
K_d = soil-water distribution coefficient (L/kg)
Q_p = volumetric rate of percolation (m^3/day)
$Q_p = q_p \times A_o$
q_p = percolation rate (m/day)
A_o = planar area of soil contamination (m^2)
Q_A = volumetric flow of groundwater (m^3/day)
$Q_A = K_S \times I \times A_A$
K_S = saturated hydraulic conductivity (m/day)
I = horizontal hydraulic gradient (m/m)
A_A = cross-sectional area perpendicular to flow (m^2)

The Summers model incorporates the physical and chemical characteristics of the solute and the characteristics of the receiving aquifer to simulate the migration of the solute. The model is considered to be highly conservative. In addition, the calculated concentration is considered to be highly dependent on K_d values, which can range over several orders of magnitude. As such, the uncertainty in the result can range over several orders of magnitude, especially for metals and radionuclides. Therefore, the trigger level concentrations estimated using the model should be assessed with caution.

C.2.2 Calculations of Limiting COC Concentrations in Soil and Contaminated Soil Volume

6. The fraction factor f_i (= $C_{SE,i}/TL_i$) for each COC represents the impact it may have on groundwater contamination.

7. If the f_i value for a COC < 0.1, then that particular COC is dropped from further calculation and calculation is progressed with the rest of the COCs.

8. The sum of fractions f for the site-specific COCs determines whether the soil requires excavation to minimize impacts to groundwater.

9. If $f < 1.0$, then no further calculation is necessary. It can be concluded that soil cleanup is not required. If the sum of fractions is greater than 1.0, soil cleanup will be necessary.

10. The initial area of contamination was taken as the footprint of the contaminated site. This area is redefined by contouring the data sorted by the comparison of detected concentrations with their respective TLs.

11. The new area A_i (i.e., the area bounded by the TL) is then compared with the old area A_o. If $A_i > A_o$, then the procedure is moved back to Step 5 where A_o is replaced with A_i as the new A_o.

12. If $A_i \leq A_o$, then leachate modeling is performed using SESOIL. The model calculates contaminant flux into the shallow water table beneath the site over a 100-year period. Using the results from the leachate modeling, saturated flow and contaminant transport modeling is performed using AT123D. This model predicts the maximum groundwater concentration (C_{gw}) at the receptor location.

13. Based on the maximum groundwater contamination after migration and natural attenuation, the COC trigger level concentrations are revised according to the following equation:

$$TL_R = C_W \times \frac{C_{SE}}{C_{gw}}$$

where,

TL_R = revised trigger level for soil cleanup (mg/kg or pCi/g)
C_W = target groundwater concentration based on 10^{-4} cancer risk, if available; otherwise 1.0 hazard quotient (mg/L or pCi/L)
C_{SE} = soil exposure concentration for the area of soil contamination (pCi/g or mg/kg)
C_{gw} = AT123D-predicted maximum groundwater concentration at the receptor location (pCi/L or mg/L)

14. The modified trigger level values are considered the limiting COC concentrations. These values are again compared with the respective C_{SE} values of the COC, and the sum of fractions f is calculated.

$$f = \sum_{i=1}^{N} \frac{C_{SE,i}}{TL_{Ri}}$$

15. If $f \geq 1.0$, the volume of soil that should be excavated (i.e., soil within the TL_R) is calculated by developing a three-dimensional (3-D) concentration isosurface.

C.3 DESCRIPTION OF THE PARAMETERS AND REPRESENTATIVE VALUES

Vertical Percolation. Vertical percolation or recharge to the shallow groundwater system in CBV is based on Gerald Moore's water budget analysis for the groundwater parameters and flow systems near Oak Ridge National Laboratory (Moore 1992).

Horizontal Area of Spill. Contaminated soil areas vary in size in Bethel Valley; therefore, soil removal for minimizing impacts to groundwater will be based on location-specific data. The Tank W-1A leak in the North Tank Farm area is a known source of significant groundwater contamination and is used in this example to demonstrate the method of determining soil cleanup requirements for minimizing impacts to groundwater protection. The Tank W-1A leak is the source of the Core Hole 8 contaminant plume, considered to be one of the most significant groundwater contaminant plumes in Bethel Valley. The dimensions of the Tank W-1A leak site contaminated soil mass are approximately 6 × 9 m (20 × 29 ft), thus the horizontal area of the spill A_o is 6×9 m = 54 m^2 (20 × 29 ft = 580 ft^2).

Hydraulic Conductivity in Saturated Zone. The hydraulic conductivity in the saturated zone is based on single-well hydraulic conductivity tests (slug tests and straddle packer tests) and ranges from 1.20E-05 cm/s to 1.2E-01 cm/s (Ketelle 1999) with an average of 3.56E-04 cm/s, and a geometric mean of 5.13E-05 cm/s. According to the Summers model, a lower conductivity leads to a smaller volume of groundwater flow in the mixing zone. As less groundwater volume becomes available for diluting a given influx of contaminant into the mixing zone, the lower conductivity leads to a lower trigger level. The geometric mean represents a reasonably conservative estimate of the lower value; therefore, 5.13E-05 cm/s has been used in these sample calculations for conservatism.

Table C.1. Hydrogeologic Parameters for Central Bethel Valley

Parameter	Symbol	Units	Value	Source/Justification
Vertical percolation	q_p	in/yr	1.3	Water budget analysis by Gerald Moore (1992).
Horizontal area of spill	A_p	ft^2	580	Noted Tank W-1A leak site area as 6 × 9 m (20 × 29 ft) from Attachment J.1 (RI/FS); the attachment took the dimensions from DOE (1996).
Hydraulic conductivity in saturated zone	K_S	cm/sec	5.1E-05	Appendix E noted the measured Ks range as 1.2E-5 cm/sec to 1.2E-1 cm/sec. Took the geometric mean as a reasonable conservative value.
Hydraulic gradient in saturated zone	I_S	unitless	0.043	An average value based on potentiometric surface across the site (Figure 5.20; p. 5-97 of the RI/FS, DOE 1999).
Aquifer thickness	h	ft	130	Assumed a regolith thickness of 10 m (33 ft) and well depth of 50 m (164 ft) to obtain an aquifer thickness of 40 m (130 ft).
Source width perpendicular to groundwater flow	w	ft	20	Based on the smallest dimension of Tank W-1A leak site [6 x 9 m (20 x 29 ft)] for conservatism.
Source length parallel to groundwater flow	l	ft	29	Based on the largest dimension of Tank W-1A leak site [6 x 9 m (20 x 29 ft)] for conservatism.
Fraction organic carbon	f_{oc}	unitless	0.002	Based on statistical analysis of site-specific values.

RI = remedial investigation
FS = feasibility study

Hydraulic Gradient in Saturated Zone. Based on the potentiometric surface presented in Fig. 5.20 of the RI/FS for Bethel Valley (DOE 1999), the hydraulic gradient ranges from 0.026 to 0.06 with an average of 0.043. According to the Summers model, a lower gradient leads to a smaller volume of groundwater flow rate in the mixing zone. As less groundwater volume becomes available for diluting a given influx of contaminant into the mixing zone, the lower gradient leads to a lower trigger level. A hydraulic gradient value of 0.043 was used in these sample calculations.

