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D&D Alternatives Risk Assessment for Building 3515 at Oak Ridge National Laboratory Oak Ridge, Tennessee

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ORNL/ER-334

D&D Alternatives Risk Assessment for Building 3515 at Oak Ridge National Laboratory Oak Ridge, Tennessee

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Date Issued—September 1995

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Transmittal of Final *D&D Alternatives Risk Assessment for Building 3515 at Oak Ridge National Laboratory, Oak Ridge, Tennessee* report, ORNL/ER-334

Enclosed you will find a copy of *D&D Alternatives Risk Assessment for Building 3515 at Oak Ridge National Laboratory, Oak Ridge, Tennessee*, ORNL/ER-334. The purpose of this document is to present the D&D Alternatives Risk Assessment (DARA). The DARA evaluates and documents the potential risks to human health, human safety, and the environment associated with the proposed action at Building 3515. The results of the DARA may be used by project managers along with engineering information in making decisions regarding the final disposition of Building 3515. This risk assessment has been prepared to conform with the requirements of the streamline risk evaluation contained in the Engineering Evaluation/Cost Analysis.

Please contact me at 241-4549 if you have any questions or concerns.

Sincerely,

Karen M. Golden

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PREFACE

This Decontamination and Decommissioning (D&D) Alternatives Risk Assessment for Building 3515 at the Oak Ridge National Laboratory (ORNL) provides the Environmental Restoration Program and Building 3515 project managers with information to assist them in choosing the appropriate remedial alternative for the building. The document was prepared under Work Breakdown Structure 1.4.12.6.2.01 (Activity Data Sheet 3701, Facilities D&D) and presents the results of the Level 3 D&D Alternatives Risk Assessment (DARA) performed on Building 3515. This Level 3 DARA meets the requirements of the streamlined risk assessment necessary for an Engineering Evaluation/Cost Analysis.

CONTENTS

PREFACE iii

TABLES vii

EXECUTIVE SUMMARY ix

1. INTRODUCTION 1
   1.1 BACKGROUND 1
   1.2 OBJECTIVES AND SCOPE OF THE DARA 2
   1.3 ORGANIZATION OF THIS REPORT 3

2. DEFINITION OF ALTERNATIVES 4
   2.1 NO-ACTION ALTERNATIVE 4
   2.2 COMPLETE DISMANTLEMENT ALTERNATIVE 4

3. DATA EVALUATION 6
   3.1 SUMMARY OF FACILITY CHARACTERIZATION DATA 6
   3.2 CONTAMINANTS OF CONCERN 7
      3.2.1 Contaminants of Concern for No-Action Alternative 7
      3.2.2 Contaminants of Concern for Complete Dismantlement Alternative 7
   3.3 RECEPTOR CHARACTERIZATION DATA 8
   3.4 UNCERTAINTY 8

4. EVALUATION OF LONG-TERM EFFECTIVENESS 8
   4.1 NO-ACTION ALTERNATIVE 13
   4.2 COMPLETE DISMANTLEMENT ALTERNATIVE 14

5. EVALUATION OF SHORT-TERM EXPOSURE RISKS 14
   5.1 EXPOSURE ASSESSMENT 15
      5.1.1 Characterization of the exposure setting 15
      5.1.2 Identification of Potential Exposure Pathways 16
      5.1.4 Results of the Exposure Assessment 18
   5.2 TOXICITY ASSESSMENT 18
   5.3 RISK CHARACTERIZATION 20
   5.4 UNCERTAINTY 22

6. EVALUATION OF SHORT-TERM PHYSICAL RISKS OF D&D ALTERNATIVES 22
   6.1 IDENTIFICATION OF HAZARDS 22
      6.1.1 No-Action Alternative 22
      6.1.2 Complete Dismantlement Alternative 22
   6.2 HAZARD ANALYSIS 22
      6.2.1 No-action Alternative 23
      6.2.2 Complete Dismantlement Alternative 23
   6.3 UNCERTAINTY 24

7. SUMMARY 24

8. REFERENCES 25

TABLES

ES.1. Summary of risks associated with remedial alternatives at Building 3515 x
1. COCs concentration in WAG 1 soil samples taken near Building 3515 7
2. Summary of worker activities for the complete dismantlement alternative 9
3. Estimated ILCRs associated with future land use scenarios 14
4. Results of exposure assessment for complete dismantlement 19
5. Worker exposure limits 20
6. Results of short-term risk characterization for complete dismantlement 21
7. Potential hazards associated with waste transport 24
8. Summary of risks associated with remedial alternatives at Building 3515 25

ACRONYMS

BRA	baseline risk assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLP	Contract Laboratory Procedure
COCs	contaminants of concern
COPCs	contaminants of potential concern
CSL	Close Support Laboratory
DARA	D&D alternatives risk assessment
D&D	Decontamination and Decommissioning
DOE	U.S. Department of Energy
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
GAAT	Gunite and Associated Tanks
HEPA	high-efficiency particulate air (filter)
ILCR	Incremental Lifetime Cancer Risk
Energy Systems	Lockheed Martin Energy Systems, Inc.
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
OU	operable unit
QC	Quality Control
RAS	Risk Analysis Section
RI/FS	Remedial Investigation/Feasibility Study
SFMP	Surplus Facilities Management Program
S&M	surveillance and maintenance
TLD	thermoluminescent dosimeter
VOCs	volatile organic compounds
WAC	waste acceptance criteria
WAG	Waste Area Grouping

EXECUTIVE SUMMARY

This report presents the results of the Level 3 Decontamination and Decommissioning (D&D) Alternatives Risk Assessment (DARA) performed on Building 3515 located at the Oak Ridge National Laboratory (ORNL). The goal of the risk evaluation process is to provide risk information necessary to assist decision making for Environmental Restoration (ER) Program D&D facilities. This risk information is developed in the baseline risk assessment (BRA) and in the DARA. The BRA provides risk information necessary for determining whether or not a facility represents an unacceptable risk and requires remediation. In addition, the BRA also provides an estimation of the risks associated with the no-action alternative for use in the DARA.

The objective of this Level 3 DARA is to evaluate and document the potential risks to human health, human safety, and the environment associated with the proposed remedial action at Building 3515. A Level 3 assessment is the least rigorous type of DARA. The decision to conduct a Level 3 DARA was based on the fact that characterization data from the facility are limited, and currently only one remedial alternative (complete dismantlement) is being evaluated in addition to the no-action alternative. The results of the DARA along with cost and engineering information may be used by project managers in making decisions regarding the final disposition of Building 3515. This Level 3 assessment meets the requirements of the streamlined risk assessment necessary for an Engineering Evaluation/Cost Analysis (EE/CA).

Building 3515 is located within the Gunite and Associated Tanks (GAAT) Operable Unit (OU) east of the south tank farm on Fourth Street south of Central Avenue. This building was built in 1948 and was modified throughout its operational life. The original facility consisted of a concrete pad with tanks and a tent surrounding the shield blocks. In 1950–51, construction of a hot cell was begun with 18-in. thick, solid masonry block walls and a 2-ft-thick, reinforced concrete roof. Lean-to buildings contained the operating area. A small valve pit that contains valves and controls is located on the north side of this building. Building 3515 was used to extract radioisotopes of ruthenium, strontium, cesium, cerium, and other elements from liquid waste that came from ORNL operations and Chalk River clean-up operations in Canada.

Operations in this facility resulted in severe contamination of the interior surfaces due to the practice of overflowing the piping and vessels with purge liquids for decontaminating to allow entry for work. The building contains two rooms with solid masonry block walls shielding the process equipment. Currently, concrete shielding surrounds the entire structure, and all doorways are sealed. The drain from this building contained highly radioactive material, resulting in the evacuation of the operating area due to high radiation fields from the drain. It is known that this line leaked and that the soil was extensively contaminated.

In 1976, Building 3515 was transferred to the Surplus Facilities Management Program (SFMP) for eventual D&D. Since that time, routine surveillance and maintenance (S&M) has been performed, including extensive roof repairs. Building 3515 is now a D&D facility in the ER Program.

The building interior is currently inaccessible since it is completely enclosed by an added concrete shield wall. A stainless steel roof was installed to prevent leakage of rainwater into the building. A substantial amount of fission products still exists within the building; however, because of decay, the major radionuclides remaining are ^{137}Cs and ^{90}Sr. Only ^{137}Cs has been detected from the external radiation measurements. In addition, there is extensive contamination of the soil under and

around this building due to the leaky drain line and subsequent leaks; however, this soil is not included in the potential remediation of Building 3515 but will be considered as part of the GAAT OU.

