INEEL/EXT-02-01252

Constructing Predictive Estimates for Worker Exposure to Radioactivity During Decommissioning: Analysis of Completed Decommissioning Projects

D. L. Dettmers

October 2002

Idaho National Engineering and Environmental Laboratory
Bechtel BWXT Idaho, LLC

CONSTRUCTING PREDICTIVE ESTIMATES FOR WORKER EXPOSURE TO RADIOACTIVITY DURING DECOMMISSIONING: ANALYSIS OF COMPLETED DECOMMISSIONING PROJECTS

A Thesis

Presented in Partial Fulfillment of the Requirements for the

Degree of Master of Science

with a

Major in Environmental Science

in the

College of Graduate Studies

University of Idaho

by

Dana Lee Dettmers

October 2002

Major Professor: Maxine E. Dakins, Ph.D.

AUTHORIZATION TO SUBMIT
THESIS

This thesis of Dana Lee Dettmers, submitted for the degree of Master of Science with a major in Environmental Science and titled "Constructing Predictive Estimates for Worker Exposure to Radioactivity During Decommissioning: Analysis of Completed Decommissioning Projects", has been reviewed in final form. Permission, as indicated by the signatures and dates given below, is now granted to submit final copies to the College of Graduate Studies for approval.

Major Professor ______________________________ Date____________
Maxine E. Dakins

Committee Members ______________________________ Date____________
Steven J. Piet

______________________________ Date____________
Jerry L. Harbour

______________________________ Date____________
Lee T. Ostrom

Department Administrator ______________________________ Date____________
Margrit von Braun

Discipline's College Dean ______________________________ Date____________
Joseph R. Zeller

Final Approval and Acceptance by the College of Graduate Studies

______________________________ Date____________
Charles R. Hatch

ABSTRACT

An analysis of completed decommissioning projects is used to construct predictive estimates for worker exposure to radioactivity during decommissioning activities. The preferred organizational method for the completed decommissioning project data is to divide the data by type of facility, whether decommissioning was performed on part of the facility or the complete facility, and the level of radiation within the facility prior to decommissioning (low, medium, or high). Additional data analysis shows that there is not a downward trend in worker exposure data over time. Also, the use of a standard estimate for worker exposure to radioactivity may be a best estimate for low complete storage, high partial storage, and medium reactor facilities; a conservative estimate for some low level of facility radiation facilities (reactor complete, research complete, pits/ponds, other), medium partial process facilities, and high complete research facilities; and an underestimate for the remaining facilities. Limited data are available to compare different decommissioning alternatives, so the available data are reported and no conclusions can been drawn. It is recommended that all DOE sites and the NRC use a similar method to document worker hours, worker exposure to radiation (person-rem), and standard industrial accidents, injuries, and deaths for all completed decommissioning activities.

ACKNOWLEDGEMENTS

This research was funded under two INEEL LDRD projects. I would like to thank the principal investigators of these projects, Steve Piet and Steve Eide, for their support and guidance to conduct this research. Many thanks to my committee members Max Dakins, Steve Piet, Jerry Harbour, and Lee Ostrom for their time spent reviewing this document and providing valuable comments, suggestions, and insights.

Other acknowledgments for help with this research include: Dick Meservey for his time and contribution of personal knowledge and experience included as vital information in this thesis, Kyle Oswald for his contribution of the historical data collected during development of the ROM Model, Bernice Kunkel and Theresa Oh for their help finding and retrieving documents from the INEEL Technical Library and from other DOE libraries, and MaRee Rosen for providing document copies from the INEEL D&D department.

Thanks also to the INEEL Academic Center for Excellence graduate fellowship program for providing the opportunity to work at the INEEL while attending graduate school.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

ANL-E	Argonne National Laboratory-East
ARA	Auxiliary Reactor Area
ARMF	Advanced Reactivity Measurement Facility
ARVFS	Army Reactor Vehicle Facility Site
BORAX	Boiling Water Reactor Experiment
C&S Building	Certification and Segregation Building
CFA	Central Facilities Area
CFRMF	Coupled Fast Reactivity Measurement Facility
CPP	Chemical Processing Plant (now INTEC)
DOE	Department of Energy
DOE-EM	Department of Energy Office of Environmental Management
DOE-S&H	Department of Energy Office of Safety and Health
EBWR	Experimental Boiling Water Reactor
EGG	Edgerton, Germeshausen, and Grier (used in document identification to represent publications under a former contractor at the INEEL)
EPA	Environmental Protection Agency
EROIS	Environmental Restoration Optical Imaging System
ESHRAP	Environment, Safety, and Health Risk Assessment Program
ETR	Engineering Test Reactor
EXT	external (used in document identification to show approval for external release)
IAEA	International Atomic Energy Agency
IET Facility	Initial Engine Test Facility
INEEL	Idaho National Engineering and Environmental Laboratory
INEEL D&D	Idaho National Engineering and Environmental Laboratory Decontamination and Dismantlement
INTEC	Idaho Nuclear Technology and Engineering Center (formerly CPP)
LANL	Los Alamos National Laboratory

LOFT	Loss-of-Fluid Test
LSDDP	Large-Scale Demonstration and Deployment Program
MTA	Mobile Test Assembly
MTR	Material Test Reactor
NEA	Nuclear Energy Agency
NRC	Nuclear Regulatory Commission
OMRE	Organic Moderated Reactor Experiment
ORNL	Oak Ridge National Laboratory
OSHA	Occupational Safety and Health Administration
OSTI	Office of Science and Technology Information
OWR	Overhead Working Reservoir
PM-2A	TAN Radioactive Liquid Waste Evaporator System
PREPP	Process Experimental Pilot Plant
RaLa	Radioactive Lanthanum-140
RAPIC	Remedial Action Program Information Center
ROM Model	Rough Order of Magnitude Model
RWMC	Radioactive Waste Management Complex
S&M	surveillance and maintenance
SPERT	Special Power Excursion Reactor Test
TA	Technical Area (facility locations at LANL)
TAN	Test Area North
TEDE	Total Effective Dose Equivalent
TRA	Test Reactor Area
TSF	Test Support Facility
UCLA	University of California-Los Angeles
WCF	Waste Calcination Facility
WINCO	Westinghouse Idaho Nuclear Company, Inc. (former CPP contractor)

CHAPTER 1.
INTRODUCTION

The United States Department of Energy (DOE) and its predecessor agencies constructed over 20,000 facilities during the course of nuclear weapons production and energy research (DOE-EM, 2000). Although research and development at nuclear facilities continues, an estimated 7,000 facilities no longer serve a mission and await decommissioning (DOE and EPA, 1997; National Research Council, 1999). The DOE Environmental Management (DOE-EM) Program and the Environmental Protection Agency (EPA) estimate that it will cost $20.6 billion to decommission these 7,000 surplus facilities (DOE and EPA, 1997). The Idaho National Engineering and Environmental Laboratory (INEEL) Decontamination and Dismantlement (D&D) program has over 200 surplus facilities planned to undergo some sort of decommissioning within the next ten years (INEEL D&D, 2000). For commercial nuclear facilities, the Nuclear Regulatory Commission (NRC) currently has 18 nuclear power plant sites that have been permanently shutdown and are in some phase of the decommissioning process (NRC, 2001). With these decommissioning needs in mind, the objective of this research is to construct predictive estimates for worker exposure to radioactivity during decommissioning activities using information from completed decommissioning projects.

CHAPTER 2.
BACKGROUND

WHAT IS DECOMMISSIONING?

Decommissioning takes place at the end of a facility's life cycle. DOE defines decommissioning activities to include actions "taken at the end of the life of a facility to retire it from service with adequate regard for the health and safety of workers and the public and protection of the environment" (DOE-EM, 2000). These activities can include decontaminating building surfaces, dismantling piping and equipment, and demolishing the structure. Waste and debris are packaged and transported to appropriate treatment and burial sites (DOE-EM, 2000). The NRC defines the actions of decommissioning as those "to remove a facility or site safely from service and reduce residual radioactivity to a level that permits: release of the property for unrestricted use and termination of the license; or release of the property under restricted conditions and termination of the license" (NRC, 2001).

The stages of a facility's life cycle outlined by the DOE are shown in Figure 2.1. After shutdown of a facility, DOE separates post-operation activities into deactivation and decommissioning, but there is overlap in what happens during these two stages. For this research, what is considered a decommissioning activity will include all activities that take place after shutdown until the facility reaches its end state; therefore deactivation will be listed as an activity under decommissioning.

Throughout DOE documents, decommissioning activities are often referred to with the acronyms D&D or D&D&D but what the Ds stand for is not consistent. These two acronyms have been used to represent any combination of the following terms: deactivation, decontamination, dismantlement, demolition, and decommissioning. In this thesis, the acronym D&D is only used in reference to the INEEL D&D department.

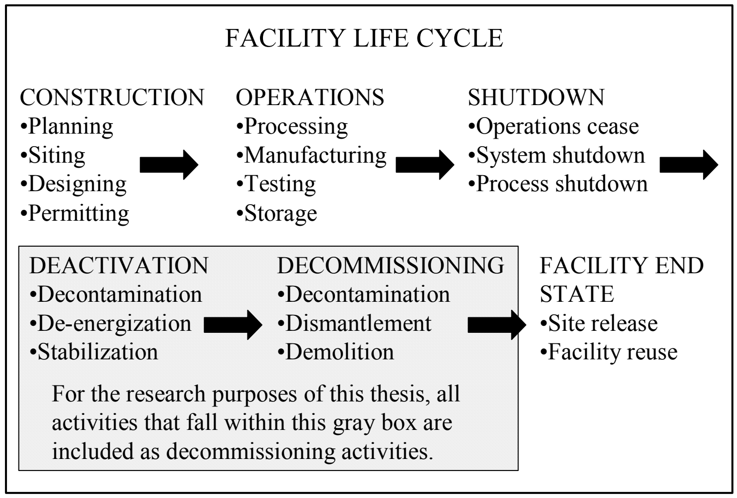

Figure 2.1. Facility Life Cycle (modified from DOE and EPA, 1997).

NEED FOR THIS RESEARCH

This research was sponsored through two research and development projects at the INEEL. The principal investigators for the projects had specific information requests that could possibly be answered through organization and analysis of the data set compiled in this research. The results and conclusions presented in this thesis could be used to support these two research projects or other projects with similar goals. A description of the research needs for the two projects is included to provide examples of the types of data uses.

The first project, the Environment, Safety, and Health Risk Assessment Program (ESHRAP), is a "comprehensive and quantitative risk model framework for environmental management activities" (Eide et al., 2002) including waste management programs, environmental restoration efforts, decommissioning projects, and planned long-term stewardship activities. ESHRAP is being developed to provide best estimates for environment, safety, and health risks (Eide et al., 2002).

Future plans for ESHRAP include developing two methods for predicting decommissioning risks. The first part of the ESHRAP decommissioning component would include a stand-alone decommissioning analysis to predict worker hours, exposure, and standard industrial risks during the following activities:

Characterization

Surveillance and maintenance

One-time deactivation, decontamination, and dismantlement

Deactivation

Decontamination

Dismantlement

Asbestos removal

One-time barrier enhancement

Safe Store

Entombment

Demolition and site restoration

The second part will be targeted at facilities modeled as part of the Waste Management and Environmental Restoration programs. This component will be similar to the construction component currently in ESHRAP. It will be built to predict standard industrial risks based on a standard multiplier and number of years and radiation exposure calculated from a standard estimate for worker exposure. Case study data from this research will provide a basis that can be edited or improved as more decommissioning activities take place or as more information about decommissioning activities is found, in addition to providing information for comparing actual data with standard estimates.

The second project, the KONVERGENCE Framework for Sustainable Decisions, "is a way of viewing, developing, organizing, and evaluating alternatives for decisions (or decision processes)" using "knowledge, values, and resources (the K, V, and R in *K*ON*V*E*R*GENCE)". This framework "anticipates that decisions must continue to work over long time periods in an ever-changing decision environment" (Kerr et al., 2002) and there must be konvergence of knowledge (of the problem and solution), resources to implement the solution, and values of those affected. This project also aims to facilitate early engagement of stakeholders (Piet et al., 2002). The Konvergence Framework is currently under development at the INEEL.

One goal for developing the Konvergence Framework is to be able to provide tools and comparisons based on extrapolation of existing knowledge for screening decommissioning alternatives. Existing data could be used for clues, indicators, or factors that will assist future decision processes prior to carrying out detailed engineering analyses of alternatives for high priority decision alternatives. Risk assessment engineering analyses could be completed through the use of ESHRAP (Piet et al., 2002). Thus a connection of this thesis research to the Konvergence Framework is through providing a method to determine risk during decommissioning activities using the ESHRAP decommissioning component.

One goal of the Konvergence Framework is to provide a way to compare different decommissioning alternatives. Three broad categories of solutions/alternatives are defined: reusable or dismantlement (cleaned sufficiently to reuse site/facility), closed or entombment (hazards remain in place), and adaptable or safe store (Piet et al., 2002). Entombment includes encasing radioactive contaminants in a structurally sound material such as concrete and maintaining and monitoring the facility until the radioactivity decays to a level permitting release of the property. Safe store of a facility includes maintaining and monitoring a facility in a condition that allow the radioactivity to decay until it is dismantled (NRC, 2000a).

The researchers developing the Konvergence Framework seek answers to questions such as: Is there a relationship between worker hours and exposure? What factor of worker hours or exposure reduction could potentially be saved by choosing the less time consuming or less risky decommissioning option? What unique features about a facility increase worker hours and exposure? Using ESHRAP to make this comparison provides a way to quantify different decommissioning alternatives discussed during the process of using the Konvergence Framework.

PREVIOUS WORK

Compiling Decommissioning Information

Some research has been completed for compiling various forms of decommissioning information (e.g. technologies, costs). A comprehensive collection of decommissioning technical information can be found through the Remedial Action Program Information Center (RAPIC) funded by the DOE Office of Environmental Restoration at the Oak Ridge National Laboratory (ORNL). RAPIC provides a bibliographic database of technical information about decontamination and decommissioning of nuclear facilities and remediation of sites contaminated with hazardous and/or radioactive materials (RAPIC, 2002).

In 1994, a paper was presented at the Waste Management Conference on conducting research to gather information for a review of 32 completed DOE decommissioning projects. The goal of this review was to share decommissioning experience with interested parties for future planning needs. The DOE Assistant Secretary for Environmental Restoration and Waste Management supported this work (Price, 1994). This conference paper listed good work practices that took place during the decommissioning projects and the format of how information would be listed for each of the completed decommissioning projects. A bibliographic search of the ANL-E technical library, RAPIC (RAPIC, 2002), and on the DOE Office of Science and Technical Information (OSTI) Bridge internet site (OSTI, 2002) did not locate additional publications about this project. It is unclear if the research was finished, and if so, where the results can be found.

The INEEL D&D Department organized a summary report of major decommissioning projects that took place between fiscal years 1992-2001 (Schanz, 2001). This report contains pictures and brief descriptions of the projects including information about worker exposure and size of facility's footprint reduction (total area decommissioned reported in square feet). The INEEL D&D Department also publishes long-range plan reports, which include planning information for future activities and in some cases includes a project history section listing completed projects and supporting documentation (Buckland et al., 1995).

Predicting Worker Hours and Exposure

The NRC calculated estimates of worker exposure and some worker hour estimates based on cost. This information is reported in a series of decommissioning reports. Examples include information for the following types of facilities:

Nuclear Research and Test Reactors (Konzek, 1983)

Boiling Water Reactors (NRC, 1980a)

Pressurized Water Reactor Power Stations (Konzek, 1988)

Non-Fuel-Cycle Nuclear Facilities (Short, 1989)

Nuclear Fuel Reprocessing Plants (NRC, 1977)

Mixed Oxide Fuel Fabrication Plants (NRC, 1979)

Low-Level Waste Burial Grounds (NRC, 1980b)

Uranium Fuel Fabrication Plants (NRC, 1980c).

Most of these reports were first published in the late 70s and early 80s and have been updated through addendums as calculations and data are reevaluated. The U.S. Congress Office of Technology Assessment used information from these reports to discuss issues surrounding decommissioning and to state the difficulties associated with estimating costs and worker exposure for decommissioning activities. Information in this report showed that worker exposure estimates for decommissioning pressurized water reactor power stations range from 308 to 1,215 person-rem and for boiling water reactors range from 326 to 1,874 person-rem (U.S. Congress Office of Technology Assessment, 1993). Person-rem is the total worker exposure reported for all employees involved in a decommissioning project. Rem is a unit of dosage reported when the factors of biological effectiveness of radiation are taken into account (Murray, 1994). Rem is an abbreviation for roentgen equivalent man and roentgen is a unit used to report the amount of radiation in air (Stacy, 2000).

NRC estimated worker exposure is significantly higher than the completed DOE decommissioning projects worker exposure presented in this research. An example of why this may be is that the NRC data for decommissioning pressurized water reactor power stations is based on data from steam generator replacements at commercial facilities (Konzek, 1988) and could show a conservative estimate, whereas the DOE data are actual data from completed decommissioning activities. A second reason may be that some NRC decommissioning projects are completed on a larger size scale or contain larger amounts and higher levels of facility radiation than DOE projects. This can lead to difficulties comparing exposures between commercial nuclear power plants and test research reactors. Conclusions are not drawn between comparisons of DOE and NRC data in this document because only one NRC data point reported both worker hours and worker exposure in person-rem. In the future, significant NRC decommissioning projects may be completed. Information from these activities could be used as additional data sources for this research if the NRC makes this information available to the public through published literature (additional discussion is in Chapter 3, Data Source section, Nuclear Regulatory Commission subsection).

Researchers at ORNL and the University of Tennessee in Oak Ridge constructed a methodology to perform human health risk assessments for facilities. This methodology was constructed to analyze facilities under the DOE Programmatic Environmental Impact Statement (PEIS) to provide guidance on:

Estimating contaminant inventories within facilities

Defining release scenarios for contaminants from facilities

Evaluating exposure pathways

Modeling contaminant transport through the environment

Estimating abandonment risk to the public

Estimating worker risk during remediation

Estimating risk to the public after remediation

To estimate worker risk during remediation, the researchers used NRC determined values from the series of decommissioning reports previously mentioned, for worker hours and exposure associated with activities for end states of greenfield, safe storage, and entombment of facilities (Arquiett et al., 1997). This information and additional ORNL literature sources about the methodology were reported in a Pollution Engineering article, but the ORNL Technical Library staff could not locate the listed additional literature sources and the authors of the article are no longer ORNL employees. Since additional literature beyond the article is not available, it is difficult to understand how the researchers compared the NRC data to DOE facilities while taking into account facility size differences. In addition, the types of decommissioning activities for each remediation approach used in their methodology (Table 2.1) are not easily comparable to the types of decommissioning activities in this research, as listed in the Need for This Research section.

Table 2.1. Decommissioning activities of the Human Health Risk Assessment for Facilities Methodology performed at ORNL (Arquiett et al., 1997).

Remediation Approach	Activities
Greenfield	Clean equipment removal.
	Transuranic piping removal.
	Clean lining removal.
	Transuranic equipment removal.
	Clean piping removal.
	Transuranic asbestos removal.
	Insulation removal.
	Metal frame removal.
	Offsite fractionation of structures.
	Production reactor removal.
	Research reactor removal.
	Low-level waste metal frame removal.
	Low-level waste lining removal.
	Low-level waste solids from surface decontamination.
	Low-level waste asbestos removal.
	Low-level waste equipment removal.
	Low-level waste piping removal.
	Low-level waste concrete scabbling.
	Hazardous solids from surface decontamination.
	Transuranic concrete scabbling.
Safe Store	Low-level waste solids removal from surface decontamination.
	Hazardous solids removal from surface decontamination.
	Transuranic waste solids removal from surface decontamination.
	Transuranic concrete scabbling.
	Transuranic piping removal.
	Transuranic asbestos removal.
	Transuranic equipment removal.
Entombment	Immobilization in solid matrix.
	Low-level waste solids removal from surface decontamination.
	Hazardous solids removal from surface decontamination.
	Transuranic waste solids removal from surface decontamination.
	Transuranic concrete scabbling.
	Transuranic piping removal.
	Transuranic asbestos removal.
	Transuranic equipment removal.

TLG Services, Inc., a private company who contracts work to the DOE, developed the DECCER (DECommissioning Costs, Exposures and Radwaste) code. The purpose of this code is "to develop site-specific estimates of the resources and requirements necessary to decommission power plants, fuel recycle facilities, research reactors, and other types of contaminated facilities". This code uses an established inventory to calculate exposure to workers based on worker hours for decontamination, removal, and packaging of the radioactive components for shipping. The worker exposure estimates provide an upper limit for exposure estimates to use for planning safe, conservative limits for occupational exposure (TLG Services, Inc., 2002), whereas the goal of this research is to provide a best estimate of the worker exposure actually incurred during the decommissioning activity.

At the INEEL, the Deactivation and Decommissioning Rough Order of Magnitude Model (ROM Model) was built to estimate costs and waste volumes associated with decommissioning activities (Black and Rodriguez, 2001). As part of the cost estimates, the output also provides an estimate of worker hours. This model provides worker hour estimates for deactivation, surveillance and maintenance (S&M), and decommissioning. The use of worker hour estimates from the ROM Model is explored as an additional data source for this research.

CHAPTER 3.
METHODS

DATA SOURCES

The research for this project was completed by collecting information about completed decommissioning case studies. Case study information includes decommissioning projects completed by the INEEL, other DOE sites, and commercial sites. The type of information collected included: the types of decommissioning activities; worker hours (collected for both the total number of project management and physical decommissioning worker hours); worker radiation exposure (presented as both total person-rem, which is calculated by adding together all individual exposures for the employees involved in a decommissioning project; and person-rem per worker hour, which is calculated by dividing the total person-rem by the total number of physical worker hours for the decommissioning project); standard industrial accidents, injuries, and/or deaths (represents on-the-job accidents that happened during the decommissioning activity); the size of the facility (square feet); the dates for physical decommissioning activities; a ranking of the level of facility radiation as high, medium, low, or not ranked (descriptions of the rankings can be found in Chapter 4 in the Data Organization section) (Meservey, 2002); categorization as a partial or complete facility (whether decommissioning took place in a room or part of a facility (partial) or throughout an entire facility (complete); and any additional information about the use of the facility. Detailed information for each case study is included as Appendix A.

Department of Energy

Sources of information for INEEL case studies were collected from the INEEL D&D library located in the Idaho Falls Technical Support Building B (TSB), the INEEL Technical Library, the INEEL Environmental Restoration Optical Imaging System (EROIS) (EROIS, 2002), and the INEEL Science and Technical Information (STI) (INEEL STI, 2002) website. Some of the worker hour data for INEEL case studies were obtained from historical data used to construct the ROM Model (Oswald, 2002). INEEL

D&D project reports were used to match other information about the case study to the ROM Model worker hour data.

Case study information for other DOE sites was researched on the Internet at the DOE OSTI Bridge (OSTI, 2002) and at the RAPIC (RAPIC, 2002) sites. Information was also found in conference proceeding including the Waste Management Symposium; Decommissioning, Decontamination, and Reutilization; and Spectrum (a conference on nuclear and hazardous waste management). Additional information was collected through requests for documents about completed decommissioning projects from employees working for the INEEL D&D department and employees performing decommissioning research at the INEEL and other DOE sites.

Nuclear Regulatory Commission

Attempts were made to collect information about decommissioning projects performed by the NRC. Actual data from NRC completed decommissioning case studies were difficult to find. The NRC was contacted to help locate these data. The response was "as for your questions on the number of worker hours, exposure in person-rem (other than inspections or if there is an accident), and standard industrial accidents, NRC does not track this information" (Virgilio, 2002). However, limited information for decommissioning two research reactors at university campuses, which are regulated by the NRC, was found in the published literature and this information is included in this research.

Although estimates for decommissioning data are available in NRC decommissioning documents; these documents do not contain actual information similar to what was found for the DOE decommissioning activities. These documents and their data are discussed in the Previous Work section of this paper.

Rough Order of Magnitude Model Generated Data

The ROM Model is designed to predict the number of worker hours needed to complete a decommissioning project based on several parameters, which are discussed later. From the number of predicted worker hours generated by the ROM Model, a rough order of magnitude cost is calculated for the decommissioning project. Thus for the purposes of this research project, if worker exposure to radiation for a project is known, but the number of worker hours is unknown, then the ROM Model could be used to estimate the number of worker hours for the project. With these predicted worker hour data, a value for person-rem per worker hour could be calculated.

The ROM Model uses percentage estimates for several parameters to predict worker hours. These parameters include the amount of the total facility that is considered as having low, medium, and high levels for the categories of asbestos, hazardous materials, radiological, characterization performed, and system complexity. In addition, facility information about the size, number of levels, year built, dates of activities, type (e.g. percentage of facility that is concrete or steel and percentage of facility that is roads and lots or yards), and other ranking values to compare multiple facilities are entered into the ROM Model (Black and Rodriguez, 2001).

The ROM Model user can estimate percentages through different methods. One option is to estimate percentages using information found in final reports and other documents. This information may not provide sufficient knowledge for making accurate estimates, thus adding additional user variability to the existing variability of the ROM Model. A second option is to have a subject matter expert (e.g. someone who worked on the decommissioning project) estimate the percentages. After consideration of the difficulty of estimating percentages, the uncertainties, and the irreproducibility of the results, it was decided that ROM estimates of worker hours would not be used for this research.

Physical Versus Project Management Worker Hours

Some of the worker hour data collected in this research are reported as a total number of worker hours including both physical and project management (manual and non-manual) worker hours. For the purpose of this research, only physical worker hours are used to represent the decommissioning activity to provide an accurate comparison to the worker exposure measurements, which are only collected during physical worker hours.

To determine a ratio between physical and project management worker hours, all of the worker hour data listed for specific case studies in the ROM historical data set were divided into the two categories. Project management worker hours represented 38% of the total and physical worker hours represented 62% of the total. This is a ratio of 1.6 physical worker hours to 1 project management worker hour. To validate these percentages, an INEEL D&D expert was asked for his estimate of the two categories. His estimate, based on extensive experience planning decommissioning activities, was 30-40% for project management and 60-70% for physical worker hours (Meservey, 2002). Since the calculated values fall within his range, whenever only a combined total for physical and project management worker hours is listed, then the physical worker hours are calculated using 62% of the total worker hours.

RESEARCH HYPOTHESES

From the research object, requests of the research sponsors, and initial data collection, three research hypotheses were postulated:

1. Best Estimate Predictions,
2. Trends in Exposure Data, and
3. Comparison to Standard Estimates.

Best Estimate Predictions

The first hypothesis is that analysis and interpretation of past decommissioning case studies can provide sufficient information to quantify best estimate predictions for potential exposure to radioactivity and industrial accidents incurred during future decommissioning scenarios for the following activities:

Characterization

Surveillance and maintenance

One-time deactivation, decontamination, and dismantlement

Deactivation

Decontamination

Dismantlement

Asbestos removal

One-time barrier enhancement

Safe Store

Entombment

Demolition and site restoration

This hypothesis will be tested by answering the following questions:

- Are there sufficient data available to make predictions about exposure to radioactivity and industrial accidents?

  Method: Collect and organize the data.

- Can total exposure be predicted from the total number of worker hours?

  Method: Plot exposure data against worker hours to see if there is a relationship. Use linear regression analysis to determine if a significant relationship exists.

- Can total exposure be predicted from the size of the facility? Can the total number of physical worker hours be predicted from the size of the facility?

  Method: Plot exposure against size of the facility to see if there is a relationship. Plot worker hours against the size of the facility to see if there is a relationship. Use linear regression analysis to determine if significant relationships exist.

- Can exposure and worker hour data be divided into the different decommissioning activities listed in this hypothesis?

  Method: Divide exposure and worker hours into the different decommissioning facilities using available information.

- By looking at all the variables of data, what is the best way to organize the data for use in constructing predictive estimates?

  Method: Organize the data into tables and plot the data by type of facility and level of facility radiation.

Definitions of Decommissioning Activities

This section describes each of the decommissioning activities. Although these definitions include information from other sources, they are tailored to the specific purposes of this research.

Characterization

This includes work done to provide a "comprehensive radiological, chemical, and physical description of the facility to aid in the decommissioning decision analysis phase" (Buckland et al., 1995). For this research, this activity includes radiological surveys, sampling and analysis of the facility, and any activities completed in preparation or to help with the decision-analysis processes for decommissioning activities.

Surveillance and maintenance

This includes inspection and proper upkeep of the facility to assure compliance with all applicable safety, environmental, and procedural standards to ensure adequate containment of contamination and provide physical safety and security controls (Buckland et al., 1995). For this research, this activity is listed after characterization, but it can take place during any stage of the decommissioning process.

One-time deactivation, decontamination, and dismantlement

The goal of this activity can vary depending on the plans for the future use of the facility, which could be restricted reuse of part or all of the building or unrestricted use of the land following demolition of a building. There are four subsections for this activity.

Deactivation

This includes removing all loose contamination, which can include any contaminated material or waste that can be easily removed from the facility.

Decontamination

This includes cleaning the building surfaces to prepare the building for reuse or disposal of building materials in a less or non-hazardous or radiological disposal site.

Dismantlement

This includes removal of any fixed hazards. This can include dismantling equipment or structures within the building.

Asbestos removal

This includes removing all asbestos containing material from the facility.

One-time barrier enhancement

The goal of this activity is to construct a physical barrier around the contaminated facility or portions of the contaminated material to provide a temporary to permanent end state with continued S&M. There are two subsections for this activity.

Safe Store

This includes improving the barrier around the facility to place it into long-term storage until future decommissioning activities take place. The site may be available for restricted use.

Entombment

This includes closure of the facility with hazards remaining in place to provide a permanent end state for the facility. The site may have unrestricted use except for the exclusion area immediately around the entombment and any activities that would compromise the physical barrier.

Demolition and site restoration

The goal of this activity is to demolish the building structure and remove any excess debris and contaminated soil resulting in a site that will no longer need S&M and will be available for unrestricted use in the future. Restoration activities can include backfilling excavated areas, grading the surface to match surrounding contours, and reseeding. The site will be available for unrestricted use because it has been decontaminated until no hazards exist and is considered radiologically clean (Buckland et al., 1995).

Trends in Exposure Data

The second hypothesis is that there could be a downward trend in the data for exposure to radioactivity over time from the 1970s to current time.

This hypothesis will be tested by answering the following question:

- Is there a downward trend in the exposure data plotted over time?
  Method: Plot exposure data over time divided by level of facility radiation. Use regression analysis to determine if significant relationships exist.

Exposure Over Time

This hypothesis was formulated based on the idea that with more experience, additional safe work practices (e.g. As Low As Reasonably Achievable (ALARA) standards), and improved technology; safe work methods will improve resulting in lower worker exposure totals for decommissioning projects. Every year, the DOE Office of Safety and Health (DOE-S&H) compiles an occupational radiation exposure report to provide summary and analysis of the occupational radiation exposure received by individuals working at DOE facilities. Unfortunately, this report does not have a category for exposure during decommissioning work. It divides exposures by worker categories and type of facilities currently in operation. Occupational exposures are compared from year to year using the collective Total Effective Dose Equivalent (TEDE), which is the sum of the effective dose equivalent for external exposures and the committed effective dose equivalent for internal exposures. The TEDE represents the average rem exposure to each employee per year (DOE-S&H, 1999; DOE-S&H, 2000). In the 2000 report, the collective TEDE Dose, recorded in person-rem, was reported as decreasing from 1,652 in 1996 to 1,266 in 2000 (DOE-S&H, 2000).

Comparison to Standard Estimates

The third research hypothesis is that comparison of accumulated exposure and accident data with standard estimates will validate the use of standard estimates in a comprehensive risk model.

This hypothesis will be tested by answering the following questions:

- Is the ESHRAP standard estimate for exposure similar to the person-rem per physical worker hour data calculated from the collected case study information?

  Method: Compile collected exposure data from the case studies to see if sufficient data exist. Compare the ESHRAP standard estimate to the calculated person-rem per physical worker hour data.

- Can the accumulated accident data be compared to the standard estimate in ESHRAP?

  Method: Compile accident data collected for case studies to see if sufficient data exist.

ESHRAP Standard Estimates

<u>Exposure Estimate</u>

The ESHRAP standard estimate was calculated by averaging the measurable TEDE values reported from 1995 to 1999 (Table 3.4) as reported in the DOE Occupational Radiation Exposure 1999 Report (DOE-S&H, 1999). The average of 0.075 rem per year is divided by 2,000 worker-hrs per year (40 hours a week times 50 working weeks a year) to give the value of 3.8E-5 rem per worker hour.

Table 3.4. Exposure values used to calculate the ESHRAP standard estimate.

Calendar Year	Average Measurable TEDE (rem)
1995	0.078
1996	0.073
1997	0.073
1998	0.074
1999	0.078
ESHRAP Average	**0.075 rem per year**
ESHRAP Standard Estimate	**3.8E-05 rem per worker hour**

Standard Industrial Death Estimate

The ESHRAP standard value used for standard industrial deaths during all activities is 7.0E-09 deaths per worker hour for all involved workers and 7.0E-10 deaths per worker hour for all non-involved workers (ESHRAP, 2002).

CHAPTER 4.
RESULTS

In this chapter, analyses and results of the hypotheses are stated beginning with the organization of the data collected from case studies. Through a variety of data combinations, possible relationships or patterns were explored including relationships between exposure and worker hours, exposure and size of facility, and exposure and date. Data divisions by type of decommissioning activity were also attempted. Finally, analysis by type of facility and level of facility radiation was completed and is shown in tables and plots for the data divided into categories for complete, partial, reactor, and all facilities. Within each of these categories, the data are shown for physical worker hours (the number of manual worker hours for each decommissioning project, which does not include project management worker hours), total person-rem (the total worker exposure to all employees involved in a decommissioning project), and person-rem per worker hour (represents the total person-rem divided by the physical worker hours for each decommissioning project where data are available).

DATA ORGANIZATION

The data collected for this thesis research are presented in Appendix A. For each case study, the data are organized in the following format:

Abbreviated Title of Case Study

Name:

The full name of the case study is listed.

Location:

The name of DOE site or other location where the activities took place is listed.

Dates of Activities:

Represents the start to finish dates for the case study activities.

Type of Facility:

One of the following categories: Reactors, Reactor Support, Process, Research, Storage, Pits/Ponds, or Other. These categories are defined later in this chapter in the Analysis of Data by Type of Facility and Level of Facility Radiation section.

Total Worker Hours:

Represents total worker hours to complete the decommissioning work. Project management hours are listed in parentheses.

Physical Worker Hours:

Represents the worker hours for physical decommissioning work. For some of the case studies, divisions of worker hours into different decommissioning activities are listed in parentheses. For other case studies, the worker hour data does not accurately represent the total worker hours for the case study activities and should not be used in comparison with the other data in the case study. These case studies are labeled as worker hour data incomplete.