Aquifer Thickness. The CBV area at ORNL is underlain by seven geologic units of the Chicamagua Group (p. E3-1, Ketelle 1999). This entire section of geologic strata dips at approximately 30° to the southeast with strike parallel to the valley axis. Near the surface and above the bedrock, the weathered regolith is fairly uniform in consistency. The thickness of regolith ranges from 0.3 m to 7 m (1 to 23 ft) (Table E.1, Ketelle 1999). Below the regolith/bedrock interface, the strata are distinct. In general, groundwater flow and associated contaminant transport occur along strike-parallel direction, and they are confined to individual strata. Each stratum acts as an individual pathway, and estimation of aquifer thickness becomes difficult. A well is assumed to extract water from a depth of 50 m (164 ft) below ground surface and from a stratum with contamination (Fig. C.2). The thickness of the regolith is assumed to be 10 m (33 ft), yielding an aquifer thickness of 40 m (130 ft).

Table C.2. Example trigger levels for the Bethel Valley COCs applied to Tank W-1A soils

COC	K_{oc} (L/kg)	K_d (L/kg)	Target groundwater concentration (mg/L or pCi/L)		Trigger Levels (mg/kg or pCi/g)
Metals and inorganic compounds					
Antimony		45 [a]	0.041	H	1.74E+02
Arsenic		29 [a]	0.019	C	5.20E+01
Mercury		52 [a]	0.0031	C	1.52E+01
Zinc		62 [a]	31	H	1.81E+05
Radionuclides					
Actinium-228		450 [c]	9,900	C	4.21E+05
Americium-241		1900 [c]	49	C	8.79E+03
Carbon-14		1 [c]	16,000	C	1.51E+03
Cesium-134		3000 [d]	340	C	9.63E+04
Cesium-137		3000 [d]	510	C	1.44E+05
Cobalt-60		800 [d]	850	C	6.42E+04
Curium-244		40 [e]	64	C	2.42E+02
Europium-152		40 [e]	2,800	C	1.06E+04
Europium-154		40 [e]	1,700	C	6.42E+03
Lead-210		100 [d]	24	C	2.27E+02
Potassium-40		30 [d]	1,300	C	3.68E+03
Promethium-147		650 [b]	11,000	C	6.75E+05
Radium-226		3000 [d]	54	C	1.53E+04
Radium-228		3000 [d]	65	C	1.84E+04
Strontium-90		30 [e]	390	C	1.10E+03
Thallium-208		71 [d]	910,000	C	6.10E+06
Thorium-228		3000 [d]	250	C	7.08E+04
Tritium		0.06 [c]	220,000	C	1.25E+03
Uranium-232		40 [d]	200	C	7.55E+02
Uranium-234		40 [d]	360	C	1.36E+03
Uranium-235		40 [d]	350	C	1.32E+03
Uranium-238		40 [d]	370	C	1.40E+03
Zirconium-95		600 [c]	4,100	C	2.32E+05
Volatile organic compounds					
1,2-Dichloroethene (total)	77.5 [h]	0.155	0.92	H	1.35E+01
cis-1,2-Dichloroethene	35.5 [g]	0.071	1	H	6.70E+00
trans-1,2-Dichloroethene	38 [f]	0.076	2	H	1.43E+01
Trichloroethene	94.3 [f]	0.1886	2.6	C	4.63E+01
Vinyl chloride	18.6 [g]	0.0372	0.015	C	5.27E-02

[a] K_d values from EPA Soil Screening Guidance: Technical Background Document, May 1996.
[b] Baes et. al. 1984
[c] Sheppard and Thibault 1990
[d] ORNL 1997, Table X.1 for Melton Valley
[e] DOE 1999. RI/FS for the Bethel Valley watershed at Oak Ridge National Laboratory, Oak Ridge, Tennessee.
[f] Measured K_{oc} values from EPA Soil Screening Guidance: Technical Background Document, May 1996.
[g] Calculated K_{oc} values from EPA Soil Screening Guidance: Technical Background Document, May 1996.
[h] EPA Treatability Database (RREL Version 5.0)

C = PRG at Cancer Risk of 10^{-4}
COC = containment of concern
EPA = U.S. Environmental Protection Agency
H = PRG at Hazard Quotient of 1.0
K_d = soil-water distribution coefficient
K_{oc} = organic carbon partition coefficient
PRG = preliminary remediation goal
RREL = Risk Reduction Engineering Laboratory

Source Length Parallel to Groundwater Flow. The source length parallel to groundwater flow is related to the horizontal area of spill. A site-specific source-length will be determined for each area of

contaminated subsurface soil at the time of remediation. According to the Summers model, a longer length leads to larger influx of contaminants in the mixing zone, consequently leading to a lower trigger level for a given target groundwater concentration. For purposes of these sample calculations, the horizontal area is based on the Tank W-1A leak site dimensions of 6 × 9 m (20 × 29 ft) and a source length parallel to groundwater flow of 9 m (29 ft) was selected.

Fraction Organic Carbon. The fraction of organic carbon (f_{oc}) is selected based on measured values of total organic carbon content (TOC) in the Bethel Valley area. Statistical analysis was conducted on the sampling results obtained from measurements taken in 1991 (70 samples). Based on statistical analysis, the data represent a lognormal distribution with a mean f_{oc} value of 0.0027, having a 95% lower confidence limit (LCL) of 0.002. The LCL value is identical to the U.S. Environmental Protection Agency (EPA) default value. According to the Summers model, a lower f_{oc} yields a lower K_d, and the lower K_d leads to a lower trigger level. A lower K_d reduces the soils capacity to contain contaminants through adsorption. Therefore, the 95% LCL value of 0.002 was selected for conservatism. In areas of significant VOC contamination of soil, additional fraction of organic carbon measurements will be made to refine the analysis of potential VOCs in soil to contaminate underlying groundwater.

Soil-Water Distribution Coefficient. The K_d for metals and inorganic compounds and for radionuclides were obtained based on previous investigations and published literature values. The value of the coefficient for a chemical may vary over a wide range, and selection of a unique value for the coefficient becomes difficult. As such, a simple method was followed in selecting the value. First, a site-specific or site-related value may be selected from the Solid Waste Storage Area 6 performance assessment (ORNL 1997). If a site-specific value is not found, the value may be taken from EPA (1996). If the value is not found in EPA (1996), the value may be searched in Sheppard and Thibault (1990) for sand. Finally, if the value is not found in Sheppard and Thibault (1990), the value may searched in Baes and Sharp (1984). A unique value for each element in the periodic table is presented in Baes and Sharp (1984).

The soil-water distribution coefficients for volatile organic compounds are estimated as the product of f_{oc} and soil K_{oc}. The selection of f_{oc} is discussed above. Values for K_{oc} may be found in the EPA Soil Screening Guidance Technical Background Document (EPA 1996) or in the EPA Treatability Database (EPA 1994).

Target Concentration in Groundwater. As previously indicated, the target concentration in groundwater is based on the PRG at a cancer risk of 10^{-4} or the PRG at an HQ of 1.0 under the industrial exposure scenario.