Two Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) criteria exist for the evaluation of remedial alternatives requiring assessment of risk: long-term and short-term effectiveness of remedial actions. Long-term risks are those that remain after D&D is complete (i.e., residual risks). The long-term effectiveness of an option is its ability to mitigate this type of risk. Short-term risks are those that occur during implementation of a D&D alternative; this criterion considers quantifying the potential magnitude of exposure and risk to the community, workers, and the environment during remediation. The short-term effectiveness criterion also addresses the risk of physical injury to workers and members of the community as a result of accidents during remediation.

This DARA is made up of three components that address these criteria:

- **Long-term effectiveness**—addresses the residual risks remaining after D&D is complete.
- **Short-term exposure**–addresses the potential risks associated with exposure to contaminants by workers, members of the public, and ecological receptors during implementation of the D&D alternative.
- **Short-term physical hazards**—addresses the risk of physical injury during remediation.

Potential long- and short-term risks associated with remedial alternatives at Building 3515 are summarized in Table ES.1. The no-action alternative is not associated with any implementation exposure risks. However, the long-term (residual) risks associated with this alternative range from 6×10^{-9} for off-site residents to 6×10^{-2} for an intruder in the building. The potential for injury to this intruder is small (3.3×10^{-4} injuries). The complete dismantlement alternative will eliminate all potential sources of contamination and therefore all future (residual) risk from the facility. The complete dismantlement alternative has estimated short-term risks to remediation workers ranging from 3×10^{-5} for exposure of remediation workers to the external concrete pad to $6^{-1} \times 10$ for exposure of remediation workers to radiation from inside the building; these risks may be reduced by implementing proper worker protection safe guards. This alternative could result in 6.1×10^{-1} injuries.

Table ES.1. Summary of risks associated with remedial alternatives at Building 3515

Alternative	Residual (long-term) Risk (ILCR)[A]	Short-term Exposure Risk (ILCR)[B]	Short-term Physical Hazard
No-Action	6×10^{-9} - 6×10^{-1}	0	3.3×10^{-4} injuries[C] 2.5×10^{-4} fatalities[C]
Complete Dismantlement	0	3×10^{-5} - 6×10^{-1}	6.1×10^{-1} injuries[D] 2.9×10^{-3} fatalities[D]

[A]Receptors include an on-site intruder and off-site resident.
[B]Receptors are remediation workers.
[C]Hazard to an intruder.
[D]Hazard to remediation workers.

1. INTRODUCTION

As part of its ongoing Environmental Restoration (ER) Program, the U.S. Department of Energy (DOE) has reduced operations at various federal installations, including the Oak Ridge Reservation (ORR) in Oak Ridge, Tennessee, as missions have been determined obsolete or have been relocated. Any of the facilities at these installations may pose a threat to human health and the environment as a result of radioactive and/or chemical contaminants remaining at the site. Therefore, these buildings have been identified for decontamination and decommissioning (D&D) within DOE's ER Program for further evaluation and remediation. Elimination of potential environmental or public health risk, the significant reduction of the risk of adverse publicity, and the decrease in the risk of potential personnel contamination caused by these buildings are significant goals to be achieved by the ER Program (Energy Systems 1992).

Building 3515 (Fission Product Pilot Plant) at Oak Ridge National Laboratory (ORNL) is managed by Lockheed Martin Energy Systems, Inc. (Energy Systems) and is a D&D facility within the Energy Systems ER Program. A baseline risk assessment (BRA) conducted for this facility indicates that contaminants present at the facility could pose a threat to human health. Remedial actions may be necessary at Building 3515 to avoid the potential spread of contamination and potential human and environmental exposures as the building and equipment deteriorate. The Risk Analysis Section (RAS) of the Health Sciences Research Division at ORNL has been tasked with preparing a D&D alternatives risk assessment (DARA) for Building 3515 to assess the potential risks to human health and the environment posed by remedial alternatives at this facility to assist in choosing the appropriate alternative.

1.1 BACKGROUND

ORNL is a large, multifunctional, research and development facility for the federal government. It supports applied research and engineering development programs in fission, fusion, conservation, fossil, and other energy technologies, as well as the performance of research in the physical and life sciences. Past research and development and waste management activities have resulted in a significant number of sites or areas that have been contaminated with low-level radioactive and\or hazardous chemical wastes that will potentially require remediation. Remediation of contamination is being conducted concurrently with other ongoing operational and maintenance activities, and as a result, remediation is technically and logistically complicated.

Building 3515 is located at ORNL within the Gunite and Associated Tanks (GAAT) Operable Unit (OU) of Waste Area Grouping 1 (WAG 1) and east of the south tank farm on Fourth Street south of Central Avenue. Therefore, Building 3515 D&D activities and remediation of the tanks and soils within the GAAT OU must be coordinated.

Building 3515 was built in 1948 and was modified throughout its operational life. The original facility consisted of a concrete pad with tanks and a tent surrounding the shield blocks. In 1950–51, construction of a hot cell was begun with 18-in. thick, solid masonry block walls and a 2-ft-thick, reinforced concrete roof. Lean-to buildings (i.e., supported roof sections extending from the main building) contained the operating area. A small valve pit that contains valves and controls is located on the north side of this building. Building 3515 was used to extract radioisotopes of ruthenium, strontium, cesium, cerium, and other elements from liquid waste that came from ORNL operations

and Chalk River clean-up operations in Canada. Operations in this facility resulted in severe contamination of the interior surfaces due to the practice of overflowing the piping and vessels with purge liquids for decontaminating to allow entry for work. The building contains two rooms with solid masonry block walls shielding the process equipment. Currently, additional concrete shielding surrounds the entire structure, and all doorways are sealed. The drain from this building contained highly radioactive material, resulting in the evacuation of the operating area due to high radiation fields from the drain. It is known that this line leaked and that the soil was extensively contaminated. The drain has since been covered with a new concrete floor (poured over the original floor) thereby preventing any additional movement of contaminants out of the building. Contaminants present in the drain may continue to migrate to the surrounding soil. This movement will be minimal because the building acts as a cap to keep rainwater from entering the drain or surrounding soil.

In 1976, Building 3515 was transferred into the Surplus Facilities Management Program (SFMP) for eventual D&D. Since that time, routine surveillance and maintenance (S&M) has been performed, including extensive roof repairs. Building 3515 is now an ER Program D&D facility.

The building interior is currently inaccessible since it is completely enclosed by an added concrete shield wall. A stainless steel roof was installed to prevent leakage of rainwater into the building. Little information is available on the equipment or systems still located inside the building. A remote controlled camera was used to provide a visual inspection of the inside of the building. A substantial amount of fission products still exists within the building; however, because of decay, the major radionuclides remaining are ^{137}Cs and ^{90}Sr. Only ^{137}Cs has been detected from the external radiation measurements. In addition, there is extensive contamination of the soil under and around this building due to the leaky drain line. This soil is not included in the potential remediation of Building 3515 but will be dealt with as part of the GAAT OU.

1.2 OBJECTIVES AND SCOPE OF THE DARA

The purpose of this report is to present the DARA for Building 3515. The goal of the risk evaluation process is to provide risk information necessary to assist decision making for ER Program D&D facilities. This risk information is developed in the BRA and in the DARA. The BRA provides risk information necessary for determining whether or not a facility represents an unacceptable risk and requires remediation. The BRA also provides an estimation of the risks associated with the no-action alternative for use in the DARA. The objective of this Level 3 DARA is to evaluate and document the potential risks to human health, human safety, and the environment associated with the proposed remedial action at Building 3515. A Level 3 assessment is the least rigorous type of DARA. This assessment is based on minimal sampling data and uses worst-case (or near worst-case) assumptions to fill in data gaps. The results of the DARA along with cost and engineering information may be used by project managers in making decisions regarding the final disposition of Building 3515.

This DARA is designed to conform to U.S. Environmental Protection Agency (EPA) guidance (1988, 1989, 1990, 1991) for conducting alternative risk assessments under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The steps involved in this DARA are to:

- define the alternatives to be evaluated;
- determine contaminants of concern (COCs) applicable to each alternative;

- determine potential long-term and short-term exposure pathways and receptors (human and ecological) associated with each alternative;
- estimate exposure and risks associated with each pathway, either quantitatively or qualitatively;
- identify potential worker safety risks associated with implementation of each alternative; and
- identify potential public safety risks associated with implementation of each alternative.

Two CERCLA criteria exist for the evaluation of remedial alternatives requiring assessment of risk: long-term and short-term effectiveness of remedial actions. Long-term risks are those that remain after D&D is complete (i.e., residual risks). The long-term effectiveness of an option is its ability to mitigate this type of risk. Short-term risks are those that occur during implementation of a D&D alternative. This criterion is concerned with quantifying the potential magnitude of exposure and risk to the community, workers, and the environment during remediation. The short-term effectiveness criterion also addresses the risk of physical injury to workers and members of the community as a result of accidents during remediation.