Total Exposure (Person-Rem):

Represents the total exposure for all the decommissioning activities. If a breakdown of the data was available, it is listed in parentheses. For INEEL case studies, if the documentation states no exposure above background levels or if the thermoluminescent dosimeters did not record exposure, then 0.00 person-rem was recorded for the case study exposure (Schanz, 2001).

Person-Rem Per Worker Hour:

Represents the total exposure divided by the physical worker hours.

Size of Facility (Square Feet):

Represents the size of the area decommissioned. Some values are calculated from the size of the building(s) as listed in case study documents. Other INEEL case studies list footprint reduction, which represents the size of the area decommissioned. The type of information used for determining the size of the facility is listed in parentheses.

Level of Facility Radiation:

Each facility is categorized as low, medium, high, or not ranked based on the level of facility radiation prior to the start of decommissioning activities. An INEEL D&D expert ranked the case studies based on his experience and knowledge about each case study and in comparison with other decommissioning case studies. Low ranked facilities would generally have less than 10 mR/hr general radiation field strengths throughout the entire facility. Medium would have between 10 and 100 mR/hr general radiation field strengths. Both low and medium rankings could contain low-level waste, generally mixed fission products, but no transuranic waste. High would have greater than 100 mR/hr and could contain transuranic waste (greater than 10 nCi) or other hazardous materials such as mercury (Meservey, 2002). Case studies that were not ranked were ones he was not familiar with.

Complete or Partial Facility:

Each case study was ranked as complete (if decommissioning took place throughout the entire facility) or partial (if decommissioning took place in a room or part of the facility).

Purpose of Facility Prior to Decommissioning:

Description of the facility's purpose before decommissioning took place.

Prior Decommissioning Activities Completed:

Lists if and when prior decommissioning activities took place, for example if reactors were defueled or deactivated.

Description of Decommissioning Activities:

Lists what activities took place for each case study.

Reference:

Document(s) containing the listed and additional information about each case study.

Standard Industrial Accidents, Injuries, and Deaths

Appendix A does not include data about standard industrial accidents, injuries, and deaths incurred during decommissioning activities. The information found for INEEL and DOE sites on this topic includes:

- An INEEL D&D department Occupational Safety and Health Administration (OSHA) recordable injury rate of 3.3 per 200,000 worker hours. This rate is reported for a 4.75 year time period from October 1997 through July 2001 (Schanz, 2001).

- Three near misses for INEEL case studies.
    1. Airline respirator pinched resulting in a worker removing the respirator and receiving airborne alpha contamination (Smith and Scott, 1984).
    2. A breathing air compressor failed while a worker was inside a tank (confined area). The worker was examined by medical personnel and released (Hansen, 1993).
    3. A metal tie-down plate broke loose and flew through the safety glass window of an excavator. The metal plate landed in the excavator operator's lap. The operator was not injured (Howell and Long, 2001).
- Accident information for nine case studies at other DOE sites than the INEEL. Seven of these nine case studies also had information about both worker hours and/or exposure.

  Information for case studies that also had worker hours and/or exposure information:
    1. An OSHA recordable rate of 5.09 accidents per 200,000 worker hours was reported for the N Area case study at Hanford (Environmental Restoration at Hanford, 1998).
    2. 14 OSHA recordable injury cases were reported for the C Reactor case study at Hanford (Pak et al., 2000).
    3. 8 first aid cases and 1 recordable injury case were reported for the 190-D Complex case study at Hanford (Thoren, 1996).
    4. 1 recordable accident for the K-25 Cooling Towers case study at Oak Ridge (Larson et al., 1997).
    5. 1 OSHA recordable injury, a fractured and lacerated finger, for the Janus Reactor case study at Argonne National Laboratory-East (Fellhauer et al., 1997).
    6. No lost time injuries were reported for the Apollo Nuclear Fuel case study (B&W NESI, 1997).
    7. 2 near misses occurred during activities for the EBWR case study at Argonne National Laboratory-East. One person experienced an electrical shock and one

person fell into a pool of water and was immersed up to knee-level (Fellhauer et al, 1996).

Information for case studies without worker hour and exposure information:

1. 1 OSHA recordable accident, 1 first aid case, and 2 work restrictions were reported for Building 889 at Rocky Flats (Dorr et al., 1997).
2. Zero OSHA recordable accidents, zero first aid cases, and zero work restrictions were reported for the gloveboxes in Building 371 at Rocky Flats (Sexton et al., 1997).

RELATIONSHIP OF EXPOSURE AND WORKER HOURS

The exposure data in person-rem were plotted against the physical worker hour data to see if there is a relationship (Figure 4.1). Data points with less than 200,000 worker hours and less than 40 person-rem are shown in Figure 4.2. Linear regression analysis (Manly, 2001) was used to test the strength of the relationship. The slope of the line for all of the data (Figure 4.1) was significant ($p = 8.0E-14$) with an intercept of -4.1 and a slope of 0.0003. The slope of the line for the data less than 200,000 worker hours and less than 40 person-rem (Figure 4.2) was also significant ($p = 0.002$) with an intercept of -0.16 and a slope of 0.0001.

RELATIONSHIP OF EXPOSURE AND SIZE OF FACILITY

To determine if there is a relationship between exposure and size of facility, the exposure data were plotted against the size of the facility (Figure 4.3). Next, the worker hours were plotted against the size to see if worker hours could be related to exposure through the two relationships. Exposure versus size (Figure 4.3) and worker hours versus size (Figure 4.5) plots show the data points divided into low, medium, and high categories based on the level of facility radiation. Exposure versus size (Figure 4.4) and worker hours versus size (Figure 4.6) plots show the same data points also divided based on whether the starting date of the project was pre-1990 or post-1990. Linear regression analysis (Manly, 2001) was used to test the strength of the relationships, both overall and divided by level of facility radiation and date. All of the analyses showed the lines were insignificant (Table 4.1).

Table 4.1. Linear regression analysis significance levels for exposure versus size and worker hours versus size.

Relationship	p-value
Overall, exposure and size	0.48
Overall, worker hours and size	0.06
Low level of facility radiation, exposure and size	0.62
Medium level of facility radiation, exposure and size	0.70
High level of facility radiation, exposure and size	0.42
Low level of facility radiation, worker hours and size	0.99
Medium level of facility radiation, worker hours and size	0.73
High level of facility radiation, worker hours and size	0.21
Pre-1990, exposure and size	0.79
Post-1990, exposure and size	0.59
Pre-1990, worker hours and size	0.07
Post-1990, worker hours and size	0.24

RELATIONSHIP OF EXPOSURE AND DATE

Exposure data, for both person-rem and rem per worker hour, were plotted by project date to determine if there were downward trends in the data over time. The data were plotted by both the start date (Figures 4.7 and 4.9) and completion date of the project (Figure 4.8 and 4.10) and divided into the level of facility radiation categories. Linear regression analysis (Manly, 2001) showed that the slopes of the lines for the person-rem data were insignificant ranging from $p = 0.12$ to $p = 0.84$. The person-rem per worker hour data for low and high levels of facility radiation were insignificant ranging from $p = 0.18$ to $p = 0.24$. The person-rem per worker hour data for medium level of facility radiation were significant ($p = 0.01$ starting date, $p = 0.002$ completion date), but the data are clustered into two groups and only four data points are available.

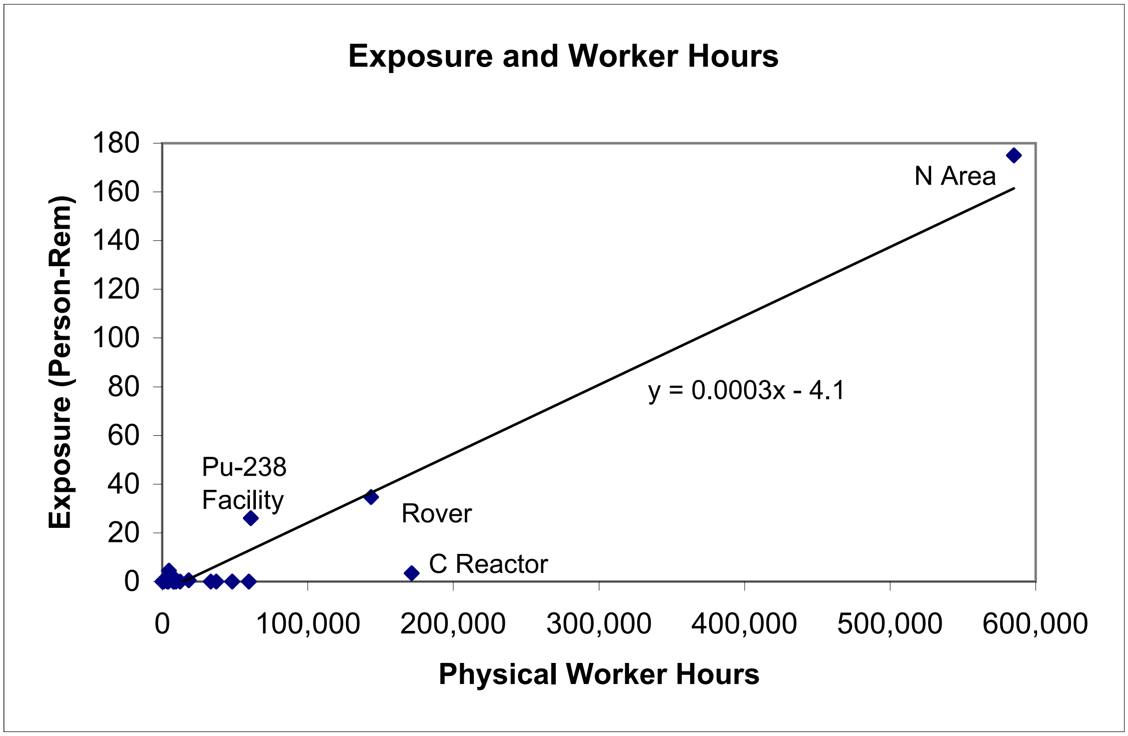

Figure 4.1. Physical worker hours versus exposure in person-rem.

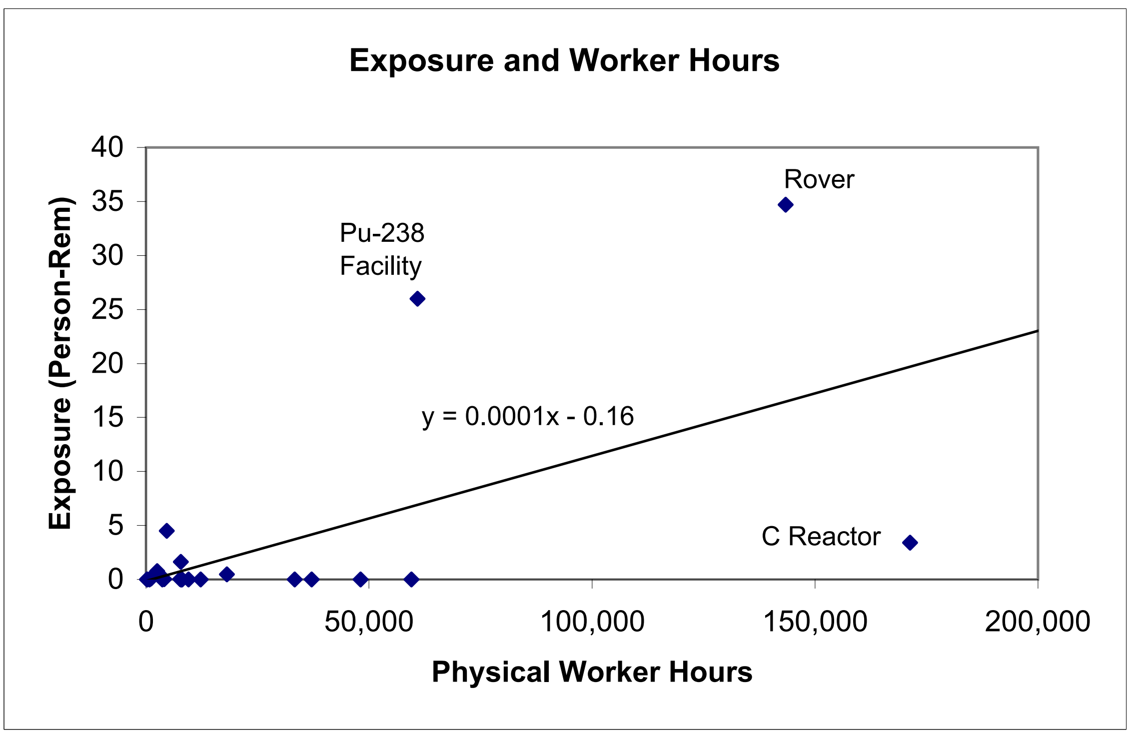

Figure 4.2. Physical worker hours versus exposure in person-rem. Figure 4.1 zoomed to less than 200,000 physical worker hours and less than 40 person-rem.

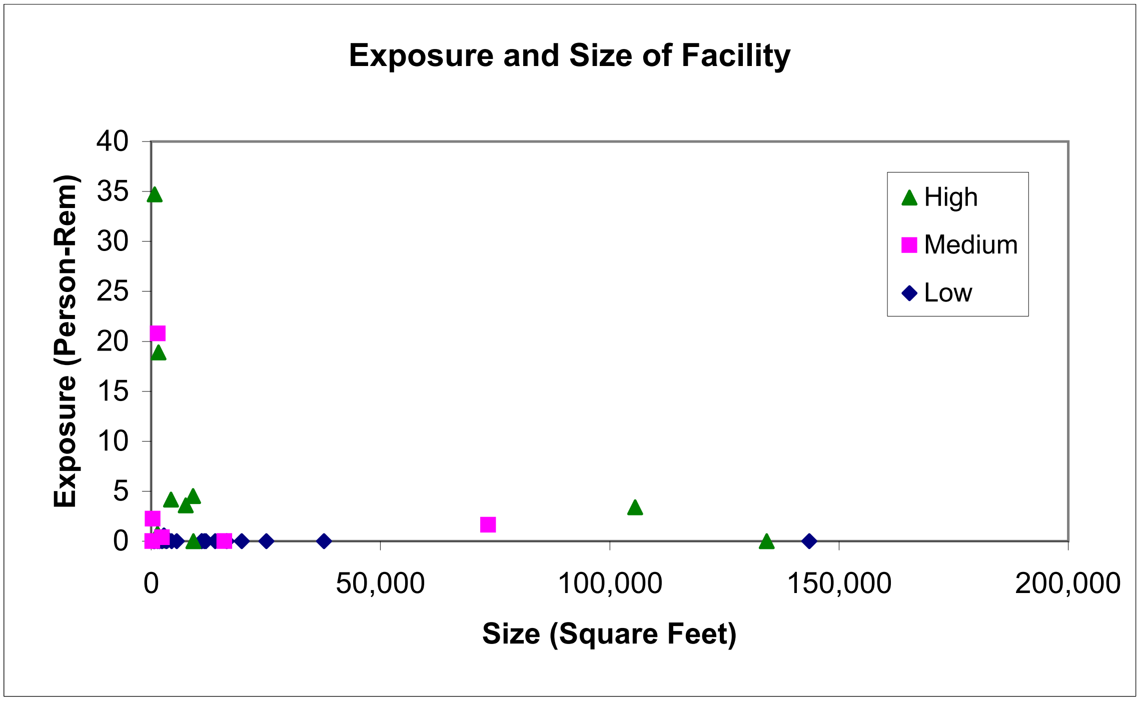

Figure 4.3. Size in square feet versus exposure in person-rem, also divided by low, medium, or high level of facility radiation.

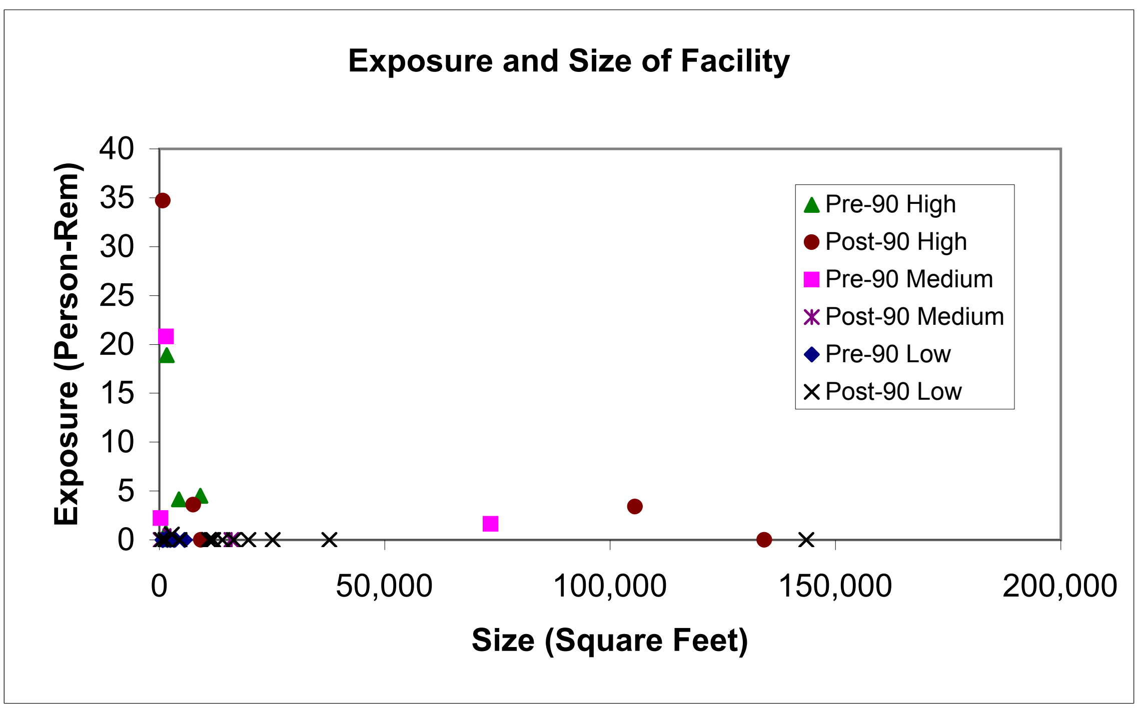

Figure 4.4. Size in square feet versus exposure in person-rem, also divided by low, medium, or high level of facility radiation and by Pre-1990 or Post-1990 starting date of the decommissioning project.

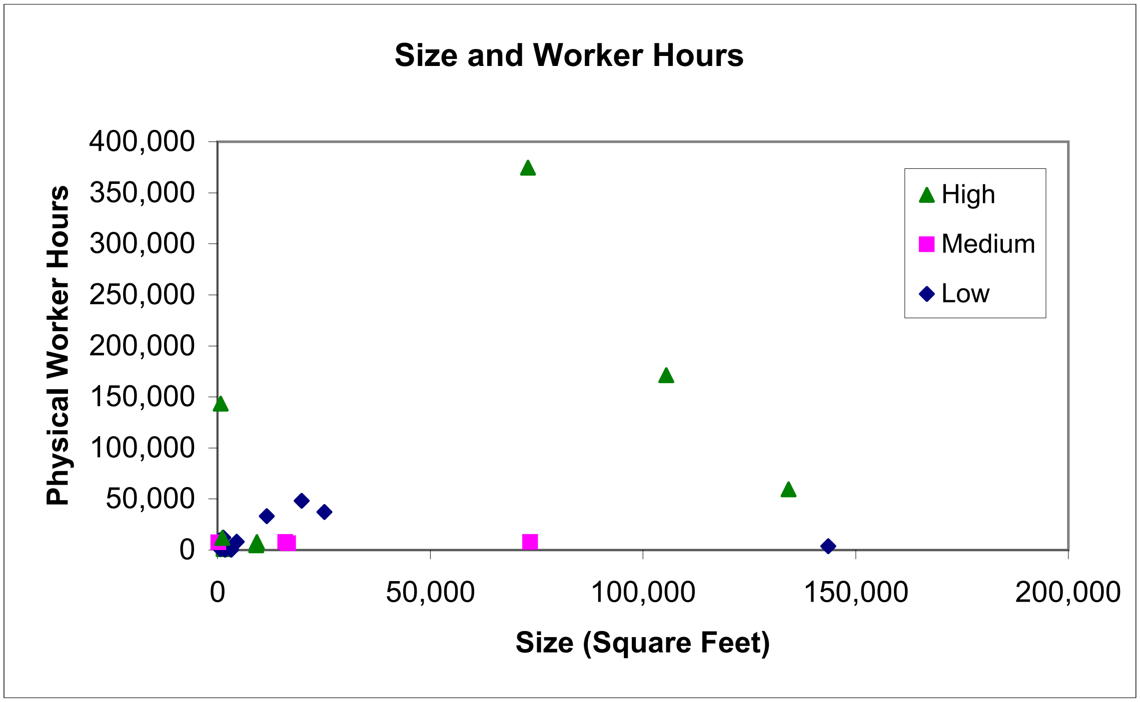

Figure 4.5. Size in square feet versus physical worker hours, also divided by low, medium, or high levels of facility radiation.

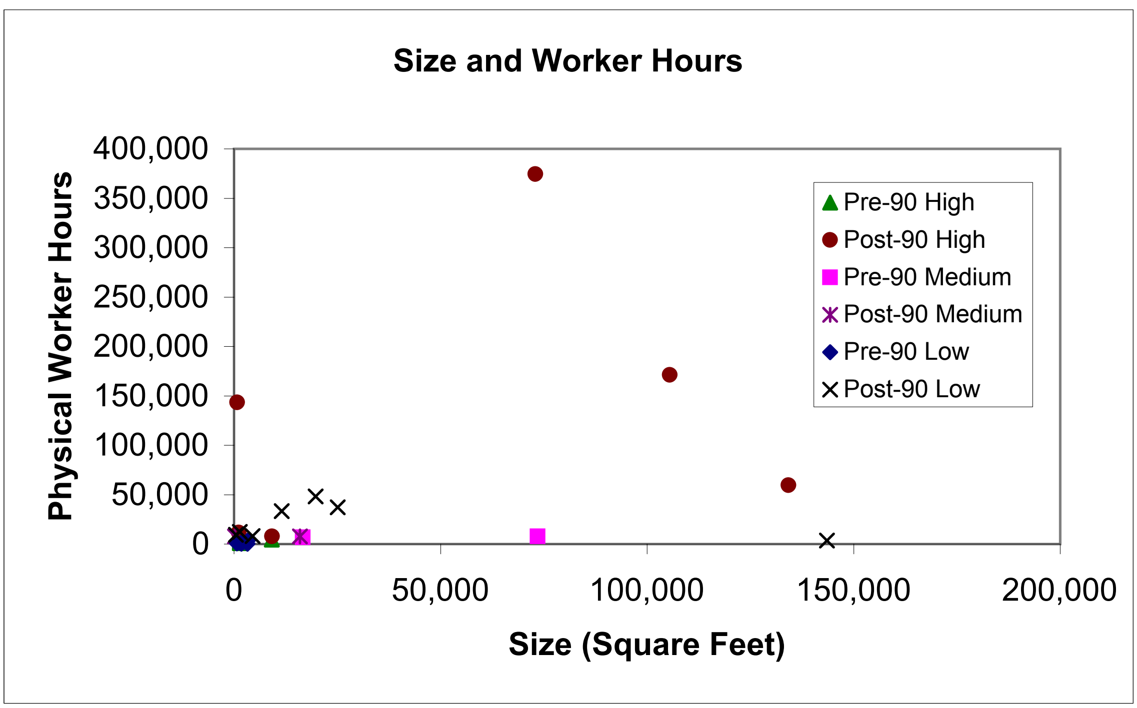

Figure 4.6. Size in square feet versus physical worker hours, also divided by low, medium, or high levels of facility radiation and by Pre-1990 or Post-1990 starting date of the decommissioning project.

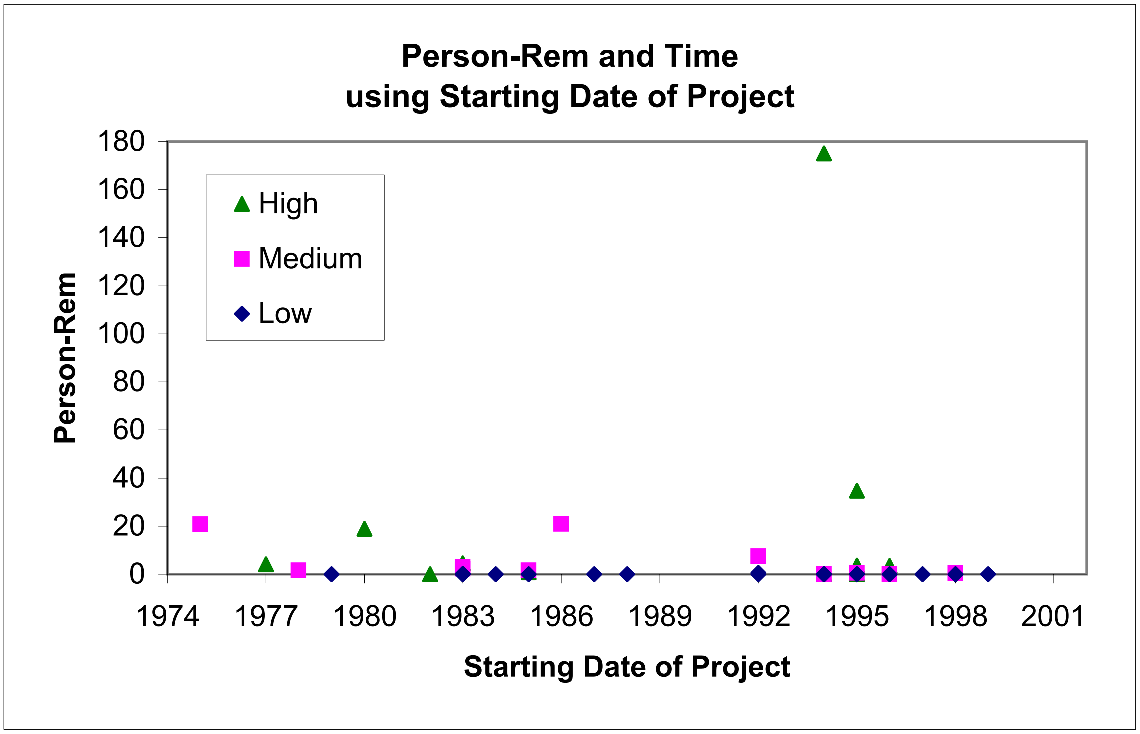

Figure 4.7. Person-rem plotted over time by the starting date of the project.

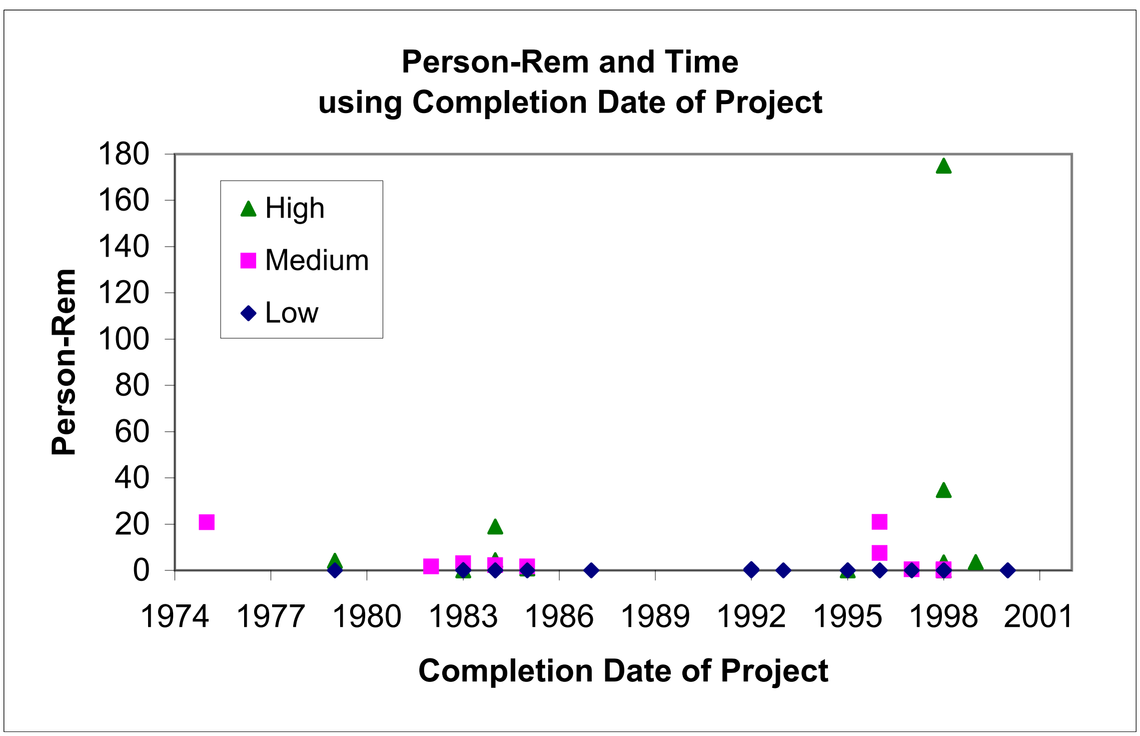

Figure 4.8. Person-rem plotted over time by the completion date of the project.

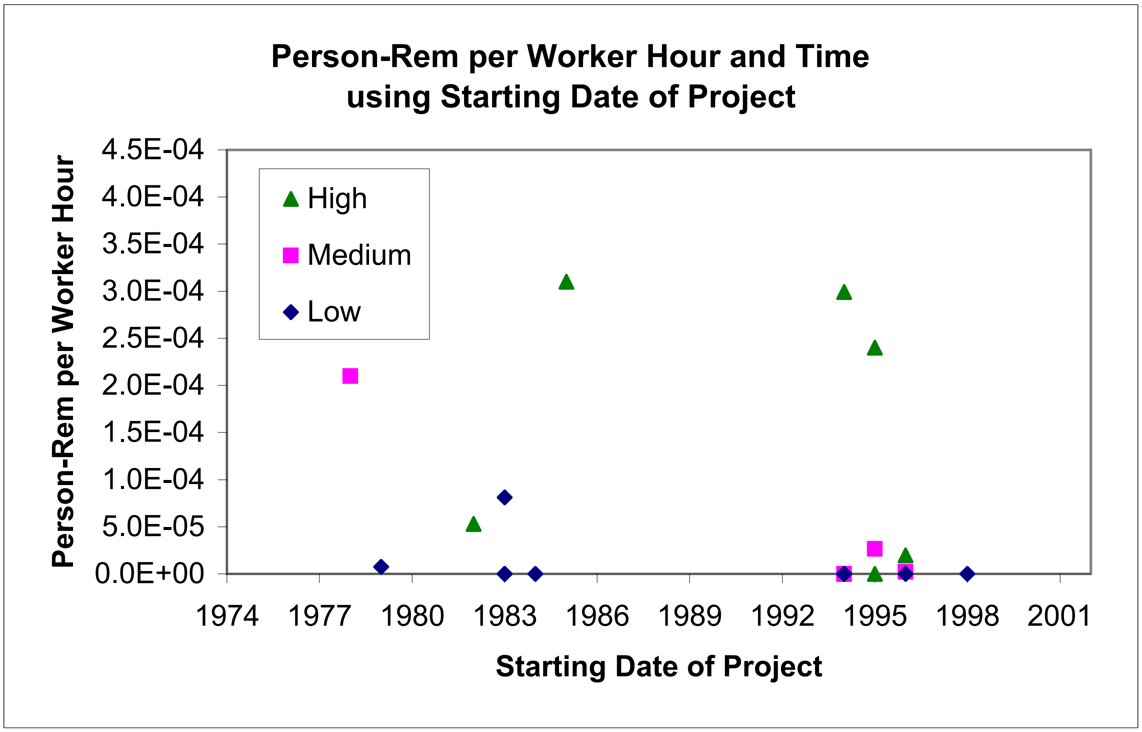

Figure 4.9. Person-rem per worker hour plotted over time by the starting date of the project.

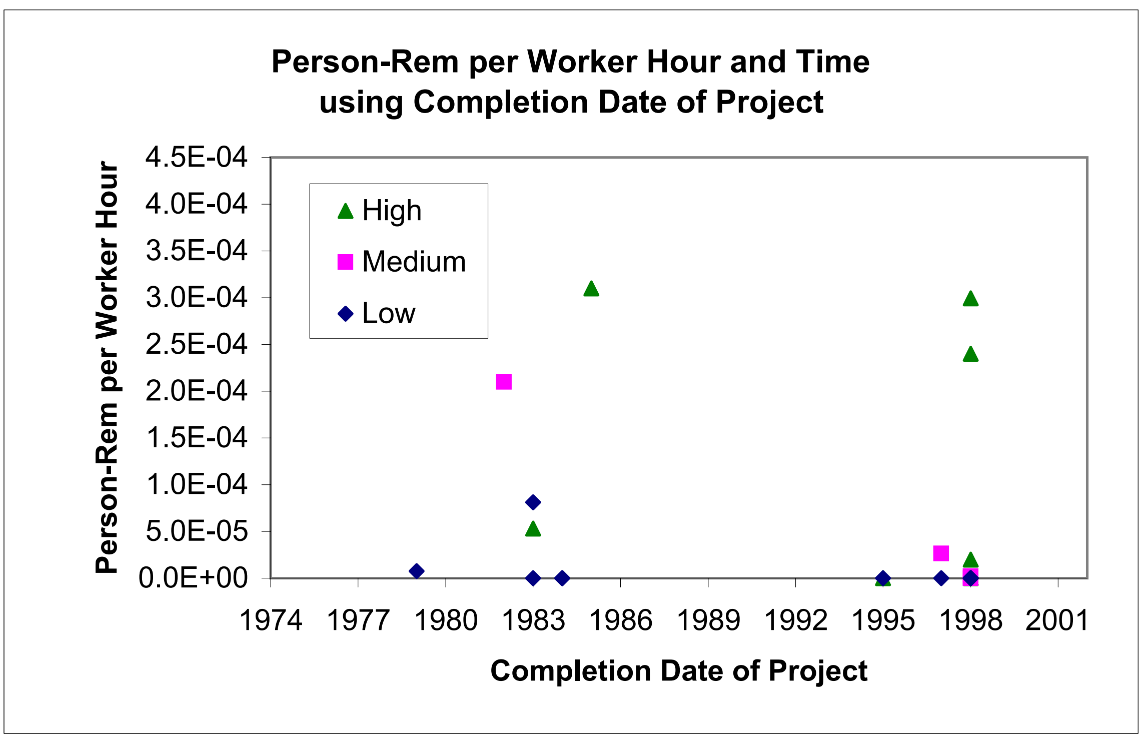

Figure 4.10. Person-rem per worker hour plotted over time by the completion date of the project.