C.4 MODELS SELECTED

C.4.1 SESOIL

SESOIL was used to simulate the vertical transport of contaminants from the source areas down through the vadose zone to the shallow groundwater (water table). SESOIL is a one-dimensional, vertical transport code for the unsaturated soil zone designed to simultaneously model water transport and pollutant fate. The program was originally developed by EPA (Bonazountas and Wagner 1984) and has been extensively modified to enhance its capabilities (Hetrick et al. 1989; Hetrick et al. 1986; and Hetrick and Travis 1988).

The SESOIL model defines the "soil compartment" as a soil column extending from the ground surface through the unsaturated zone to the water table. Processes are simulated in SESOIL in both the

hydrologic cycle and the pollutant cycle, each of which is a separate submodule in the SESOIL code. The hydrologic cycle includes rainfall, surface runoff, infiltration, soil water content, evapotranspiration, and groundwater recharge. The pollutant cycle includes convective transport, volatilization, adsorption/desorption, and degradation/decay. A contaminant in SESOIL can partition in up to four phases (liquid, adsorbed, air, and pure).

SESOIL is well recognized and accepted by the scientific community utilizing soil-chemical fate models. Attributes of SESOIL that make it particularly attractive and suitable for the vadose zone soil leaching at this site include the following:

- SESOIL has been extensively validated and shown to work under a number of scenarios. It has also been used for similar applications in other parts of the country and is capable of providing the information required from this study (Hetrick 1984; Watson and Brown 1985; Hetrick et al. 1986; Melancol, Pollard, and Hern 1986; Hetrick and Travis 1988; Hetrick et al. 1989; Hetrick, Luxmoore, and Tharp 1993; Hetrick and Scott 1993).

- SESOIL has the advantage of fewer input requirements and faster run times than more complex unsaturated zone models, while still maintaining considerable resolution of the pollutant front in both time and space.

- The model can be divided into as few as two layers and as many as four layers, with as many as ten sublayers in each of the layers. This compartmental nature of the model allows for user-specified tailoring to suit a particular site.

C.4.2 AT123D

The AT123D is a well-known and commonly used analytical groundwater pollutant fate and transport model. This model was developed by Yeh (1981) and has been updated by GSC (1996). It computes the spatial-temporal concentration distribution of chemicals in the aquifer system and predicts the transient spread of a chemical plume through a groundwater aquifer. The fate and transport processes accounted for in AT123D are advection, dispersion, adsorption/retardation, and decay. This model can be used as a tool for estimating the dissolved concentration of a chemical in three dimensions in groundwater resulting from a mass release (either continuous or instant or depleting source) over a source area (i.e., point, line, area, or volume source).

C.4.3 SESOIL and AT123D Model Parameters

The hydrologic modeling parameters used for fate and transport modeling are based on findings from previous investigations. Representative parameter values were selected to represent the variability in the hydraulic system and the most likely conditions within that variability. Time-varying model runs were performed using the representative values. Model runs were calibrated using site data. AT123D modeling represents the worst-case flow direction; therefore, it is likely that the model runs will generally overestimate actual transport of contaminants.

The chemical-specific model parameters include solubility in water, organic carbon partition coefficient, Henry's Law constant, soil-water distribution coefficient, diffusion coefficients in air and water, and first order decay constant. These are literature-based parameters and a conservative approach should always be utilized for selecting the values of these parameters. Chemical-specific source inputs, radioactive decay, and biodegradation rates were developed and presented in the final estimate of volume.

C.5 MODEL APPLICATION AND RESULTS

C.5.1 Example Use of Bethel Valley Soil Cleanup Level Calculations for Minimizing Impacts to Groundwater

To demonstrate the use of the process outlined above, sample calculations of soil removal at the Tank W-1A leak site were performed. For purposes of this example, calculations were performed for all the COCs selected from the Bethel Valley RI (DOE 1999) for minimizing impacts to groundwater, although not all of these COCs occur at the Tank W-1A leak site.

The Summers model was applied to each COC for predicting its trigger level at Tank W-1A. The results of the model application to all the COCs are shown in Table C.2. The first column lists the COCs. The second, third, and fourth columns list the K_{oc}, K_d, and C_w, respectively, of the COCs. The fifth column lists the TL of the COCs.

For purposes of this example, it is assumed that three COCs, ^{90}Sr, ^{14}C, and tritium, are detected in a CSZ at CBV. It is assumed that statistical analysis indicates the maximum concentration of these COCs exceed their respective TLs. Therefore, the sum-of-fractions is also greater than 1.0. The area of the soil contamination zone based on comparison to the TLs is assumed to be smaller than the area used in Summers model. Contaminant transport using SESOIL and AT123D models are performed for these constituents, and maximum concentrations at the receptor location are predicted. Plots of concentration versus time at the receptor location are presented in Fig. C.3 through C.5. As can be seen from these figures, the times of maximum concentration are 140 years for ^{90}Sr, 50 years for C^{14}, and 8 years for tritium.

For this example, the maximum soil concentration of ^{90}Sr in the CSZ of 20,000 pCi/g is used in the SESOIL modeling with the 54 m^2 (580 ft^2) area of soil contamination exceeding the ^{90}Sr TL. Depth of soil contamination used in the modeling is 1.8 to 3.4 m (6 to 11 ft) below ground surface and the leaching zone below the soil contamination is 1.7 m (5.5 ft) [i.e., depth to water table is 5.0 m (16.5 ft)]. The predicted maximum groundwater concentration based on SESOIL and AT123D modeling at the receptor location is 471 pCi/L. Therefore, the revised (updated) TL ^{90}Sr is given by:

$$\begin{aligned} TL_R &= (20{,}000 \text{ pCi/g} \times 390 \text{ pCi/L}) / 471 \text{ pCi/L} \\ &= 16{,}560 \text{ pCi/g} \end{aligned}$$

Since the maximum soil concentration of ^{90}Sr in the CSZ (i.e. 20,000 pCi/g) is greater than its TL_R, soil cleanup is necessary for this site. The volume of soil that should be excavated (i.e., soil within the 16,560 pCi/g) for cleanup may be estimated by developing 3-D concentration isosurfaces.

C.5.2 TL Verification and Sum of Fractions

As shown in Table C.3, by using the sum-of-fractions approach, the cumulative risk to an industrial groundwater user can be derived and it can be easily determined whether cleanup of soil is necessary. Note that the sum-of-fractions calculations for Scenario 2 assumes that all the COCs considered reach a peak concentration at the same time. If an alternative assumption is made (i.e., the concentration peaks differ), then Scenario 2 may also meet the groundwater target risk.

For example, assume that the three COCs considered above are ^{90}Sr, ^{14}C, and tritium. The SESOIL and AT123D modeling results presented earlier show that these COCs should reach peak concentrations at markedly different times. Therefore, because none of the fractions exceeds 1, the cumulative risk at all times can be expected to remain below 1E-04, and no cleanup would be necessary for Scenario 2

contaminated soils. Issues such as these will need to be addressed in developing the estimate of final volume for excavation at CBV.

C.6 LIMITATIONS/ASSUMPTIONS

Based upon data availability, a conservative approach was used, and the contaminant concentration in groundwater may have been overestimated. Following are key assumptions used in this analysis:

- The aquifer is homogenous and isotropic.
- Flow is under steady-state condition.
- Flow and transport are not affected by density variations.
- The interaction between solid- and solution-phase concentrations follows equilibrium, reversibility, and linearity.
- There is no interaction between different solutes in the groundwater.