This DARA is made up of 3 components which address these criteria:

- **Long-term effectiveness**—addresses the residual risks remaining after D&D is complete.
- **Short-term exposure**—addresses the potential risks associated with exposure to contaminants by workers, members of the public, and ecological receptors during implementation of the D&D alternative.
- **Short-term physical hazards**—addresses the risk of physical injury during remediation.

The decision to conduct a Level 3 DARA was based on the fact that characterization data from the facility are limited and only one remedial alternative (complete dismantlement) is currently being evaluated in addition to the no-action alternative. Complete dismantlement is the only option evaluated in this DARA because the building is extensively contaminated and so small in square footage that decontamination for reuse or performing partial D&D is not feasible. This Level 3 assessment meets the requirements of the streamlined risk assessment necessary for an Engineering Evaluation/Cost Analysis (EE/CA). This DARA is limited to evaluation of Building 3515, its contents, and the adjacent external concrete pad. Contaminated piping and drain lines under the building and contaminated soil under and around the building will be addressed as part of the GAAT OU remediation.

1.3 ORGANIZATION OF THIS REPORT

This DARA is presented in six sections. An overview of the DARA process and background information on Building 3515 have been presented in Chapter 1. Chapter 2 provides a description of the alternatives to be evaluated. Chapter 3 provides a description of the collection and evaluation of facility and alternative characterization data. Evaluation of long-term risks is presented in Chapter 4. Chapters 5 and 6 provide the evaluation of the short-term effectiveness of each alternative. Short-term effectiveness is broken down into the evaluation of exposure related risks (Chapter 5) and physical hazards (Chapter 6). The results of the DARA are summarized in Chapter 7.

2. DEFINITION OF ALTERNATIVES

Two alternatives are evaluated for remediation of Building 3515: the no-action alternative and complete dismantlement. These alternatives are defined in the following subsections.

2.1 NO-ACTION ALTERNATIVE

A no-action alternative is evaluated to provide a baseline for comparison of other remedial alternatives. This no-action alternative is developed in the BRA (Energy Systems 1995). The hypothetical no-action scenario makes the assumption that Building 3515 is abandoned by the DOE at the start of the evaluation. In this scenario, DOE makes no attempt to prevent contaminant release from the facility or restrict access to the facility. One current and two future hypothetical exposure scenarios are evaluated for the no-action alternative. The current scenario considers a maintenance worker involved in routine maintenance activities in close proximity to Building 3515. The worker does not enter the building but is exposed to external radiation from each of the external walls of the building and from the contaminated soil located beneath the exterior floor pad.

The future scenarios consider an adult intruder and an off-site (i.e., outside of DOE property) resident. Because Building 3515 is on the ORR and DOE is not likely to release the ORR property for development, the area around the building is expected to remain industrial even if the building is abandoned. Therefore, it is assumed that residential development will not occur at this site. However, it is assumed that an adult intruder could enter the building on a limited basis. Because the intruder would be in direct contact with contamination in the facility, this receptor provides an upperbound estimate of the potential human health risks.

If the building is abandoned by DOE (i.e., all building maintenance is discontinued), it will eventually decay and collapse. The possibility also exists that the building could be destroyed by a catastrophic event (e.g., earthquake, tornado). The building structure currently acts as a containment vessel for the contaminants inside. As the building decays or if it is destroyed, these contaminants will be released to the environment. Such releases could potentially result in exposure of off-site residential receptors.

2.2 COMPLETE DISMANTLEMENT ALTERNATIVE

This alternative provides for the complete removal of all equipment and the above and below grade structures including the external concrete pad. The complete dismantlement of Building 3515 would begin with drilling a hole in the roof over the south cell and installing a High-Efficiency Particulate Air (HEPA)-filtered exhaust system to constantly draw a vacuum in the interior. This would keep airborne radioactivity from being released through unmonitored pathways. No exterior superstructure would be required to prevent the release of radionuclides since the facility would be dismantled from the inside out (Snedaker and Mandry 1995).

The next activity would be drilling access holes in the roof over the north and south cells, upon which remotely controlled robotic arms would be mounted. Each robotic arm assembly would contain three arms. The first arm would hold a video camera and light to allow the operators to view the work being performed. The second arm would be a lifting arm to hold the objects and move them to the egress panel. The third arm would be installed with any of several tools that would cut or otherwise disassemble the equipment within the cells (Snedaker and Mandry 1995).

Access to the interior of the north and south cells would be by egress panels cut into the bottom portion of the doorway. A shielded tunnel would be constructed to provide for a completely shielded passage from the loading area for disposal boxes located outside Building 3515. A track system would be installed to allow empty disposal boxes to be pushed into the interior and filled with contaminated equipment and materials (Snedaker and Mandry 1995). When the disposal boxes are filled, the box would be pulled outside the cell and closed, placed into a shielded shipping container, and removed to be disposed of in a DOE-licensed radioactive waste disposal facility off-site (i.e., HanfordSite , Nevada Test Site) (Mandry 1995).

The removal of equipment and materials from the cell would be entirely remotely controlled. The robotic arm would grab a piece of piping to be cut, and the third arm would cut the pipe at the two ends. The holding arm would place the pipe in the disposal box and return to the work area to grab another pipe or other item, whereupon the process would be repeated. Items too large to be placed into the disposal boxes intact would have to be crushed or cut apart to fit inside a box. The entire interior of each cell would be stripped in an identical way (Snedaker and Mandry 1995).

After the interior is empty, the concrete walls would be removed by diamond wire saw cutting. In this technique, holes are drilled at the extremes of the desired cut piece. A diamond studded wire cable is then routed through the holes, and the ends are connected to form a complete circle. The wire is drawn through the holes at a high speed and high tension, effecting a smooth cut through the concrete and any embedded materials such as rebar, pipe sleeves, conduit, and all other construction materials. At Building 3515, the interior wall separating the north and south cells would be removed first, followed by the original (i.e. inner) exterior walls. The roof is supported by the final exterior concrete block wall; therefore, the entire building would be removed from the inside out (Snedaker and Mandry 1995).

Once the original walls have been removed, the roof can be dismantled followed by the remaining walls. The radiation hazard of these concrete pieces would be such that the shielded transport tunnel would not be necessary for their removal and measurement of surface radioactive contamination. At this time, the robotic arms would be dismantled and decontaminated for reuse at another project. Alternatively, a support structure may be built to support the roof in place while the external walls are dismantled and removed. The roof would then be cut apart to fit into disposal boxes (Snedaker 1995).

After the roof and walls are removed, the floor—which is still highly radioactive—would be segmented using remote controlled floor saws that would cut the floor into pieces suitable for placing into disposal boxes. The external concrete pad would be removed and disposed of in the same fashion (Snedaker and Mandry 1995). Currently, the scope of this project includes the building and external concrete pad only. The soil, drain lines, and piping under the building and pad will be addressed by the soils OU (Mandry 1995).

Given the operational history of the facility and known operations at nearby structures, the soil within which the drains and pipes are buried is known to be highly contaminated. Soil disturbed by the excavation would be disposed of in disposal boxes along with the pipes and drains. However, the remaining soil that is still highly contaminated would be left for a later remediation project. At the end of the removal of Building 3515, the contaminated soil would be covered with an impermeable plastic layer to prevent rainwater intrusion, and a 30-cm layer of clean soil and possibly a concrete pad would be placed to act as shielding for the highly contaminated soil (Snedaker and Mandry 1995, Mandry 1995).

3. DATA EVALUATION

The purpose of data collection and evaluation is to acquire chemical, radionuclide, facility structure, and receptor population data; assess the available data for data quality; and estimate the ability of the sampling and analytical methods used to meet the needs of a quantitative risk assessment. Characterization data describing the facility structure and contaminant concentrations are presented and evaluated in the BRA (Energy Systems 1995). No additional characterization data were collected for this DARA. A brief summary of the characterization data used for the BRA and DARA is presented in Sect. 3.1. COCs are identified in Sect 3.2, and receptor data specific to this DARA are presented in Sect. 3.3.

3.1 SUMMARY OF FACILITY CHARACTERIZATION DATA

The majority of contamination at Building 3515 is dispersed throughout the interior walls, floor, and equipment. In addition, a concrete pad, which serves as a cap for contaminated soil, is located adjacent to the building. The building has been encased with concrete since c. 1964 and therefore serves as both a primary (original walls) and secondary (new outer walls) containment system for the contaminants in the building. Currently, no information is available that suggests release of contaminants to the environment is occurring, although there is a measurable dose rate associated with the external walls of the building. Contaminants have been previously released via the drain line under the building. This drain line is currently sealed off to prevent or minimize further contaminant migration.