ANALYSIS OF DATA BY DECOMMISSIONING ACTIVITIES

Exposure

For most case studies, exposure was reported as a total value for all activities. Some exposures were divided by type of worker or certain locations within a total project or area, but no total exposures were divided into the decommissioning activities identified in the Best Estimate Predictions hypothesis. Data for exposure divisions are listed next to the total exposure for the specific case studies in Appendix A. Case studies with exposure divisions include: 60" Cyclotron Facility, HB-2 Cubicle, Process Cells A, B, C, D, and L, and S1G Reactor Vessel.

Worker Hours

For the case studies with divisions and descriptions of the worker hours, the total worker hours were divided into the different decommissioning activities listed in the Best Estimate Predictions hypothesis using personal judgment and interpretation of deciding what descriptions of activities fell under what decommissioning categories. Information for worker hour divisions are listed under the total worker hours and physical worker hour categories for each case study in Appendix A.

ANALYSIS OF DATA BY TYPE OF FACILITY AND LEVEL OF FACILITY RADIATION

Case study data for size, physical worker hours, total person-rem, and rem per worker hour; were organized by type of facility and the level of facility radiation prior to decommissioning. The seven types of facilities include:

Reactor – building or facility that contained a reactor

Reactor Support – used to support operations at a reactor facility

Process – used for processing radioactive or hazardous materials or waste

Research – used for research purposes (e.g. laboratories, gloveboxes, research cubicles)

Storage – used for temporary or permanent storage of radioactive or hazardous materials or waste

Pits/Ponds – used to collect and evaporate discharged wastewater

Other – not included in any of the other six categories (e.g. hot laundry facility or sewage treatment plant)

For the purposes of data analysis, the data are organized into categories for partial, complete, reactor, and all facilities. For each of these categories, tables and plots are shown for physical worker hours, person-rem, and person-rem per worker. The tables show averages for each division of low, medium, high, and not ranked within each type of facility category, in addition to averages for all rankings for each type of facility and overall averages for the three categories of physical worker hours, total person-rem, and rem per worker hour. The plots show the data divided by type of facility with the mean and 95% confidence interval on the mean. The scales for all groups (worker hours, person-rem, and rem per worker hour) are the same to provide comparison among the categories of partial, complete, reactor, and all facilities. This constant scale will cut off the top value for the 95% confidence interval on some plots. Also, the level of facility radiation is labeled for each data point and outlier data points are labeled by the case study name.

Partial Facilities

Partial facilities include all decommissioning activities that were performed on only part of a facility (e.g. only a room or cubicle). Partial facility data are shown in Table 4.2. Partial facility plots for physical worker hours are shown in Figures 4.11 (less than 600,000), total person-rem in Figures 4.12a (less than 180) and b (less than 8), and person-rem per worker hour in Figure 4.13.

Table 4.2. Partial facilities data divided by type of facility and level of radiation.

Type of Facility	Level of Radiation	Size (sq ft)	Physical Worker Hours		Total Person-Rem	Rem per Worker Hour	Average Worker Hours	Average Total Person-Rem	Average Rem per Worker Hour	Name of Case Study
Reactor	Medium				3.042					S1G Reactor
Reactor	**Medium**							**3.0420**		
Reactor Support	Not Ranked		*124,000*	*						K-25 Cooling Towers
Reactor Support	**Not Ranked**						**124,000.0**			
Process	Low	2800			0.563					Chloride Removal System
Process	**Low**							**0.5630**		
Process	Medium	319			2.234					BIF Filter Room
Process	Medium	260	7652		0.015	2.0E-06				CPP-631/709/734
Process	Medium	1,472			20.8					MTR OWR
Process	**Medium**						**7652.0**	**7.683**	**2.00E-06**	
Process	High	1602			18.906					Process Cells A,B,C,D, and L
Process	High	750	*143,392*	*	34.7	2.4E-04				Rover
Process	**High**						**143,392.0**	**26.80**	**2.40E-04**	
Process	**All**						**75,522.0**	**12.87**	**1.21E-04**	
Research	Medium				7.45					Hot Cells
Research	High	1400	2507		0.765	3.1E-04				HB-2 Cubicle
Research	Not Ranked				1.26					Plutonium Gloveboxes
Research	**All**						**2,507.0**	**3.158**	**3.10E-04**	
Storage	Medium				1.623					RaLa Off-gas Cell and Storage Tank
Storage	High	1408	938		0.05	5.3E-05				Plug Storage Facility
Storage	Not Ranked	80			0.14					Gamma Irradiation Facility
Storage	**All**						**938.0**	**0.604**	**5.30E-05**	
Other	Low		1535							TAN-606 Calibration Well
Other	**Low**						**1535.0**			
Overall Averages							**91,681.3**	**12.87**	**1.21E-04**	**Partial Facilities**

** Physical Worker Hours calculated as 62% of the total worker hours. Rover worker hours estimated by project management.*

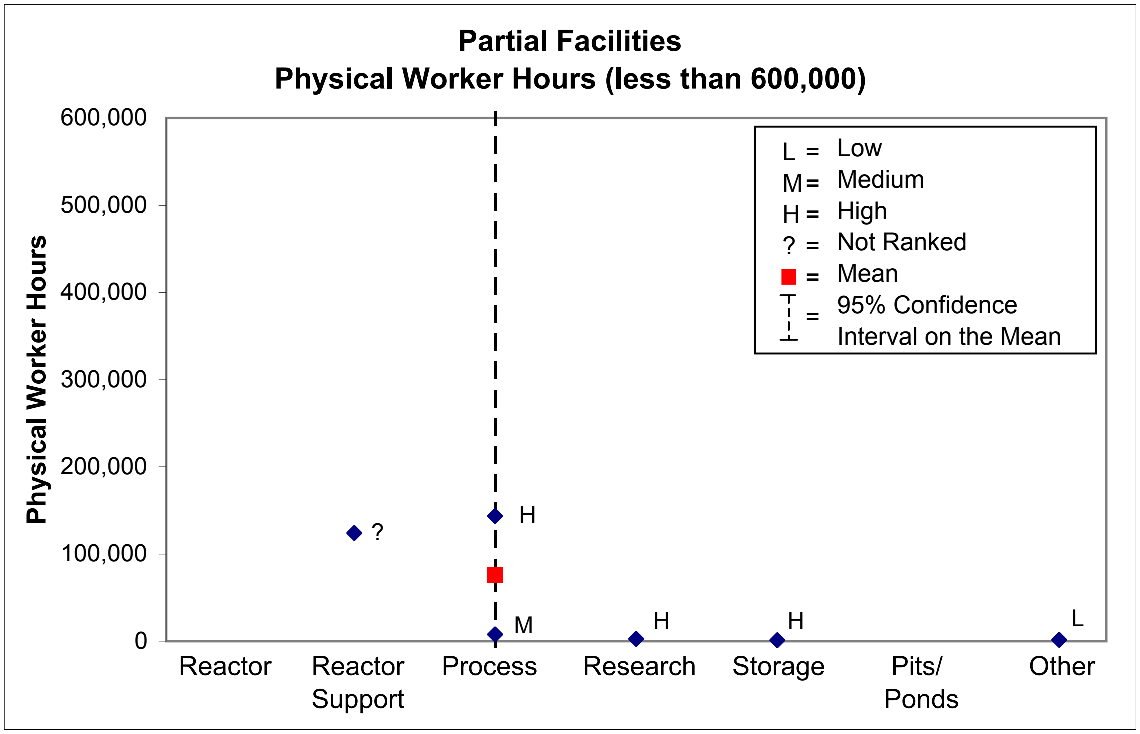

Figure 4.11. Physical worker hours (less than 600,000) for partial facilities.

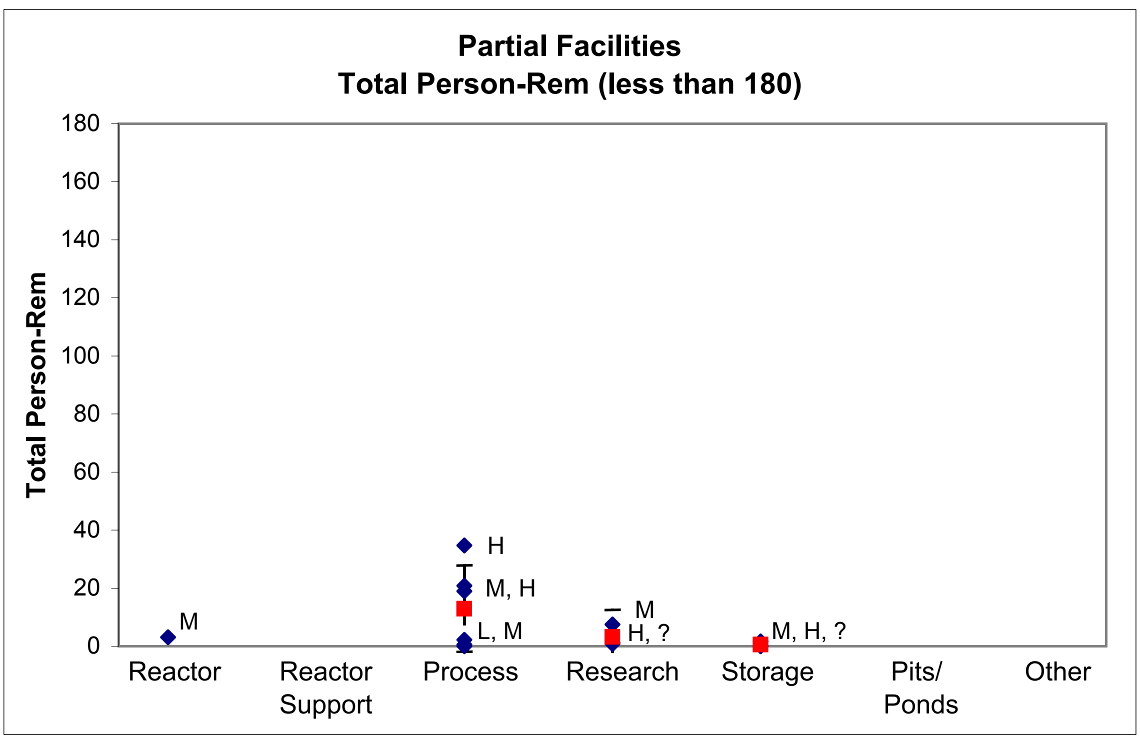

Figure 4.12a. Total person-rem (less than 180) for partial facilities.

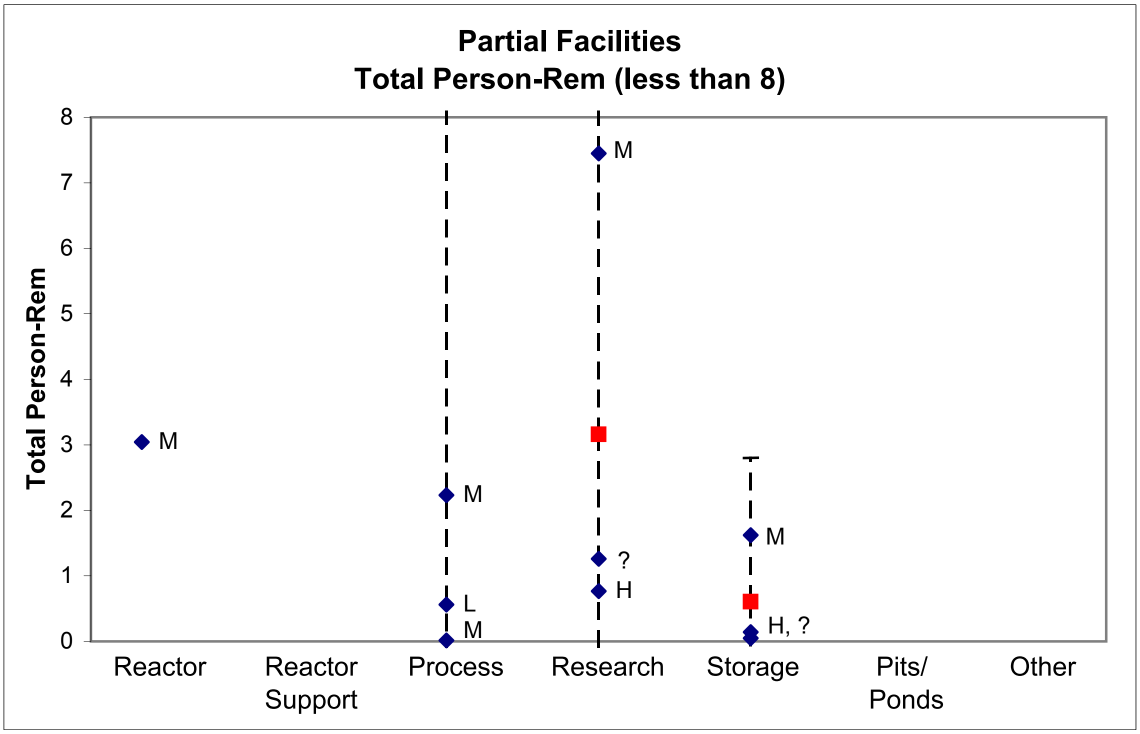

Figure 4.12b. Total person-rem (less than 8) for partial facilities.

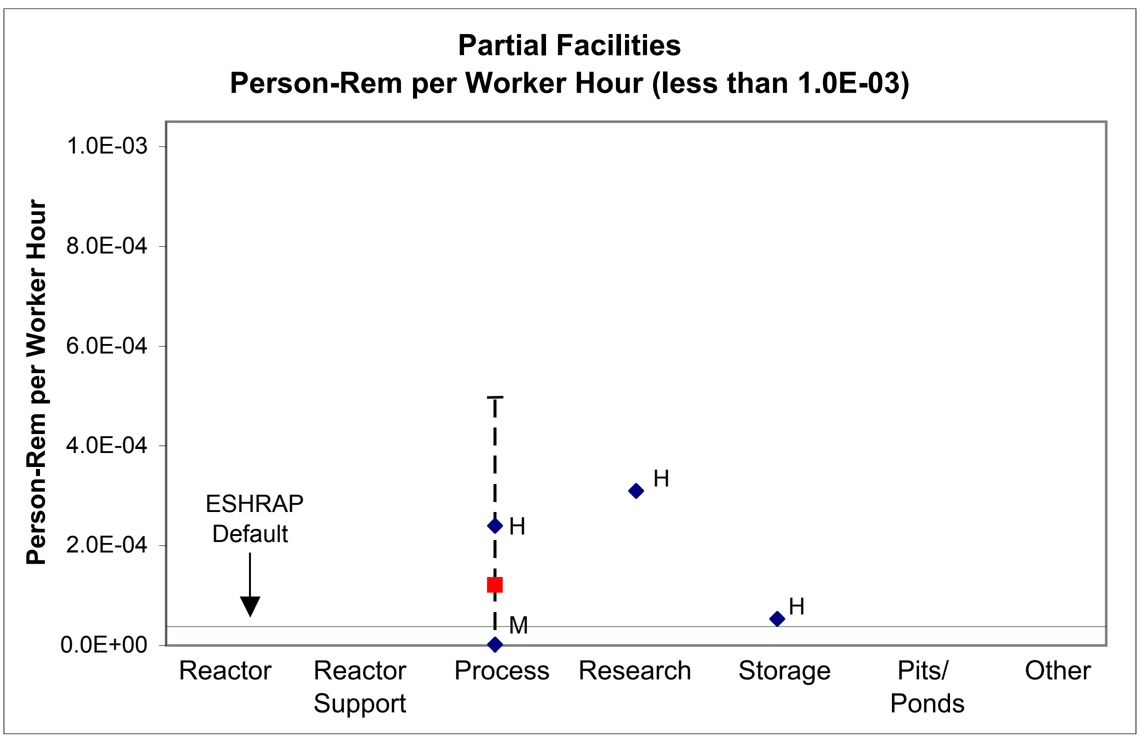

Figure 4.13. Person-rem per worker hour (less than 1.0E-03) for partial facilities.

Complete Facilities

Complete facilities include all decommissioning activities completed for an entire facility. Complete facility data are shown in Table 4.3. Complete facility plots for physical worker hours are shown in Figures 4.14a (less than 600,000) and b (less than 60,000); total person-rem in Figures 4.15a (less than 180) and b (less than 8); and person-rem per worker hour in Figures 4.16a (less than 1.0E-03) and b (less than 3.0E-04).

Table 4.3. Complete facilites data divided by type of facility and level of radiation.

Type of Facility	Level of Radiation	Size (sq ft)	Physical Worker Hours		Total Person-Rem	Rem per Worker Hour	Average Worker Hours	Average Total Person-Rem	Average Rem per Worker Hour	Name of Case Study
Reactor	Low	11,559	33,321		0.00	0.0E+00				ARA-II
Reactor	Low	25,132	37,124		0.00	0.0E+00				ARA-III
Reactor	Low	5600			0.00					ARA-IV
Reactor	Low	800			0.00					SPERT-I Reactor
Reactor	Low	3500	4077		0.03	7.4E-06				SPERT-IV Reactor
Reactor	**Low**						**24,840.7**	**0.006**	**2.47E-06**	
Reactor	Medium	2,400			0.393					ARMF/ CFRMF
Reactor	Medium				20.87					EBWR
Reactor	Medium		18,174		0.482	2.7E-05				Janus Reactor
Reactor	Medium	16,630	6700							SPERT-II & III Reactors
Reactor	**Medium**						**12,437.0**	**7.248**	**2.70E-05**	
Reactor	High	9235	7818		0.00	0.00E+00				BORAX-V Reactor Building
Reactor	High	105,530	*171,306*	*	3.4	2.0E-05				C Reactor
Reactor	High	28,255								ETR
Reactor	High	1,141	11,764							LOFT MTA
Reactor	High		*584,970*	*	175.014	3.0E-04				N Area
Reactor	High	4300			4.153					OMRE
Reactor	**High**						**193,964.5**	**45.64**	**1.06E-04**	
Reactor	Not Ranked				69.4					Ames Lab
Reactor	Not Ranked				1					LAPRE 11 Reactor
Reactor	Not Ranked				0.00					Thermal Source Reactor
Reactor	Not Ranked				3.87					UCLA Boelther Reactor
Reactor	Not Ranked	12000			4.99					UHTREX Reactor
Reactor	Not Ranked				4.35					Water Boiler Reactor
Reactor	**Not Ranked**							**13.9**		
Reactor	**All**						**97,250.4**	**16.0**	**5.04E-05**	

Table 4.3. Complete facilites data divided by type of facility and level of radiation.

Type of Facility	Level of Radiation	Size (sq ft)	Physical Worker Hours		Total Person-Rem	Rem per Worker Hour	Average Worker Hours	Average Total Person-Rem	Average Rem per Worker Hour	Name of Case Study
Reactor Support	Low	2400			0.00					BORAX-V Facility Turbine Building
Reactor Support	Low				0.00					SPERT-IV Waste Holdup Tank Ancillaries
Reactor Support	Low	11,000			0.00					WMO and AEF-603
Reactor Support	**Low**							**0.000**		
Process	Medium	73,500	7814		1.64	2.1E-04				PM-2A
Process	Medium	15,952	7,904		0.00	0.0E+00				TRA-645/751
Process	**Medium**						**7859.0**	**0.820**	**1.05E-04**	
Process	High	73,000	*374,480*	*						Apollo Nuclear Fuel
Process	High	2000								Liquid Waste Treatment Facility
Process	High	9120	4673		4.5	9.6E-04				Process Water Building
Process	High	7560			3.6					WCF
Process	**High**						**189,576.5**	**4.05**	**9.60E-04**	
Process	Not Ranked	4306	9067							Contaminated Filter Building
Process	Not Ranked	10,000	60,912		26	4.3E-04				Pu-238 Facility
Process	Not Ranked	640			0.00					Waste Ion Exhange
Process	**Not Ranked**						**34,989.5**	**13.0**	**4.30E-04**	
Process	**All**						**77,475.0**	**6.0**	**3.99E-04**	
Research	Low	19,778	48,141		0.00	0.0E+00				ARA-I
Research	Low	13,981			0.00					IET Facility
Research	Low	37,695			0.00					PREPP
Research	**Low**						**48,141.0**	**0.000**	**0.00E+00**	
Research	High	134,260	59,485		0.00	0.0E+00				190-D Complex
Research	**High**						**59,485.0**	**0.000**	**0.00E+00**	
Research	Not Ranked	4000			0.436					60" Cyclotron Facility
Research	**Not Ranked**							**0.436**		
Research	**All**						**53,813.0**	**0.087**	**0.00E+00**	

Table 4.3. Complete facilites data divided by type of facility and level of radiation.

Type of Facility	Level of Radiation	Size (sq ft)	Physical Worker Hours		Total Person-Rem	Rem per Worker Hour	Average Worker Hours	Average Total Person-Rem	Average Rem per Worker Hour	Name of Case Study
Storage	Low	468	9544		0.00	0.0E+00				ARVFS
Storage	Low	143,550	3622		0.00	0.0E+00				C&S Building
Storage	Low	1575	1112		0.09	8.1E-05				TAN/TSF-3 Concrete Pad
Storage	Low	11,946			0.00					Warehouse
Storage	Low	11,000			0.00					WMO and AEF-603
Storage	**Low**						**4759.3**	**0.018**	**2.70E-05**	
Pits/Ponds	Low	1800	213		0.00	0.0E+00				BORAX-V Leach Pond
Pits/Ponds	Low	675	796		0.00	0.0E+00				SPERT-I Seepage Pit
Pits/Ponds	Low	3250	311		0.00	0.0E+00				SPERT-III Large Leach Pond
Pits/Ponds	Low									TRA Filter Pit
Pits/ Ponds	**Low**						**440.0**	**0.000**	**0.00E+00**	
Other	Low	4494	8070		0.00	0.0E+00				Hot Laundry
Other	Low	16,452			0.00					Security Training Facility
Other	Low	1368	12,257		0.00	0.0E+00				Sewage Treatment Plant
Other	Low		5414							TAN-607 Ancillary Facilities
Other	**Low**						**8,580.3**	**0.000**	**0.00E+00**	
Overall Averages	**All**						**4,510.2**	**0.0**	**0.00E+00**	**Complete Facilities**

** Physical Worker Hours calculated as 62% of the total worker hours.*

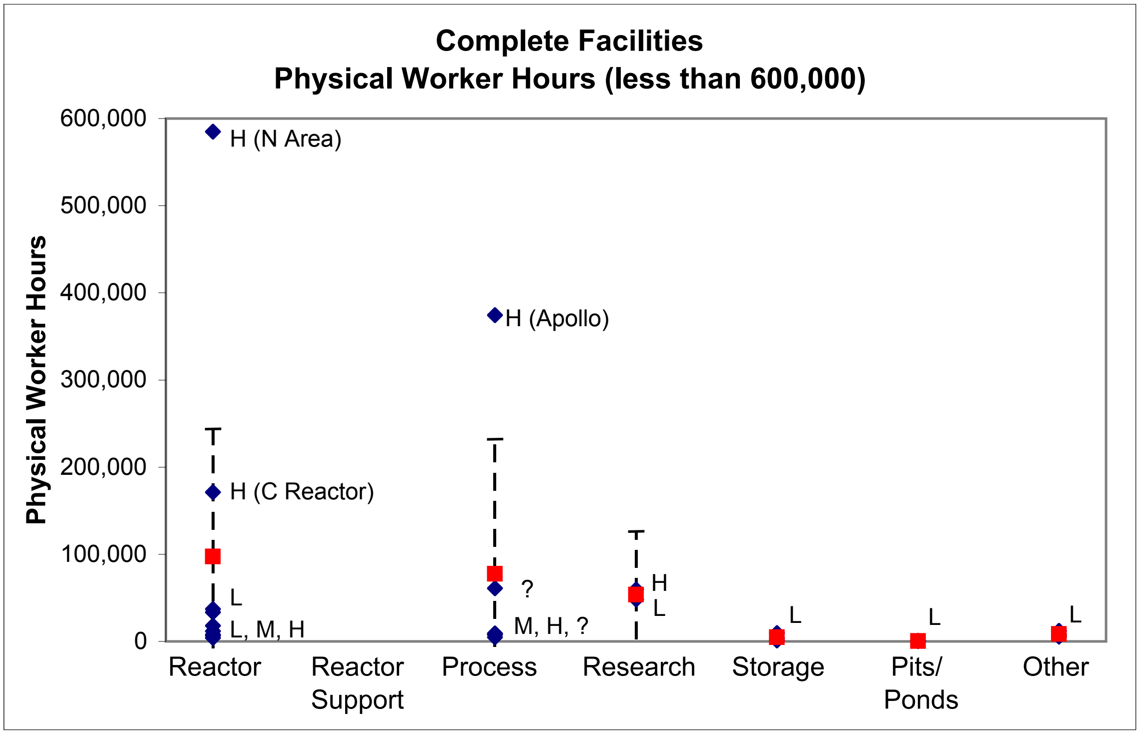

Figure 4.14a. Physical worker hours (less than 600,000) for complete facilities.

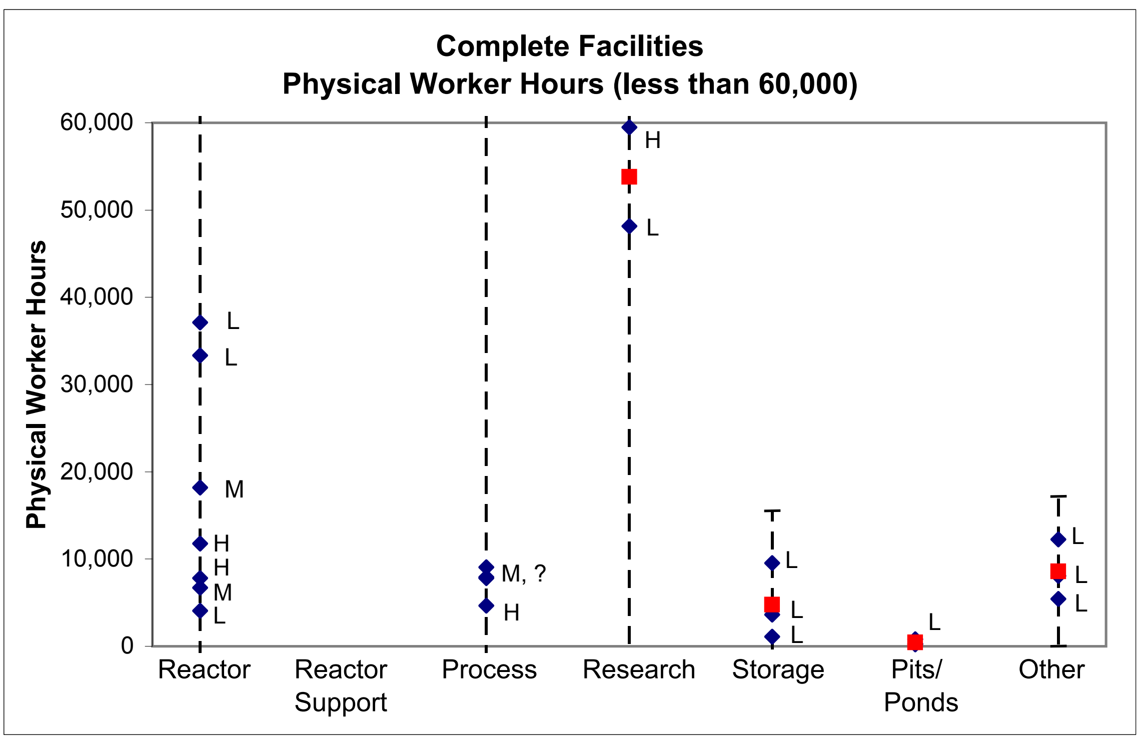

Figure 4.14b. Physical worker hours (less than 60,000) for complete facilities.

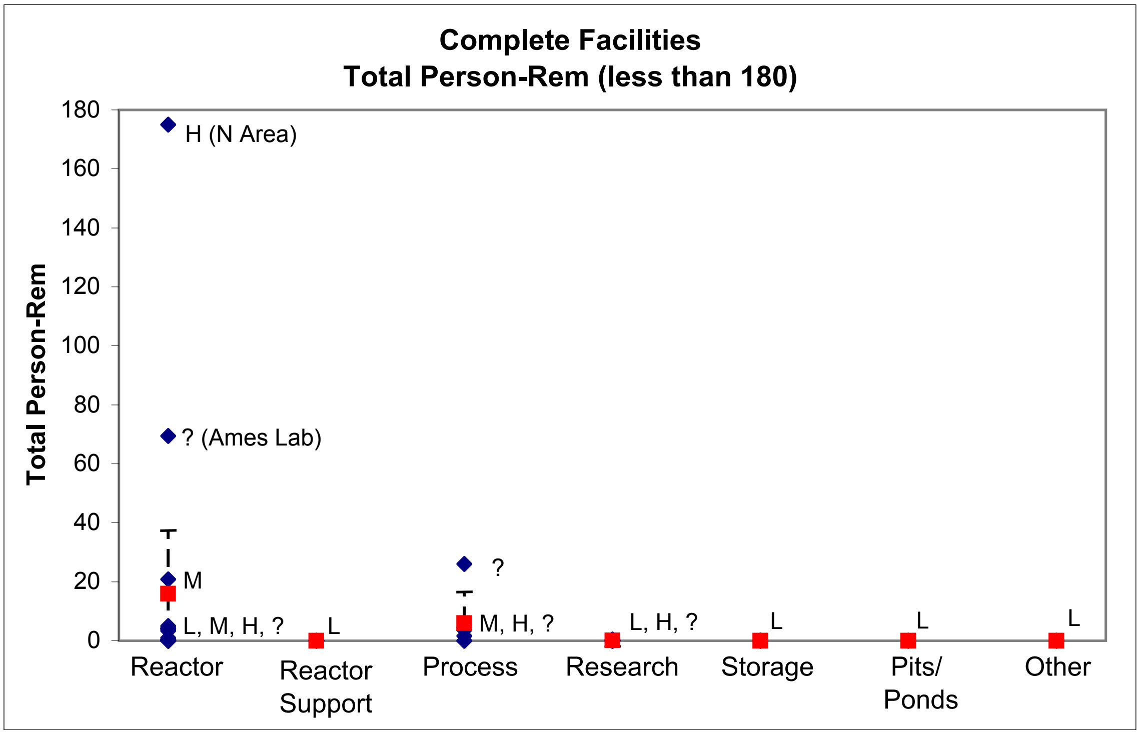

Figure 4.15a. Total person-rem (less than 180) for complete facilities.

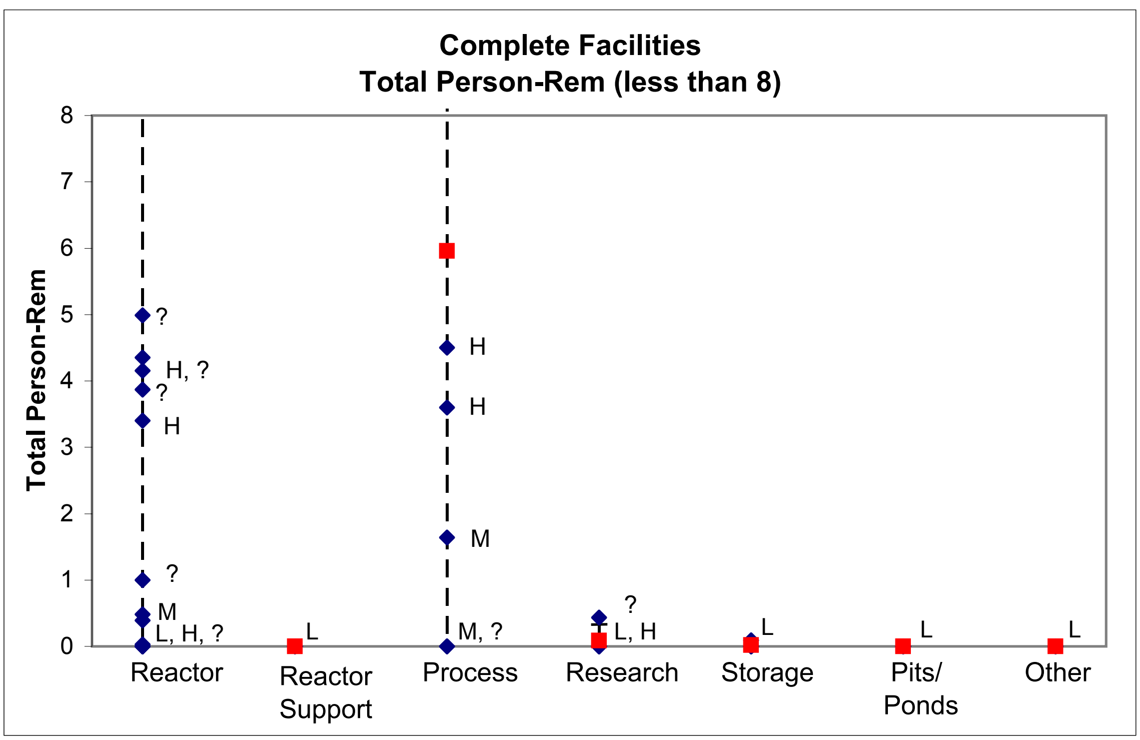

Figure 4.15b. Total person-rem (less than 8) for complete facilities.

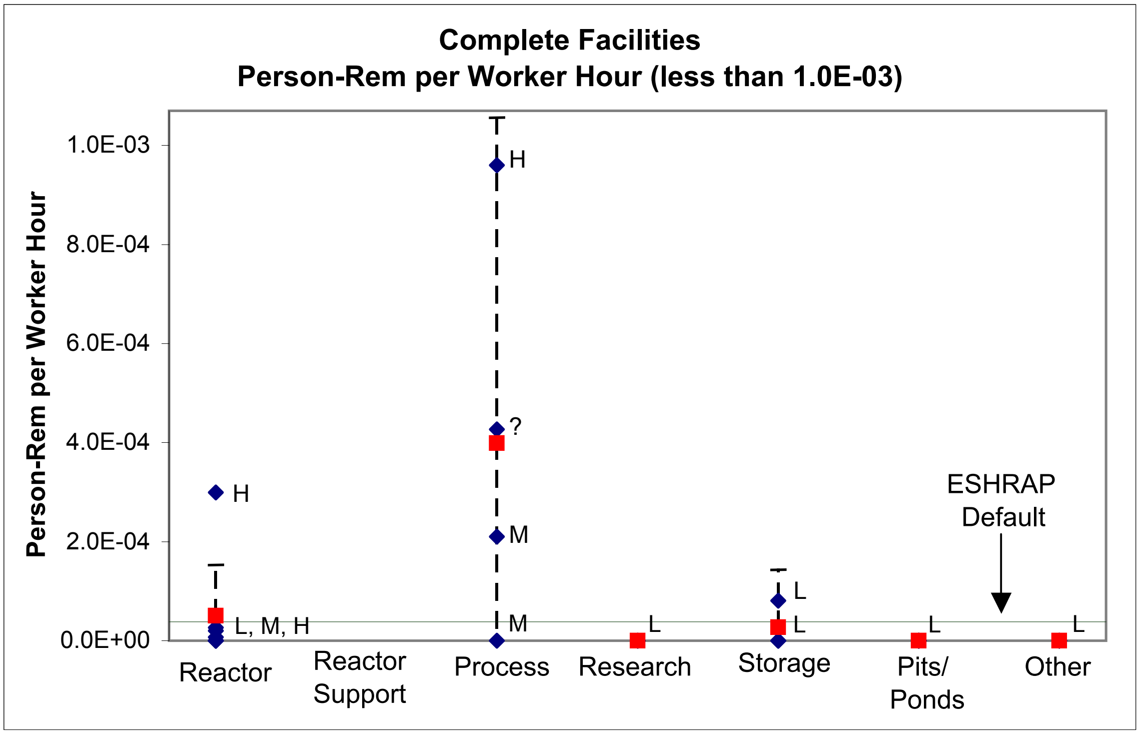

Figure 4.16a. Person-rem per worker hour (less than 1.0E-03) for complete facilities.