The inherent uncertainties associated with these assumptions must be recognized. The geochemistry of the site may be significantly affected by the interaction between different solutes present at the site and, hence, may change over time. Projected organic concentrations in the aquifer are expected to be highly conservative due to the use of steady-state source without any biodegradation.

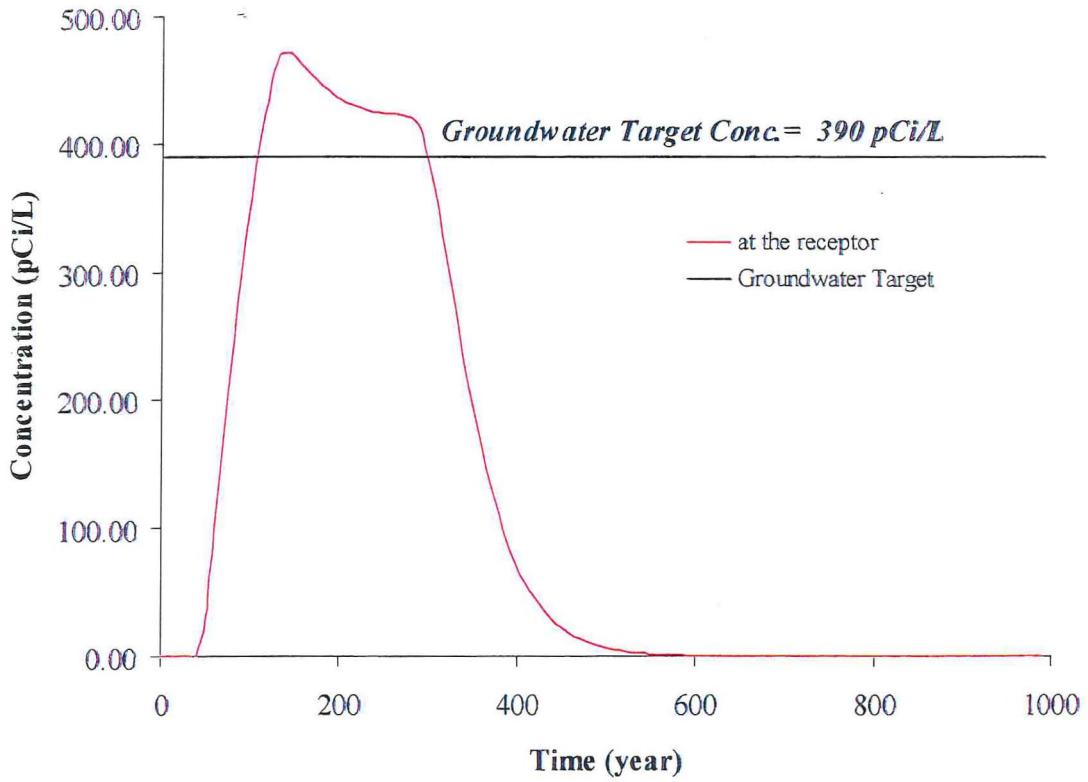

Fig. C.3. Predicted groundwater concentration of ^{90}Sr based on assumed soil concentration in CBV.

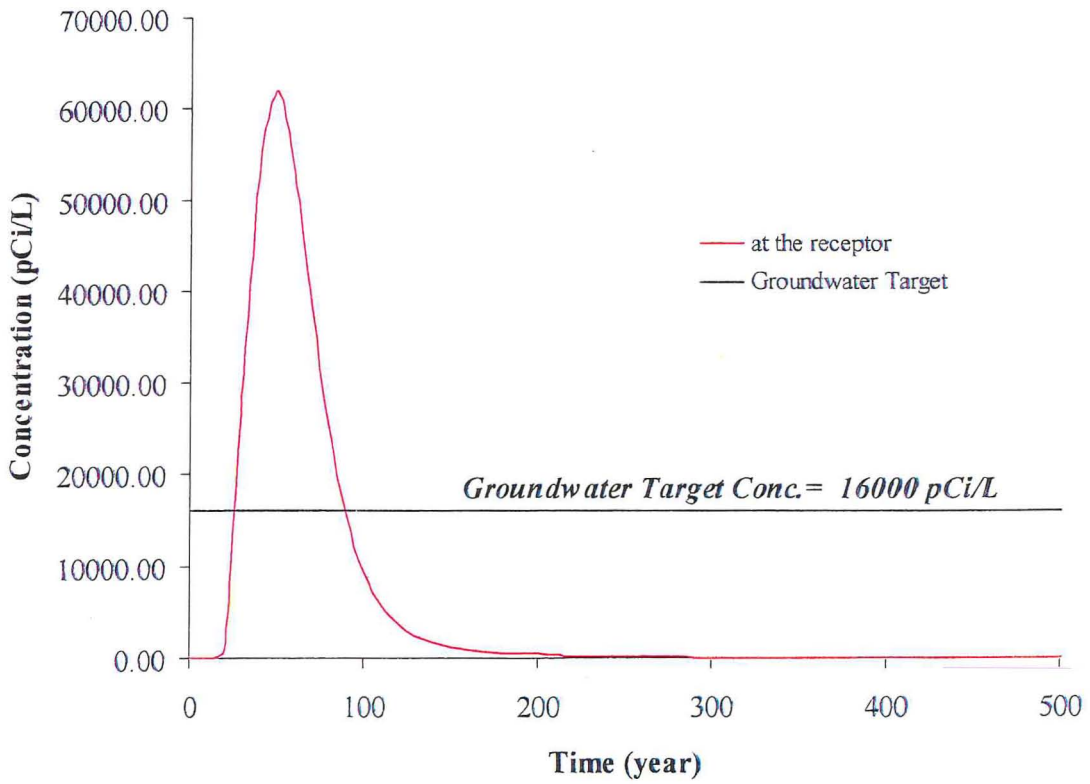

Fig. C.4. Predicted groundwater concentration of ^{14}C based on assumed soil concentration in CBV.