Both chemical and radiological analyses were performed on a variety of samples. Samples consisted of three concrete cores taken from two coring locations in the exterior floor slab (pad), which is located outside the south wall of the building; a subfoundation soil sample; and a paint chip sample from the south cell doorway.

Field radiological measurements were taken inside the building for both the north and south cell areas. Because of the high radiation fields encountered, measurements were obtained remotely using long-handled tools. Thermoluminescent dosimeter (TLD) strings deployed on four sides of a 2-in. pole to face up, down, south, and north were used to obtain the horizontal absorbed dose profile for the interior of both cells. TLDs in each string were approximately 1 ft apart and approximately 3 to 4 ft above the floor. This assembly was exposed to the cell radiation fields for 10 minutes.

Smear analyses were also performed for both the north and south cells. The smear for the north cell was taken from the floor and is assumed to have covered approximately 100 cm^2. The smear for the south cell is assumed to cover approximately 10–20 cm^2. The gross smears obtained from the south cell were too highly radioactive to be analyzed at the Close Support Laboratory (CSL) for gross alpha, gross beta/gamma, and gamma spectroscopy; therefore, a secondary smear was taken from the gross smear (by touching the two smears together) and analyzed at the CSL.

A preliminary decommissioning study report for Building 3515 (Horton 1984) provided data concerning a radiation survey conducted around the exterior of the building. The field measurements outlined in this report were used to calculate risks to maintenance workers resulting from external exposures while in close proximity to Building 3515. It should be noted that only the measurement taken on the west side was above background for this area of the ORR.

Two soil borings were hand-augered approximately 12–14 ft from the building as part of the WAG I Remedial Investigation (RI) (Bechtel 1994). Three samples from these borings were analyzed for chemical [volatile organic compounds (VOCs), base neutral acids, metals, and cyanide) and radiological contamination. These samples were not included in the BRA as this soil is outside the scope of Building 3515 but are used in this DARA to evaluate potential worker exposures. Small quantities of organic and inorganic chemicals were detected in these samples in addition to several radionuclides. A summary of the results of this analysis for the COCs are provided in Table 1.

Table 1. COCs concentration in WAG 1 soil samples taken near Building 3515

Location	Depth (ft)	Contaminant	Concentration (pCi/g)	Uncertainty (±)
Approximately 14 ft from Building 3515, 3 ft from the southwest corner of the concrete pad.	0-2	Gross Alpha	216	55
		Gross Beta	17047	2558
		Total Sr	2180	240
		^{137}Cs	429	25
Approximately 12 ft from Building 3515, 8 ft from the southeast corner of the concrete pad.	0-2	Gross Alpha	47.2	16.7
		Gross Beta	1615	244
		Total Sr	5.2	0.8
		^{137}Cs	103	6
	2-4	Gross Alpha	180	46
		Gross Beta	34381	5159
		Total Sr	169	30
		^{137}Cs	1389	81

The documentation for both the chemical and radiological laboratory analyses met Remedial Investigation/Feasibility Study (RI/FS) Quality Control (QC) Level III requirements. The QC Level III mandates that QC data, including raw data, be reported in the Contract Laboratory Procedure (CLP) data package. The data were validated and met the RI/FS QC level II requirements. These requirements were sufficient for fulfilling the data quality requirements for this risk assessment.

3.2 CONTAMINANTS OF CONCERN

Contaminants of potential concern (COPCs) were identified in the BRA (Energy Systems 1995). COCs to be carried through the DARE are those COPCs which were shown to contribute significantly to risks at the facility in the BRA and any additional contaminants which may be introduced as a result of implementing the alternative.

3.2.1 Contaminants of Concern for No-Action Alternative

The COCs for the no-action alternative are ^{137}Cs and ^{90}Sr based on the results of the BRA (Energy Systems 1995) which showed these contaminants to be the major contributors to risk at the facility.

3.2.2 Contaminants of Concern for Complete Dismantlement Alternative

The COCs for the complete dismantlement alternative are also ^{137}Cs and ^{90}Sr based on the results of the BRA (Energy Systems 1995) which showed these contaminants to be the major contributors

to risk at the facility. No additional contaminants will be introduced during the dismantlement and disposal of the facility.

3.3 RECEPTOR CHARACTERIZATION DATA

Receptor data required for characterization of long-term risks are presented in the BRA (Energy Systems 1995). No additional long-term data are required. The evaluation of short-term effectiveness requires remedial activity data for each alternative. These data must include:

- types of activities to be performed (e.g., scabbling) and whether or not these activities may result in exposure of workers or release of contaminants,
- length of time required for remedial activities, and
- worker hours required for remedial activities.

The no-action alternative does not include any remedial activity. Worker activity data for the complete dismantlement alternative is available in the *D&D Buildings 3506 and 3515, ORNL Alternatives Evaluation* (Ebasco 1993). This document provides a complete listing of worker hours by activity. A summary of the worker activities that could result in worker exposure or injury is provided in Table 2. Assumptions are made (Sect 5.1.3.2) regarding the number of worker hours provided by a single worker.

3.4 UNCERTAINTY

The characterization data used in this DARA were not collected specifically for use in a risk assessment; therefore, data gaps existed and required assumptions and approximations in estimating exposure concentrations. Due to the high radiation fields encountered inside Building 3515, the data were obtained remotely using long-handled tools inserted through holes created in the building walls for this purpose. This limited the amount of data that could be obtained and introduced some uncertainty into the exact identification of sampling points. The presence of contaminated equipment (which was not sampled) in the cells introduces a great deal of complexity and uncertainty when extrapolating TLD measurements to estimate Curie loadings. Additionally, the limited amount of smear data increases the uncertainty when extrapolating the data to the entire room.

Data describing worker activities required for complete dismantlement are preliminary. The exact methods for dismantlement have not been determined for this facility. Therefore, uncertainty exists in the work hours used to evaluate short-term effectiveness.

4. EVALUATION OF LONG-TERM EFFECTIVENESS

The evaluation of the long-term effectiveness of D&D alternatives addresses the results of D&D actions in terms of the risk remaining at the facility after completion of the action. From a risk perspective, the assessment of long-term effectiveness is concerned with quantifying the magnitude of residual risks associated with exposure to untreated contaminants or treatment residuals remaining at a facility at the conclusion of D&D activities.

Table 2. Summary of worker activities for the complete dismantlement alternative[A]

Remedial Activity	Estimated Worker Hours: Potential Worker Exposure	Estimated Worker Hours: Potential Worker Injury
MISC. ACTIVITIES		
Boundary Control Station	24	24
Temporary Power	80	80
Build Temporary Cover over roof	48	48
Stairway scaffold	24	24
Cut 10" diameter hole in stainless roof	5	5
Core drill 8" hole 2" depth	38	38
Set up HEPA filter system	40	40
Set up camera/detector remote manipulator at first location on roof	36	36
Relocate camera/detector to 2nd location	8	8
mobilization and demobilization	27	27
REMOVE EXISTING STEAM & AIR LINES		
Remove existing pipe supports	32	32
New 20' pipe support	4	4
New 4' pipe support	26	26
AIR LINE		
Cut & remove 4" CS air line	8	8
Cap existing air line	2	2
Cut & prep existing line to tie in	1	1
4"SCH 40 CS pipe	18	18
4" tee, BW ends	11	11
4" 90 deg elbow, BS ends	23	23
Cap one end of new tee	0	0
STEAM LINE		
Remove pipe insulation place in one B-25 box	36	36
Cut & remove 8" CS steam line	20	20
Cap existing steam line	4	4
Cut & prep existing line for tie in	1	1
8"SCH 40 CS pipe	33	33
8" tee, BW ends	22	22
8" 90 deg elbow, BW ends	43	43
Cap one end of new tee	0	0
2" fiberglass insulation	62	62
0.16" alum jacket	142	142
MISC		
Pipe cleaning	12	12
Pipe testing	12	12
Pipe identification	3	3
Fire Watch		100
Truck & Trailer	16	16
Mobilization & demobilization	15	15