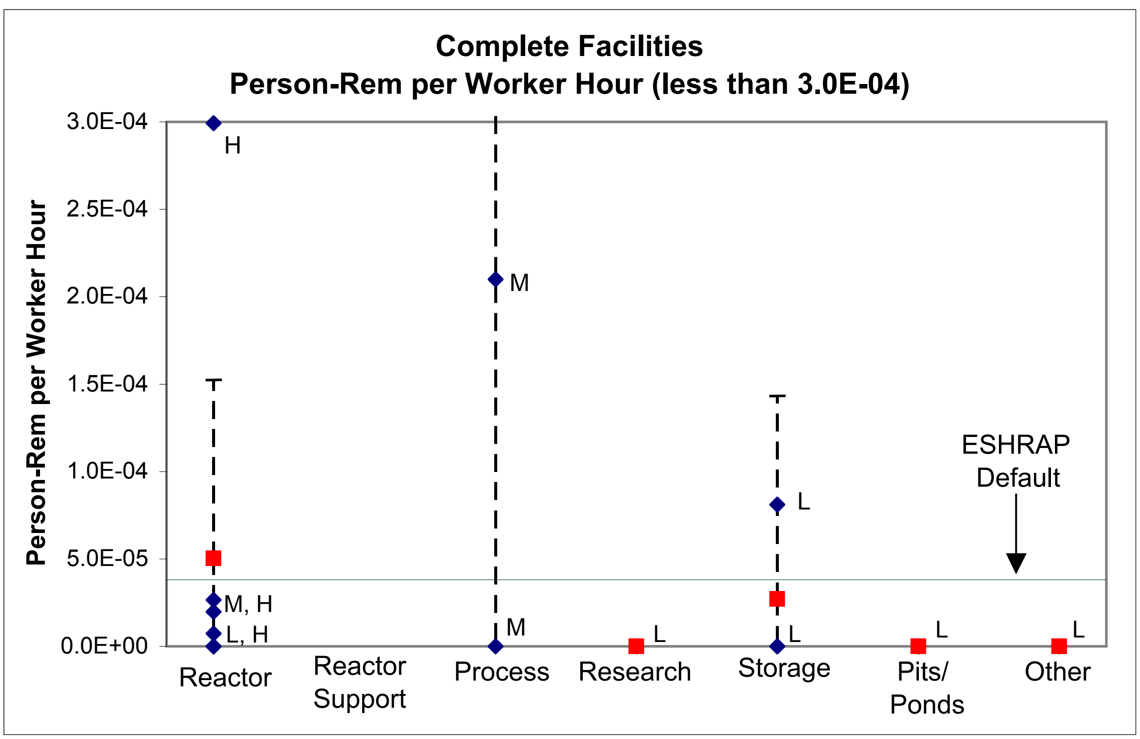

Figure 4.16b. Person-rem per worker hour (less than 3.0E-04) for complete facilities.

Reactor Facilities

The reactor facilities were divided into categories based on the type of decommissioning activity. These activities included: closure with hazards remaining in place (entombment), facilities placed into long-term storage (safe store), deactivation of the reactor facility prior to the decommissioning activities represented by this data (dismantlement after previous deactivation), and reactors not included in the other categories (reactor other). Reactor facility data are shown in Table 4.4. Reactor facility plots for physical worker hours are shown in Figures 4.17a (less than 600,000) and b (less than 60,000); total person-rem in Figures 4.18a (less than 180) and b (less than 8); and person-rem per worker hour in Figures 4.19a (less than 1.0E-03) and b (less than 3.0E-04).

Table 4.4. Reactor facility data divided by level of radiation and type of decommissioning.

Level of Radiation	Type of Decommissioning	Physical Worker Hours		Total Person-Rem	Rem per Worker Hour	Average Worker Hours	Average Total Person-Rem	Average Rem per Worker Hour	Name of Case Study
Low	Dismantlement After Previous Deactivation	33,321		0.00	0.00E+00				ARA-II
Low	Dismantlement After Previous Deactivation	37,124		0.00	0.00E+00				ARA-III
Low	Dismantlement After Previous Deactivation			0.00					ARA-IV
Low	Dismantlement After Previous Deactivation			0.00					SPERT-I Reactor Building
Low	**Dismantlement After Previous Deactivation**					**35,222.5**	**0.000**	**0.00E+00**	
Low	Reactor Other	4077		0.03	7.4E-06				SPERT-IV Reactor
Low	**Reactor Other**					**4077.0**	**0.030**	**7.40E-06**	
Low	**All**					**24,840.7**	**0.006**	**2.47E-06**	
Medium	Dismantlement After Previous Deactivation			0.393					ARMF/CFRMF
Medium	Dismantlement After Previous Deactivation			20.87					EBWR
Medium	Dismantlement After Previous Deactivation	18,174		0.482	2.7E-05				Janus Reactor
Medium	Dismantlement After Previous Deactivation	6700							SPERT-II & III Reactors
Medium	**Dismantlement After Previous Deactivation**					**12,437.0**	**7.248**	**2.70E-05**	
Medium	Reactor Other			3.042					S1G Reactor
Medium	**Reactor Other**						**3.0420**		
Medium	**All**					**12,437.0**	**6.197**	**2.70E-05**	
High	Entombment	7818		0.00	0.00E+00				BORAX-V Reactor Building
High	Safe Store	*171,306*	*	3.4	2.0E-05				C Reactor
High	**Entombment/ Safe Store**					**89,562.0**	**1.70**	**9.92E-06**	
High	Dismantlement After Previous Deactivation								ETR
High	Dismantlement After Previous Deactivation			4.153					OMRE
High	**Dismantlement After Previous Deactivation**						**4.1530**		
High	Reactor Other	11,764							LOFT MTA
High	Reactor Other	*584,970*	*	175.014	3.0E-04				N Area
High	**Reactor Other**					**298,367.0**	**175.0140**	**2.99E-04**	
High	**All**					**193,964.5**	**45.64**	**1.063E-04**	

Table 4.4. Reactor facility data divided by level of radiation and type of decommissioning.

Level of Radiation	Type of Decommissioning	Physical Worker Hours		Total Person-Rem	Rem per Worker Hour	Average Worker Hours	Average Total Person-Rem	Average Rem per Worker Hour	Name of Case Study
Not Ranked	Dismantlement After Previous Deactivation			0.00					Thermal Source Reactor
Not Ranked	Dismantlement After Previous Deactivation			4.99					UHTREX Reactor
Not Ranked	Dismantlement After Previous Deactivation			4.35					Water Boiler Reactor
Not Ranked	Dismantlement After Previous Deactivation			1					LAPRE 11 Reactor
Not Ranked	Dismantlement After Previous Deactivation			3.87					UCLA Boelther Reactor
Not Ranked	**Dismantlement After Previous Deactivation**						**2.8**		
Not Ranked	Reactor Other			69.4					Ames Lab
Not Ranked	**Reactor Other**						**69.40**		
Not Ranked	**All**						**13.9**		
All	**Dismantlement After Previous Deactivation**					**23,829.8**	**3.1**	**8.84E-06**	
All	**Reactor Other**					**200,270.3**	**61.9**	**1.53E-04**	
All	**Dismantlement After Previous Deactivation and Reactor Other**					**99,447.1**	**16.9**	**6.66E-05**	**Reactor Facilities**
All	**Entombment/ Safe Store**					**89,562.0**	**1.70**	**9.92E-06**	
All	**All**					**97,250.4**	**15.3**	**5.04E-05**	

** Physical Worker Hours calculated as 62% of the total worker hours.*

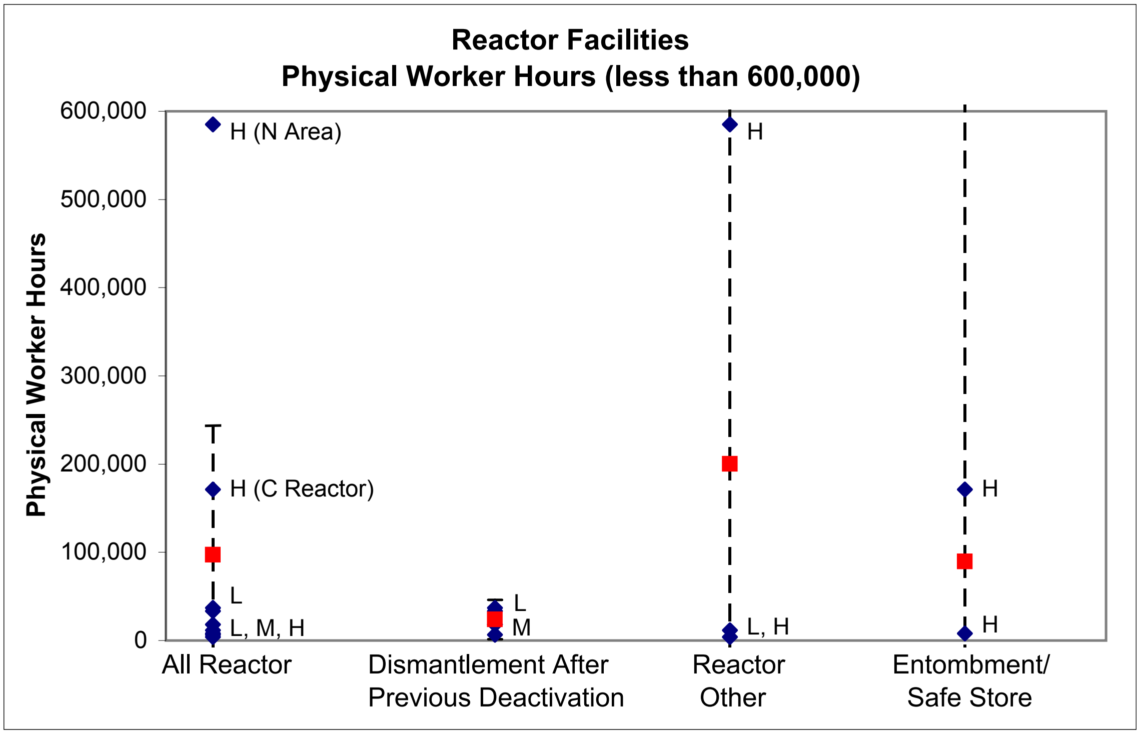

Figure 4.17a. Physical worker hours (less than 600,000) for reactor facilities.

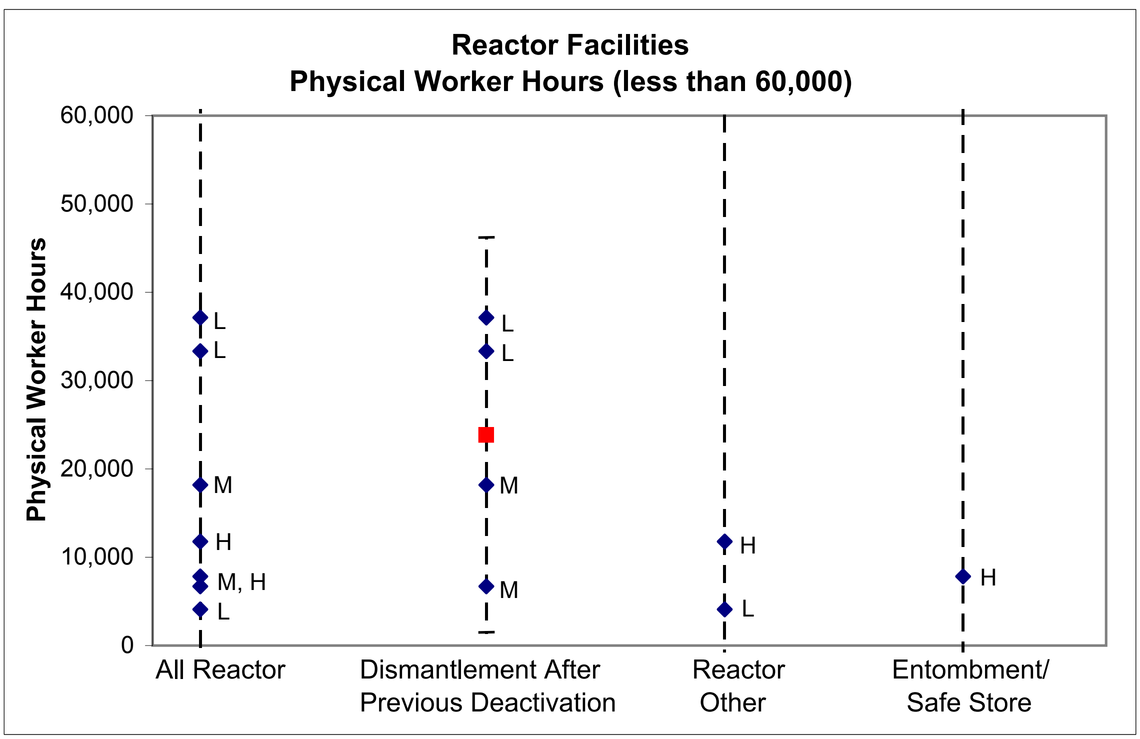

Figure 4.17b. Physical worker hours (less than 60,000) for reactor facilities.

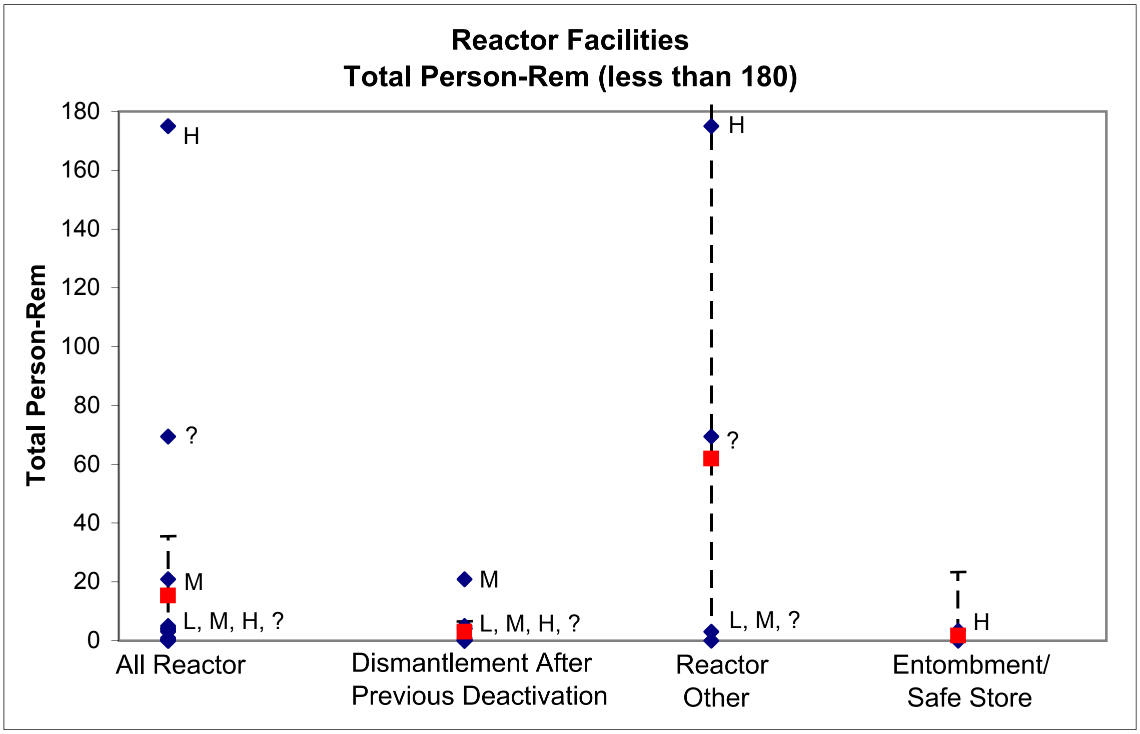

Figure 4.18a. Total person-rem (less than 180) for reactor facilities.

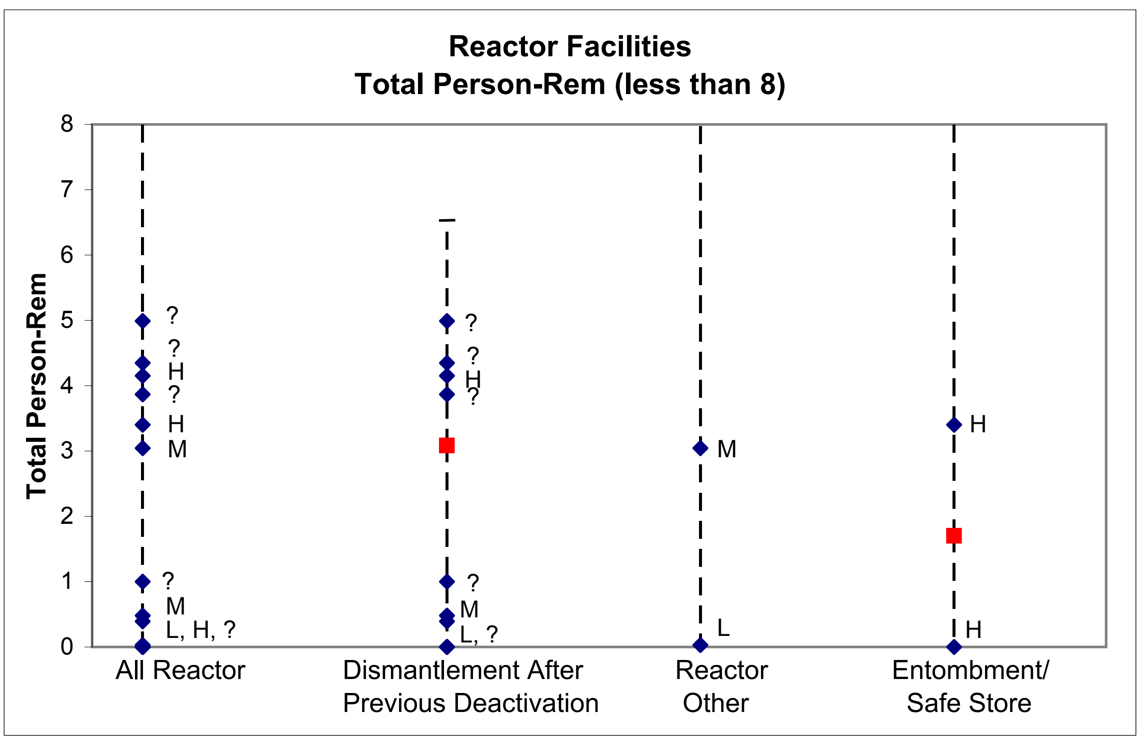

Figure 4.18b. Total person-rem (less than 8) for reactor facilities.

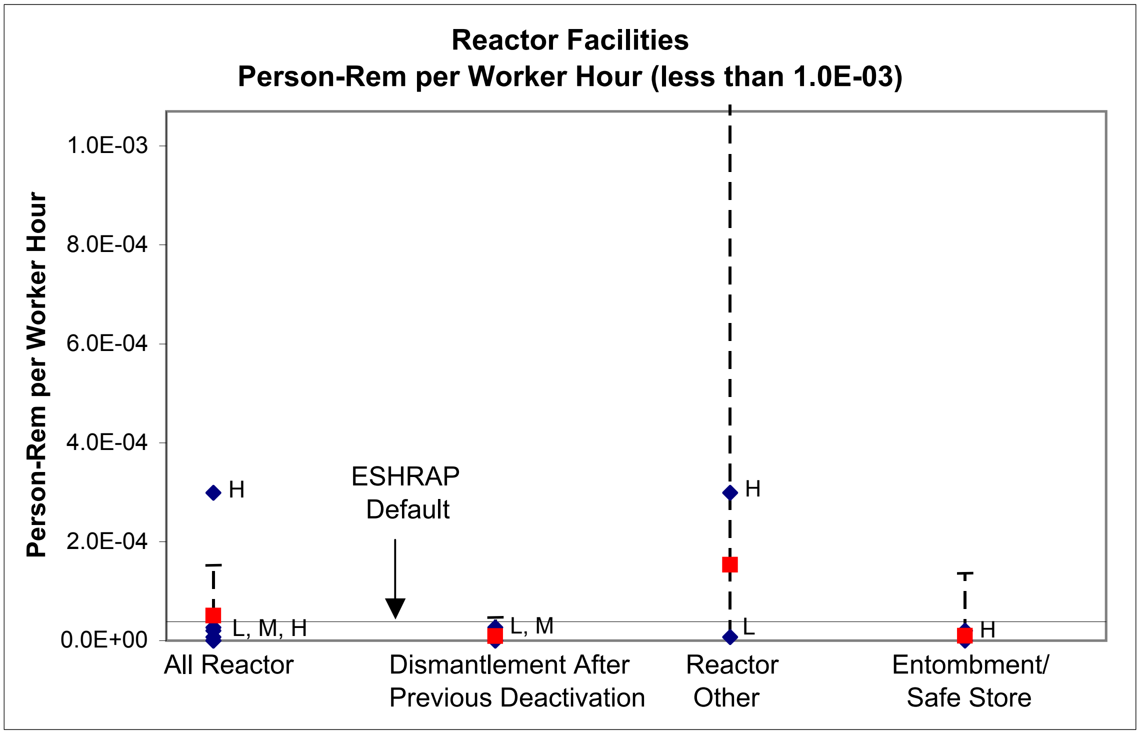

Figure 4.19a. Person-rem per worker hour (less than 1.0E-03) for reactor facilities.

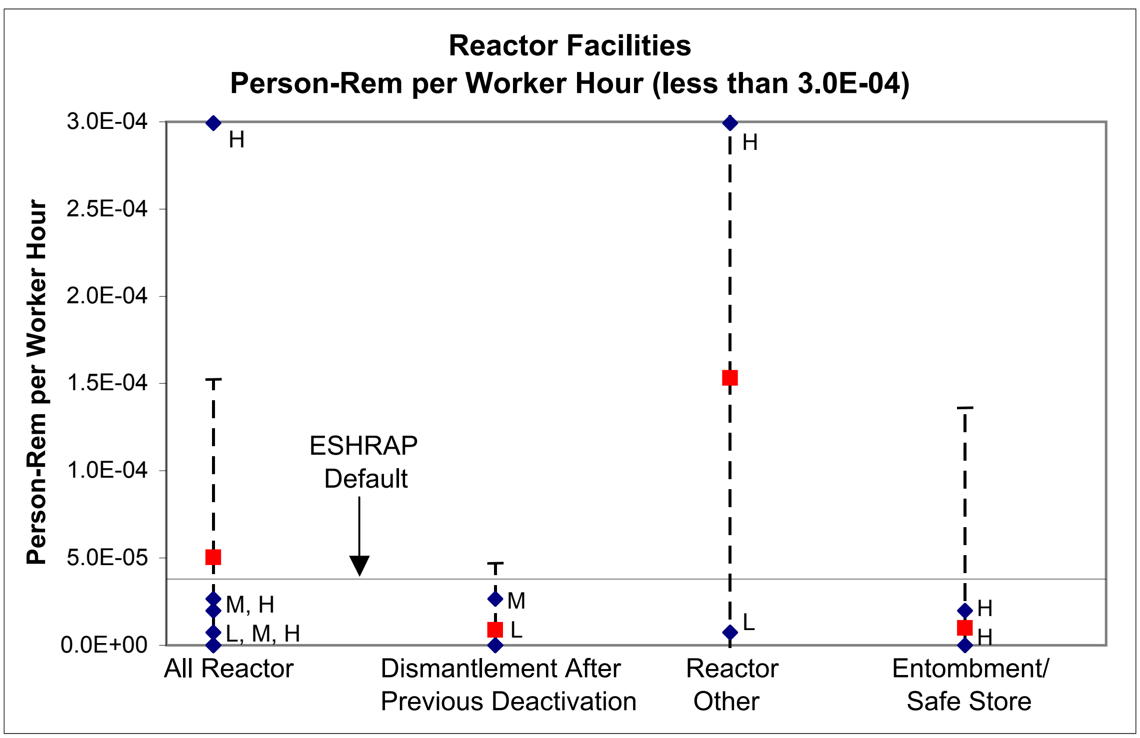

Figure 4.19b. Person-rem per worker hour (less than 3.0E-04) for reactor facilities.

All Facilities

The partial and complete data are combined for the all facilities tables and plots. All facilities data are shown in Table 4.5 and a summary of the averages is shown in Table 4.6. Physical worker hours for all the facilities are shown in Figures 4.20a (less than 600,000) and b (less than 60,000). Total person-rem data for all facilities are shown in Figures 4.21a (less than 180 person-rem), 4.21b (less than 8 person-rem), and 4.21c (less than 1 person-rem). Person-rem per worker hour data for all facilities are shown in Figures 4.22a (less than 1.0E-03) and 4.22b (less than 3.0E-04).

Table 4.5. All facilities data divided by type of facility and level of radiation.

Type of Facility	Level of Radiation	Size (sq ft)	Physical Worker Hours		Total Person-Rem	Rem per Worker Hour	Average Worker Hours	Average Total Person-Rem	Average Rem per Worker Hour	Name of Case Study
Reactor	Low	11,559	33,321		0.00	0.0E+00				ARA-II
Reactor	Low	25,132	37,124		0.00	0.0E+00				ARA-III
Reactor	Low	5600			0.00					ARA-IV
Reactor	Low	800			0.00					SPERT-I Reactor
Reactor	Low	3500	4077		0.03	7.4E-06				SPERT-IV Reactor
Reactor	**Low**						**24,840.7**	**0.006**	**2.47E-06**	
Reactor	Medium	2,400			0.393					ARMF/ CFRMF
Reactor	Medium				20.87					EBWR
Reactor	Medium		18,174		0.482	2.7E-05				Janus Reactor
Reactor	Medium				3.042					S1G Reactor
Reactor	Medium	16,630	6700							SPERT-II & III Reactors
Reactor	**Medium**						**12,437.0**	**6.197**	**2.70E-05**	
Reactor	High	9235	7818		0.00	0.0E+00				BORAX-V Reactor Building
Reactor	High	105,530	*171,306*	*	3.4	2.0E-05				C Reactor
Reactor	High	28,255								ETR
Reactor	High	1,141	11,764							LOFT MTA
Reactor	High		*584,970*	*	175.014	3.0E-04				N Area
Reactor	High	4300			4.153					OMRE
Reactor	**High**						**193,964.5**	**45.64**	**1.06E-04**	
Reactor	Not Ranked				69.4					Ames Lab
Reactor	Not Ranked				1					LAPRE 11 Reactor
Reactor	Not Ranked				0.00					Thermal Source Reactor
Reactor	Not Ranked				3.87					UCLA Boelther Reactor
Reactor	Not Ranked	12000			4.99					UHTREX Reactor
Reactor	Not Ranked				4.35					Water Boiler Reactor
Reactor	**Not Ranked**							**13.9**		
Reactor	**All**						**97,250.4**	**15.3**	**5.04E-05**	

Table 4.5. All facilities data divided by type of facility and level of radiation.

Type of Facility	Level of Radiation	Size (sq ft)	Physical Worker Hours		Total Person-Rem	Rem per Worker Hour	Average Worker Hours	Average Total Person-Rem	Average Rem per Worker Hour	Name of Case Study
Reactor Support	Low	2400			0.00					BORAX-V Facility Turbine Building
Reactor Support	Low				0.00					SPERT-IV Waste Holdup Tank Ancillaries
Reactor Support	Low	11,000			0.00					WMO and AEF-603
Reactor Support	**Low**							**0.000**		
Reactor Support	Not Ranked		*124,000*	*						K-25 Cooling Towers
Reactor Support	**Not Ranked**						**124,000.0**			
Reactor Support	**All**						**124,000.0**	**0.000**		
Process	Low	2800			0.563					Chloride Removal System
Process	**Low**							**0.5630**		
Process	Medium	319			2.234					BIF Filter Room
Process	Medium	260	7652		0.015	2.0E-06				CPP-631/709/734
Process	Medium	1,472			20.8					MTR OWR
Process	Medium	73,500	7814		1.64	2.1E-04				PM-2A
Process	Medium	15,952	7,904		0.00	0.0E+00				TRA-645/751
Process	**Medium**						**7790.0**	**4.94**	**7.07E-05**	
Process	High	73,000	*374,480*	*						Apollo Nuclear Fuel
Process	High	2000								Liquid Waste Treatment Facility
Process	High	1602			18.906					Process Cells A,B,C,D, and L
Process	High	9120	4673		4.5	9.6E-04				Process Water Building
Process	High	750	*143,392*	*	34.7	2.4E-04				Rover
Process	High	7560			3.6					WCF
Process	**High**						**174,181.7**	**15.43**	**6.00E-04**	
Process	Not Ranked	4306	9067							Contaminated Filter Building
Process	Not Ranked	10,000	60,912		26	4.3E-04				Pu-238 Facility
Process	Not Ranked	640			0.00					Waste Ion Exhange
Process	**Not Ranked**						**34,989.5**	**13.0**	**4.30E-04**	
Process	**All**						**76,986.8**	**9.4**	**3.06E-04**	
Research	Low	19,778	48,141		0.00	0.0E+00				ARA-I
Research	Low	13,981			0.00					IET Facility
Research	Low	37,695			0.00					PREPP
Research	**Low**						**48,141.0**	**0.000**	**0.00E+00**	
Research	Medium				7.45					Hot Cells
Research	**Medium**							**7.450**		
Research	High	134,260	59,485		0.00	0.0E+00				190-D Complex

Table 4.5. All facilities data divided by type of facility and level of radiation.

Type of Facility	Level of Radiation	Size (sq ft)	Physical Worker Hours		Total Person-Rem	Rem per Worker Hour	Average Worker Hours	Average Total Person-Rem	Average Rem per Worker Hour	Name of Case Study
Research	High	1400	2507		0.765	3.1E-04				HB-2 Cubicle
Research	**High**						**30,996.0**	**0.383**	**1.55E-04**	
Research	Not Ranked	4000			0.436					60" Cyclotron Facility
Research	Not Ranked				1.26					Plutonium Gloveboxes
Research	**Not Ranked**							**0.848**		
Research	**All**						**36,711.0**	**1.239**	**1.03E-04**	
Storage	Low	468	9544		0.00	0.0E+00				ARVFS
Storage	Low	143,550	3622		0.00	0.0E+00				C&S Building
Storage	Low	1575	1112		0.09	8.1E-05				TAN/TSF-3 Concrete Pad
Storage	Low	11,946			0.00					Warehouse
Storage	Low	11,000			0.00					WMO and AEF-603
Storage	**Low**						**4759.3**	**0.018**	**2.70E-05**	
Storage	Medium				1.623					RaLa Off-gas Cell and Storage Tank
Storage	**Medium**							**1.6230**		
Storage	High	1408	938		0.05	5.3E-05				Plug Storage Facility
Storage	**High**						**938.0**	**0.050**	**5.30E-05**	
Storage	Not Ranked	80			0.14					Gamma Irradiation Facility
Storage	**Not Ranked**							**0.140**		
Storage	**All**						**3804.0**	**0.238**	**3.35E-05**	

Table 4.5. All facilities data divided by type of facility and level of radiation.

Type of Facility	Level of Radiation	Size (sq ft)	Physical Worker Hours		Total Person-Rem	Rem per Worker Hour	Average Worker Hours	Average Total Person-Rem	Average Rem per Worker Hour	Name of Case Study
Pits/Ponds	Low	1800	213		0.00	0.0E+00				BORAX-V Leach Pond
Pits/Ponds	Low	675	796		0.00	0.0E+00				SPERT-I Seepage Pit
Pits/Ponds	Low	3250	311		0.00	0.0E+00				SPERT-III Large Leach Pond
Pits/Ponds	Low									TRA Filter Pit
Pits/ Ponds	**Low**						**440.0**	**0.000**	**0.00E+00**	
Other	Low	4494	8070		0.00	0.0E+00				Hot Laundry
Other	Low	16,452			0.00					Security Training Facility
Other	Low	1368	12,257		0.00	0.0E+00				Sewage Treatment Plant
Other	Low		5414							TAN-607 Ancillary Facilities
Other	Low		1535							TAN-606 Calibration Well
Other	**Low**						**6819.0**	**0.000**	**0.00E+00**	
Overall Averages	**All**						**55,284.2**	**7.4**	**1.05E-04**	**All Facilities**

** Physical Worker Hours calculated as 62% of the total worker hours. Rover worker hours estimated by project management.*

Table 4.6. Summary statistics from Table 4.5.