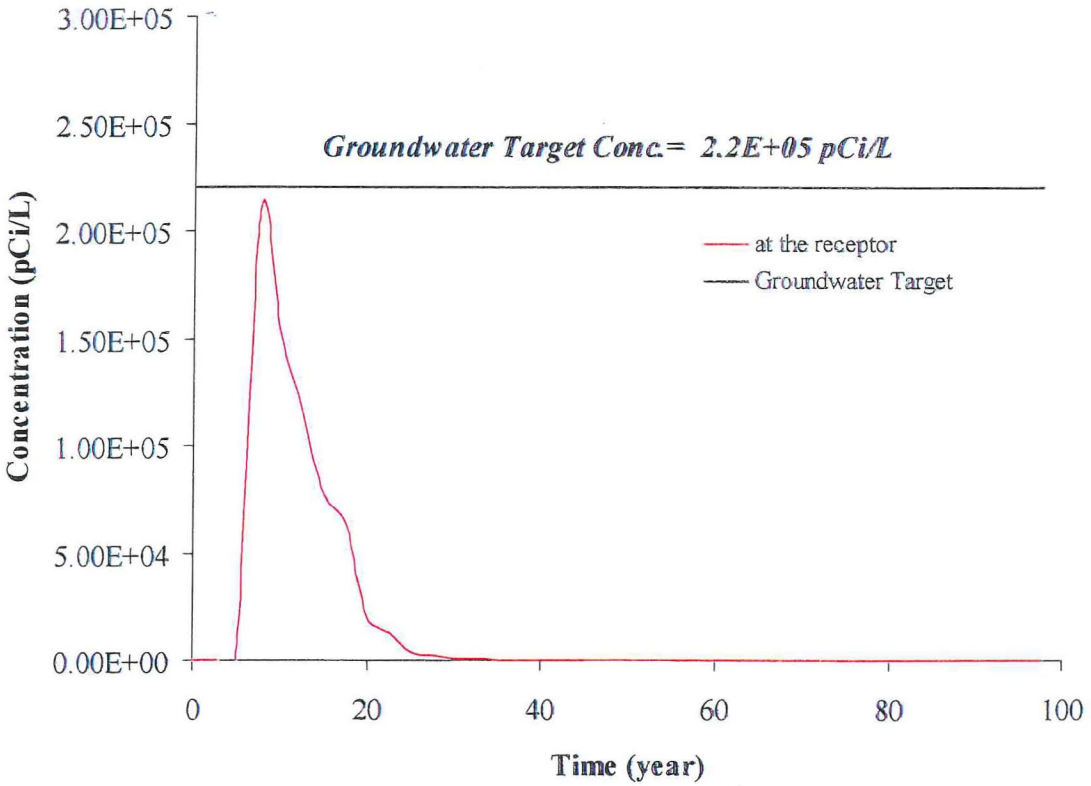

Fig. C.5. Predicted groundwater concentration of tritium based on assumed soil concentration in CBV.

Table C.3. Use of sum of fractions with the risk-based Trigger Levels

Scenario	Example COC concentration	Example TL	Fraction	Result
1	2	1	2	Scenario 1 will require cleanup because the fraction for Scenario 1 COCs exceeds TL. This indicates that risk from a single COC (as well as total risk) would exceed the target risk of 1E-04.
	5	100	0.05	
	10	100	0.1	
Sum of Fractions			**2.15**	
2	0.5	1	0.5	Scenario 2 will require cleanup because the sum of fractions for Scenario 2 is > 1. This indicates that total risk would exceed the target of risk of 1E-04.
	50	100	0.5	
	10	100	0.1	
Sum of Fractions			**1.1**	
3	0.5	1	0.5	Scenario 3 is accepted because the sum of fractions for the COCs is not exceeded. This indicates that the total risk would be less than the target risk of 1E-04.
	3	100	0.03	
	10	100	0.1	
Sum of Fractions			**0.63**	

COC = contaminant of concern
TL = trigger level

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APPENDIX D

COMPARATIVE EVALUATION FOR SITE COMPONENTS

Table D.1. Comparative evaluation of Central/East Bethel Valley building alternatives, ORNL, Oak Ridge, Tennessee

Criteria		Alternative C-1 (no action)	Alternative C-2 (removal, surface & subsurface)	Alternative C-3 (building surface removal, decon subsurface)	Alternative C-4 (surface removal, grout subsurface)
Overall protection of human health and the environment		No protection from radiological exposure.	Complete removal of all contamination associated with buildings. Debris disposed appropriately. Exception is Graphite Reactor which is grouted and is protective.	Basically same as Alternative C-2 but may be less certain that all subsurface contamination has been removed.	Relies on containment to control migration of and access to subsurface contamination. Complete removal of surface contamination. Graphite Reactor grouted as in Alternative C-2.
Compliance with ARARs		No ARARs.	Meets all ARARs.	Meets all ARARs.	Meets all ARARs.
Reduction of toxicity, mobility, or volume through treatment		No reduction of toxicity, mobility, or volume through treatment.	No reduction of toxicity, mobility, or volume through treatment.	No reduction of toxicity, mobility, or volume through treatment.	No reduction of toxicity, mobility, or volume through treatment.
Short-term effectiveness		No short-term impacts because no remedial actions taken.	Greatest potential for worker exposure or transportation accidents due to greatest amount of work and waste generated. However, the short-term impacts are controllable.	Slightly less potential for worker exposure and transportation accidents than from Alternative C-2, but greater potential than Alternative C-4.	Less potential for worker exposure and transportation accidents than from Alternative C-3.
Implementability		Easy to implement.	Technically feasible but numerous challenges in removing subsurface features if plant remains active. No administrative issues. Available disposal outlet.	Technically feasible. Easier to implement at active facility than Alternative C-2 but more difficult than Alternative C-4. Available disposal outlets.	Technically feasible. Slightly easier to implement than Alternatives C-2 and C-3. Available disposal outlets.
Base action cost (unescalated)	Capital	$0	$84,700,000	$82,200,000	$80,600,000
	Annual O&M	$0	$0	$0	$0[1]

ARAR = applicable or relevant and appropriate requirement
ORNL = Oak Ridge National Laboratory
NA = not applicable
O&M = operation and maintenance

[1] Institutional control costs built into site-wide alternative costs

Table D.2. Comparative evaluation of Central/East Bethel Valley buried waste alternatives, ORNL, Oak Ridge, Tennessee

Criteria		Alternative C-1 (no action)	Alternative C-2 (removal)	Alternative C-3 (containment)	Alternative C-4 (containment)
Overall protection of human health and the environment		No protection from exposure to buried waste.	Complete removal of all contamination associated with buried waste. Material disposed appropriately.	Protective to extent caps and covers are maintained and institutional controls are implemented.	See Alternative C-3.
Compliance with ARARs		No ARARs.	Meets all ARARs.	Meets all ARARs.	Meets all ARARs.
Long-term effectiveness and permanence		Not effective.	Most effective and permanent as all contamination is removed.	Effectiveness relies on long-term maintenance and institutional controls. Controls at an active laboratory can be effectively implemented.	See Alternative C-3.
Reduction of toxicity, mobility, or volume through treatment		No reduction of toxicity, mobility, or volume through treatment.	No reduction of toxicity, mobility, or volume through treatment.	No reduction of toxicity, mobility, or volume through treatment.	See Alternative C-3.
Short-term effectiveness		No short-term impacts because no remedial actions taken.	Most significant potential for worker exposure during excavation and accidents during transportation. Takes up considerable disposal space but should have outlets available.	Limited potential for construction accidents during capping and accidents during cover transportation.	See Alternative C-3.
Implementability		Easy to implement.	Although more challenging than Alternative C-3, technically feasible with few challenges due to less contaminated contents. Disposal outlets available.	Easy to implement. No administrative difficulties.	See Alternative C-3.
Base action cost (unescalated)	Capital	$0	$10,500,000	$940,000	$940,000
	Annual O&M	$0	$0	$23,000[1]	$23,000[1]

ARAR = applicable or relevant and appropriate requirement
NA = not applicable
O&M = operation and maintenance
ORNL = Oak Ridge National Laboratory

[1] Institutional control costs built into site-wide alternative costs.