Table 2. continued

Remedial Activity	Estimated Worker Hours: Potential Worker Exposure	Estimated Worker Hours: Potential Worker Injury
REROUTE EXISTING POWER POLES		
40' creosoted wood pole	18	18
Relocate telephone & electric lines& equipment to new poles	48	48
Mobilization & demobilization	7	7
PIPE SUPPORT FOUNDATIONS		
Excavate for footing	8	8
Concrete footing	13	13
Anchor bolts	6	6
Backfill	5	5
STAGING & ACCESS AREA		
Regrade	3	3
Spread & compact crushed stone	8	8
Grade checker	8	8
SHIELDED ACCESS STRUCTURE		
Install access door frame	16	16
Set up structure & access doors	170	170
MISC.		
Decon equipment	4	4
Mobilization & demobilization	36	36
MANIPULATORS		
Set up remaining remote manipulators at 1st location on roof	60	60
Relocate remote manipulators to 2nd location on roof	16	16
ACCESS HOLES (REMOTE)		
Drill holes for wire say & lifting eyes		7
Setup wire saw		8
Cut concrete		16
Remove concrete block & place in B-25 box		2
Place roller conveyor in opening & anchor to concrete slab		8
BUILDING INTERNALS DEMOLITION (REMOTE)		
Place container inside building		1
Place lead bricks in container		115
Mix epoxy mixture for container void		1
Place epoxy mixture inside building		1
Fill void spaces in container with epoxy		5
Remove container from building		1
Place cover over container		16
LIQUIDS		
Set up & attach pump	60	60
Remove & drum liquids	8	8
Drum handling	2	2
Spill protection	4	4

Table 2. continued

Remedial Activity	Estimated Worker Hours: Potential Worker Exposure	Estimated Worker Hours: Potential Worker Injury
HVAC		
HVAC equipment	166	166
PIPING (REMOVE & CUT UP)		
1-1/2" to 2" piping		343
½" to 3/4" tubing		192
3/8" to ½" rod stock		451
Tanks (removed in 1 piece)		50
Glass flask		44
Misc process equipment & support steel		156
Water heater		32
ELECTRICAL REMOVE & CUT UP		
100 AMP safety switch		20
100 AMP lighting panel		32
Vapor proof lights		96
120V receptacle & box		8
Toggle switch & box		8
Telephone & box		2
Par-36 lamp & socket		72
1" & 3/4" conduit		104
Cable		104
BOX CUT UP MAT'L		
Place shielded box in building (crane)		8
Place material in shielded box (remote)		256
Remove shielded box from building		8
Place cover on shielded box (crane)		32
Mobilization & demobilization	60	60
SHIELDING STRUCTURE		
Remove shielding structure & access doors & load on truck for transport to ORNL storage area	47	47
Transport to ORNL storage area	173	173
Unload shielding structure & access doors at ORNL storage area	12	12
DEMO STRUCTURE		
Remove stainless steel roof, cut up and place in B-25 boxes		20
RELOCATE MANIPULATORS		
Remove remote manipulators after 50% of roof is removed	16	16
Set up remote manipulators on building slab	36	36
Remove remote manipulators after walls are removed	16	16
Cover manipulators with plastic	8	8
Load & transport manipulators to ORNL storage	2	2
Unload manipulators at ORNL storage facility	1	1
CONCRETE WALLS AND ROOF		
Drill holes for wire saw & lifting eyes	109	109

Table 2. continued

Remedial Activity	Estimated Worker Hours	
	Potential Worker Exposure	Potential Worker Injury
Set up wire saw	268	268
Cut concrete	403	403
CONCRETE SLAB		
Setup concrete saw	96	96
Cut concrete	65	65
Drill holes for wire saw & lifting eyes	20	20
PACKAGE CONCRETE BLOCKS		
Install lifting eye for concrete pieces	38	38
Place concrete pieces into B-25 boxes for disposal	32	32
Place cover on box	34	34
LEAD BRICKS		
Place lead bricks in container (manipulator)	173	173
Mix epoxy mixture for container void	2	2
Fill void spaces in containers	8	8
Place cover on container	24	24
Mobilization & demobilization	93	93
SOIL & LINER COVER		
60 mil HDPE liner	11	11
Excavate & borrow area	3	3
Haul & dump (10 mile round trip w/12 CY dump)	65	65
Backfill, spread & compact	32	32
Seed and mulch	5	5
Silt fence	4	4
Mobilization & demobilization	12	12
TRANSPORT		
Load & transport containers of lead bricks to Energy Systems WM (2 loads 1-hr round trip)	2	2
Load & transport shielded boxes to disposal facility(3 per load, 1-hr round trip)	1	1
Load & transport B-25 boxes (asbestos & concrete) to disposal facility (3 per load, 1-hr round trip)	12	12
Load & transport drums to PWTF (1-hr round trip	1	1
Mobilization & demobilization	9	9
TOTAL	2319	5754

[A]From Ebasco 1993.

The long-term effectiveness of the no-action and complete dismantlement alternatives are presented in the following subsections.

4.1 NO-ACTION ALTERNATIVE

The BRA for Building 3515 (Energy Systems 1995) provides an estimate of the magnitude of residual risk from the no-action alternative. The results of the BRA are summarized in the following text.

4.1.1 Current Land Use

The receptor evaluated for the current land use scenario is a maintenance worker outside of Building 3515. The total exposure rate and Incremental Lifetime Cancer Risk (ILCR) for the maintenance worker considered under current land use are 0.016 rem/year and a risk of 3×10^{-4}. This exposure rate is within the 1.5 rem per year worker exposure limit used by ORNL as an administrative control limit. The estimated risk is just above the EPA's range of acceptable risk and results entirely from external radiation. The dose rates around the building exterior (of which only one measured value exceeded the background radiation in that area of the plant site) are due to ^{137}Cs inside the building and beneath the exterior pad.

4.1.2 Future Land Use

Two receptors were evaluated for the future land use scenario: an adult intruder and an off-site resident. The adult intruder is assumed to enter the facility for a short period. The off-site resident is exposed following transport of contaminants beyond the DOE property boundary as a result of a catastrophic event (e.g., tornado or earthquake) destroying the facility or as a result of normal facility decay over time. Future off-site residents were evaluated at two potential receptor locations: White Oak Creek and White Oak Dam.

The total risks to the adult intruder and the residents at White Oak Creek and White Oak Dam are presented in Table 3. Risks to the off-site residents are given for acute releases resulting from a catastrophic event and for chronic releases from the building and the soil immediately beneath (i.e., in contact with the concrete) the exterior pad resulting from normal degradation of the building and pad over time.

All of the risks presented in Table 3 exceed the EPA's range of acceptable risk. Risks to the intruder are dominated by external exposures to radionuclides (specifically, ^{137}Cs). External exposures were estimated for the intruder using TLD data (i.e., direct radiation measurements) taken from inside the north and south cells.

Risks to the residents are driven by the ingestion of vegetables grown and irrigated with surface water potentially contaminated by contaminant releases from Building 3515. The driving contaminants for residential exposures are ^{137}Cs and ^{90}Sr. Risks resulting from the catastrophic event require an initiating event and should be evaluated in context with the probability of such an event occurring. A catastrophic release could result from an event such as an earthquake. Studies have suggested that the annual frequency of a severe earthquake at the ORR would be approximately 4×10^{-8} (Benedict 1993). The risk associated with a catastrophic event is equal to the probability of the event occurring times the health risk resulting from the event. This would reduce the risks from a catastrophic release to 6×10^{-9} for a resident at White Oak Creek or White Oak Dam.

Table 3. Estimated ILCRs associated with future land use scenarios

Receptor	ILCR
Adult Intruder	6×10^{-2}
Resident at White Oak Creek	
Catastrophic event	6×10^{-1} $(6 \times 10^{-9})^{A}$
Chronic release	5×10^{-2}
Resident at White Oak Dam	
Catastrophic event	6×10^{-1} $(6 \times 10^{-9})^{A}$
Chronic release	4×10^{-2}

[A] Includes probability of an initiating event.

The most significant human health risks at Building 3515 result from exposures to ^{137}Cs and ^{90}Sr. It should be noted that all of the risk estimates presented in the BRA (Energy Systems 1995) are associated with varying levels of uncertainty. Of particular importance is the limited amount of sampling data used to estimate exposure concentrations. Due to the high levels of contamination present in the building, characterization efforts for the interior of the facility had to be performed remotely, which prevented extensive sampling. In addition, off-site exposure concentrations were estimated using the fate and transport computer models MEPAS and GENII to simulate the migration of contaminants in the environment as described in the BRA (Energy Systems 1995). Uncertainties arise in modeling from having to simulate an infinitely complex system using a finite number of variables. To compensate for these uncertainties, the methodology used and exposure parameters selected are designed to overestimate exposure.

4.2 COMPLETE DISMANTLEMENT ALTERNATIVE

The complete dismantlement alternative includes complete removal of the building structure and foundation, all process equipment, and the exterior concrete pad. As documented in the BRA (Energy Systems 1995), these elements are the only sources of contamination included in the Building 3515 remediation; therefore, no residual risks are expected to remain from this facility after remediation is complete. The soil in this area is heavily contaminated with radionuclides and will present a continuing risk after removal of Building 3515. However, this soil is outside the scope of the Building 3515 remediation project and will be remediated separately.