Type of Facility	Level of Radiation	Average Worker Hours	Average Total Person-Rem	Average Rem per Worker Hour
Reactor	Low	24,841.7	0.006	2.47E-06
Reactor	Medium	12,437.0	6.197	2.70E-05
Reactor	High	193,965.5	45.64	1.06E-04
Reactor	Not Ranked	No Data	13.9	No Data
Reactor	**ALL**	**97,250.4**	**15.3**	**5.04E-05**
Reactor Support	Low	No Data	0.000	No Data
Reactor Support	Not Ranked	124,000.0	No Data	No Data
Process	Low	No Data	0.5630	No Data
Process	Medium	7,790.0	4.94	7.07E-05
Process	High	174,181.7	15.43	6.00E-04
Process	Not Ranked	34,989.5	13.0	No Data
Process	**ALL**	**76,986.8**	**9.4**	**3.06E-04**
Research	Low	48,141.0	0.000	0.00E+00
Research	Medium	No Data	7.450	No Data
Research	High	30,996.0	0.383	1.55E-04
Research	Not Ranked	No Data	0.848	No Data
Research	**ALL**	**36,711.0**	**1.239**	**1.03E-04**
Storage	Low	4,759.3	0.018	2.70E-05
Storage	Medium	No Data	1.6230	No Data
Storage	High	938.0	0.050	5.30E-05
Storage	Not Ranked	No Data	0.140	No Data
Storage	**ALL**	**3,804.0**	**0.238**	**3.35E-05**
Pits/Ponds	Low	440.0	0.000	0.00E+00
Other	Low	6,819.0	0.000	0.00E+00
Overall Averages		**55,284.2**	**7.4**	**1.05E-04**

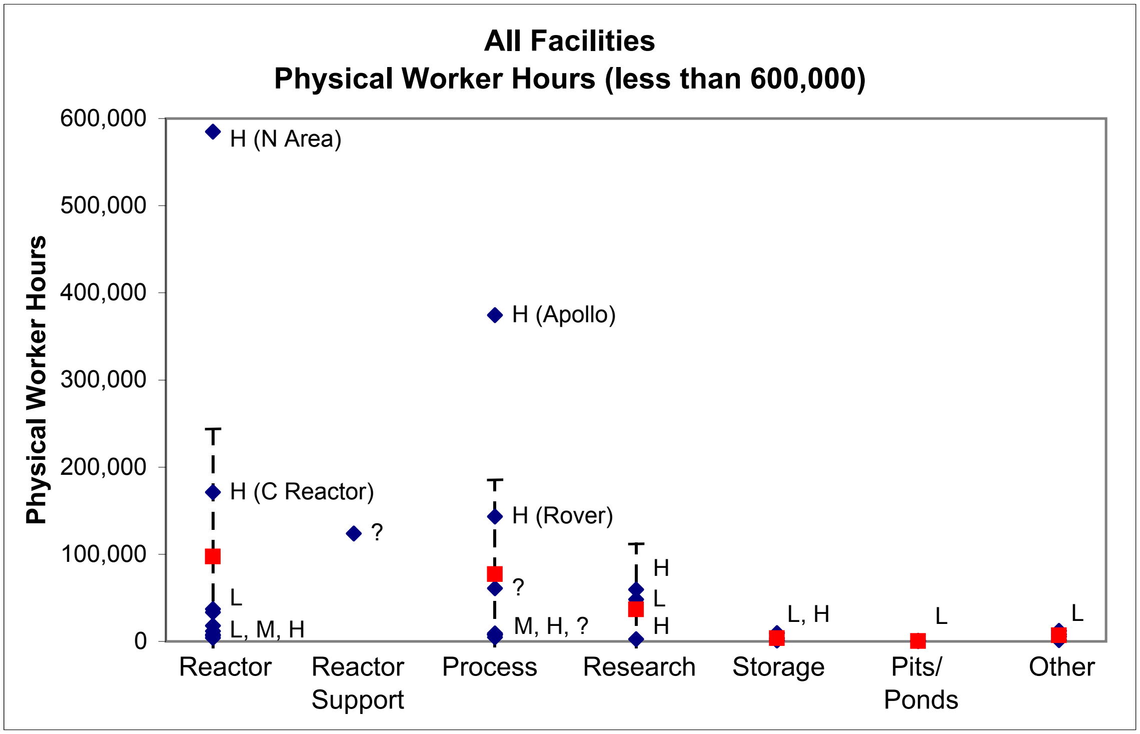

Figure 4.20a. Physical worker hours (less than 600,000) for all facilities.

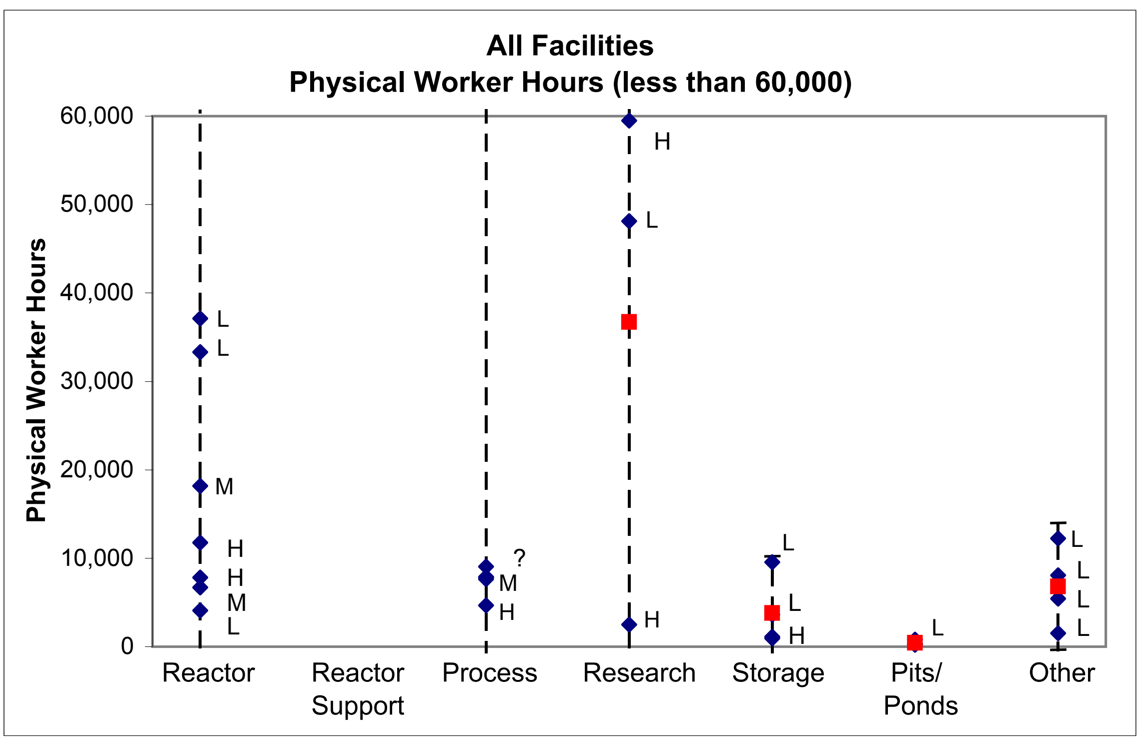

Figure 4.20b. Physical worker hours (less than 60,000) for all facilities.

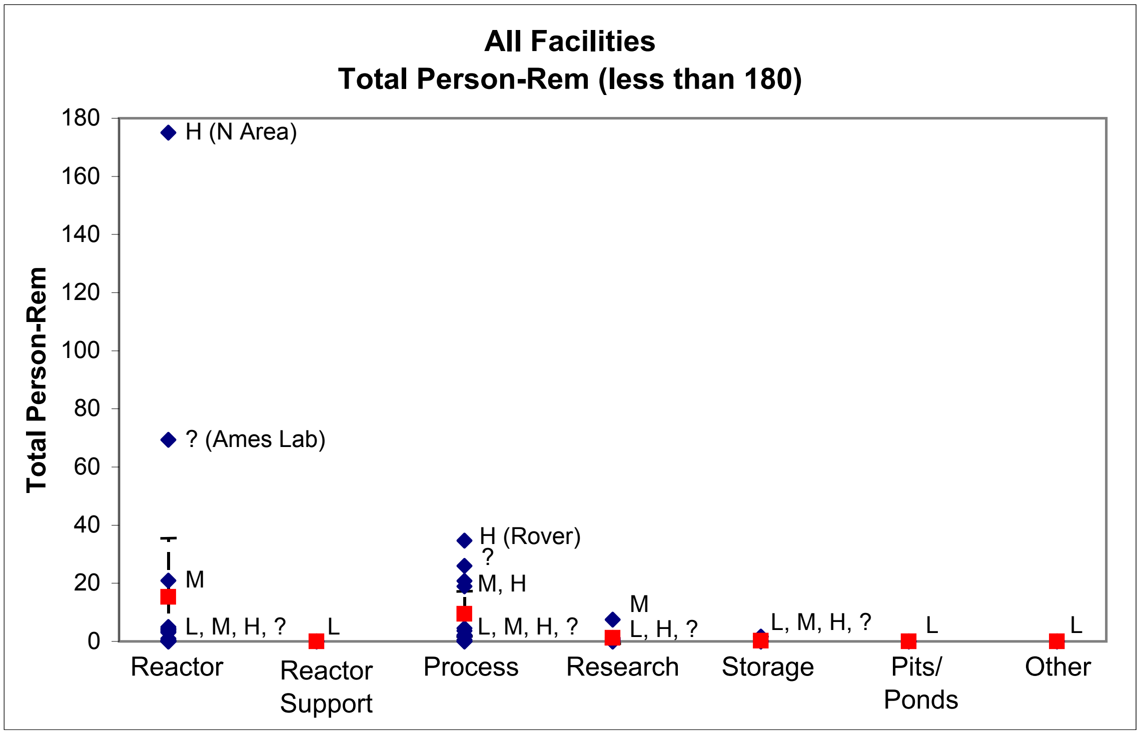

Figure 4.21a. Total person-rem (less than 180) for all facilities.

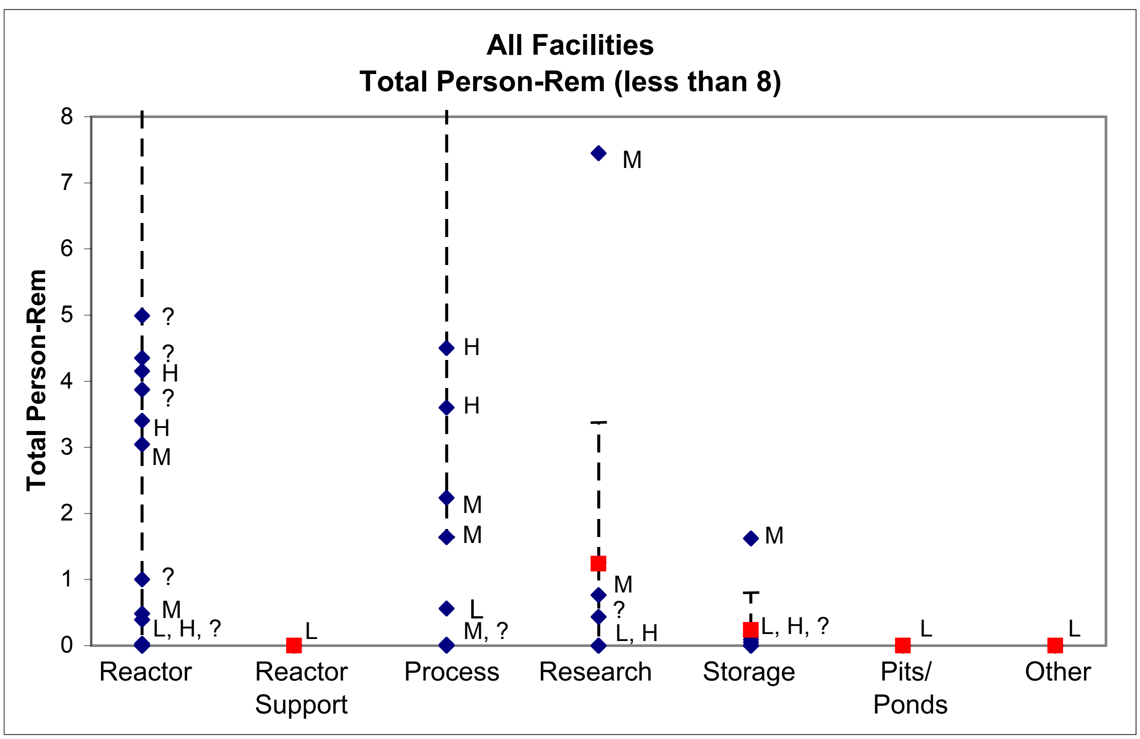

Figure 4.21b. Total person-rem (less than 8) for all facilities.

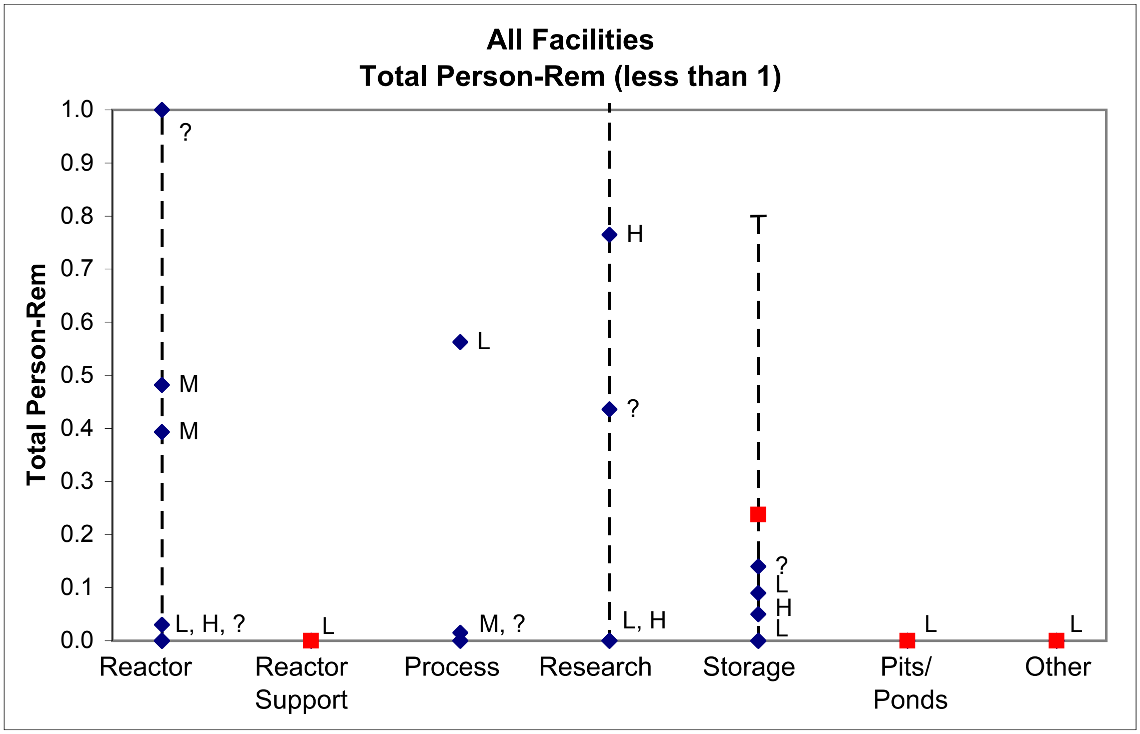

Figure 4.21c. Total person-rem (less than 1) for all facilities.

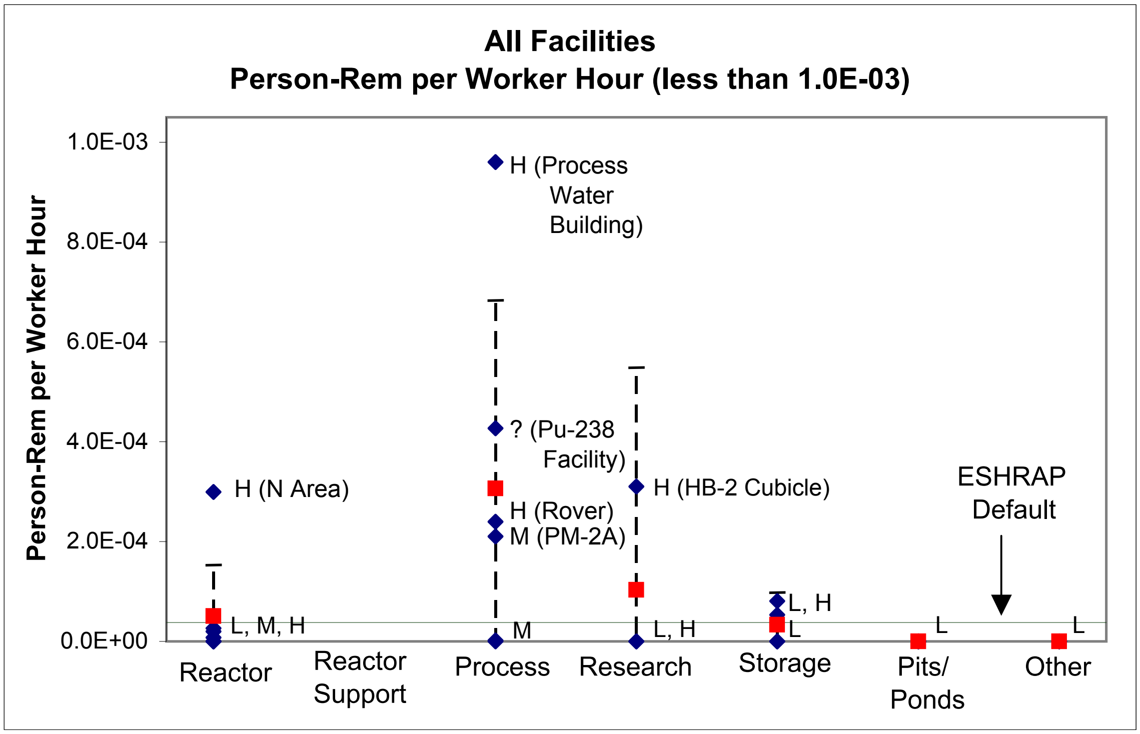

Figure 4.22a. Person-rem per worker hour (less than 1.0E-03) for all facilities.

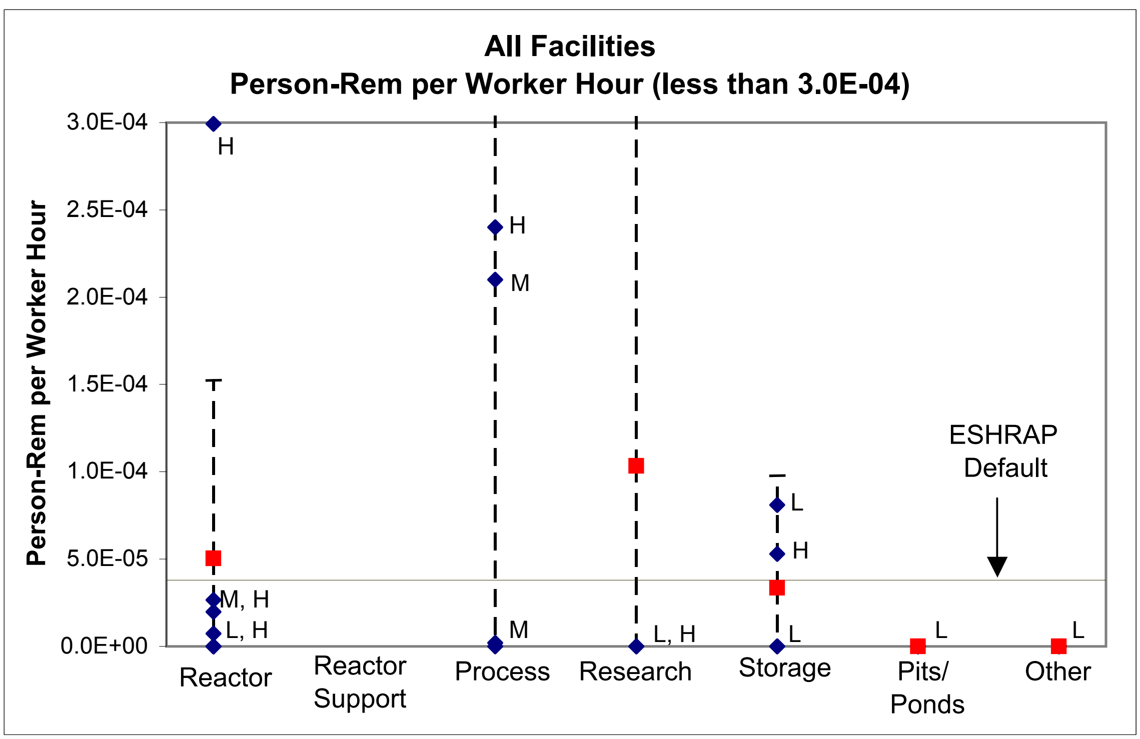

Figure 4.22b. Person-rem per worker hour (less than 3.0E-04) for all facilities.

CHAPTER 5.
DISCUSSION

This chapter discusses the hypothesis testing results listed in chapter 4. For each of the three hypotheses, there is a subsection stating and answering the questions asked to test the hypothesis. Also, limitations and assumptions of the data are discussed.

BEST ESTIMATE PREDICTIONS

Sufficient Data

Are there sufficient data available to make predictions about exposure to radioactivity and industrial accidents?

Collecting data for decommissioning activities is difficult since recorded information about the completed activities is limited. Data availability is restricted to the type of information published and identifying experts in the field. In addition, requirements for reporting completed activities are not consistent or absent for the different DOE sites and the NRC. The DOE-EM reported that 233 decommissioning projects have been completed (DOE and EPA, 1997); yet worker hour and/or person-rem data were only found for 65 case studies (63 completed by DOE, 2 completed by NRC), all reported in this research. Of these 65 case studies, worker hour data were reported for 35 case studies, person-rem data were reported for 55 case studies, and 25 case studies reported both worker hours and person-rem so that a value for person-rem per worker hour could be calculated. Continued discussion of this topic is located in the Lack of Recorded Information subsection within the Data Limitation and Assumptions section of this chapter.

Although the worker exposure to radiation data are not abundant, data analysis was performed and the conclusions can be validated or be used to provide a basis for additional refinement. For standard industrial accidents, injuries, and deaths, the available data are not abundant, which may show a good safety record or may reflect a lack of published information. Further analysis of standard industrial accidents, injuries, and deaths will not be carried out.

Relationship of Exposure and Worker Hours

Can total exposure be predicted from the total number of worker hours?

Figures 4.1 and 4.2 show the majority of the data points are close to zero person-rem with only a few high value data points. Data with high exposure and high worker hours represent deactivation activities (N Area, Rover, Pu-238 Facility; Figure 4.1). The one data point with high worker hours but low exposure represents safe store of a reactor facility (C Reactor; Figure 4.1). Although linear regression analysis shows significance in the slope of the lines, predicting exposure only based on worker hours with all the case studies grouped together may not be a meaningful comparison.

Relationship of Exposure and Size

Can total exposure be predicted from the size of the facility? Can the total number of worker hours be predicted from the size of the facility?

The scatter plots of exposure and size (Figures 4.3 and 4.4) and worker hours and size (Figures 4.5 and 4.6) seem to indicate no relationships within the two sets of variables. The results of linear regression analysis for exposure and size data showed that the slopes of the lines for all divisions of the data (overall, level of facility radiation, and date) were insignificant; therefore, a relationship cannot be determined between worker hours and exposure.

The plots of size versus exposure show the data running along either the x- or y-axis. Most of the high exposure data represents small sized areas and most of the low exposure data represents large sized areas. These results may show that for the majority of decommissioning projects, entire projects are not completed as one event, rather divided into multiple projects. For example, small areas within a building (e.g. research cubicles, hot cells, gloveboxes) are decommissioned as a separate project prior to decommissioning an entire building or facility. These small areas may have higher worker exposures than larger areas, as illustrated in this example: if one corner of a room has a high level of facility radiation, workers may have higher exposures if the room is 400 sq ft rather than 1000 sq ft because in the 1000 sq ft room workers will be able to stay further away from the high radiation area than in the 400 sq ft room. Also, the 400 sq ft room has a higher chance for high levels of facility radiation to be throughout the entire room. Therefore, size cannot be used to predict exposure and worker hours cannot be linked to exposure data because there is not a relationship between the two variables in each set.

Analysis of Data by Decommissioning Activities

Can exposure and worker hour data be divided into the different decommissioning activities listed in the Best Estimate Predictions hypothesis?

From the data collected in this research, exposure and worker hour data cannot be easily divided into the different decommissioning activities. The available information is listed in Appendix A under each case study description, but is not sufficient for analysis.

Analysis of Data by Type of Facility and Level of Facility Radiation

By looking at all the variables of data, what is the best way to organize the data for use in constructing predictive estimates?

Since the previous attempts to determine relationships between worker hours and exposure or size and exposure were unsuccessful, the data were organized by type of facility and level of radiation within that type of facility. This organization of the data is shown in Tables 4.2 through 4.6 and plots of these data are shown in Figures 4.11 through 4.22. This is the preferred method of organization for the data set in this research. The following subsections discuss the data for each type of facility.

Reactors

All of the reactors were decommissioned as a complete facility except for one case study, a submarine reactor. The types of decommissioning activities for reactor facilities are split into four categories: closure with hazards remaining in place (entombment), facilities placed into long-term storage (safe store), deactivation of the reactor facility prior to the decommissioning activities represented by this data (dismantlement after previous deactivation), and reactors not included in the other categories (reactor other) (Figures 4.17, 4.18, and 4.19 and Table 4.4).

The averages for the reactor facilities divided by type of facility are shown in Table 5.1. For rem per worker hour, the averages increase by an order of magnitude from low to medium to high levels of facility radiation. The average person-rem also increases as the level of facility radiation increases.

Table 5.1. Reactor facilities averages.

Level of Facility Radiation	Average Worker Hours	Average Person-rem	Average Rem per Worker Hour	95% Confidence Interval for Rem per Worker Hour
Low	24,841	0.01	2.5E-6	0 to 1.3E-5
Medium	12,437	6.20	2.7E-5	One data point
High	193,965	45.64	1.6E-4	0 to 5.2E-4
Not Ranked	No data	13.9	No data	No data

Reactor Support

Three of the four case studies are ranked as low, which should be an appropriate level for reactor support facilities since these facilities are often separate structures from the main buildings that contain high levels of facility radiation. The fourth case study is not ranked. Since only one case study has information about worker hours (Figure 4.14a), additional information would be useful to represent an average for worker hours. Person-rem is 0.00 for all of the case studies (Figure 4.15a) and appropriately matches the consistent low level of facility radiation ranking. No data are available for rem per worker hour.

Process

The case studies for process facilities should be divided into complete or partial facilities. Averages for level of facility radiation and complete or partial categories are shown in Table 5.2. The average person-rem for medium and high partial facilities is greater than the complete facilities. The rem per worker hour averages are all similar except the partial medium facilities.

Table 5.2. Process facilities averages.

Level of Facility Radiation	Complete or Partial	Average Worker Hours	Average Person-rem	Average Rem per Worker Hour	95% Confidence Interval for Rem per Worker Hour
Low	Partial	No data	0.56	No data	No data
Medium	Partial	7,652	7.68	2.0E-06	One data point
Medium	Complete	7,859	0.82	1.1E-04	0 to 1.4E-3
High	Partial	143,392	26.80	2.4E-04	One data point
High	Complete	189,577	4.05	9.6E-04	One data point
Not Ranked	Complete	34,990	13.0	4.3E-04	One data point

Research

There is a large separation between the average worker hours for partial (2,507 worker hours, Figure 4.11b) versus complete facilities (average of 53,813 worker hours, Figure 4.14a and 4.14b). This separation shows that fewer worker hours are needed to decommission hot cells, research cubicles, or gloveboxes versus an entire research facility; therefore, it is appropriate to use the worker hour divisions for partial and complete rather than an average for all facilities combined. The averages for different levels of facility radiation and complete or partial facility categories are shown in Table 5.3. The person-rem data for the partial facilities are higher than the complete facilities, supporting the discussion in the Relationship of Exposure and Size section about decommissioning activities in smaller sized facilities may have higher exposure levels than larger facilities.

Table 5.3. Research facilities averages.

Level of Facility Radiation	Complete or Partial	Average Worker Hours	Average Person-rem	Average Rem per Worker Hour	95% Confidence Interval for Rem per Worker Hour
Low	Complete	48,141	0.00	0.0E+0	One data point
Medium	Partial	No data	7.45	No data	No data
High	Complete	59,468	0.00	0.0E+0	One data point
High	Partial	2,507	0.77	3.1E-4	One data point
Not Ranked	Complete	No data	0.44	No data	No data
Not Ranked	Partial	No data	1.26	No data	No data

Storage

The case studies for complete storage facilities all have low levels of facility radiation, whereas partial storage facilities have one case study for medium, one high, and one not ranked (Table 5.4). This may indicate that higher levels of facility radiation are stored in smaller areas. For the complete facilities with low levels of facility radiation, the rem per worker hour average of 2.7E-05 is skewed high by one case study value of 8.1E-05 while the other two case studies are 0.00 (Figure 4.16a). For partial facilities, there is only one case study with data for worker hours and rem per worker hour (Figure 4.13).

Table 5.4. Storage facilities averages.

Level of Facility Radiation	Complete or Partial	Average Worker Hours	Average Person-rem	Average Rem per Worker Hour	95% Confidence Interval for Rem per Worker Hour
Low	Complete	4,759	0.02	2.7E-05	0 to 1.4E-4
Medium	Partial	No data	1.62	No data	No data
High	Partial	938	0.05	5.3E-05	One data point
Not Ranked	Partial	No data	0.14	No data	No data

Pits/Ponds

All of the case studies have a low level of facility radiation ranking, which should be an accurate representation of this category since these facilities were primarily used to collect discharged water. Following evaporation, the only contamination remaining is in the soil. The averages of 440 worker hours (Figure 4.14) and 0.00 person-rem and rem per worker hour (Figures 4.15 and 4.16) should be good representations of the decommissioning activities for site restoration including removing contaminated soil or leaving the soil in place, backfilling the area with clean soil, grading the area to match surrounding contours, and seeding the area with native grasses. All of the case studies were categorized as complete facilities.

Other

Facilities in the other category all have low level of facility radiation rankings and 0.00 person-rem and rem per worker hour (Figures 4.21 and 4.22), which should be appropriate since this category contains facilities that may never contain radiological materials but could potentially be exposed to it. The complete facilities within this category have an average of 8,580 worker hours, which is appropriate since the three data points fall above, close to, and below the average value (Figure 4.14b). The one data point for partial facilities is 1,535 worker hours, which is lower than all of the complete facility worker hour data (Figure 4.11).

TRENDS IN EXPOSURE DATA

Relationship of Exposure and Date

Is there a downward trend in the exposure data plotted over time?

By looking at the plots of exposure and date divided by level of facility radiation (Figures 4.7, 4.8, 4.9 and 4.10), there is a scattering of the data and no apparent trends are present, except for the medium person-rem per worker hour category but this is probably not a meaningful relationship since only four data points are plotted and they cluster in two groups.

COMPARISON TO STANDARD ESTIMATES

Exposure

Is the ESHRAP standard estimate for exposure similar to the person-rem per physical worker hour data calculated from the collected case study information?

Averages for rem per worker hour are shown in Figure 5.1 and Table 5.5. Averages close to the ESHRAP standard estimate include the low, high, and all categories for storage and the medium and all categories for reactors. These categories could potentially be represented by the ESHRAP standard estimate.

The categories of low research complete, pits/ponds, other, and high research complete are well below the ESHRAP average. No rem per worker hour data are available for reactor support facilities to make a comparison. The low reactor complete and medium process partial categories are slightly below the ESHRAP standard estimate. Low storage complete, medium reactor complete, and high storage partial are close to the ESHRAP standard estimate. The remaining categories are above the ESHRAP standard estimate (Table 5.5 and Figure 5.1). The ESHRAP standard estimate may be used as a conservative or protective estimate if it is higher than the average rem per worker hours as shown in pits/ponds, other, and low research. The ESHRAP standard estimate falls within the 95% confidence interval on the mean for the all of the categories except reactor low.

The overall trend of average person-rem per worker hour data in Figure 5.1 seem to show a gradual increase from low to medium to high levels of facility radiation. This trend is consistent and could be a method to validate the categorization ranking completed by an INEEL D&D expert (Meservey, 2002). This shows that predictors for planning decommissioning projects include the type of facility, level of facility radiation, and whether decommissioning took place in part or the complete facility.

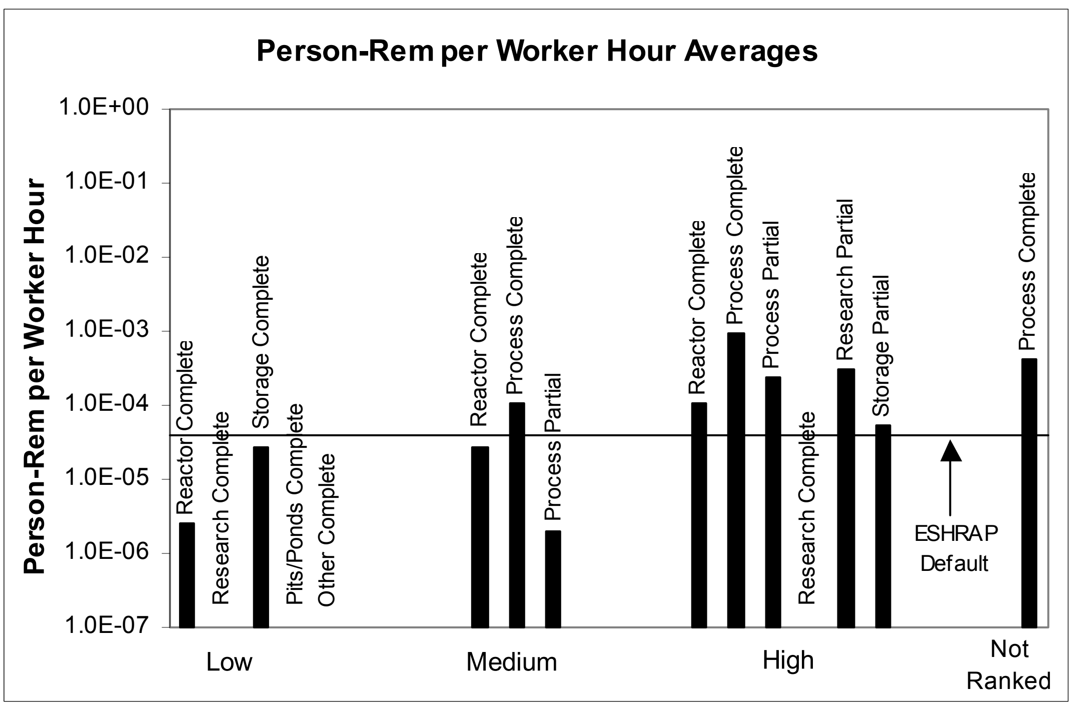

Figure 5.1. Person-rem per worker hour averages.

Table 5.5. Rem per worker hour averages.

Type of Facility	Level of Facility Radiation	Average Rem per Worker Hour	95% Confidence Interval
Reactor (Complete)	Low	2.47E-06	0 to 1.31E-05
Reactor (Complete)	Medium	2.70E-05	One data point
Reactor (Complete)	High	1.06E-04	0 to 5.22E-04
Reactor	**ALL**	**5.04E-05**	**0 to 1.52E-04**
Process (Complete)	Medium	1.05E-04	0 to 1.4E-03
Process (Partial)	Medium	2.00E-06	One data point
Process (All)	Medium	7.07E-05	0 to 3.70E-04
Process (Complete)	High	9.60E-04	One data point
Process (Partial)	High	2.40E-04	One data point
Process (All)	High	6.00E-04	0 to 5.17E-03
Process (Complete)	Not Ranked	4.30E-04	One data point
Process	**ALL**	**3.06E-04**	**0 to 6.83E-04**
Research (Complete)	Low	0.0E+00	0
Research (Complete)	High	0.00E+00	0
Research (Partial)	High	3.10E-04	One data point
Research (All)	High	1.55E-04	0 to 2.12E-03
Research	**ALL**	**1.03E-04**	**0 to 5.48E-04**
Storage (Complete)	Low	2.70E-05	0 to 1.43E-04
Storage (Partial)	High	5.30E-05	One data point
Storage	**ALL**	**3.35E-05**	**0 to 9.77E-05**
Pits/Ponds (Complete)	Low	0.0E+00	0
Other (Complete)	Low	0.0E+00	0
ALL Facilities	ALL	1.05E-04	1.5E-05 to 2.0E-04
ESHRAP Standard		3.8E-05	

Accidents

Can the accumulated accident data be compared to the standard estimate in ESHRAP?