Table D.3. Comparative evaluation of Central/East Bethel Valley Gunite/Concrete Tanks (etc.) alternatives, ORNL, Oak Ridge, Tennessee

Criteria		Alternative C-1 (no action)	Alternative C-2 (lining removal, backfill)	Alternative C-3 (backfill)	Alternative C-4 (backfill)
Overall protection of human health and the environment		No protection from cover failure or exposure.	Complete removal of all contamination associated with these tanks. Debris disposed appropriately.	Relies on containment to control migration and access to subsurface contamination. Almost no maintenance required.	See Alternative C-3.
Compliance with ARARs		No ARARs.	Meets all ARARs.	Meets all ARARs.	Meets all ARARs.
Long-term effectiveness and permanence		Not effective.	Most effective and permanent as all contamination is removed.	Contamination remains but is effectively controlled by fill/grout. Little reliance on maintenance and institutional control for continued effectiveness.	See Alternative C-3.
Reduction of toxicity, mobility, or volume through treatment		No reduction of toxicity, mobility, or volume through treatment.	No reduction of toxicity, mobility, or volume through treatment.	No reduction of toxicity, mobility, or volume through treatment.	See Alternative C-3.
Short-term effectiveness		No short-term impacts because no remedial actions taken.	Removal of liner enhances potential for worker exposure over Alternative C-3, but is controllable.	No significant short-term impacts.	See Alternative C-3.
Implementability		Easy to implement.	Challenging to remove liner without potential for collapse. Feasible but notably more difficult than Alternative C-3.	Technically feasible with no administrative difficulties.	See Alternative C-3.
Base action cost (unescalated)	Capital	$0	$34,000,000	$5,800,000	$5,800,000
	Annual O&M	$0	$0	$0[1]	$0[1]

ARAR = applicable or relevant and appropriate requirement
NA = not applicable
O&M = operation and maintenance
ORNL = Oak Ridge National Laboratory

[1] Includes inspection, mowing, and erosion control.

Table D.4. Comparative evaluation of Central/East Bethel Valley pipeline and steel tank alternatives, ORNL, Oak Ridge, Tennessee

Criteria		Alternative C-1 (no action)	Alternative C-2 (removal after grouting)	Alternative C-3 (grout tanks and pipelines)	Alternative C-4 (grout tanks)
Overall protection of human health and the environment		No protection from radiological exposure nor migration of contaminants.	Complete removal of all contamination associated with steel tanks and pipelines. Material disposed of appropriately.	Protection from exposure provided by grout and institutional controls. Protection from contaminant migration provided by grout.	Protection from exposure provided by grout and institutional controls. No protection from contaminant migration through pipelines provided.
Compliance with ARARs		No ARARs.	Meets all ARARs.	Meets all ARARs.	Meets all ARARs.
Long-term effectiveness and permanence		Not effective.	Most effective and permanent as all contamination is removed.	Effective but some reliance on long-term controls is needed.	Effective at preventing exposure but not effective at controlling groundwater contamination through pipelines.
Reduction of toxicity, mobility, or volume through treatment		No reduction of toxicity, mobility, or volume through treatment.	No reduction of toxicity, mobility, or volume through treatment.	Reduction of mobility of residual contamination in tanks and pipelines as a result of grouting.	Reduction of mobility of residual contamination in tanks as a result of grouting.
Short-term effectiveness		No short-term impacts because no remedial actions taken.	Greater potential for worker exposure due to significant construction effort to remove tanks and pipelines. Significant volumes of waste transported. Impacts can be controlled.	Limited potential for worker exposure since contamination left in place. No impacts to community via releases or transportation accidents. Could impact plant operations during pipeline grouting.	Limited potential for worker exposure since contamination left in place. No impacts to community via releases or transportation accidents.
Implementability		Easy to implement.	Technically feasible but numerous challenges in removing grouted tanks and pipelines if plant remains active. No administrative issues. Available disposal outlets.	Technically feasible but locating appropriate pipelines to grout will be a challenge.	Technically feasible—all actions have been done before.
Base action cost (unescalated)	Capital	$0	$22,400,000[1]	$21,600,000	$6,400,000
	Annual O&M	$0	$0	$0[2]	$0[2]

ARAR = applicable or relevant and appropriate requirement
NA = not applicable
O&M = operation and maintenance
ORNL = Oak Ridge National Laboratory

[1] Costs only for grouting tanks and pipelines. Removal costs included in soil removal costs.
[2] Institutional control costs built into site-wide alternative costs.

Table D.5. Comparative evaluation of Central/East Bethel Valley soil alternatives, ORNL, Oak Ridge, Tennessee

Criteria		Alternative C-1 (no action)	Alternative C-2 [removal to 3 m (10 ft) and to minimize impacts to groundwater]	Alternative C-3 [removal to 0.6 m (2 ft) and to minimize impacts to groundwater]	Alternative C-4 [removal to 0.6 m (2 ft)]
Overall protection of human health and the environment		No protection from radiological exposure or of groundwater	Two-phase removal protects ORNL workers in near-term and unrestricted industrial workers in future. Deeper excavation protects groundwater.	Removal protects ORNL (restricted) workers along with institutional controls. Deeper soils still have unacceptable risk. Minimizes impacts to groundwater from greatest soil sources through removal.	Removal protects ORNL (restricted) workers along with institutional controls. Deeper soils still have unacceptable risk and potential impact on groundwater.
Compliance with ARARs		No ARARs.	Meets all ARARs.	Meets all ARARs.	Meets all ARARs.
Long-term effectiveness and permanence		Not effective.	Most effective and permanent as most contamination removed. Institutional controls necessary to prevent access below 3 m (10 ft) or by a resident.	Effective; however does rely on institutional controls.	Effective for protecting human health although does rely on institutional controls. Does not minimize impacts to groundwater from soil sources.
Reduction of toxicity, mobility, or volume through treatment		No reduction of toxicity, mobility, or volume through treatment.	No reduction of toxicity, mobility, or volume through treatment.	No reduction of toxicity, mobility, or volume through treatment.	No reduction of toxicity, mobility, or volume through treatment.
Short-term effectiveness		No short-term impacts because no remedial actions taken.	Significant potential for worker exposure or accident or for transportation accidents due to removal of almost 765,000 m^3 (1,000,000 yd^3) of soil. Potential can be controlled with a lot of engineering controls.	Potential for worker exposure during soil excavation. Potential for accidents from transportation. These potentials can be controlled.	Potential for worker exposure during soil excavation a little less than Alternative C-3 since deeper soils not excavated. Potential can be controlled.
Implementability		Easy to implement.	Technically feasible but difficult to implement. Final soil removal almost impossible until ORNL is inactive. Questionable future disposal outlets.	Technically feasible. Deeper soil excavation can be challenging but has been done. No administrative difficulties. Known disposal outlets.	Technically feasible and a little easier than Alternative C-3 since deep soil not excavated.
Base action cost (unescalated)	Capital	$0	$380,000,000[1]	$61,400,000	$60,200,000
	Annual O&M	$0	$86,000[2]	$58,000[2]	$58,000[2]

ARAR = applicable or relevant and appropriate requirement
NA = not applicable
O&M = operation and maintenance
ORNL = Oak Ridge National Laboratory

[1] Includes near-term $8,000,000 soil removal and future $374,000,000 soil removal.
[2] Includes visual inspection, mowing, erosion control (Alt. C-2, until future large scale soil action implemented).