5. EVALUATION OF SHORT-TERM EXPOSURE RISKS

The evaluation of short-term effectiveness is divided into two parts: the evaluation of exposure risks and the evaluation of physical risks (Chapter 6). The evaluation of short-term exposure risks is designed to provide an estimate of the potential human health risks to remediation workers and the public directly associated with the remedial alternatives. The evaluation of short-term exposure risks follows the same steps used in the BRA (Energy Systems 1995): exposure assessment, toxicity assessment, and risk characterization.

No short-term risks are associated with the no-action alternative. Short-term risks associated with the complete dismantlement alternative are evaluated in the following sections.

5.1 EXPOSURE ASSESSMENT

The exposure assessment for the evaluation of short-term exposures follows the same steps used in the exposure assessment for the BRA (Energy Systems 1995). Steps include characterization of the exposure setting, identification of potential exposure pathways, and quantification of exposure.

5.1.1 Characterization of the exposure setting

The first step in the exposure assessment is characterizing the facility and the surrounding area where exposures may occur; this establishes the setting in which potential exposures could occur. The facility and contamination have been characterized previously in the BRA (Energy Systems 1995). A brief summary is provided here. The building contains two rooms with solid masonry block walls shielding the process equipment. Currently, concrete shielding surrounds the entire structure, and all doorways are sealed. Operations in this facility resulted in severe contamination of the interior surfaces due to the practice of overflowing the piping and vessels with purge liquids for decontaminating to allow entry for work. The drain from this building contained highly radioactive material, resulting in the evacuation of the operating area due to high radiation fields from the drain. It is known that this line leaked and that the soil was extensively contaminated.

The interior of Building 3515 is currently inaccessible since it is completely enclosed by an added concrete shield wall. A stainless steel roof was installed to prevent leakage of rainwater into the building. A substantial amount of fission products exist within the building; however, because of decay, the major radionuclides remaining are ^{137}Cs and ^{90}Sr. Only ^{137}Cs has been detected from the external radiation measurements. In addition, extensive contamination of the soil under and around this building is likely due to the leaky drain line. A description of the setting during remediation is provided in Sect. 2.2 of this DARA.

Populations potentially exposed to contaminants in Building 3515 and/or released to the environment from Building 3515 during remediation include both human and ecological receptors. Potential receptors can be divided into the following groups:

- remediation workers,
- public receptors including residents of Oak Ridge and surrounding communities (individuals who use the recreational facilities on or near the ORR),
- public receptors living near transport routes for disposal of contaminated material, and
- potential ecological receptors including terrestrial and aquatic organisms who spend all or part of their lives on or near the ORR and organisms living near transport routes used for transporting contaminated material for disposal.

Remediation workers may be exposed to contaminants at the facility during the dismantlement and disposal of the structure and equipment. Because the facility will be dismantled from the inside out, the risk of release of contaminants to off-site receptors (human and ecological) during dismantling is negligible. Contaminants may be released during transport to an off-site disposal location as a result of a transport accident. Such an accident could also result in the exposure of ecological receptors along the transport route. The current plan for disposal includes placing the contaminated material in disposal boxes, filling the boxes with an epoxy or grout material, and placing these boxes into secondary shielding containers for transport (Mandry 1995). The immobilization of the contaminated material in fill material and the original form of the contaminated

material (construction debris) will combine to prevent or strongly minimize the potential for contaminant migration should a transport accident occur en route to the off-site disposal facility. Therefore, potential exposures will be limited to exposure to external radiation by receptors in the immediate area of the accident (e.g., people involved in the accident and emergency response personnel). Under this scenario ecological exposures will be negligible.

5.1.2 Identification of Potential Exposure Pathways

Exposure pathways link the source, location, and type of contaminant release with the potential receptor. For this short-term risk evaluation exposure pathways consist of three elements:

- a source of contaminants,
- a point of potential receptor contact (exposure point), and
- an exposure route (e.g.,external radiation).

The sources of contamination at Building 3515 are the walls and floor of the building, equipment within the building, the concrete pad outside the building, and the soil immediately under this pad.

All dismantlement activities are designed to be conducted remotely. Workers will not enter the facility during remediation. Therefore, potential exposure points are limited to:

- the roof (during installation of the HVAC and robotics systems) and
- the outside of the building (during installation of a shielded tunnel for passage of disposal boxes from the loading area).

Workers may also be exposed to radiation while sampling the contents of the disposal boxes for compliance with waste acceptance criteria (WAC) and while covering the boxes. A method for this sampling has not yet been developed; therefore, this potential exposure is evaluated qualitatively. Workers will not come into direct contact with contaminated materials; therefore, the only anticipated exposure route is external exposure to radiation.

The exposure pathways evaluated in this short-term risk assessment are the external exposure of remediation workers to radiation from the facility structure and equipment while working on the roof and outside the building (quantitative) and potential exposure of public receptors resulting from a transport accident during off-site disposal (qualitative).

5.1.3 Quantification of Exposure

In this section, the magnitude, frequency, and duration of exposure are estimated. Standard EPA (1989, 1991) exposure models presented in the BRA are used in this assessment. The quantification of exposure is broken down into three steps: the estimation of exposure concentrations, selection of appropriate exposure parameters, and the calculation of radiological dose. The same equations apply to short-term exposures as those presented for long-term exposures in the BRA. The exposure parameters reflect the short-term nature of the exposures. Equations used to estimate exposure are:

Estimation of exposure from dose rate data:

$$\text{Dose} = C \times ET,$$

where

Dose = Lifetime dose (mrem),
C = Exposure concentration (mrem/hour),
ET = Exposure time (hours).

Estimation of exposure from radionuclide specific concentration data:

$$\text{Dose} = C \times ED \times Te \times (1\text{-}Se),$$

where

Dose = External radiation dose (pCi-yr/g),
C = Exposure concentration (pCi/g),
ED = Exposure duration (yr),
Te = gamma exposure time (unitless); number of hours spent in gamma field over possible exposure hours per year,
Se = gamma shielding factor (unitless).

5.1.3.1 Exposure concentrations

Four exposure concentrations are used in this risk assessment: (1) radiation dose outside the building, (2) ^{137}Cs and ^{90}Sr concentration from the external concrete pad, (3) radiation dose inside the building, and (4) ^{137}Cs and ^{90}Sr concentration from the soil around the building. A complete description of the derivation of these exposure concentrations is provided from the first three data sets in the BRA (Energy Systems 1995). A brief summary is provided in the following list:

- Radiation dose outside the building (from the building)—exposure rates (mrem/hr) for the external walls of Building 3515 were taken directly from a preliminary decommissioning study report (Horton 1984). It is assumed that worker activities will be required all around the facility; therefore, an average of the exposure rates measured from each of the 4 walls is used.

- ^{137}Cs and ^{90}Sr concentrations from the external concrete pad—three core samples were taken from the exterior concrete pad along with a sample of the underlying soil. Concentrations in the underlying soil were used to calculate the inventory of radionuclides to which a worker would be exposed while working on top of the pad.

- Radiation dose inside the building—the direct measurement and TLD string exposure concentrations were derived based on a lifetime exposure in mrems. Direct measurements for both beta/gamma and alpha were reported for each cell. The exposure rates used for calculating risk from external exposure in each cell correspond to the upper 95% confidence limit of the TLD data.

The concentrations of ^{137}Cs and total external radiation in the soil around the building are estimated from two soil cores taken approximately 12–14 ft from the building as part of the WAG 1 RI (Bechtel 1994). The maximum detected concentration is used in this exposure assessment.

The complete dismantlement alternative calls for deconstructing the facility from the inside out using remote controlled (robotic) equipment. Worker exposures to contaminants may occur while drilling access holes and installing the robotic systems, while installing a shielded access tunnel for transport of disposal boxes into and out of the facility, while processing disposal boxes outside the shielded tunnel, and while performing other tasks outside the building.

Due to the limited characterization data and the preliminary nature of the dismantlement plan, exact estimates of exposure concentrations and exposure times cannot be made. Therefore, a range of exposure times is used in this risk assessment. A radiation shielding factor of 0.99956 is assumed to be attributable to the concrete pad in estimating exposures to the soil beneath the pad. The derivation of this factor is given in Appendix A of the BRA (Energy Systems 1995). The soil beneath the pad will no longer be shielded after this pad is removed. It is assumed that this pad will be one of the last things removed thereby minimizing the amount of time the soil is unshielded. A default radiation shielding factor of 0.2 is used for estimating exposure to radionuclides in the soil surrounding the facility.