Since sufficient data does not exist for standard industrial accidents, injuries, and deaths during decommissioning activities, this part of the hypothesis cannot be tested and the standard estimate should be used.

DATA LIMITATIONS AND ASSUMPTIONS

Experience and completion of decommissioning activities is limited, making collection of information difficult. Although the data collected for this research are the best available, there are still many limitations and assumptions associated with this data set including lack of recorded information, use of charge numbers to collect worker hours, identifying when a building is surplus, and the type of decommissioning work completed.

Lack of Recorded Information

As of October 1996, the DOE-EM had recorded 233 completed decommissioning projects out of the estimated total of 7,000 facilities that need to be decommissioned (DOE and EPA, 1997), but the desired information for most of these case studies could not be found in government documents or the published literature. For DOE sites, methods for collecting information about decommissioning activities vary. In the 1980s, the INEEL D&D department wrote final report documents including worker hour data, but final reports in the 1990s no longer included this data. The INEEL prepares final reports under direction of a management control procedure to ensure that the same information for each decommissioning project is recorded in the same format (Peterson, 2000). Some of the other DOE sites do not prepare final reports; so limited information is available in conference papers or in other published literature sources.

The author of this document attended a Large-Scale Demonstration and Deployment Program (LSDDP) conference call on Thursday, May 16, 2002. The purpose of the LSDDP in relation to decommissioning projects is "to validate performance of D&D [decontamination and decommissioning] technologies and introduce the application of alternative technologies in parallel with baseline technologies" (National Research Council, 1998). At this conference call, those present were informed about this research and were asked for contacts at other DOE sites or references for completed decommissioning project documents. A representative from the Rocky Flats Environmental Technology Site replied that subcontractors perform all their decommissioning work under fixed contracts, so the requested information would not be available. A representative from Fernald Environmental Management Project suggested two people from their decontamination and demolition department to contact. One contact referred the other one, but replies to information inquires were not received. The same situation was true for requesting information from Mound. A representative from

Hanford suggested a Bechtel Hanford decontamination and decommissioning department employee to contact. This employee sent limited information about four projects at Hanford including the project name, conditions of the area, collective dose in person-rem, and duration listed in weeks or months, but additional information beyond this could not be obtained so these case studies are not included in the data set.

The authors of the NRC document for estimating safety, technology, and costs of decommissioning nuclear research and test reactors included a section describing why it is not always possible to extract from the public records many of the details for a particular reactor decommissioning project. These reasons include: no requirement for a standard decommissioning closeout data sheet, many small-reactor projects are completed on a fixed-price, competitive bid system ("the winning contractor's itemized cost breakdown could provide competitors with proprietary information of an advantageous nature on some future bid" (Konzek, 1993)), and student labor is used for university reactor decommissioning projects and these records are not available for reconstruction (Konzek, 1993).

Use of Charge Numbers

The use of charge numbers is the most efficient way to collect worker hours; however, inaccuracies may be present. Methods of recording work by charge numbers can vary among employees. Some employees may track their work down to every ten minutes, while others may approximate by the fraction of a day spent on a project. Inaccuracies could also occur if there is confusion about what charge number is used for what part of a project or if a decommissioning project is funded under a charge number that is not part of the decommissioning department. Errors from the use of charge numbers may be present in any of the worker hour data reported in this research.

Examples of the inaccuracies are in the ROM historical data set. Charge number data sheets were used to report the worker hour and cost information for INEEL decommissioning projects from 1994-1998. This time span of charge numbers did not catch all of the INEEL D&D department projects going on during those years or the decommissioning projects were completed through different departments. Also, collecting data only between 1994-98 limits the collection of worker hours for a project that took place before 1994 or after 1998, therefore some of the worker hours for the projects may be too low. An example of a missed case study is the decommissioning of the Waste Calcination Facility (WCF), which took place from April 1995 through May 1999 (Schanz, 2001), but is not listed in the ROM historical data set.

Surplus Buildings

Decommissioning work may begin before a building is determined to be surplus and officially transferred to the department performing the decommissioning work. This is often the case with characterization, S&M, and deactivation worker hours. Lilly and Gans submitted a conference paper in 1996 explaining the preferred S&M practices for the DOE Office of Environmental Restoration. They identified that S&M should take place post-operation or during transition periods when the availability of the building is made known throughout the DOE complex and to other governmental organizations for another use. During this phase, S&M could be considered an extension of operations. Other stages of S&M include pre-deactivation, during deactivation, pre-decommissioning, during decommissioning, and long-term S&M (Lilly and Gans, 1996). The department performing the decommissioning activities may not receive the building until after deactivation. It all depends on how decommissioning is defined within the department (to included characterization, S&M, and deactivation or not) and when the building is determined to not have a future use. Characterization of the building may need to take place to determine if the building is suitable for a future use or not, just as S&M may take place with the idea for a future use of the building, but the decision is later changed.

Type of Decommissioning Work Completed

In the data set for this research, 39% of the case studies reported 0.00 person-rem. From a safety standpoint, this is a good result, but it brings up questions concerning the type of work that has been completed versus what work will be done in the future. Are all of the lower level of radiation facilities being decommissioned first and the higher level of radiation facilities waiting around to be decommissioned in the future? Will this create higher worker exposures in future years? Or will these facilities be left to sit and decay until the levels of facility radiation are lower?

CHAPTER 6.
CONCLUSIONS

RESEARCH HYPOTHESES CONCLUSIONS

Best Estimate Predictions

Following data collection, analysis was carried out for worker exposure to radioactivity but not for standard industrial accidents, injuries, or deaths. Analysis showed a significant relationship between worker exposure to radiation and worker hours, but this relationship may not be an accurate way to represent the data since additional variables should be taken into consideration. After a variety of analyses, the preferred method to organize this data is by the type of facility, the level of facility radiation prior to decommissioning, and whether decommissioning was performed on part of the facility or the complete facility.

Recommendations For Divisions of Data by Type of Facility and Level of Facility Radiation

The goal to predict exposure based on the decommissioning activities listed in the Best Estimate Predictions hypothesis will be difficult to carry out using the data found in this research. Instead, the data could be divided based on the type of facility, level of facility radiation, whether decommissioning was performed on part of the facility or the complete facility, and the type of decommissioning for reactor facilities. The following subsections provide details for each type of facility.

<u>Reactors</u>

- All facilities are categorized as complete (with exceptions such as submarine vessels).
- Levels of worker exposure (person-rem and rem per worker hour) increase from low to medium to high levels of facility radiation.
- Reactors categorized as other (these include deactivation activities) have an average of 1.53E-4 rem per worker hour, higher than the ESHRAP standard estimate

Reactor Support

- All facilities are categorized as complete facilities (with exceptions such as cooling towers).
- All facilities are categorized as having low level of facility radiation.
- One data point of 124,000 for worker hours for partial facilities.
- All facilities have 0.00 person-rem.
- No data are available for person-rem per worker hour.

Process

- Facilities are divided into categories for complete or partial and divided by level of facility radiation.
- Medium partial and complete facilities have an average of 7,790 worker hours.
- High partial and complete facilities have an average of 174,182 worker hours
- Average levels of exposure (person-rem) for partial facilities are higher than complete facilities.
- All of the averages for rem per worker hour are higher than the ESHRAP average except partial facilities with medium level of facility radiation.

Research

- Facilities are divided into categories for complete or partial and divided by level of facility radiation.
- Partial facilities represent hot cells, research cubicles, and gloveboxes.
- Partial facilities have one data point of 2,507 worker hours.
- Partial facilities data include medium, high, or not ranked levels of facility radiation.
- Partial facilities have one data point of 3.1E-04 rem per worker hour, higher than the ESHRAP standard estimate.
- Complete facilities represent entire research facilities.
- Complete facilities have an average of 53,813 worker hours.
- Complete facilities are primarily ranked as having low levels of facility radiation, except for one data point with high and one not ranked.

- Complete facilities have 0.00 rem per worker hour values for low and high levels of facility radiation, well below the ESHRAP standard estimate.
- Partial facilities have higher levels of worker exposure (person-rem and rem per worker hour) than complete facilities.

Storage

- Facilities are divided into complete or partial categories.
- All complete facilities have low level of facility radiation.
- Complete facilities have an average of 4,759 worker hours, 0.018 person-rem, and 2.7E-05 rem per worker hour.
- Partial facilities have medium, high, and not ranked levels of facility radiation.
- Partial facilities have one data point of 938 worker hours, an average of 0.60 person-rem, and one data point of 5.3E-05 rem per worker hour.
- The rem per worker hour averages for all storage facilities is similar to the ESHRAP standard estimate.

Pits/Ponds

- All facilities are categorized as complete facilities.
- All facilities are categorized as having low levels of facility radiation.
- Average of 440 worker hours.
- All facilities have 0.00 person-rem.
- All facilities have 0.00 rem per worker hour, well below the ESHRAP standard estimate.

Other

- Facilities are divided into complete or partial categories.
- All facilities are categorized as having low levels of facility radiation.
- Complete facilities have an average of 8,580 worker hours.
- Partial facilities have one data point of 1,535 worker hours.
- All facilities have 0.00 person-rem and rem per worker hour, well below the ESHRAP standard estimate.

Trends in Exposure Data

Plotting the worker exposure to radiation data (both in person-rem and person-rem per worker hour and divided by level of facility radiation) over time showed that there are not meaningful relationships between the date when the activities took place and worker exposure to radiation.

Comparison to Standard Estimates

The use of standard estimates for worker exposure to radiation may be a best estimate for low complete storage, high storage partial, and medium reactor complete facilities; a conservative estimate for some low level of radiation facilities (reactor complete, research complete, pits/pond, and other), medium process partial, and high research complete; and an underestimate for the remaining facilities.

COMPARISON OF DIFFERENT DECOMMISSIONING ALTERNATIVES

One sponsor of this research requested comparing the decommissioning alternatives of dismantlement, entombment, and safe store. Following data collection, entombment case studies were identified for reactor (BORAX-V Reactor Building) and process (WCF) facilities and safe store was identified for only reactor (C Reactor) facilities. The WCF case study had information for worker exposure data and did not have worker hour data; therefore, comparison of decommissioning alternatives was only completed for reactor facilities (Table 4.4 and Figures 4.17, 18, and 19).

The BORAX-V and C Reactor case studies were both ranked as having high levels of facility radiation, so these case studies should be compared to other reactor facilities with high levels of facility radiation (Table 6.1). It is difficult to make comparisons of entombment and safe store to dismantlement due to differences in the way data are reported. Most of the dismantlement data in this research do not include data for deactivation of the facility, so it is not appropriate to compare dismantlement to entombment and safe store alternatives where deactivation has not taken place. For example, the person-rem data for the OMRE case study does not include deactivation activities, whereas the N Area case study person-rem includes only deactivation activities. Since the data are limited, no conclusions can be drawn.

Although there is little information to quantitatively compare dismantlement, entombment, and safe store, current trends indicate that DOE may be exploring entombment and safe store as viable decommissioning alternatives. The impacts of entombment and safe store cannot be understood unless more data are collected. The NRC believes that worker exposure to radioactivity during entombment and safe store tend to be less than during dismantlement (NRC, 2000b). Although the data are inconclusive, the available data are consistent with the NRC's belief.

Table 6.1. Reactors with high levels of facility radiation.

Type of Decommissioning	Size (sq ft)	Worker Hours	Person-Rem	Person-Rem per Worker Hour	Case Study
Entombment	9,235	7818	0.00	0.00E+0	BORAX-V Reactor Building
Safe Store	105,530	171,306	3.4	2.0E-5	C Reactor
Dismantlement After Previous Deactivation	4,300		4.2		OMRE
Reactor Other	1,141	11,764			LOFT MTA
Reactor Other		584,970	175.0	3.0E-04	N Area

RECOMMENDATIONS FOR DOCUMENTATION OF DECOMMISSIONING PROJECTS

This research shows that although decommissioning projects have taken place, documentation of the final results for worker hours, worker exposure to radiation, and standard industrial accidents, injuries, and deaths could only be found for 63 DOE and 2 NRC case studies. For some projects, this data may have been reported in overall company reports or the data are grouped with other project results. This lack of accessible documentation limits the opportunity for the DOE, NRC, and other companies involved with decommissioning projects to use past experiences to plan and complete future decommissioning projects.

Past data could be reconstructed, but the process would be difficult and time consuming. The creators of the ROM Model reconstructed worker hour data from old charge number sheets (Oswald 2002). Worker exposure to radiation could be reconstructed using radiation work permits to determine what employees worked on the project and matching the dates of the project to dates on the employees' radiation exposure records. At the INEEL, standard industrial accidents, injuries, and deaths from 1994 to present are recorded in an electronic database based on the employee's organization number. Also, incident reports are filed and kept in the INEEL Public Reading Room following accidents. It would be rather difficult to determine which accidents occurred during decommissioning projects and then accurately match these data to a specific decommissioning project. In the long run, it would be beneficial for this information to be collected and reported immediately following completion of each decommissioning project.

The INEEL has a management control procedure for writing INEEL D&D final reports (Peterson, 2000). This procedure requires reporting personnel exposure, but does not specify how it should be reported. Most reports state the person-rem, but a standard method should be identified. The only reporting of standard industrial accidents, injuries, and deaths in INEEL D&D final reports are near misses in the lessons learned sections. Some final reports written by the INEEL in the late 1970s and early 1980s include breakdowns of work activities and worker hours. Excellent examples can be found in "Final Report- Decontamination and Decommissioning of TAN Radioactive Liquid Waste Evaporator System (PM-2A)" (Smith, 1983) and "Final Report- SPERT-IV Decontamination and Decommissioning" (Smith, 1979). Requirements to include a worker hour breakdown should be added to the current management control procedure, in addition to specifying reporting of worker exposure in person-rem and reporting all standard industrial accidents, injuries, and deaths in the lessons learned section.

Ideally, this format should be used at all DOE sites to maintain a consistent reporting method to provide information about decommissioning projects. In addition, all DOE sites should submit copies of these final reports to the RAPIC Program at ORNL (RAPIC, 2002) to be included in this electronic database of information. The INEEL D&D department currently submits reports to RAPIC. The NRC could also use this format as a model of how to collect and report information about their decommissioning projects.

Since individual facilities have many unique aspects, there is a large amount of variability in data stemming from the types of decommissioning activities, types of facilities, and levels of facility radiation. This variability makes it difficult to use this data to make future predictions. The predictive estimates reported in this research are strongly dependent upon the type of decommissioning that took place (this variation is shown in the case study descriptions in Appendix A, specifically the Description of Decommissioning Activities category for each case study). In addition, information reported from one case study to the next varies. Although INEEL D&D final reports follow a management control procedure, there is still variation in the type of data reported. This could depend on factors such as the author of the document, amount of funding for the project, or when the report was written. It is difficult to see progress if the data are not recorded in consistent and transparent format.

Overall, this information would be valuable to use for future planning, but it cannot be used if the information is not accessible. The DOE and NRC are missing the opportunity to collect and use this data for planning future decommissioning projects, making future decisions about how to decommission facilities, and use this information for future reactor or facility designs. Since decommissioning can include so many different types of facilities, different activities, and different levels of facility radiation, it is important to have this information as a reference so that each time a unique facility is decommissioned, information from past projects could be found and hopefully be helpful in the decision, planning, and physical decommissioning processes.

FUTURE RESEARCH

Additional sources of information to support and/or continue this research include the European Commission Data Base Tool (EC DB-Tool), which is "a computerized database on costs, radiation exposure, working time and waste arising from unit operations" for decommissioning of nuclear installations (EC, 2002). Adding data from the EC DB-Tool will add complexity comparing decommissioning activities completed in the United States under the NRC or DOE versus those completed under the direction of individual countries included in the European Commission. Other sources of international decommissioning information could be accessed through International Atomic Energy Agency (IAEA) documents. The document, “Decommissioning of Nuclear Facilities Other Than Reactors”, contains an extensive list of facilities that have been shut down and are either decommissioned or in the process of being decommissioned (IAEA, 1998). Also, an analysis of international decommissioning cost estimates was performed by the Nuclear Energy Agency (NEA) and titles of decommissioning projects included in the analysis are listed in the document, “Decommissioning Nuclear Facilities” (NEA, 1991). These documents do not include the type of information researched in this thesis, but the documents list other references, which may contain this information.

Other sources of data could include generating additional worker hour data using the ROM Model. This option was explored in this research, but in order to generate high quality, reliable data, a subject matter expert for each decommissioning case study needs to be interviewed and assist with estimating percentages to use in the ROM Model. Also, the data analysis behind constructing the ROM Model needs to be explored so the researcher understands how each parameter influences the worker hour prediction. This ROM Model generated data could be used to supplement and/or validate the data set in this research in addition to validating the accuracy of using estimates from the ROM Model in conjunction with ESHRAP predictions.

A final future research project, branching from this research, would be to explore decommissioning-friendly building designs. From final report documents, lessons learned, personal interviews, and other information about completed decommissioning activities; a researcher could explore what features, complexities, or areas of decommissioning projects require a large number of worker hours or resulted in high worker exposures. From this information, the researcher could explore future building designs to reduce the amount of time and exposure associated with decommissioning activities.

CHAPTER 7.
REFERENCES

Arquiett, Candy, Irene Datskou, and Karen Golden. 1997. *Human Health Risk Assessment for Facilities*. Pollution Engineering. <http://www.pollutionengineering.com/archives/1997/pol0402.97/04sjk2f0.htm> (Date of access 29 April 2002).

Babcock and Wilcox, Nuclear Environmental Services, Inc. (B&W NESI). 1997. *Final Technical Report- Apollo Decommissioning Project, Apollo, Pennsylvania.* DOE/EW/40017-T6 Rev. 0.

Black, Robert, and Jennifer Rodriguez. 2001. *D&D ROM Model Manual*. INEEL/EXT-01-00354 Rev. 0. August 2001.

Buckland, R.J., D.J. Kenoyer, and S.A. LaBuy. 1995. *INEL D&D Long-Range Plan*, INEL-95/0453, September 1995.

Department of Energy (DOE) and Environmental Protection Agency (EPA). 1997. *Decommissioning Benchmarking Study Final Report*. 15 January 1997. <http://www.em.doe.gov/dd/decom_doc.html> (Date of access 17 June 2002).

Department of Energy Office of Environmental Management (DOE-EM). 2000. *Decommissioning Home Page*. 8 June 2000. <http://www.em.doe.gov/dd/> (Date of access 21 June 2002).

Department of Energy Office of Safety and Health (DOE-S&H). 1999. *DOE Occupational Radiation Exposure 1999 Report*, DOE/EH-0629. <http://rems.eh.doe.gov> (Date of access 6 August 2002).

Department of Energy Office of Safety and Health (DOE-S&H). 2000. *DOE Occupational Radiation Exposure 2000 Report*. DOEW/EH-0267. <http://rems.eh.doe.gov> (Date of access 6 August 2002).

Dorr, K. A., R. J. Sexton, M. E. Hickman, and B. J. Henderson. 1997. *Decontamination and Decommissioning of Building 889 at Rocky Flats Environmental Technology Site*. Waste Management 1997 Conference. 29 April 1997. <http://www.wmsym.org/wm97/Index.html> (Date of access 29 January 2002).

Eide, S.A., R. L. Nitschke, and T. E. Wierman. 2002. *Comprehensive WM/ER/D&D/LTS Risk Model for the INEEL*. Waste Management 2002 Conference. 24-28 February 2002, Tucson, AZ.

Environment, Safety, and Health Risk Assessment Program (ESHRAP). 2002. ESHRAP Lookups Option within the Microsoft Access Program. Project Data Input Form. Accident/Injury Constants.

Environmental Restoration at Hanford. 1998. *N Area Project Closeout Summary*. Presentation to BHI (Bechtel Hanford, Inc.) Board of Directors. December 8, 1998.

Environmental Restoration Optical Imaging System Retrieval (EROIS). 2002. *EROIS Home Page*. 30 July 2002. <http://zeus.inel.gov:8080/docs/ois/ois_index.html> (Date of access 1 August 2002).

European Commission (EC). 2002. *EC DB NET European Commission Data Base Network*. <http://www.ec-decom.be/network/initnetwork.htm> (Date of access 4 March 2002).

Fellhauer, C. R., L. E. Boing, and J. Aldana. 1996. *Decontamination and Decommissioning of the Experimental Boiling Water Reactor (EBWR): Project Final Report, Argonne National Laboratory*. ANL/D&D/TM-96/4. March 1997.

Fellhauer, C. R., G. A.Garlock, and F. R. Clark. 1997. *Decontamination and Dismantlement of the JANUS Reactor at Argonne National Laboratory-East Project Final Report*. ANL/D&D/97-1. October 1997.

Hansen, C. B. 1993. *Final Report for the Decontamination and Decommissioning of the SPERT-IV Waste Holdup Tank Ancillaries*. EGG-ER-11000. Rev. 0. September 1993.

Howell, W. F. and J. D. Long. 2001. *Final Report of the Decontamination and Decommissioning of the Test Area North Initial Engine Test Facility, Railroad, and Underground Utilities*. INEEL/EXT-2000-01112. January 2001.

Idaho National Engineering and Environmental Laboratory – Decontamination and Dismantlement (INEEL D&D) Program. 2000. *D&D Program Home Page*. <http://xcavator.inel.gov/> (Date of access 20 May 2002).

Idaho National Engineering and Environmental Laboratory- Science and Technical Information (INEEL STI) System. 2002. *STI Home Page*. <http://webaccess/sti/index2.asp> (Date of access 1 August 2002).

International Atomic Energy Agency (IAEA). 1998. *Decommissioning of Nuclear Facilities Other Than Reactors*. Technical Reports Series No. 386. Vienna, Austria. STI/DOC/010/386.

Kerr, T.A., et. all. 2002. The *K*ON*VER*GENCE Model for Sustainable Decisions. Spectrum 2002. American Nuclear Society. 9th Biennial International Conference on Nuclear and Hazardous Waste Management. 4-8 August 2002, Reno, Nevada.

Konzek, G.J . 1983. *Technology, Safety and Costs of Decommissioning Reference Nuclear Research and Test Reactors*, Nuclear Regulatory Commission, NUREG/CR-1756-Addendum. (See also NUREG/CR-1756: Konzek, G. J., J. D. Ludwick, W. E. Kennedy, Jr., and R. I. Smith, 1982, Volume 1 and 2.)

Konzek, G. J., and R. I. Smith. 1988. *Technology, Safety and Costs of Decommissioning a Reference Pressurized Water Reactor Power Station*, Nuclear Regulatory Commission, NUREG/CR-0130 Addendum 4. (See also NUREG/CR-0130: Smith, R. I., G. J. Konzek, and W.E. Kennedy, Jr., 1978, Volume 1 and 2. Smith, R. I. and L. M. Polentz, 1979, Addendum 1. Holter, G. M. and E. S. Murphy, 1983, Addendum 2. Murphy, E. S., 1984, Addendum 3.)

Larson, E. P., A.C. Lay, T. L. Hatmaker, R. DiDonato, and R. L. Yust. 1997. *Demolition of Cooling Towers at the Oak Ridge K-25 Site, Oak Ridge, Tennessee*. Waste Management 1997 Conference, 29 April 1997, <http://www.wmsym.org/wm97/Index.html> (Date of access 29 January 2002).

Lilly, M. Judson, III, and George M. Gans. 1996. *Surveillance and Maintenance Practices in the Office of Environmental Restoration (EM-40) U.S. Department of Energy*, Proceedings Decommissioning, Decontamination, and Reutilization Worldwide Experience – DD&R, What Does It Mean, White, M.G. (ed.), pg. 16-21.

Manly, Bryan F. J. 2001. *Statistics for Environmental Science and Management*. Boca Raton, Florida: Chapman and Hall/CRC. pg. 72-80.

Meservey, Richard. 2002. Personal Communication. Former INEEL D&D department manager with extensive decommissioning experience.

Murray, Raymond L. 1994. *Understanding Radioactive Waste*. Columbus: Battelle Press. pg. 20-21.

National Research Council. 1998. *A Review of Decontamination and Decommissioning Technology Development Programs at the Department of Energy*. Washington D.C.: National Academy Press. 88 pg.

National Research Council. 1999. *Decision Making in the U.S. Department of Energy's Environmental Management Office of Science and Technology*. Washington D.C.: National Academy Press.

Nuclear Energy Agency (NEA). 1991. *Decommissioning of Nuclear Facilities: An Analysis of the Variability of Decommissioning Cost Estimates*. Paris: Organization for Economic Co-operation and Development.

Nuclear Regulatory Commission (NRC). 1977. *Technology, Safety and Costs of Decommissioning a Reference Nuclear Fuel Reprocessing Plant*. NUREG/CR-0278.

Nuclear Regulatory Commission (NRC). 1979. *Technology, Safety and Costs of Decommissioning a Reference Small Mixed Oxide Fuel Fabrication Plant*. NUREG/CR-0130.

Nuclear Regulatory Commission (NRC). 1980a. *Technology, Safety and Costs of Decommissioning a Reference Boiling Water Reactor Power Station*. NUREG/CR-0672. (See also NUREG/CR-0672: 1983, Addendum 1. 1984, Addendum 2. 1988, Addendum 3. 1990, Addendum 4.)

Nuclear Regulatory Commission (NRC). 1980b. *Technology, Safety and Costs of Decommissioning a Reference Low-Level Waste Burial Ground*. NUREG/CR-0570.

Nuclear Regulatory Commission (NRC). 1980c. *Technology, Safety and Costs of Decommissioning a Uranium Fuel Fabrication Plant*. NUREG/CR-1266.

Nuclear Regulatory Commission (NRC). 2000a. *Staff Responses to Frequently Asked Questions Concerning Decommissioning of Nuclear Power Plants*. NUREG-1700. June 2000. <http://www.nrc.gov/NRC/COMMISSION/SECYS/200-0129scy.html> (Date of access 1 October 2002).

Nuclear Regulatory Commission (NRC). 2000b. *Workshop Findings on the Entombment Option for Decommissioning Power Reactors and Staff Recommendations on Further Activities*. SECY-00-0129. June 12, 2000. <http://www.nrc.gov/NRC/COMMISSION/SECYS/2000-0129scy.html> (Date of access 1 October 2002).

Nuclear Regulatory Commission (NRC). 2001. *Decommissioning Nuclear Power Plants*. U.S. Nuclear Regulatory Commission Website. December 2001. <http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/decommissioning.html> (Date of access 19 June 2002).

Office of Scientific and Technical Information (OSTI) Bridge. 2002. *Information Bridge Home Page*. <http://www.osti.gov/bridge/> (Date of access 1 August 2002).

Oswald, Kyle. 2002. Personal Communication. Received a spreadsheet containing historical data used to construct the ROM Model.

Pak, Paul, Dennis Houston, and Robert F. Potter. 2000. *D&D of Hanford's Retired Production Reactors: An Opportunity to Demonstrate Best Commercial Procurement Practices*. Waste Management 2000 Conference.

Peterson, Dennis. 2000. *Final Report for D&D&D Projects*, MCP-267, August 2000.

Piet, S. J., et. all, 2002, A Framework for Making Sustainable Cleanup Decisions using the *K*ON*V*E*R*GENCE Model. Spectrum 2002. American Nuclear Society. 9th Biennial International Conference on Nuclear and Hazardous Waste Management. 4-8 August 2002, Reno, Nevada.

Price, Wesley J. 1994. *Department of Energy Decontamination and Decommissioning Project Experience*. Waste Management 1994 Conference. 27 February – 3 March 1994, Tucson, Arizona.

Remedial Action Program Information Center (RAPIC). 2002. *RAPIC Home Page*. 11 January 2002. <http://www.em.doe.gov/rapic/> (Date of access 16 July 2002).

Schanz, Dennis B. 2001. *Deactivation, Decontamination, and Decommissioning Projects History*, INEEL/EXT-2001-01047, August 2001.

Sexton, R. J., M. E. Hickman, and B. J. Henderson. 1997. *Decontamination and Dismantlement of Gloveboxes in Building 371 at Rocky Flats Environmental Technology Site*. Waste Management 1997 Conference, 29 April 1997. <http://www.wmsym.org/wm97/Index.html> (Date of access 29 January 2002).

Short, S. M. 1989. *Technology, Safety and Costs of Decommissioning Reference Non-Fuel-Cycle Nuclear Facilities*. Nuclear Regulatory Commission. NUREG/CR-1754. Addendum 1.

Smith, Donald L. 1979. *Final Report- SPERT-IV Decontamination and Decommissioning*. TREE-1373. August 1979.

Smith, Donald L. 1983. *Final Report- Decontamination and Decommissioning of TAN Radioactive Liquid Waste Evaporator System (PM-2A)*. EGG-2236. March 1983.

Smith, Donald L. and Jack G. Scott. 1984. *Final Report- Decontamination and Decommissioning of CPP-601 Process Cells "A," "B," "C," "D," and "L"*. EGG-2304. September 1984.

Stacy, Susan M. 2000. *Proving the Principle: A History of the Idaho National Engineering and Environmental Laboratory 1949-1999*. DOE/ID-10799. Idaho Falls: Idaho Operations Office of the Department of Energy.

Thoren, S. D. 1996. *Final Report for the 190-D Complex Decontamination and Decommissioning*. BHI-00903 Rev. 0. September 1996.

TLG Services, Inc. 2002. *An Introduction to DECCER, a D&D Cost Estimating Code.* <http://www.tlgservices.com/costing/deccer.htm> (Date of access 21 June 2002).

United States (U.S.) Congress Office of Technology Assessment. 1993. *Aging Nuclear Power Plants: Managing Plant Life and Decommissioning*. Washington D.C.: U.S. Government Printing Office. OTA-E-575.

Virgilio, Rosetta. 2002. Personal e-mail communication through the NRC website. *Decommissioning*. Date received 25 April 2002.

APPENDIX A. DESCRIPTION OF CASE STUDIES

Ames Lab
Name:
Ames Laboratory Research Reactor (Link and Voigt, 1982; Struss, 1985)
Location:
Ames, Iowa
Dates of Activities:
1978-1981 (Struss, 1985)
Type of Facility:
Reactor
Total Worker Hours:
No data
Physical Worker Hours:
No data
Total Exposure (Person-Rem):
69.4 (Link and Voigt, 1982; Struss, 1985)
Person-Rem Per Worker Hour:
No data
Size of Facility (Square Feet):
No data
Level of Facility Radiation:
Not Ranked
Complete or Partial Facility:
Complete
Purpose of Facility Prior to Decommissioning:
Research reactor operated for research programs by Iowa State University and the Ames Laboratory facilities (Struss, 1985).
Prior Decommissioning Activities Completed:
None listed
Description of Decommissioning Activities:
Removed reactor fuel, dismantled reactor, dismantled cooling and auxiliary systems, decontaminated the reactor facility and left the building for reuse (Struss, 1985).
Reference:
Link, B. W. and A. F. Voigt. 1982. Decommissioning of Ames Laboratory Research Reactor. CONF-821005. *Decontamination and Decommissioning: A Series of Bibliographies*. DOE/TIC-3391 February 1985.
Struss, Roland G. 1985. Decommissioning of the Ames Laboratory Research Reactor. CONF-851115. *Transactions of the American Nuclear Society: Proceedings of an American Nuclear Society Winter Meeting* 50:198.

Apollo Nuclear Fuel
Name:
Apollo Nuclear Fuel Facility

Location:
Borough of Apollo, Armstrong County, Pennsylvania
Dates of Activities:
1990-95
Type of Facility:
Process
Total Worker Hours:
604,000
Physical Worker Hours:
374,480 (62% of total)
Total Exposure (Person-Rem):
Not listed as total person-rem, 0.00173 rem/employee
Person-Rem Per Worker Hour:
No data
Size of Facility (Square Feet):
73,000
Level of Facility Radiation:
High
Complete or Partial Facility:
Complete
Purpose of Facility Prior to Decommissioning:
This facility was owned by Babcock & Wilcox (B&W) and manufactured low enriched uranium dioxide fuel for use in commercial nuclear power plants.
Prior Decommissioning Activities Completed:
Decommissioning activities, beginning in 1978, included site characterization, demolition of certain building structures, and some soil remediation.
Description of Decommissioning Activities:
Removed utility and ventilation systems, demolished East Bay, decontaminated and demolished Apollo Office Building, removed sewer lines, excavated contaminated soil, and removed concrete foundations.
Reference:
B&W NESI (Babcock and Wilcox, Nuclear Environmental Services, Inc). 1997. *Final Technical Report- Apollo Decommissioning Project, Apollo, Pennsylvania.* DOE/EW/40017-T6 Rev. 0.

ARA-I
Name:
Auxiliary Reactor Area-I (Pell, 2000; Schanz 2001)
Location:
Idaho National Engineering and Environmental Laboratory (INEEL)
Dates of Activities:
1994-98 (Oswald, 2002)
Type of Facility:
Research

Total Worker Hours:
72,725 (24,584 project management) (Oswald, 2002)
Physical Worker Hours:
48,141 (Oswald, 2002) (4,020 characterization, 29,696 miscellaneous decommissioning, 1,230 decontamination, 5,734 asbestos removal, 7,461 demolition and site restoration)
Total Exposure (Person-Rem):
0.00 (Pell, 2000; Schanz 2001)
Person-Rem Per Worker Hour:
0.00
Size of Facility (Square Feet):
19,778 (footprint reduction) (Schanz, 2001)
Level of Facility Radiation:
Low
Complete or Partial Facility:
Complete
Purpose of Facility Prior to Decommissioning:
ARA-I did not include a reactor, rather provided hot cells, laboratory support, and housed maintenance equipment. It was used until the late 1980s as a nuclear research area with various operations related to examinations or storage of radioactively contaminated materials (Pell, 2000).
Prior Decommissioning Activities Completed:
All nuclear fuel materials were removed and preliminary decontamination took place prior to 1988 (Pell, 2000).
Description of Decommissioning Activities:
Removal of asbestos, dismantled building interiors, demolished building exteriors, decontaminated and removed foundations and concrete floors, and demolished the hot cells in ARA-626 (Pell, 2000).
Reference:
Oswald, Kyle. 2002. Personal Communication. Calculated from data used to build the ROM Model.
Pell, George. 2000. *Final Report of the Decommissioning and Dismantlement of the Auxiliary Reactor Area I Facility*. INEEL/EXT-2000-00928. Rev. B. November 2000.
Schanz, Dennis B. 2001. *Deactivation, Decontamination, and Decommissioning Projects History*. INEEL/EXT-2001-01047. August 2001.