Table D.6. Comparative evaluation of Central/East Bethel Valley sediment and floodplain soil alternatives, ORNL, Oak Ridge, Tennessee

Criteria		Alternative C-1 (no action)	Alternative C-2 [sediment and floodplain soil removal to average 1.5 m (5 ft)]	Alternative C-3 [sediment and floodplain soil removal to 0.6 m (2 ft)]	Alternative C-4 [sediment and floodplain soil removal to 0.6 m (2 ft)]
Overall protection of human health and the environment		No protection of surface water or of recreational use of creek.	Removal of all contaminated sediment to protect surface waters and recreational receptors plus floodplain soil to protect unrestricted industrial user requires almost no reliance on long-term controls.	Removal of all contaminated sediment to protect surface waters and recreational receptors plus floodplain soil to protect controlled industrial user requires long-term control over the residual soil.	See Alternative C-3.
Compliance with ARARs		No ARARs.	Meets all ARARs.	Meets all ARARs.	Meets all ARARs.
Long-term effectiveness and permanence		Not effective.	Effective and permanent as all sediment and floodplain soil contamination is removed	Effective and permanent for removed sediment. Effectiveness for floodplain soil requires long-term controls.	See Alternative C-3.
Reduction of toxicity, mobility, or volume through treatment		No reduction of toxicity, mobility, or volume through treatment.	No reduction of toxicity, mobility, or volume through treatment.	No reduction of toxicity, mobility, or volume through treatment.	No reduction of toxicity, mobility, or volume through treatment.
Short-term effectiveness		No short-term impacts because no remedial action.	Considerable short-term impacts to aquatic organisms located in or near sediment to be removed. Potential for slug releases of sediment to Melton Valley during implementation. This impact can be controlled.	Very similar to Alternative C-2. Difference in floodplain soil volumes means lower transported volumes than Alternative C-2.	See Alternative C-3.
Implementability		Easy to implement.	Engineering controls required to control sediment releases during excavation increase difficulty but still technically implementable.	Very similar to Alternative C-2. Lower volumes of excavated flood plain soil decreases difficulty.	See Alternative C-3.
Base action cost (unescalated)	Capital	$0	$46,000,000	$19,600,000	$19,600,000
	Annual O&M	$0	$0	$0	$0

ARAR = applicable or relevant and appropriate requirement
NA = not applicable
O&M = operation and maintenance
ORNL = Oak Ridge National Laboratory

Table D.7. Comparative evaluation of Central/East Bethel Valley groundwater alternatives, ORNL, Oak Ridge, Tennessee

Criteria	Alternative C-1 (no action)	Alternative C-2a (deep extraction, ex situ treatment of VOC plume)	Alternative C-2b (deep extraction, in situ treatment of VOC plume)	Alternative C-3a (deep extraction, ex situ treatment of VOC plume)	Alternative C-3b (deep extraction, in situ treatment of VOC plume)	Alternative C-4 (shallow extraction)
Overall protection of human health and the environment	No protection of surface water nor reduction in groundwater concentrations.	Protects surface water through removal. Reduces concentrations but relies on long-term institutional controls as considerable contamination remains.	Very similar to Alternative C-2a. Uses insitu treatment on VOC Plume.	See Alternative C-2a	See Alternative C-2b	Protects surface water through removal. Does not attempt to reduce groundwater concentrations. Relies on long-term institutional controls as considerable contamination remains.
Compliance with ARARs	No ARARs	Meets all ARARs.		Meets all ARARs.		Meets all ARARs.
Long-term effectiveness and permanence	Not effective.	Most reliable because extracts more than necessary to protect surface water causing the mass of contaminants to be reduced.	Similar to Alternative C-2a except effectiveness of insitu treatment to reduce VOC levels less certain at this stage.			Slightly less reliable as only the minimum necessary to protect surface water is implemented.
				See Alternative C-2a	See Alternative C-2b	
Reduction of toxicity, mobility, or volume through treatment	No reduction of toxicity, mobility, or volume through treatment.	Reduction of toxicity and volume through exsitu treatment.	Reduction of toxicity and volume through exsitu and insitu treatment.	See Alternative C-2a	See Alternative C-2b	See Alternative C-2a
				See Alternative C-2a	See Alternative C-2b	
Short-term effectiveness	No short-term impacts because no remedial action taken.	Minimal short-term effects on workers since little exposure. No impacts to community or environment.	See Alternative C-2a.	See Alternative C-2a	See Alternative C-2a.	See Alternative C-2a.

Table D.7. Comparative evaluation of Central/East Bethel Valley groundwater alternatives, ORNL, Oak Ridge, Tennessee (continued)

Criteria		Alternative C-1 (no action)	Alternative C-2a (deep extraction, ex situ treatment of VOC plume)	Alternative C-2b (deep extraction, in situ treatment of VOC plume)	Alternative C-3a (deep extraction, ex situ treatment of VOC plume)	Alternative C-3b (deep extraction, in situ treatment of VOC plume)	Alternative C-4 (shallow extraction)
Implementability		Easy to implement.	Treatment plants already operational and treating groundwater. Location of extraction most difficult.	Similar to Alternative C-2a except less effort involved in insitu VOC treatment.	See Alternative C-2a.	See Alternative C-2b	See Alternative C-2a
Base action cost (unescalated)	Capital		$4,200,000	$4,200,000	$4,200,000	$4,200,000	$2,100,000
	Annual O&M		$12,500,000[1]	$12,300,000[1]	$12,500,000[1]	$12,300,000[1]	$9,000,000[1]

ARAR = applicable or relevant and appropriate requirement
NA = not applicable
O&M = operation and maintenance
ORNL = Oak Ridge National Laboratory
VOC = volatile organic compound

[1] Water treatment costs

Table D.8. Comparative evaluation of West Bethel Valley/Raccoon Creek buried waste/soil alternatives, ORNL, Oak Ridge, Tennessee

Criteria		Alternative W-1 (no action)	Alternative W-2 (removal)	Alternative W-3 (removal)	Alternative W-4a (cap and grout)	Alternative W-4b (cap)	Alternative W-5 (cap)
Overall protection of human health and the environment		No protection from radiological exposure.	Protection provided by removal of all waste above unrestricted labels. No reliance of institutional controls.	See Alternative W-2.	Containment and institutional controls are protective. Grout enhances protection of groundwater.	Containment and institutional controls are protective.	See Alternative W-4b.
Compliance with ARARs		No ARARs.	Meets all ARARs.	Meets all ARARs.	Meets all ARARs.	Meets all ARARs.	Meets all ARARs.
Long-term effectiveness and permanence		Not effective.	Effective and permanent as all contamination in buried waste or soil is removed and disposed appropriately.	See Alternative W-2.	Although effectiveness depends on long-term institutional controls, it is improved with grout which would limit subsidence and lessen leaching to groundwater.	Effectiveness depends on long-term institutional controls.	See Alternative W-4b.
Reduction of toxicity, mobility, or volume through treatment		No reduction of toxicity, mobility, or volume through treatment.	Some minor reduction of mobility may be needed on part of excavated waste to meet LDRs.	See Alternative W-2.	Grouting of SWSA-3 would reduce mobility of those contaminants.	No reduction of toxicity, mobility, or volume through treatment.	See Alternative W-4b
Short-term effectiveness		No short-term impacts because no remedial action.	Significant waste volumes (88,000 cy) would require transportation as would borrow material. Large excavation activities increase potential for worker exposure.	See Alternative W-2.	Noticeably less short-term impacts than from Alternative W-2.	Least short-term impacts of any alternative.	See Alternative W-4b.
Implementability		Easy to implement	Most difficult to implement. Parts of SWSA-3 may be concreted and may be very contaminated. Standard equipment could be used but would occur slowly.	See Alternative W-2	Some technical challenges in grouting buried waste. Much easier than Alternative W-2.	Caps are easy to implement.	See Alternative W-4b.
Base action cost (unescalated)	Capital	$0	$100,000,000	$100,000,000	$38,000,000	$7,000,000	$7,000,000
	Annual O&M	$0	$0	$0	$85,000	$85,000	$85,000