5.1.3.2 Other exposure parameters

The complete dismantlement alternative is estimated to require 21,665 man hours to implement (Ebasco 1993). Of these, 2319 hours will be spent in activities that could result in exposure of workers to radiation. These exposure hours are further broken down into 389 hours spent near access holes (and therefore exposed to radiation fields from inside the facility) and 1930 hours spent outside but in close proximity to the facility. More than one person will be performing this work; therefore, it is assumed that an individual worker could have an exposure time of 49 to 97 hours near access holes (two to four workers with time divided equally between the North and South cells) and 241 to 483 hours (four to eight workers) outside the facility.

Remediation should be completed in 6 months to 1 year. An exposure duration of 1 year is assumed for this assessment.

5.1.4 Results of the Exposure Assessment

The results of the quantitative short-term exposure assessment for the complete dismantlement alternative are presented in Table 4. Exposure to public receptors may occur as a result of a transport accident. Contaminated materials will be transported by truck and/or railcar to a DOE-licensed waste facility. It is unlikely that an accident will occur during waste transport as described in Subsect. 6.2.2.2. If an accident occurs and results in the disposal boxes being thrown from the truck or railcar, receptors in the immediate vicinity of the accident could be exposed to external radiation.

5.2 TOXICITY ASSESSMENT

No noncarcinogenic or chemical carcinogenic COCs exist at Building 3515. The following discussion of toxicity values refers only to the carcinogenic effects of radionuclides. EPA guidance (1989, Part A) recommends that lifetime average exposures always be used to estimate carcinogenic risks because the cancer slope factors are based on lifetime average exposures. Since risks from short-term exposures are averaged over a 70-year lifetime, they will generally appear to be relatively minor in comparison to risks from longer-term exposures. The adjustment of short-term exposures may underestimate the risk for "early-stage" carcinogens (i.e., DNA-damaging agents). The EPA is currently investigating several methods for characterizing effects from short-term exposure to

carcinogens; however, the EPA does not have any recommended method for short-term carcinogenic assessments at this time.

A risk factor of 7.3E-7 risk/mrem is used to calculate external exposure risk using external dose data. This risk factor is the total risk per effective dose for fatal and nonfatal cancers and severe genetic effects (ICRP 1991). This risk factor is designed for continuous exposures of the general public over an average lifetime of 70 years. A slope factor of 2.1×10^{-6} risk/year per pCi/g is used to calculate external exposure risk from ^{137}Cs (BEIAS 1994). As is expected for a weak beta emitter, no slope factor is available for estimating risk from external exposure to ^{90}Sr (BEIAS 1994).

Table 4. Results of exposure assessment for complete dismantlement

Exposure Point	Contaminant Source	Exposure Time (Hours)	Exposure Point Concentration	Estimated Dose
Access holes - South cell	Interior surfaces and equipment	49	shallow: $3.6 \times 10^{2\,A}$ deep: $1.6 \times 10^{3\,A}$	$1.8 \times 10^{4\,B}$ $7.8 \times 10^{4\,B}$
		97	shallow: $3.6 \times 10^{2\,A}$ deep: $1.6 \times 10^{3\,A}$	$3.5 \times 10^{4\,B}$ $1.6 \times 10^{5\,B}$
Access holes - North cell	Interior surfaces and equipment	49	shallow: $7.7 \times 10^{3\,A}$ deep: $7.9 \times 10^{3\,A}$	$3.8 \times 10^{5\,B}$ $3.9 \times 10^{5\,B}$
		97	shallow: $7.7 \times 10^{3\,A}$ deep: $7.9 \times 10^{3\,A}$	$7.5 \times 10^{5\,B}$ $7.7 \times 10^{5\,B}$
Outside building	Exterior of building	241	$3.3 \times 10^{-1\,A}$	$7.9 \times 10^{1\,B}$
		483	$3.3 \times 10^{-1\,A}$	$1.6 \times 10^{2\,B}$
Outside building	Concrete pad and underlying soil	241	^{137}Cs: $1.3 \times 10^{6\,C}$ ^{90}Sr: $2.5 \times 10^{5\,C}$	$1.6 \times 10^{1\,D}$ $3.0 \times 10^{0\,D}$
	Concrete pad and underlying soil	483	^{137}Cs: $1.3 \times 10^{6\,C}$ ^{90}Sr: $2.5 \times 10^{5\,C}$	$3.1 \times 10^{1\,D}$ $6.1 \times 10^{0\,D}$
Outside building	Soil surrounding and underlying facility	241	^{137}Cs: $1.4 \times 10^{3\,C}$ total external: $3.5 \times 10^{4\,C}$	$3.1 \times 10^{1\,D}$ $7.7 \times 10^{2\,D}$
	Soil surrounding and underlying facility	483	^{137}Cs: $1.4 \times 10^{3\,C}$ total external: $3.5 \times 10^{4\,C}$	$6.1 \times 10^{1\,D}$ $1.5 \times 10^{3\,D}$

[A] values are mrem/hour
[B] values are mrem
[C] values are pCi/g
[D] values are pCi-yr/g

Short-term radiation exposure limits are available in the form of worker protection limits. Worker protection limits have been developed by the DOE and Energy Systems. Worker exposure limits are shown in Table 5.

Table 5. Worker exposure limits

Source	Dose Limit (rem/year)*
DOE radiation dose limit during routine conditions	5
DOE administrative control level during routine conditions	2
ORNL administrative control level during routine conditions	1.5

*(ORNL, 1993)

For this level 3 DARA, risks are calculated using slope factors developed for long-term exposures as recommended by EPA. Estimated short-term radiation doses are also compared to worker exposure limits.

5.3 RISK CHARACTERIZATION

The short-term risk characterization follows the same principles and uses the same equations as presented in the BRA for the evaluation of long-term risks. Radionuclide carcinogen risks are calculated using slope factors. In addition, radiation doses are compared to short-term dose limits.

For carcinogenic contaminants, risk is expressed in terms of the probability of contracting cancer over a lifetime, over and above the normal background risk. This is the ILCR and is estimated as the product of the estimated exposure to a carcinogen and the contaminant-specific, route-specific slope factor:

$$\text{ILCR} = \text{SF} \times \text{Dose},$$

where

ILCR = Incremental lifetime cancer risk (unitless probability),
SF = Slope factor (Risk-g/pCi-yr) or risk conversion factor (Risk/mrem),
Dose = External radiation dose (pCi-yr/g) or (mrem).

The previous equation is linear and is usually applicable for estimating low level risks (i.e., below estimated risks of 0.01). For situations where risks are above 0.01, an alternative calculation was used:

$$\text{ILCR} = 1\text{-exp}(\text{-Dose} \times \text{SF}).$$

In the United States, the normal incidence of cancer occurrence is 3.0E-1 or .30 (American Cancer Society 1990). The ILCR (also referred to as excess cancer risk) is defined as the estimated increased risk that occurs over an assumed average lifespan of 70 years as the result of exposure to a specific known carcinogen. Therefore, an ILCR of one in one million (1.0E-6) may be interpreted as an increase in the baseline population cancer incidence from 300,000 per million population to 300,001 per million population. Current radiation protection standards for workers include a limit of 5 rem for the annual effective dose equivalent. This dose equates to a 25-year lifetime risk corresponding to 5×10^{-2}. Similar protection standards for members of the public include a limit of 0.1 rem per year. This dose equates to a 70-year lifetime risk of 4.0E-3 (ORNL 1993).

The results of the short-term risk characterization for the complete dismantlement alternative are presented in Table 6. The ILCR to a worker who spends 241 to 483 hours outside the building ranges from 6×10^{-5} to 1×10^{-4}. These risks are within generally acceptable levels for both CERCLA and worker protection standards. The ILCR to a worker exposed to radiation from inside the facility (e.g., while creating access holes) for 49 to 97 hours ranges from 1×10^{-2} to 6×10^{1} ; most of the estimated risks to this worker exceed both the CERCLA acceptable risk range and worker protection standards. Based on these results, careful monitoring and minimization of worker exposures at access holes may be necessary. Additional worker risks may occur during sampling of disposal boxes for compliance with WAC. Use of robotics or other exposure minimization measures may be necessary to protect workers during this sampling.