ARA-II
Name:
Auxiliary Reactor Area-II (Nelson and Horsburgh, 1999; Schanz, 2001)
Location:
INEEL
Dates of Activities:
1994-98 (Oswald, 2002)

Type of Facility:
    Reactor
Total Worker Hours:
    40,121 (6,800 project management) (Oswald, 2002)
Physical Worker Hours:
    33,321 (Oswald, 2002) (175 characterization, 81 S&M, 17,776 miscellaneous decommissioning, 52 asbestos removal, 15,238 demolition and site restoration)
Total Exposure (Person-Rem):
    0.00 (Nelson and Horsburgh, 1999; Schanz, 2001)
Person-Rem Per Worker Hour:
    0.00
Size of Facility (Square Feet):
    11,559 (footprint reduction) (Schanz, 2001)
Level of Facility Radiation:
    Low
Complete or Partial Facility:
    Complete
Purpose of Facility Prior to Decommissioning:
    This was a test site for the Army Stationary Low-Power Reactor No. 1 (SL-1), which was a prototype 200 kW reactor system and heat source intended for use at remote military bases. This was the location of an accidental nuclear excursion in 1961 (Nelson and Horsburgh, 1999).
Prior Decommissioning Activities Completed:
    Cleanup after the excursion included burying radioactive waste, the SL-1 reactor building, and 6-8 inches of contaminated soil (Nelson and Horsburgh, 1999).
Description of Decommissioning Activities:
    Removed asbestos; demolished aboveground portions of metal buildings, concrete floors and foundations; emptied, dug up, and removed underground tanks; and excavated underground utilities. Left the buried reactor building and contaminated soil in place with a fence around it (Nelson and Horsburgh, 1999).
Reference:

    Nelson, R.V. and J. Horsburgh. 1999. *Final Report of the Decontamination and Dismantlement of the Auxiliary Reactor Area II Facility*. INEEL/EXT-99-00905. September 1999.
    Oswald, Kyle. 2002. Personal Communication. Calculated from data used to build the ROM Model.
    Schanz, Dennis B. 2001. *Deactivation, Decontamination, and Decommissioning Projects History.* INEEL/EXT-2001-01047. August 2001.

ARA-III
Name:
    Auxiliary Reactor Area-III (Jones, 1999; Schanz, 2001)
Location:
    INEEL

Dates of Activities:
    1994-98 (Oswald, 2002)
Type of Facility:
    Reactor
Total Worker Hours:
    55,235 (18,111 project management) (Oswald, 2002)
Physical Worker Hours:
    37,124 (Oswald, 2002) (269 characterization, 64 S&M, 16,403 miscellaneous decommissioning, 7,986 decontamination, 5,835 dismantlement, 5,078 asbestos removal, 1,489 demolition and site restoration)
Total Exposure (Person-Rem):
    0.00 (Jones, 1999; Schanz, 2001)
Person-Rem Per Worker Hour:
    0.00
Size of Facility (Square Feet):
    25,132 (footprint reduction) (Schanz, 2001)
Level of Facility Radiation:
    Low
Complete or Partial Facility:
    Complete
Purpose of Facility Prior to Decommissioning:
    Constructed for development and experimental testing of the Army Gas-Cooled Reactor from 1959-65. From 1965-88, the facility was used as a component and instrumentation laboratory for testing and evaluating items used in nuclear reactor experiments (Jones, 1999).
Prior Decommissioning Activities Completed:
    Facility deactivated in 1988. Reactor building was decontaminated prior to 1994 (Jones, 1999).
Description of Decommissioning Activities:
    Removed, dismantled, and demolished nine buildings including the gas-cooled reactor building. Excavated some of the underground utilities. Structures below 10 feet were left in place, such as the boiler pit, reactor pit, reactor heater pit, and mechanical equipment pit (Jones, 1999).
Reference:
    Jones, R. W. 1999. *Final Report- Decontamination and Decommissioning of Auxiliary Reactor Area-III*. INEEL/EXT-99-00590. Rev. 0. Formerly EGG-ER-11493. November 1999.
    Oswald, Kyle. 2002. Personal Communication. Calculated from data used to build the ROM Model.
    Schanz, Dennis B. 2001. *Deactivation, Decontamination, and Decommissioning Projects History*. INEEL/EXT-2001-01047. August 2001.

ARA-IV
Name:
    Auxiliary Reactor Area-IV

Location:
    INEEL
Dates of Activities:
    1987
Type of Facility:
    Reactor
Total Worker Hours:
    No data
Physical Worker Hours:
    No data
Total Exposure (Person-Rem):
    0.00 No readings above background.
Person-Rem Per Worker Hour:
    No data
Size of Facility (Square Feet):
    5,600 (from using map scale, ARA-616 is 70 by 80)
Level of Facility Radiation:
    Low
Complete or Partial Facility:
    Complete
Purpose of Facility Prior to Decommissioning:
    Operated by the Army from 1957-65 as part of research for a compact, lightweight, mobile power reactor that could be easily transported and require minimal time for shutdown and start-up including the Gas-Cooled Reactor Experiment (GCRE) and Mobile Low Power Plant (ML-1). In 1967 the Nuclear Effects Reactor or Fast Transient Reactor (FRAN) was transported to the INEEL from the Nevada Test Site.
Prior Decommissioning Activities Completed:
    The FRAN reactor was moved to the Lawrence Livermore National Laboratory in 1970 and the ARA-IV was shutdown.
Description of Decommissioning Activities:
    Removed equipment, piping, asbestos and demolished ARA-616. Removed asbestos from ARA-617 and the fuel tank berm areas. Drained, cleaned, and backfilled the stainless steel sump. Filled, graded, and seeded the entire area.
Reference:
    Rhoades, William A. 1988. *Final Report- Decontamination and Decommissioning of the Auxiliary Reactor Area IV Facility*. EGG-2518. March 1988.

ARMF/CFRMF
Name:
    TRA-660 ARMF (Advanced Reactivity Measurement Facility) / CFRMF (Coupled Fast Reactivity Measurement Facility) (Antonson, 2002)
Location:
    INEEL

Dates of Activities:
1998 (Oswald, 2002)
Type of Facility:
Reactors
Total Worker Hours:
5,101 (2,899 project management) (Oswald, 2002)
Physical Worker Hours:
2,202 (912 characterization, 1,290 S&M, doesn't represent all worker hours for the exposure listed) (Oswald, 2002)
Total Exposure (Person-Rem):
0.393 (Antonson, 2002)
Person-Rem Per Worker Hour:
No data
Size of Facility (Square Feet):
2,400 (building size 40 by 60) (Antonson, 2002)
Level of Facility Radiation:
Medium
Complete or Partial Facility:
Complete
Purpose of Facility Prior to Decommissioning:
Two reactors were built within TRA-660, ARMF-I &II, designed after the Reactivity Measurement Facility (RMF) reactor. ARMF-II was renamed as CFRMF when a fast neutron spectrum zone was installed in the center of the core. The ARMF was used for nondestructive testing of reactor fuels and control rods. The CFRMF was used to measure fast neutron fission product capture effects and fast reactor dosimetry development (Antonson, 2002).
Prior Decommissioning Activities Completed:
Neither reactor had been operated since 1991 and the reactors were defueled in 1997 (Antonson, 2002).
Description of Decommissioning Activities:
Removed the two reactors and support equipment from the TRA-660 building; removed the canal water and sludge, decontaminated it, and backfilled the canal and sump pump pit with clean material; irradiated capsules from TRA-660; and left the building for unrestricted use (Antonson, 2002).
Reference:
Antonson, C. D. 2002. *Final Report for the Decontamination and Decommissioning of the Test Reactor Area-660*. INEEL/EXT-01-00761. Rev. 0. March 2002.
Oswald, Kyle. 2002. Personal Communication. Calculated from data used to build the ROM Model.

ARVFS
Name:
Army Reentry Vehicle Facility Station (Schanz, 2001; Thiel, 1997)

Location:

INEEL

Dates of Activities:

1994-97 (Oswald, 2002)

Type of Facility:

Storage

Total Worker Hours:

27,821 (18,277 project management) (Oswald, 2002)

Physical Worker Hours:

9,544 (Oswald, 2002) (287 characterization, 583 S&M, 2,286 deactivation, 3,441 miscellaneous decommissioning, 2,947 demolition and site restoration)

Total Exposure (Person-Rem):

0.00

Person-Rem Per Worker Hour:

0.00

Size of Facility (Square Feet):

468 (footprint reduction) (Schanz, 2001)

Level of Facility Radiation:

Low

Complete or Partial Facility:

Complete

Purpose of Facility Prior to Decommissioning:

Constructed for use by the Department of Defense for experiments with the Army Reentry Vehicle project. Immediately prior to decommissioning, it was used as a Resource Conservation and Recovery Act (RCRA) storage unit for sodium/potassium (NaK) from the Experimental Breeder Reactor-I (EBR-I) from 1974 to 1995 (Thiel, 1997).

Prior Decommissioning Activities Completed:

None listed

Description of Decommissioning Activities:

The NaK was shipped to Argonne National Laboratory-West for processing in 1995. The bunker was demolished. The area was backfilled, graded, and reseeded (Thiel, 1997).

Reference:

Oswald, Kyle. 2002. Personal Communication. Calculated from data used to build the ROM Model.

Schanz, Dennis B. 2001. *Deactivation, Decontamination, and Decommissioning Projects History*. INEEL/EXT-2001-01047. August 2001.

Thiel, T. N. 1997. Decontamination and Dismantlement of Army Reentry Vehicle Facility Station (ARVFS) Bunker B17-702. INEL/EXT-97-00469. June 1997.

BIF Filter Room
Name:
CPP-603 BIF Filter Room (BIF is a division of the New York Air Brake Company, Providence, Rhode Island)
Location:
INEEL
Dates of Activities:
1983-84
Type of Facility:
Process
Total Worker Hours:
No data
Physical Worker Hours:
No data
Total Exposure (Person-Rem):
2.234
Person-Rem Per Worker Hour:
No data
Size of Facility (Square Feet):
319 (21 by 15.17 size of BIF Filter Room)
Level of Facility Radiation:
Medium
Complete or Partial Facility:
Partial
Purpose of Facility Prior to Decommissioning:
Water used to store spent nuclear fuel was recycled through the BIF Filter Room to maintain clarity.
Prior Decommissioning Activities Completed:
None listed
Description of Decommissioning Activities:
All equipment was removed from the filter room and the remaining structure decontaminated.
Reference:
Moser, C. L. 1984. *Final Report- ICPP BIF Filter Room Decontamination and Decommissioning*. WINCO-1028. December 1984.

BORAX-V Leach Pond
Name:
Boiling Water Reactor Experiment (BORAX-V) Leach Pond
Location:
INEEL
Dates of Activities:
1984
Type of Facility:
Pit/Pond

Total Worker Hours:
497 (284 project management, decision analysis, and generation of plans/procedures)
Physical Worker Hours:
213 (demolition and site restoration)
Total Exposure (Person-Rem):
0.00 No radiation exposure occurred during this project.
Person-Rem Per Worker Hour:
0.00
Size of Facility (Square Feet):
1800 (pond basin is 20 by 90 ft)
Level of Facility Radiation:
Low
Complete or Partial Facility:
Complete
Purpose of Facility Prior to Decommissioning:
Used to collect low-level radioactively contaminated liquid discharged from BORAX-II, III, IV, and V experiments from 1954-1964.
Prior Decommissioning Activities Completed:
None listed.
Description of Decommissioning Activities:
Left contaminated soil in place, backfilled the pond with clean soil, graded and seeded the area, left the discharge pipes in place, and erected a permanent marker at the pond site.
Reference:
Smith, Donald L. 1985. *Final Report- Decontamination and Decommissioning of the BORAX-V Leach Pond.* EGG-2300. January 1985.

BORAX-V Reactor Building
Name:
Boiling Water Reactor Experiment (BORAX-V) Facility Reactor Building (Rodman, 1997; Schanz, 2001)
Location:
INEEL
Dates of Activities:
1994-98 (Oswald, 2002)
Type of Facility:
Reactor
Total Worker Hours:
16,646 (8,828 project management) (Oswald 2002)
Physical Worker Hours:
7,818 (Oswald, 2002) (622 characterization, 1,169 S&M, 2,430 entombment, 3,597 demolition and site restoration)
Total Exposure (Person-Rem):
0.00 (Rodman, 1997; Schanz, 2001)

Person-Rem Per Worker Hour:

0.00

Size of Facility (Square Feet):

9,235 (footprint reduction) (Schanz, 2001)

Level of Facility Radiation:

High

Complete or Partial Facility:

Complete

Purpose of Facility Prior to Decommissioning:

At the location of BORAX-V, a series of reactor experiments took place. BORAX-II tested new core combinations using varying enrichments of U-235. BORAX-III investigated generating electric power using BWRs. BORAX-IV tested high-thermal-capacity fuel elements. BORAX-V was used to determine safety aspects and feasibility of an integral nuclear superheat system. BORAX-V experiments were conducted in a separate reactor vessel than the vessel for BORAX-II, III, and IV (Rodman, 1997).

Prior Decommissioning Activities Completed:

BORAX-II, III, IV and V reactor fuels and internal reactor vessel components were removed and disposed or are stored at INTEC. From 1985-88, equipment was removed and the metal reactor building was relocated (Rodman, 1997).

Description of Decommissioning Activities:

Lead shielding was removed; mixed waste streams were transferred to Waste Experimental Reduction Facility (WERF); below grade pits and trenches were backfilled with soil; remaining reactor building systems, 2 reactor vessels, and asbestos were buried; and remaining support systems external to the reactor building were dismantled (Rodman, 1997).

Reference:

Oswald, Kyle. 2002. Personal Communication. Calculated from data used to build the ROM Model

Rodman, Glenn R. 1997. *Final Report of the Decontamination and Dismantlement of the BORAX-V Facility Reactor Building*. INEL-96/0325 Rev. 0. May 1997.

Schanz, Dennis B. 2001. *Deactivation, Decontamination, and Decommissioning Projects History*. INEEL/EXT-2001-01047. August 2001.

BORAX-V Turbine Building

Name:

Boiling Water Experiment (BORAX-V) Facility Turbine Building

Location:

INEEL

Dates of Activities:

1988-92

Type of Facility:

Reactor Support

Total Worker Hours:
No data
Physical Worker Hours:
No data
Total Exposure (Person-Rem):
0.00
Person-Rem Per Worker Hour:
No data
Size of Facility (Square Feet):
2,400 (60 by 40 building size)
Level of Facility Radiation:
Low
Complete or Partial Facility:
Complete
Purpose of Facility Prior to Decommissioning:
Turbine building to support operations of the BORAX-V reactor.
Prior Decommissioning Activities Completed:
None listed
Description of Decommissioning Activities:
Removed and disposed of asbestos, three underground heating fuel storage tanks and piping, and other equipment in the turbine building. Dismantled the turbine building metal structure, decontaminated concrete surfaces of the turbine building foundation, demolished and backfilled the foundation, reseeded the area, and erected a permanent marker.
Reference:
Arave, Alvin E. and Glenn R. Rodman. 1992. *Final Report of the Decontamination and Decommissioning of the BORAX-V Facility Turbine Building*. EGG-2683. December 1992.

C Reactor
Name:
Hanford C Reactor
Location:
DOE Hanford Site (Hanford)
Dates of Activities:
1996-98
Type of Facility:
Reactor
Total Worker Hours:
276,300
Physical Worker Hours:
171,306 (62% of total, improve barrier- safe storage)
Total Exposure (Person-Rem):
3.4

Person-Rem Per Worker Hour:
 2.0 E-5
Size of Facility (Square Feet):
 105,530 (346 by 305)
Level of Facility Radiation:
 High
Complete or Partial Facility:
 Complete
Purpose of Facility Prior to Decommissioning:
 Graphite-moderated production reactor to produce weapons-grade plutonium.
Prior Decommissioning Activities Completed:
 None listed
Description of Decommissioning Activities:
 Removed and demolished all portions of the reactor facility outside of the reactor block shield walls, reducing the overall footprint by 80%. Steel roofing and siding were attached to the reactor core framework to place it into safe storage condition for 75 years.
Reference:
 Pak, Paul, Dennis Houston, and Robert F. Potter. 2000. D&D of Hanford's Retired Production Reactors: An Opportunity to Demonstrate Best Commercial Procurement Practices. *Waste Management 2000 Conference*.

C&S Building
Name:
 Certification and Segregation (C&S) Building (Bruce, 1999; Schanz, 2001)
Location:
 INEEL
Dates of Activities:
 1998 (Oswald, 2002)
Type of Facility:
 Storage
Total Worker Hours:
 5,723 (2,101 project management) (Oswald, 2002)
Physical Worker Hours:
 3,622 (Oswald, 2002) (22 characterization, 3,600 deactivation)
Total Exposure (Person-Rem):
 0.00 (Bruce, 1999; Schanz, 2001)
Person-Rem Per Worker Hour:
 0.00
Size of Facility (Square Feet):
 143,550 (footprint reduction) (Schanz, 2001)
Level of Facility Radiation:
 Low

Complete or Partial Facility:
Complete
Purpose of Facility Prior to Decommissioning:
Used to store Transuranic (TRU) waste on an asphalt pad with a fabric air support structure covering the asphalt pad and waste (Bruce, 1999).
Prior Decommissioning Activities Completed:
None listed
Description of Decommissioning Activities:
Removed TRU waste and demolished the air support structure and concrete foundation (Bruce, 1999).
Reference:
Bruce, J. E. 1999. *Final Report of the Decontamination and Decommissioning of the Certified and Segregated Building*. INEEL-96-0325. Rev. 0. September 1999.
Oswald, Kyle. 2002. Personal Communication. Calculated from data used to build the ROM Model.
Schanz, Dennis B. 2001. *Deactivation, Decontamination, and Decommissioning Projects History*. INEEL/EXT-2001-01047. August 2001.

Chloride Removal System
Name:
CPP-603 Annex Chloride Removal System
Location:
INEEL
Dates of Activities:
1992
Type of Facility:
Process
Total Worker Hours:
No data
Physical Worker Hours:
No data
Total Exposure (Person-Rem):
0.563
Person-Rem Per Worker Hour:
No data
Size of Facility (Square Feet):
2800 (size of annex from map of CPP-603)
Level of Facility Radiation:
Low
Complete or Partial Facility:
Partial

Purpose of Facility Prior to Decommissioning:
Used for removing chloride ions and other contaminants that were suspended in the waters of the underwater fuel storage basins in the CPP-603 Fuel Receiving and Storage Facility (FRSR).
Prior Decommissioning Activities Completed:
None listed
Description of Decommissioning Activities:
Removed asbestos and all process and electrical equipment, decontaminated the annex, and demolished the contaminant structure and restored the site.
Reference:
Moser, C. L. 1993. *Final Report- CPP-603 Chloride Removal System Decontamination and Decommissioning*. WINCO-1124. February 1993.

Contaminated Filter Building
Name:
TA (Technical Area)-21-153 Contaminated Filter Building
Location:
Los Alamos National Laboratory (LANL)
Dates of Activities:
1978
Type of Facility:
Process
Total Worker Hours:
No data
Physical Worker Hours:
9,067
Total Exposure (Person-Rem):
Not listed in total person-rem, 8 workers received exposure with the highest exposure being 0.02 rem
Person-Rem Per Worker Hour:
No data
Size of Facility (Square Feet):
4,306 (two-story, 200 sq m)
Level of Facility Radiation:
Not Ranked
Complete or Partial Facility:
Complete
Purpose of Facility Prior to Decommissioning:
The filter building was used to clean the exhaust air from several buildings at TA-21.
Prior Decommissioning Activities Completed:
The facility was shutdown in 1970 and accessible parts of the building were decontaminated.

Description of Decommissioning Activities:

Equipment within the building was dismantled and the building was demolished.

Reference:

Harper, Johnny R. and Raymond Garde. 1981. *The Decommissioning of TA-21-153, A ^{227}Ac Contaminated Old Filter Building*. LA-9047-MS. November 1981.

CPP-631/709/734

Name:

CPP-631 RaLa Off-Gas Cell, CPP-709 East-Site Service Waste (ESSW), CPP-734 West-Side Service Waste (WSSW) (Frazee, 2000)

Location:

INEEL

Dates of Activities:

1996-98 (Oswald, 2002)

Type of Facility:

Process

Total Worker Hours:

10,591 (2,939 project management) (Oswald, 2002)

Physical Worker Hours:

7,652 (Oswald, 2002) (419 decontamination, 2,275 dismantlement, 4,958 demolition and site restoration)

Total Exposure (Person-Rem):

<0.015 (Frazee, 2000; Schanz, 2001)

Person-Rem Per Worker Hour:

2.0E-6

Size of Facility (Square Feet):

260 (CPP-631 = 100, CPP-709 = 80,CPP-734 = 80, footprint reduction) (Schanz, 2001)

Level of Facility Radiation:

Medium

Complete or Partial Facility:

Partial

Purpose of Facility Prior to Decommissioning:

CPP-631 was used to extract Ba-140 from an off-gas waste stream resulting from reprocessing spent fuel in CPP-601. CPP-709 (ESSW) and CPP-734 (WSSW) are monitoring system buildings to monitor wastewater before it flowed into injection wells (Frazee, 2000).

Prior Decommissioning Activities Completed:

All of the equipment was removed from CPP-631 by 1986 (Frazee, 2000), see RaLa off-gas cell and storage tank decommissioning case study.

Description of Decommissioning Activities:

Removed asbestos and waste materials, demolished structures, and regarded the area (Frazee, 2000).

Reference:

Frazee, B. J. 2000. *Final Report of the Decontamination and Dismantlement of CPP-631, CPP-709, and CPP-734*. INEEL/EXT-97-00856 Rev. 0. February 2000.

Oswald, Kyle. 2002. Personal Communication. Calculated from data used to build the ROM Model.

Schanz, Dennis B. 2001. *Deactivation, Decontamination, and Decommissioning Projects History*. INEEL/EXT-2001-01047. August 2001.

60” Cyclotron Facility

Name:

60” Cyclotron Facility

Location:

Argonne National Laboratory – East (ANL-E)

Dates of Activities:

1997-2001

Type of Facility:

Research

Total Worker Hours:

No data

Physical Worker Hours:

No data

Total Exposure (Person-Rem):

0.436 (Prep Activities = 0.001, Hot Lab and Caves = 0.411, Cyclotron Disassembly = 0.023, Project Closeout = 0.001)

Person-Rem Per Worker Hour:

No data

Size of Facility (Square Feet):

4,000 (Main floor of facility 40 by 50 and basement)

Level of Facility Radiation:

Not Ranked

Complete or Partial Facility:

Complete

Purpose of Facility Prior to Decommissioning:

This facility operated for research and medical radioisotope production form 1952-1992.

Prior Decommissioning Activities Completed:

Some areas of the facility had been released for reuse prior to 1997.

Description of Decommissioning Activities:

Removed radioactive material, dismantled the Cyclotron support equipment, removed asbestos pipe insulation, dismantled and decontaminated caves, and decontaminated the facility for reuse.

Reference:

Collins, Edward L., Julien Boyance, Frances R. Clark, D. John Tinnin, and Andre Williams. 2001. Decontamination and Decommissioning of the 60”

Cyclotron Facility at Argonne National Laboratory-East Project Final Report. ANL/D&D/01-1. February 2001.

190-D Complex

Name:

Hanford 190-D Complex

Location:

Hanford

Dates of Activities:

1995

Type of Facility:

Research

Total Worker Hours:

No data

Physical Worker Hours:

59,485 (16,400 characterization, 3,770 deactivation, 10,555 decontamination and dismantlement, 17,434 asbestos removal, 11,326 demolition and site restoration)

Total Exposure (Person-Rem):

0.00

Person-Rem Per Worker Hour:

0.00

Size of Facility (Square Feet):

134,260 (building sizes 540 by 56, 456 by 110, 198 by 80, 304 by 76, 304 by 48, and 18 by 18)

Level of Facility Radiation:

High

Complete or Partial Facility:

Complete

Purpose of Facility Prior to Decommissioning:

The 190-D complex, located within the 100-D Area of the Hanford Site (which contained two out of nine plutonium production reactors), was modified to be a research and development laboratory for all of the plutonium production reactors at the Hanford site. The following buildings are included in this decommissioning project: a de-aeration building, refrigeration building, tank room highbay, process pump room and annex, vertical safety rod test tower, and underwater test facility.

Prior Decommissioning Activities Completed:

Facility shutdown in 1987 and 1988 with minimal surveillance and maintenance activities performed.

Description of Decommissioning Activities:

Removed hazardous materials, dismantled equipment piping and utility infrastructure, decontaminated, demolished the structure, and restored the site.

Reference:

Thoren, S. D. 1996. *Final Report for the 190-D Complex Decontamination and Decommissioning*. BHI-00903 Rev. 0. September 1996.

EBWR
Name:
Experimental Boiling Water Reactor (EBWR)
Location:
ANL-E
Dates of Activities:
1986-1996
Type of Facility:
Reactor
Total Worker Hours:
No data
Physical Worker Hours:
No data
Total Exposure (Person-Rem):
20.87
Person-Rem Per Worker Hour:
No data
Size of Facility (Square Feet):
No data
Level of Facility Radiation:
Medium
Complete or Partial Facility:
Complete
Purpose of Facility Prior to Decommissioning:
A test reactor built to show the feasibility of operating an integrated power plant using a direct cycle boiling water reactor as a heat source.
Prior Decommissioning Activities Completed:
The reactor was shutdown in 1967 and deactivated by draining and flushing the primary, secondary, and auxiliary systems. The nuclear fuel was removed and the storage pool was drained, flushed, and decontaminated. Several buildings surrounding the reactor were demolished or prepared for reuse before 1980, while the reactor remained in safe storage until 1986.
Description of Decommissioning Activities:
Removed radioactive materials and asbestos insulation, dismantled reactor piping system and reactor vessel components, and decontaminated the facility for unrestricted reuse.
Reference:
Fellhauer, C. R., L. E. Boing, and J. Aldana. 1996. *Decontamination and Decommissioning of the Experimental Boiling Water Reactor (EBWR): Project Final Report, Argonne National Laboratory*. ANL/D&D/TM-96/4. March 1997.

ETR
Name:
Engineering Test Reactor (Buckland et al., 1995)

Location:
INEEL
Dates of Activities:
1994-97 (Oswald, 2002)
Type of Facility:
Reactor
Total Worker Hours:
5,565 (2594 project management) (Oswald, 2002)
Physical Worker Hours:
Worker hour data incomplete 2,971 (Oswald, 2002) (2,443 characterization, 31 S&M, 497 miscellaneous decommissioning)
Total Exposure (Person-Rem):
No data
Person-Rem Per Worker Hour:
No data
Size of Facility (Square Feet):
63,461 (building sizes ETR reactor (TRA-642) 136 by 112, compressor (TRA-643) 125 by 108, heat exchanger (TRA-644) 2-level 66.5 by 78, secondary coolant pump house (TRA-645) 40 by 92, office building (TRA-647) 42.5 by 25.5, electrical (TRA-648) 2-level 54 by 115, critical facility (TRA-654) 40 by 50, diesel building (TRA-663) 53.5 by 19, transformer (TRA-752) 110 by 33.5, air intake (TRA-655) 12 by 25, filter pit (TRA-755) 13 by 13) (Buckland et al., 1995)
Level of Facility Radiation:
High
Complete or Partial Facility:
Complete
Purpose of Facility Prior to Decommissioning:
The ETR was built and began operation in 1957 to provide higher flux testing space, more stable flux, and a variety of flux levels compared to the MTR. In 1972, it was modified to support the breeder reactor safety program. In 1975, the reactor was modified to include an irradiation loop, a helium coolant system, and a sodium-handling system (Buckland et al., 1995).
Prior Decommissioning Activities Completed:
In 1982 the sodium in the loops was removed and the system flushed to deactivate the ETR (Buckland et al., 1995).
Description of Decommissioning Activities:
Complete decommissioning activities have not taken place, this information represents initial characterization and clean up activities to assist in the decision analysis process (Buckland et al., 1995).
Reference:
Oswald, Kyle. 2002. Personal Communication. Calculated from data used to build the ROM Model.

Buckland, R. J., D. J. Kenoyer, and S. A. LaBuy. 1995. *INEL D&D Long-Range Plan*. INEL-95/0453. September 1995.

Gamma Irradiation Facility
Name:
Building 830 Gamma Irradiation Facility
Location:
Brookhaven National Laboratory
Dates of Activities:
1999-2000
Type of Facility:
Storage
Total Worker Hours:
No data
Physical Worker Hours:
No data
Total Exposure (Person-Rem):
0.14
Person-Rem Per Worker Hour:
No data
Size of Facility (Square Feet):
80 (Pool size 8 by 10 feet)
Level of Facility Radiation:
Not Ranked
Complete or Partial Facility:
Partial
Purpose of Facility Prior to Decommissioning:
This facility was a storage pool for 354 stainless steel encapsulated cobalt-60 sources. The pool was not in compliance with current hazardous tank standards and the cobalt-60 sources were approaching the end of their useful life.
Prior Decommissioning Activities Completed:
None listed
Description of Decommissioning Activities:
Removed, packaged, and disposed of sources in pool, dismantled equipment and plumbing around the pool, discharged water from the pool, the pool liner was removed and the pit filled in and covered at floor level.
Reference:
Bowerman, Biays, Patrick T. Sullivan, and Douglas Moore. 2001. Decommissioning the Brookhaven National Laboratory Building 830 Gamma Irradiation Facility. *Waste Management 2001 Conference Proceedings*.

HB-2 Cubicle
Name:
MTR-603 HB-2 Cubicle
Location:
INEEL

Dates of Activities:
    1985
Type of Facility:
    Research
Total Worker Hours:
    4072 (1565 project management)
Physical Worker Hours:
    2507 (dismantlement)
Total Exposure (Person-Rem):
    0.765 (pipe fitters = 0.465, welders = 0.095, insulators = 0.120, equipment operators = 0.050, and supervisors = 0.035)
Person-Rem Per Worker Hour:
    3.1E-4
Size of Facility (Square Feet):
    1400 (amount of floor space available for reuse following decommissioning)
Level of Facility Radiation:
    High
Complete or Partial Facility:
    Partial
Purpose of Facility Prior to Decommissioning:
    Used for MTR out-of-pile circulating water loop experiments conducted during the 1950s and 60s.
Prior Decommissioning Activities Completed:
    None listed.
Description of Decommissioning Activities:
    Removed the cubicle contents, dismantled the cubicle walls, and decontaminated the area for reuse of floor space within the building.
Reference:
    Smith, Donald L. 1985. *Final Report- Decontamination and Decommissioning of the MTR-603 HB-2 Cubicle.* EGG-2431. December 1985.

Hot Cells
Name:
    Hot Cells K-1, K-3, M-1, M-3, and A-1, M-Wing, Building 200
Location:
    ANL-E
Dates of Activities:
    1992-96
Type of Facility:
    Research
Total Worker Hours:
    No data
Physical Worker Hours:
    No data

Total Exposure (Person-Rem):
7.45
Person-Rem Per Worker Hour:
No data
Size of Facility (Square Feet):
No Data
Level of Facility Radiation:
Medium
Complete or Partial Facility:
Partial
Purpose of Facility Prior to Decommissioning:
The M-Wing hot cells were used for isotope separation and research on heavy radioactive isotopes.
Prior Decommissioning Activities Completed:
None listed
Description of Decommissioning Activities:
Size-reduced, packaged, and removed radioactive materials and equipment and decontaminated the hot cells for restricted reuse.
Reference:
Cheever, C. L. and R. W. Rose. 1996. *Decontamination of Hot Cells K-1, K-3, M-1, M-3, and A-1, M-Wing, Building 200: Project Final Report Argonne National Laboratory – East*. ANL/D&D/TM-96/2. September 1996.

Hot Laundry
Name:
CFA-669 Hot Laundry (Schanz, 2001; Smith and Perry, 1995)
Location:
INEEL
Dates of Activities:
1994-95 (Oswald, 2002)
Type of Facility:
Other
Total Worker Hours:
11,559 (3489 project management) (Oswald, 2002)
Physical Worker Hours:
8,070 (Oswald, 2002) (201 asbestos removal, 7,869 demolition and site restoration)
Total Exposure (Person-Rem):
0.00 (Schanz, 2001; Smith and Perry 1995)
Person-Rem Per Worker Hour:
0.00
Size of Facility (Square Feet):
4,494 (footprint reduction) (Schanz, 2001)
Level of Facility Radiation:
Low

Complete or Partial Facility:
Complete
Purpose of Facility Prior to Decommissioning:
Constructed in 1950 to serve as the hot and cold laundry for site contractors. This facility was used until 1981 (Smith and Perry, 1995).
Prior Decommissioning Activities Completed:
None listed
Description of Decommissioning Activities:
Physical worker hours only account for asbestos removal and demolition and site restoration (Oswald, 2002). Additional worker hours not accounted for.
Reference:
Oswald, Kyle. 2002. Personal Communication. Calculated from data used to build the ROM Model.
Schanz, Dennis B. 2001. *Deactivation, Decontamination, and Decommissioning Projects History*. INEEL/EXT-2001-01047. August 2001.
Smith, D. L. and E. F. Perry. 1995. *Final Report- Decontamination and Dismantlement of the Old Hot Laundry, CFA-669*. INEL-94/0139. January 1995.

IET Facility
Name:
TAN-620 Initial Engine Test (IET) Facility (Howell and Long, 2001; Schanz, 2001)
Location:
INEEL
Dates of Activities:
1997-2000 (Howell and Long, 2001) (Worker hours for activities in 1998 (Oswald, 2002))
Type of Facility:
Research
Total Worker Hours:
14,949 project management (Oswald, 2002)
Physical Worker Hours:
No data
Total Exposure (Person-Rem):
0.00
Person-Rem Per Worker Hour:
No data
Size of Facility (Square Feet):
13,981 (footprint reduction) (Schanz, 2001)
Level of Facility Radiation:
Low
Complete or Partial Facility:
Complete

Purpose of Facility Prior to Decommissioning:

The IET facility was constructed to perform experiments for developing a nuclear powered aircraft engine in the 1950s. After the program stopped, the facilities were used for other programs and storage until the 1980s (Howell and Long, 2001).

Prior Decommissioning Activities Completed:

In the 1980s, the aboveground structures and contamination were removed. The underground structures were left in place and covered with soil (Howell and Long, 2001).

Description of Decommissioning Activities:

Decommissioned two underground structures (TAN-620 and –656), dismantled equipment within these two structures including electrical, mechanical, ventilation systems, associated piping, and sumps. Aboveground structures included the Coupling Station, Test Pad, and railroad tracks (Howell and Long, 2001).