ARAR = applicable or relevant and appropriate requirement
LDR= Land disposal restrictions
NA = not applicable
O&M= operation and maintenance
ORNL = Oak Ridge National Laboratory

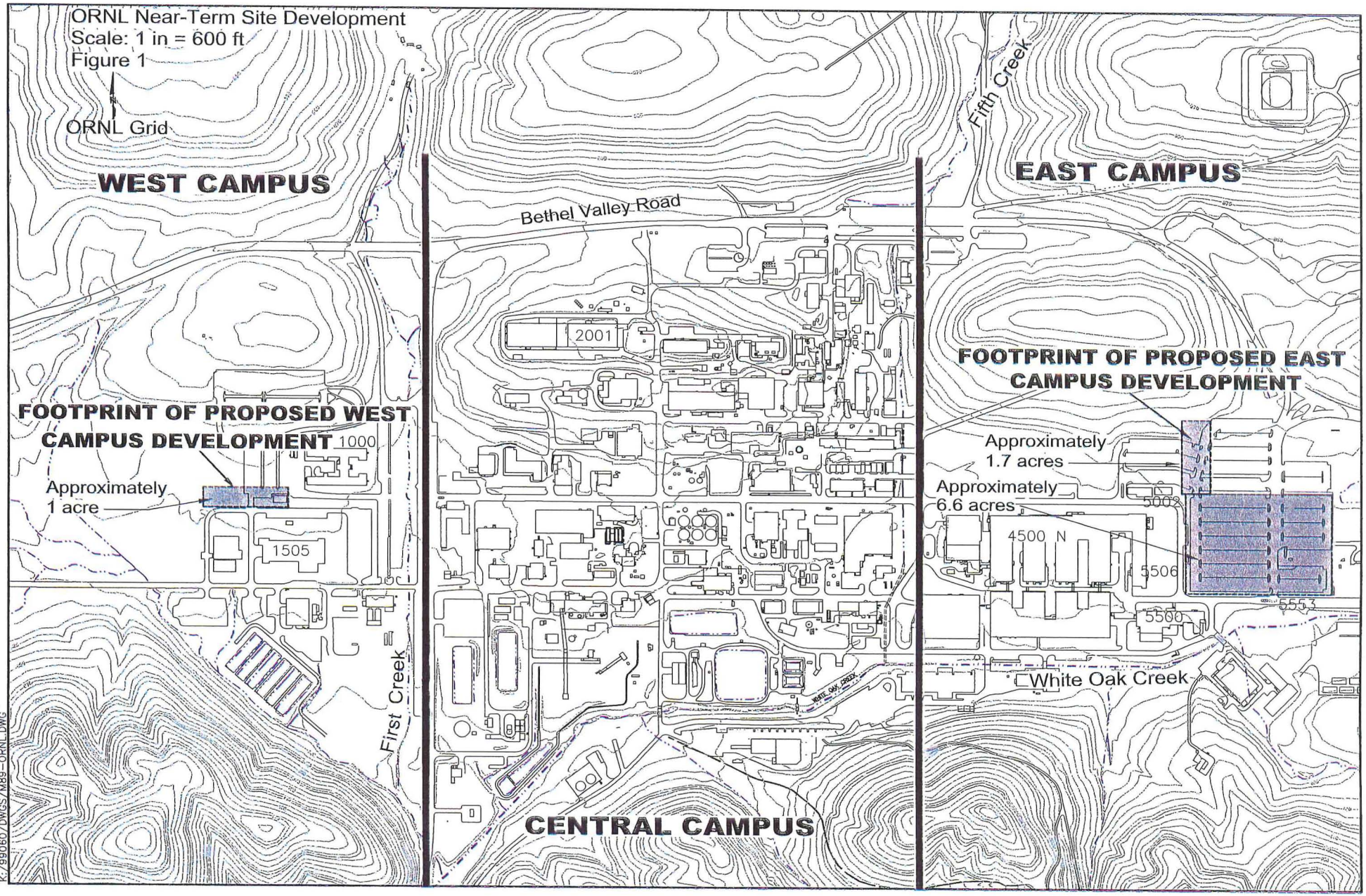
Table D.9. Comparative evaluation of West Bethel Valley/Raccoon Creek groundwater alternatives, ORNL, Oak Ridge, Tennessee

Criteria		Alternative W-1 (no action)	Alternative W-2	Alternative W-3	Alternative W-4	Alternative W-5
Overall protection of human health and the environment		Not protective of future use.	Currently protective of surface water but extraction provides more security to provide protection in future. Relies on institutional controls to prevent use.	Currently protective of surface water. Provides institutional controls to prevent use. Monitoring can assess of conditions change.	See Alternative W-2.	See Alternative W-3.
Compliance with ARARs		No ARARs.	Meets all ARARs.	Meets all ARARs.	Meets all ARARs.	Meets all ARARs.
Long-term effectiveness and permanence		Not effective.	Effectiveness depends on long-term controls. Provides some mass reduction in groundwater.	Effectiveness depends on long-term controls. Monitoring will identify any changing conditions.	See Alternative W-2.	See Alternative W-3.
Reduction of toxicity, mobility, or volume through treatment		No reduction of toxicity, mobility, or volume through treatment.	Reduction in volume by removal of Sr^{90} by ion exchange.	No reduction of toxicity, mobility, or volume through treatment.	See Alternative W-2.	See Alternative W-3.
Short-term effectiveness		No short-term impacts because no remedial action.	No significant short-term impacts. Placement of a pipeline may disrupt some ecology but no sensitive populations.	No short-term impacts. Actions are passive (controls and monitoring)	See Alternative W-2.	See Alternative W-3.
Implementability		Easy to implement.	Technically feasible but transporting extracted water to treatment plant is a challenge.	Easy to implement.	See Alternative W-2.	See Alternative W-3.
Base action cost (unescalated)	Capital	$0	$1,100,000	$200,000	$1,100,000	$200,000
	Annual O&M	$0	$2,800,000	$67,000	$2,800,000	$67,000

ARAR = applicable or relevant and appropriate requirement
NA = not applicable
O&M = operation and maintenance
ORNL = Oak Ridge National Laboratory

APPENDIX E

LAND PARCELS AVAILABLE FOR TRANSFER TO NON-FEDERAL OWNERSHIP



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Source: Modified from Figure 1 of Covenant Deferral Request, Oak Ridge National Laboratory Facilities Revitalization Project, DOE, May 2001.

Fig. E.1. Land parcels available for transfer to non-federal ownership.

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