Table 6. Results of short-term risk characterization for complete dismantlement

Exposure Point	Contaminant Source	Exposure Time (Hours)	Estimated Dose	ILCR
Access holes - South cell	Interior surfaces and equipment	49	shallow: 1.8×10^{4A} deep: 7.8×10^{4A}	1×10^{-2} 6×10^{-2}
		97	shallow: 3.5×10^{4A} deep: 1.6×10^{5A}	3×10^{-2} 1×10^{-1}
Access holes - North cell	Interior surfaces and equipment	49	shallow: 3.8×10^{5A} deep: 3.9×10^{5A}	3×10^{-1} 3×10^{-1}
		97	shallow: 7.5×10^{5A} deep: 7.7×10^{5A}	5×10^{-1} 6×10^{-1}
Outside building	Exterior of building	241	7.9×10^{1A}	6×10^{-5}
		483	1.6×10^{2A}	1×10^{-4}
Outside building	Concrete pad and underlying soil	241	^{137}Cs: 1.6×10^{1B} ^{90}Sr: 3.0×10^{0B}	3×10^{-5} NA
	Concrete pad and underlying soil	483	^{137}Cs: 3.1×10^{1B} ^{90}Sr: 6.1×10^{0B}	7×10^{-5} NA
Outside building	Soil surrounding and underlying facility	241	^{137}Cs: 3.1×10^{1B} total gamma: 7.7×10^{2B}	6×10^{-5} NA
	Soil surrounding and underlying facility	483	137Cs: 6.1×10^{1B} total gamma: 1.5×10^{3B}	1×10^{-4} NA

[A] values are mrem
[B] values are pCi-yr/g
NA - Not applicable

Risks to public receptors may occur if an accident during transport results in the damage of disposal boxes. Such risks would be limited to very short-term (minutes to hours) external exposure of emergency response personnel or individuals involved in the accident. U.S. Department of Transportation regulations mandating the labeling of transport containers are designed to prevent or minimize such exposures.

5.4 UNCERTAINTY

The primary sources of uncertainty in this evaluation of short-term exposures are:

- Estimated worker hours—details of the activities required for remediation are preliminary. Actual worker hours may vary from the hours listed. In addition, the number of workers conducting these activities (which determines the exposure per worker) is unknown at this preliminary stage.

- Exposure concentrations—exposure concentrations were estimated based on a very limited number of samples. In most cases, one or two samples were used to represent large areas of contamination.

- Exposure points—the planned methodology for the dismantlement of Building 3515 is preliminary. Gross assumptions were made regarding the location of workers during remedial activities. The location of workers will have a large impact on their exposure (e.g., inside vs. outside the building and distance from the source).

6. EVALUATION OF SHORT-TERM PHYSICAL RISKS OF D&D ALTERNATIVES

This section presents potential physical (nonexposure) risks to D&D workers and the public associated with D&D activities.

6.1 IDENTIFICATION OF HAZARDS

6.1.1 No-Action Alternative

Physical hazards associated with the no-action alternative are limited to the future intruder. Injuries may occur as a result of pieces of the decaying equipment or building structure falling on the intruder or the intruder tripping and falling over debris.

6.1.2 Complete Dismantlement Alternative

Physical hazards during complete dismantlement are restricted primarily to remedial workers. Hazards to these workers fall into two categories: (1) hazards resulting from dismantlement activities and (2) hazards resulting from transportation accidents during transport of waste to off-site disposal facilities. Members of the public may also be injured if transport accidents occur off-site.

6.2 HAZARD ANALYSIS

Physical risks associated with construction/demolition operations are estimated using historical risk data for the types of activities required. Worker risks are calculated as:

$$\text{Risk} = (PH_w)(RC),$$

where

Risk = Risk of injury or fatality expressed as the potential number of injuries or fatalities,
PH_w = Person-hours of construction/demolition work,
RC = Injury or fatality risk coefficient (risk/person-hour).

The risk coefficient is dependent upon the nature of the activities involved.

D&D alternatives requiring transport of waste may result in traffic-related accidents and deaths. Potential transportation risks associated with D&D alternatives are calculated based on the distance to the disposal sites and the accident rate per kilometer traveled:

$$\text{Risk} = (D_T)(RC),$$

where

Risk = Risk of injury or fatality expressed as the potential number of injuries or fatalities,
D_T = Total transport distance
RC = Injury or fatality risk coefficient (risk/km).

Injury and fatality risk coefficients are dependent on the area and types of roads traveled.

6.2.1 No-action Alternative

To evaluate potential hazards to the hypothetical intruder, it is assumed that the actions of the intruder will be similar to those of a construction worker (i.e., the intruder will move equipment and try to remove items of interest). The intruder is assumed to spend 5 hours in the building. For a construction worker, the injury and fatality rate per hour is 6.7×10^{-5} and 5.0×10^{-7} (U.S. Department of Labor 1992). Therefore, the hypothetical intruder scenario is estimated to result in less than 1 injury (3.3×10^{-4} injuries) or fatality (2.5×10^{-6} fatalities) to the public.

6.2.2 Complete Dismantlement Alternative

6.2.2.1 Hazards associated with dismantlement

To evaluate potential hazards to remediation workers, it is assumed that the actions of remediation workers at this facility are similar to those of a construction worker. Approximately 5754 worker hours in dismantlement activities will be required for remediation. Time spent in training, writing reports, etc., is not included in this injury assessment. For a construction worker, the injury and fatality rate per hour is 6.7×10^{-5} and 5.0×10^{-7}, respectively (U.S. Department of Labor 1992). Dismantlement activities could result in approximately 3.9×10^{-1} injuries and 2.9×10^{-3} fatalities.

6.2.2.2 Hazards associated with waste transport

Removal of all concrete and equipment from Building 3515 is expected to require approximately 8–16 trips by tractor-trailer trucks to the disposal site (approximately 160 B-25 disposal boxes of waste). The most likely potential disposal sites are the Hanford Site and the Nevada Test Site. Distances from the ORR to the Hanford Site and the Nevada Test Site are 3967 and 3463 kilometers. Therefore, the total distance traveled will range from 55,410 to 126,945 kilometers (DOE 1994). Truck routes are determined using the routing model HIGHWAY 3.1. This computer program is designed for predicting highway routes for transporting radioactive materials. Risk coefficients for

interstate truck travel in the U.S. are 2.44×10^{-7} accidents/kilometer, 2.25×10^{7} injuries/kilometer, and 2.03×10^{-8} fatalities/kilometer. Potential accidents, injuries, and fatalities associated with off-site transport of waste are presented in Table 7. It is important to note that no accidents or fatalities are expected to result from waste transport (all values are less than 1).

Table 7. Potential hazards associated with waste transport

Disposal Site	Distance from ORR (km)	Number of Trucks	Total Distance Traveled (km)	Potential Number of: Accidents	Injuries	Fatalities
Hanford site	3,967	8	63,473	0.02	0.01	0.001
		16	126,945	0.03	0.03	0.003
Nevada Test Site	3,463	8	55,410	0.01	0.01	0.001
		16	110,820	0.03	0.03	0.002

6.3 UNCERTAINTY

The primary sources of uncertainty in this evaluation of short-term physical hazards are:

- Estimated worker hours—details of the activities required for remediation are preliminary. Actual worker hours may vary from the values used.
- Activity classification—both the intruder and remediation workers are assumed to engage in "construction" activities. The intruder is a hypothetical receptor; therefore, actual activities are unknown. Remediation workers will be involved in remote dismantlement. Dismantlement activities may be more hazardous than construction; however, the use of robotics may reduce these hazards.
- Accident statistics—accident statistics provide a true picture of past injuries and a good idea of the potential for future injuries based on past experience. However, these statistics are based on a large number of workers. Actual accidents at a specific project may vary from those predicted.

7. SUMMARY

Potential long- and short-term risks associated with remedial alternatives at Building 3515 are summarized in Table 8. The no-action alternative has no implementation exposure risks associated with it. However the long-term (residual) risks associated with this alternative range from 6×10^{-9} for exposure of off-site residents following a catastrophic release to 6×10^{-2} for an intruder in the building. The potential for injury to this intruder is very small (3.3×10^{-4} injuries). The complete dismantlement alternative will eliminate all potential sources of contamination and therefore all future (residual) risk from the facility. The complete dismantlement alternative has estimated short-term risks to remediation workers ranging from 3×10^{-5} for exposure of remediation workers to the external concrete pad to 6×10^{-1} for exposure of remediation workers to radiation from inside the building. These risks may be reduced by implementing proper worker protection safe guards. This alternative could result in 6.1×10^{-1} injuries.

Table 8. Summary of risks associated with remedial alternatives at Building 3515

Alternative	Residual (long-term) Risk (ILCR)	Short-term Exposure Risk (ILCR)	Short-term Physical Hazard	Transport Hazards
No-Action	6×10^{-9}–6×10^{-1}	0	3.3×10^{-4} injuries 2.5×10^{-6} fatalities	0 0
Complete Dismantlement	0	3×10^{-5}–6×10^{-1}	6.1×10^{-1} injuries 2.9×10^{-3} fatalities	0.014–0.031 injuries 0.001–0.003 fatalities

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