Reference:

Howell, W. F. and J. D. Long. 2001. *Final Report of the Decontamination and Decommissioning of the Test Area North Initial Engine Test Facility, Railroad, and Underground Utilities*. INEEL/EXT-2000-01112. January 2001.

Oswald, Kyle. 2002. Personal Communication. Calculated from data used to build the ROM Model.

Schanz, Dennis B. 2001. *Deactivation, Decontamination, and Decommissioning Projects History*. INEEL/EXT-2001-01047. August 2001.

Janus Reactor

Name:

Janus Reactor

Location:

ANL-E

Dates of Activities:

1995-97

Type of Facility:

Reactor

Total Worker Hours:

No Data

Physical Worker Hours:

18,174

Total Exposure (Person-Rem):

0.482

Person-Rem Per Worker Hour:

2.7 E-5

Size of Facility (Square Feet):

No data

Level of Facility Radiation:

Medium

Complete or Partial Facility:
 Complete
Purpose of Facility Prior to Decommissioning:
 A biological research facility used to study the effects of high and low fluence of neutron radiation on animals.
Prior Decommissioning Activities Completed:
 The reactor operated from 1963-1992 and was defueled in 1993.
Description of Decommissioning Activities:
 Removed radioactive and hazardous materials, and decontaminated the reactor facility to unrestricted use levels.
Reference:
 Fellhauer, C. R., G. A.Garlock, and F. R. Clark. 1997. *Decontamination and Dismantlement of the JANUS Reactor at Argonne National Laboratory-East Project Final Report*. ANL/D&D/97-1. October 1997.

K-25 Cooling Towers
Name:
 Oak Ridge K-25 Cooling Towers
Location:
 Oak Ridge National Laboratory (ORNL)
Dates of Activities:
 Before 1997 (possible 1990-97)
Type of Facility:
 Reactor Support
Total Worker Hours:
 Over 200,000
Physical Worker Hours:
 124,000 (62% of total)
Total Exposure (Person-Rem):
 No data
Person-Rem Per Worker Hour:
 No data
Size of Facility (Square Feet):
 No data
Level of Facility Radiation:
 Not Ranked
Complete or Partial Facility:
 Partial
Purpose of Facility Prior to Decommissioning:
 The cooling towers and auxiliary facilities were associated with the gaseous diffusion process for uranium enrichment.
Prior Decommissioning Activities Completed:
 None listed

Description of Decommissioning Activities:

Demolished 6 cooling tower superstructures, removed sediment from the cooling tower basins, and demolished 28 above-grade basins and auxiliary facilities.

Reference:

Larson, E. P., A.C. Lay, T. L. Hatmaker, R. DiDonato, and R. L. Yust, "Demolition of Cooling Towers at the Oak Ridge K-25 Site, Oak Ridge, Tennessee." *Waste Management 1997 Conference*, 29 April 1997, <http://www.wmsym.org/wm97/Index.html> (Date of access 29 January 2002).

LAPRE 11 Reactor

Name:

TA-35 Power Reactor Experiment No. 11 (LAPRE 11)

Location:

LANL

Dates of Activities:

1989-91

Type of Facility:

Reactor

Total Worker Hours:

No data

Physical Worker Hours:

No data

Total Exposure (Person-Rem):

Less than 1 person-rem

Person-Rem Per Worker Hour:

No data

Size of Facility (Square Feet):

No data

Level of Facility Radiation:

Not Ranked

Complete or Partial Facility:

Complete

Purpose of Facility Prior to Decommissioning:

This reactor was a test for a compact homogeneous 800 kW water-cooled reactor.

Prior Decommissioning Activities Completed:

None listed

Description of Decommissioning Activities:

Removed the concrete shield plug, reactor and heat exchanger, reactor safety enclosure, fuel reservoir tank, emergency fuel recovery system, primary pump pit, secondary loop, associated piping, and contaminated soil.

Reference:

Montoya, Gilbert M. 1993. *Final Project Report- TA-35 Los Alamos Power Reactor Experiment No. II (LAPRE II) Decommissioning Project*. LA-12464. February 1993.

Liquid Waste Treatment Facility

Name:

TAN-616 Liquid Waste Treatment Facility (Jones, 2002)

Location:

INEEL

Dates of Activities:

1997 (Oswald, 2002)

Type of Facility:

Process

Total Worker Hours:

2,718 (2,407 project management) (Oswald, 2002)

Physical Worker Hours:

Worker hour data incomplete 311 (311 characterization) (Oswald, 2002)

Total Exposure (Person-Rem):

No data

Person-Rem Per Worker Hour:

No data

Size of Facility (Square Feet):

2,000 (size of TAN-616) (Jones, 2002)

Level of Facility Radiation:

High

Complete or Partial Facility:

Complete

Purpose of Facility Prior to Decommissioning:

Treated liquid wastes from TAN decontamination processes in a stainless steel evaporator. The facility operated until the evaporator malfunctioned several times and leaked process solutions onto the evaporator pit floor due to stress cracks on the bottom of the tank (Jones, 2002).

Prior Decommissioning Activities Completed:

The facility was shutdown and deactivated in 1972. In 1993, the cooling tower and the evaporator pit exhaust fan and stack were removed (Jones, 2002).

Description of Decommissioning Activities:

Decommissioning has not taken place, the worker hours represent characterization work to help with the decision process (Jones, 2002).

Reference:

Oswald, Kyle. 2002. Personal Communication. Calculated from data used to build the ROM Model.

Jones, R.W. 2002. Hazard Assessment for the Decontamination and Dismantlement of the TAN-616 Liquid Waste Treatment Facility. INEEL/EXT-01-00897. Rev. 0. January 2002.

LOFT MTA

Name:

LOFT (Loss-of-Fluid Test) MTA (Mobile Test Assembly) (Smith, 1993)

Location:
INEEL
Dates of Activities:
1994-98 (Oswald, 2002)
Type of Facility:
Reactor
Total Worker Hours:
12,046 (282 project management) (Oswald, 2002)
Physical Worker Hours:
11,764 (Oswald, 2002) (5,345 characterization, 642 S&M, 111 miscellaneous decommissioning, 5,666 dismantlement)
Total Exposure (Person-Rem):
No data
Person-Rem Per Worker Hour:
No data
Size of Facility (Square Feet):
1,141 (20 by 46 dolly, 13 ft high by 17 ft diameter shield tank) (Buckland et al., 1995)
Level of Facility Radiation:
High
Complete or Partial Facility:
Complete
Purpose of Facility Prior to Decommissioning:
The LOFT Facility operated from 1978-1985 to simulate loss of reactor coolant testing and provide experimental data during these accident conditions. The MTA was a removable shielding tank that surrounded the LOFT reactor core (Smith, 1993).
Prior Decommissioning Activities Completed:
None listed
Description of Decommissioning Activities:
The MTA was moved to the TAN Hot Shop in order to disassemble, size, package, and dispose of the MTA (Smith, 1993). (This is documented in the plan reports. No final report of the activities could be found.)
Reference:
Buckland, R. J., D. J. Kenoyer, and S. A. LaBuy. 1995. *INEL D&D Long-Range Plan*. INEL-95/0453. September 1995.
Oswald, Kyle. 2002. Personal Communication. Calculated from data used to build the ROM Model.
Smith, D. L. 1993. *Decontamination and Decommissioning Plan for the LOFT Mobile Test Assembly*. EGG-ER-10594. February 1993.

MTR OWR
Name:
MTR Overhead Working Reservoir (OWR)

Location:
INEEL
Dates of Activities:
1975
Type of Facility:
Process
Total Worker Hours:
No data
Physical Worker Hours:
No data
Total Exposure (Person-Rem):
20.8
Person-Rem Per Worker Hour:
No data
Size of Facility (Square Feet):
1,472 (32 ft diameter by 46 ft tall)
Level of Facility Radiation:
Medium
Complete or Partial Facility:
Partial
Purpose of Facility Prior to Decommissioning:
Used to hold MTR primary cooling water, which was radioactively contaminated.
Prior Decommissioning Activities Completed:
None listed
Description of Decommissioning Activities:
The overhead working reservoir was dropped to the ground, the tank interior was sprayed to fix the contamination, and the tank and piping were disposed of at the RWMC.
Reference:
Lunis, B. C. 1975. *Removal of the Materials Test Reactor Overhead Working Reservoir*. ANCR-1257. October 1975.

N Area
Name:
Hanford N Area
Location:
Hanford
Dates of Activities:
1994-98 (Environmental Restoration at Hanford, 1998a)
Type of Facility:
Reactor
Total Worker Hours:
943,500 (Environmental Restoration at Hanford, 1998a)
Physical Worker Hours:
584,970 (62% of total, deactivation)

Total Exposure (Person-Rem):
175.014 (Environmental Restoration at Hanford, 1998a)
Person-Rem Per Worker Hour:
3.0 E-4
Size of Facility (Square Feet):
No data
Level of Facility Radiation:
High
Complete or Partial Facility:
Complete
Purpose of Facility Prior to Decommissioning:
The N Reactor facility was used for producing special nuclear materials and electricity. It operated from 1963 to 1987 (Environmental Restoration at Hanford, 1998b).
Prior Decommissioning Activities Completed:
The N Reactor was defueled and the systems drained in 1987 (Environmental Restoration at Hanford, 1998b).
Description of Decommissioning Activities:
The N Reactor and its supporting 86 facilities in the N Area were deactivated. This included removing hardware, debris, sediment, and water from the N Basin (Environmental Restoration at Hanford, 1998a).
Reference:
Environmental Restoration at Hanford. 1998a. *N Area Project Closeout Summary*. Presentation to BHI (Bechtel Hanford, Inc.) Board of Directors. December 8, 1998.
Environmental Restoration at Hanford. 1998b. *Innovative Work Practices and Lessons Learned at the N Area Deactivation Project*. BHI-01222. September 1998.

OMRE
Name:
Organic Moderated Reactor Experiment (OMRE) Facility
Location:
INEEL
Dates of Activities:
1977-79
Type of Facility:
Reactor
Total Worker Hours:
No data
Physical Worker Hours:
No data
Total Exposure (Person-Rem):
4.153

Person-Rem Per Worker Hour:
No data
Size of Facility (Square Feet):
4,300 (building size)
Level of Facility Radiation:
High
Complete or Partial Facility:
Complete
Purpose of Facility Prior to Decommissioning:
This reactor was designed to investigate the use of an organic coolant and was in operation from 1957 to 1963.
Prior Decommissioning Activities Completed:
Deactivation took place immediately following shutdown in 1963. Nuclear fuel and reactor vessel internals were removed and the organic coolant was drained from all systems.
Description of Decommissioning Activities:
Removed and disposed of all contaminated articles (plant hardware, soil, basalt rock); removed piping and electrical system; disassembled air blast heat exchanger; removed process and control building in sections, excavated underground tanks; demolished concrete parts of the facility; and removed pressure vessel, silo, and reactor pad.
Reference:
Hine, Robert E. 1980. *Decontamination and Decommissioning of the Organic Moderated Reactor Experiment Facility (OMRE).* EGG-2059. September 1980.

Plug Storage Facility
Name:
MTR-657 Plug Storage Facility
Location:
INEEL
Dates of Activities:
1982-83
Type of Facility:
Storage
Total Worker Hours:
2,054 (1,116 project management)
Physical Worker Hours:
938
Total Exposure (Person-Rem):
0.05
Person-Rem Per Worker Hour:
5.3E-5
Size of Facility (Square Feet):
1,408 (29 ft by 14.8 m (48.544 ft))

Level of Facility Radiation:
High
Complete or Partial Facility:
Partial
Purpose of Facility Prior to Decommissioning:
Storage for plugs used during experiments in the MTR. Experimental assemblies were contained in the plugs and inserted into beam holes that penetrated the reactor shielding to allow access to the core region of the reactor for testing.
Prior Decommissioning Activities Completed:
None listed.
Description of Decommissioning Activities:
Remove the contents of the storage holes, decontaminate the interior of the holes, and leave the facility intact for future use as a shielded storage facility.
Reference:
Kaiser, Linda L. 1984. *Decontamination and Decommissioning MTR-657 Plug Storage Facility*. EGG-2286. January 1984.

Plutonium Gloveboxes
Name:
61 Plutonium Gloveboxes in the D-Wing of Building 212
Location:
ANL-E
Dates of Activities:
1992-96
Type of Facility:
Research
Total Worker Hours:
No data
Physical Worker Hours:
No data
Total Exposure (Person-Rem):
1.26
Person-Rem Per Worker Hour:
No data
Size of Facility (Square Feet):
No data
Level of Facility Radiation:
Not Ranked
Complete or Partial Facility:
Partial
Purpose of Facility Prior to Decommissioning:
Used from the early 1960s to 1989 for research on nuclear reactor fuel development and for determination of properties of actinide metals.
Prior Decommissioning Activities Completed:
None listed

Description of Decommissioning Activities:
Removed and packaged the contents of the plutonium gloveboxes; decontaminated, size-reduced, and packaged the gloveboxes; and decontaminated the laboratories for unrestricted use.
Reference:
Cheever, C. L. and R. W. Rose. 1996. *Decontamination and Decommissioning of 61 Plutonium Gloveboxes in D-Wing, Building 212 Argonne National Laboratory – East: Final Project Report*. ANL/D&D/TM-96/3. September 1996.

PM-2A
Location:
INEEL
Dates of Activities:
1978-82
Type of Facility:
Process
Total Worker Hours:
12,729 (4,915 project management)
Physical Worker Hours:
7,814 (5517 deactivation, 2297 demolition and site restoration)
Total Exposure (Person-Rem):
1.64
Person-Rem Per Worker Hour:
2.1E-4
Size of Facility (Square Feet):
73,500 (175 by 420 PM-2A boundaries)
Level of Facility Radiation:
Medium
Complete or Partial Facility:
Complete
Purpose of Facility Prior to Decommissioning:
Used to process waste from the TAN/TSF (Test Support Facility) liquid waste system.
Prior Decommissioning Activities Completed:
None listed.
Description of Decommissioning Activities:
Cut, characterized, and capped the liquid waste line pipes; removed, boxed, and shipped the most contaminated soil to the RWMC for burial; and dried the sludge in the underground tanks using diatomaceous earth and left the tanks and sludge buried.

Reference:

Smith, Donald L. 1983. *Final Report- Decontamination and Decommissioning of TAN Radioactive Liquid Waste Evaporator System (PM-2A)*. EGG-2236. March 1983.

PREPP

Name:

Process Experimental Pilot Plant Incinerator and Waste Stabilization Units

Location:

INEEL

Dates of Activities:

1999-2000

Type of Facility:

Research

Total Worker Hours:

No data

Physical Worker Hours:

No data

Total Exposure (Person-Rem):

0.00

Person-Rem Per Worker Hour:

No data

Size of Facility (Square Feet):

37,695 (footprint reduction)

Level of Facility Radiation:

Low

Complete or Partial Facility:

Complete

Purpose of Facility Prior to Decommissioning:

Designed and constructed to demonstrate a full-scale method for processing transuranic (TRU) waste into an acceptable form for disposal in Waste Isolation Pilot Plant (WIPP).

Prior Decommissioning Activities Completed:

Batches of sand were processed to clean the incinerator of hazardous residues, but heavy metals were found in the sand residues. The incinerator was deactivated and placed in standby condition in 1989.

Description of Decommissioning Activities:

Removed loose contamination, decontaminated equipment, cleaned ancillary equipment, and recycled, reused or sold materials.

Reference:

Schanz, Dennis B. 2001. *Deactivation, Decontamination, and Decommissioning Projects History*. INEEL/EXT-2001-01047. August 2001.

Process Cells A, B, C, D, and L
Name:
CPP-601 Process Cells A, B, C, D, and L
Location:
INEEL
Dates of Activities:
1980-84
Type of Facility:
Process
Total Worker Hours:
No data
Physical Worker Hours:
No data
Total Exposure (Person-Rem):
18.906 (A = 0.866, B = 1.499, C = 1.454, D = 6.887, L = 8.02, out of cell = 0.18)
Person-Rem Per Worker Hour:
No data
Size of Facility (Square Feet):
1602 (A = 15 by 19, B = 15 by 19, C = 20 by 19, D = 20 by 19, L = 16 by 17)
Level of Facility Radiation:
High
Complete or Partial Facility:
Partial
Purpose of Facility Prior to Decommissioning:
Process cells containing equipment and controls for separating uranium from fission products. A Cell contained fuel dissolvers, transfer tank, feed preparation tank, and off-gas condensers. B Cell contained uranium-solution storage tanks. C Cell contained process lines for dissolution of uranium-aluminum alloy fuels. D Cell is identical to C Cell. L Cell contained dissolved irradiated aluminum alloy fuel elements and isolated 140 Ba.
Prior Decommissioning Activities Completed:
None listed
Description of Decommissioning Activities:
Dismantled and removed equipment within cells, decontaminated cells, and shipped waste to RWMC.
Reference:
Smith, Donald L. and Jack G. Scott. 1984. *Final Report- Decontamination and Decommissioning of CPP-601 Process Cells "A," "B," "C," "D," and "L"*. EGG-2304. September 1984.

Process Water Building
Name:
MTR-605 Process Water Building
Location:
INEEL

Dates of Activities:
    1983-84
Type of Facility:
    Process
Total Worker Hours:
    6,342 (1,669 project management)
Physical Worker Hours:
    4,673
Total Exposure (Person-Rem):
    4.5
Person-Rem Per Worker Hour:
    7.1E-4
Size of Facility (Square Feet):
    9,120 (building is 120 by 76 ft)
Level of Facility Radiation:
    High
Complete or Partial Facility:
    Complete
Purpose of Facility Prior to Decommissioning:
    This building was used to control and condition reactor cooling water for the MTR.
Prior Decommissioning Activities Completed:
    None listed
Description of Decommissioning Activities:
    Removed contaminated equipment including piping, valves, coolant pump, and evaporators.
Reference:
    Browder, Joe H. and Evert L. Wills. 1985. *Final Report- Decommissioning of the MTR-605 Process Water Building at the Idaho National Engineering Laboratory*. EGG-2361. January 1985.

Pu-238 Facility
Name:
    Plutonium-238 Facility
Location:
    Savannah River Site
Dates of Activities:
    Before 1994 (6 month duration of activities)
Type of Facility:
    Process
Total Worker Hours:
    65,982 (5,070 project management, number of staffed personnel listed so worker hours calculated assuming 160 worker-hours/month)
Physical Worker Hours:
    60,912 (deactivation)

Total Exposure (Person-Rem):
26
Person-Rem Per Worker Hour:
4.3 E-4
Size of Facility (Square Feet):
10,000 (data reflects decommissioning of 1/3 of the building)
Level of Facility Radiation:
Not Ranked
Complete or Partial Facility:
Complete
Purpose of Facility Prior to Decommissioning:
This facility was used to produce radioisotopic heat source Pu-238 material for NASA programs from 1963-1984.
Prior Decommissioning Activities Completed:
None listed
Description of Decommissioning Activities:
Emptied and removed process cabinets and decontaminated these areas. This represents only 1/3 of the entire decommissioning project.
Reference:
Smith, R. H. Jr. and H. E. Hootman. 1994. Dismantlement and Decontamination of a Plutonium-238 Facility at the Savannah River Site. *Waste Management 1994 Conference: Technology and Programs for Radioactive Waste Management and Environmental Restoration*. 3:2029-2032.

RaLa Off-gas Cell and Storage Tank
Name:
CPP-631 RaLa Off-Gas Cell and Storage Tank
Location:
INEEL
Dates of Activities:
1985
Type of Facility:
Storage
Total Worker Hours:
No data
Physical Worker Hours:
No data
Total Exposure (Person-Rem):
1.623
Person-Rem Per Worker Hour:
No data
Size of Facility (Square Feet):
No data

Level of Facility Radiation:
Medium
Complete or Partial Facility:
Partial
Purpose of Facility Prior to Decommissioning:
Cell and storage tank were part of a system installed to handle gases generated during operation of the Radioactive Lanthanum-140 (RaLa) process system located in the L Cell of the CPP-601 Process Cell Building. The RaLa system was built to separate Barium140 from the short-cooled MTR fuel.
Prior Decommissioning Activities Completed:
None listed
Description of Decommissioning Activities:
All equipment was removed from the off-gas cell, piping cut and capped at the wall penetrations, and the remaining structure decontaminated. The tank was cut up and contaminated parts sent to the RWMC. This project preceded the CPP-631/709/734 decommissioning case study.
Reference:
Moser, C. L. 1986. *Final Report- Decontamination and Decommissioning of RaLa Off-Gas Cell and Storage Tank*. WINCO-1036. February 1986.

Rover
Name:
CPP-640 Rover Facility Material Handling Cave and Cells 3 & 4 Uranium Recovery and Reactivation (Schanz, 1998; 2001)
Location:
INEEL
Dates of Activities:
1995-98 (Schanz, 2001)
Type of Facility:
Process
Total Worker Hours:
231,277 (estimated by Rover project management) (Schanz, 2001)
Physical Worker Hours:
143,392 (62% of total)
Total Exposure (Person-Rem):
34.7 (Schanz, 1998; 2001)
Person-Rem Per Worker Hour:
2.4 E-4
Size of Facility (Square Feet):
750 (footprint reduction) (Schanz, 2001)
Level of Facility Radiation:
High
Complete or Partial Facility:
Partial

Purpose of Facility Prior to Decommissioning:

A joint program between US Atomic Energy Commission and National Aeronautical and Space Administration to develop a nuclear powered rocket (Schanz, 1998).

Prior Decommissioning Activities Completed:

The fuel was sent to INTEC for reprocessing. There were 3 false starts for deactivation (1986, 1988, and 1990) of this facility prior to the final deactivation from 1995-1998 (Schanz, 1998).

Description of Decommissioning Activities:

Deactivation of this facility included collecting, packaging, and storing uranium-bearing material from the process equipment in order to reduce the criticality potential (Schanz, 1998).

Reference:

Schanz, Dennis B. 1998. *Final Report for the CPP-640 Rover Facility Material Handling Cave and Cells 3 and 4 Uranium Recovery and Deactivation*. INEEL/EXT-98-00262. March 1998.

Schanz, Dennis B. 2001. *Deactivation, Decontamination, and Decommissioning Projects History.* INEEL/EXT-2001-01047. August 2001.

S1G Reactor Vessel

Name:

S1G Reactor Vessel (S for Submarine, 1 for first prototype, G for General Electric) (name coding found in Stacy, 2000).

Location:

INEEL

Dates of Activities:

1983 (Schoonen, 1984)

Type of Facility:

Reactor

Total Worker Hours:

No data

Physical Worker Hours:

No data

Total Exposure (Person-Rem):

3.042 (vessel transport = 0.455, installing processing system = 1.521, process operations = 0.345, process system dismantling and waste disposal = 0.721) (Schoonen, 1984)

Person-Rem Per Worker Hour:

No data

Size of Facility (Square Feet):

No data

Level of Facility Radiation:

Medium

Complete or Partial Facility:

Partial

Purpose of Facility Prior to Decommissioning:
    Submarine reactor vessel, transported from the State of New York to INEEL for decommissioning (Meservey, 2002)
Prior Decommissioning Activities Completed:
    None listed
Description of Decommissioning Activities:
    Designed a processing system to remove the sodium metal contained within the reactor vessel. After removal, the reactor was disposed of at RWMC and the processing system was dismantled and disposed of (Schoonen, 1984).
Reference:

    Meservey, Dick. 2002. Personal communication concerning decommissioning activities at the INEEL. 22 May 2002.
    Schoonen, D. H. 1984. Reactor Vessel Decommissioning Project Final Report. EGG-2298. September 1984.
    Stacy, Susan M. 2000. *Proving the Principle: A History of the Idaho National Engineering and Environmental Laboratory 1949-1999*. DOE/ID-10799. Idaho Falls: Idaho Operations Office of the Department of Energy.

Security Training Facility
Name:
    Security Training Facility
Location:
    INEEL
Dates of Activities:
    1998 (Oswald, 2002)
Type of Facility:
    Other
Total Worker Hours:
    1,523 (727 project management) (Oswald, 2002)
Physical Worker Hours:
    Worker hour data incomplete 796 (796 characterization) (Oswald, 2002)
Total Exposure (Person-Rem):
    0.00
Person-Rem Per Worker Hour:
    0.00
Size of Facility (Square Feet):
    16,452 (size of STF-601) (Peatross, 1997)
Level of Facility Radiation:
    Low
Complete or Partial Facility:
    Complete
Purpose of Facility Prior to Decommissioning:
    The initial construction of this building was to support the Experimental Organic Cooled Reactor (EOCR). The project was cancelled when construction was about

90% complete because the needed information was obtained from the operation of a similar reactor built in Canada (Peatross, 1997).

Prior Decommissioning Activities Completed:

The facility was converted for use as the STF (Peatross, 1997).

Description of Decommissioning Activities:

No final report could be found. From the decommissioning plans, activities include removal and disposal of hazardous and radioactive materials, dismantlement of equipment and interior systems, demolition of buildings (Peatross, 1997).

Reference:

Oswald, Kyle. 2002. Personal Communication. Calculated from data used to build the ROM Model.

Peatross, R. G. 1997. *Demolition Plan for the Security Training Facility (STF).* INEL/INT-97-00535. Rev. 0. August 1997.

Sewage Treatment Plant

Name:

CFA Sewage Treatment Plant

Location:

INEEL

Dates of Activities:

1996-98 (Oswald, 2002)

Type of Facility:

Other

Total Worker Hours:

15,259 (3,002 project management) (Oswald, 2002)

Physical Worker Hours:

12,257 (Oswald, 2002) (2,139 characterization, 10,118 demolition and site restoration)

Total Exposure (Person-Rem):

0.00 (Thiel, 2000)

Person-Rem Per Worker Hour:

0.00

Size of Facility (Square Feet):

1,368 (footprint reduction) (Schanz, 2001)

Level of Facility Radiation:

Low

Complete or Partial Facility:

Complete

Purpose of Facility Prior to Decommissioning:

Built to treat and dispose of both sanitary water and wastewater received from industrial sources at CFA (Thiel, 2000).

Prior Decommissioning Activities Completed:

None listed

Description of Decommissioning Activities:

Removed hazardous materials and waste, decontaminated, demolished structures, excavated foundations and footers, removed underground storage tanks and pipes, removed cement and asphalt pads, excavated the majority of underground utilities, and graded the area to match surrounding contours (Thiel, 2000).

Reference:

Oswald, Kyle. 2002. Personal Communication. Calculated from data used to build the ROM Model.

Schanz, Dennis B. 2001. *Deactivation, Decontamination, and Decommissioning Projects History.* INEEL/EXT-2001-01047. August 2001.

Thiel, T. N. 2000. *Final Report for the Decontamination and Dismantlement of the Central Facilities Area Sewage Treatment Plant*. INEEL/EXT-2000-01103 Rev. 0. November 2000.

SPERT-I Reactor Building

Name:

Special Power Excursion Reactor Test-I (SPERT-I) Reactor Building

Location:

INEEL

Dates of Activities:

1985

Type of Facility:

Reactor

Total Worker Hours:

No data

Physical Worker Hours:

No data

Total Exposure (Person-Rem):

0.00

Person-Rem Per Worker Hour:

No data

Size of Facility (Square Feet):

800 (20 by 40 size of building)

Level of Facility Radiation:

Low

Complete or Partial Facility:

Complete

Purpose of Facility Prior to Decommissioning:

SPERT-I building was used from 1955-64 to perform step- and ramp-induced power excursion tests as part of a reactor safety program. The reactor was used to conduct transient behavior and safety studies on heterogeneous, light-water moderated, enriched-fuel reactor systems that operated at very high peak power for short periods of time.

Prior Decommissioning Activities Completed:

Deactivated in 1964. Reactor vessel, tank heaters, fuel-handling equipment, and control bridge was removed and the building was decontaminated in 1965.

Description of Decommissioning Activities:

Removed contaminated material, dismantled building, backfilled area, and erected marker.

Reference:

Dolenc, Max R. 1986. *Final Report- Decontamination and Decommissioning of the SPERT-I Reactor Building at the Idaho National Engineering Laboratory*. EGG-2399. February 1986.

SPERT-1 Seepage Pit

Name:

Special Power Excursion Reactor Test-I (SPERT-I) Seepage Pit

Location:

INEEL

Dates of Activities:

1983-1984

Type of Facility:

Pit/Pond

Total Worker Hours:

1,265 (469 project management)

Physical Worker Hours:

796 (Demolition and Site Restoration)

Total Exposure (Person-Rem):

0.00 No exposure reported above background.

Person-Rem Per Worker Hour:

0.00

Size of Facility (Square Feet):

675 (15 by 45)

Level of Facility Radiation:

Low

Complete or Partial Facility:

Complete

Purpose of Facility Prior to Decommissioning:

Received waste water from the SPERT-I reactor

Prior Decommissioning Activities Completed:

None listed

Description of Decommissioning Activities:

Removed pipe and contaminated soil; backfilled, graded, and seeded the area; and erected a permanent marker.

Reference:

Suckel, Richard A. 1984. *Final Report- Decontamination and Decommissioning of the SPERT-I Seepage Pit at the Idaho National Engineering Laboratory*. EGG-2291. November 1984.

SPERT-II&III Reactors
Name:
Special Power Excursion Reactor Test-II&III (SPERT-II&III) Reactors
Location:
INEEL
Dates of Activities:
1980
Type of Facility:
Reactor
Total Worker Hours:
7044 (344 project management)
Physical Worker Hours:
6700 (1605 Characterization, 5090 Miscellaneous Decommissioning)
Total Exposure (Person-Rem):
No Data
Person-Rem Per Worker Hour:
No data
Size of Facility (Square Feet):
16,630 (SPERT-II 512 and 322 sq m; SPERT-III 428 and 285 sq m)
Level of Facility Radiation:
Medium
Complete or Partial Facility:
Complete
Purpose of Facility Prior to Decommissioning:
SPERT-II was a low pressure, heavy water reactor used to perform short transient tests for 5 years, retired in 1964. SPERT-III was a high pressure, light water reactor, retired after 10 years of testing in 1968. Both reactors were designed to examine reactor kinetics during very short power excursions of 60 MW maximum. These reactors did not accumulate large inventories of long-lived fission products.
Prior Decommissioning Activities Completed:
None listed.
Description of Decommissioning Activities:
Removed contaminated reactor system components inside the buildings (coolant systems, reactor vessels) and asbestos removal. Decommissioned for reuse of the building as an experimental contaminated metal volume reduction melter. Installed safety barricades, secured the facility, and repaired the roof.
Reference:
Hine, Robert E. 1981. *Decontamination and Decommissioning of the SPERT-II and SPERT-III Reactors at the Idaho National Engineering Laboratory*. EGG-2074. February 1981.

SPERT-III Large Leach Pond
Name:
Special Power Excursion Reactor Test-III (SPERT-III) Large Leach Pond

Location:
INEEL
Dates of Activities:
1983
Type of Facility:
Pit/Pond
Total Worker Hours:
771 (460 project management)
Physical Worker Hours:
311 (demolition and site restoration)
Total Exposure (Person-Rem):
0.00
Person-Rem Per Worker Hour:
No data
Size of Facility (Square Feet):
3,250 (65 by 50)
Level of Facility Radiation:
Low
Complete or Partial Facility:
Complete
Purpose of Facility Prior to Decommissioning:
Received waste water from the SPERT-III reactor.
Prior Decommissioning Activities Completed:
None listed.
Description of Decommissioning Activities:
Removed the fence and concrete apron around the pond, backfilled the pond, seeded the area, and placed a permanent marker indicating subsurface hardware and low-level contamination.
Reference:
Bradford, Jeffrey D. 1984. *Final Report- Decommissioning of the SPERT-III Large Leach Pond at the Idaho National Engineering Laboratory*. EGG-2306. EGG-2275. April 1984.

SPERT-IV Reactor
Name:
Special Power Excursion Reactor Test-IV (SPERT-IV) Reactor
Location:
INEEL
Dates of Activities:
1979
Type of Facility:
Reactor
Total Worker Hours:
4,553 (476 project management)

Physical Worker Hours:
 4,077 (359 characterization, 164 decontamination, 3478 dismantlement)
Total Exposure (Person-Rem):
 0.03
Person-Rem Per Worker Hour:
 7.4E-6
Size of Facility (Square Feet):
 3,500 (high bay = 22.3 by 14.6 m)
Level of Facility Radiation:
 Low
Complete or Partial Facility:
 Complete
Purpose of Facility Prior to Decommissioning:
 SPERT-IV provided a prototype for safety tests of swimming pool reactors. It operated during the 1960s and was placed in standby condition in 1970. It did not accumulate large inventories of long-lived fission products.
Prior Decommissioning Activities Completed:
 None listed.
Description of Decommissioning Activities:
 Removed two reactor pool tanks and all contaminated components of the coolant system (coolant pumps, heat exchanger, valves, and piping) and decontaminated the facility. Future occupants of this building required use of the radioactive liquid waste disposal system, so it was not removed.
Reference:
 Smith, Donald L. 1979. *Final Report- SPERT-IV Decontamination and Decommissioning*. TREE-1373. August 1979.

SPERT-IV Waste Holdup Tank Ancillaries
Name:
 Special Power Excursion Reactor Test-I (SPERT-I) Waste Holdup Tank Ancillaries
Location:
 INEEL
Dates of Activities:
 1992-93
Type of Facility:
 Reactor Support
Total Worker Hours:
 No data
Physical Worker Hours:
 No data
Total Exposure (Person-Rem):
 0.00
Person-Rem Per Worker Hour:
 No data

Size of Facility (Square Feet):
No data
Level of Facility Radiation:
Low
Complete or Partial Facility:
Complete
Purpose of Facility Prior to Decommissioning:
The waste holdup tank and underground piping were used to transfer and store low-level radioactive waste generated through SPERT-IV reactor operations.
Prior Decommissioning Activities Completed:
None listed
Description of Decommissioning Activities:
Removed, treated and stored the sludge, excavated underground piping, decontaminated interior of the waste holdup tank, removed tank and tank pad, graded and reseeded the area.
Reference:
Hansen, C. B. 1993. *Final Report for the Decontamination and Decommissioning of the SPERT-IV Waste Holdup Tank Ancillaries*. EGG-ER-11000. Rev. 0. September 1993.

TAN-607 Ancillary Facilities
Name:
Test Area North (TAN)-607 Ancillary Facilities
Location:
INEEL
Dates of Activities:
1994-97
Type of Facility:
Other
Total Worker Hours:
7,413 (1,999 project management)
Physical Worker Hours:
5,414 (3,713 asbestos removal, 1,701 miscellaneous decommissioning)
Total Exposure (Person-Rem):
No data
Person-Rem Per Worker Hour:
No data
Size of Facility (Square Feet):
No data
Level of Facility Radiation:
Low
Complete or Partial Facility:
Complete
Purpose of Facility Prior to Decommissioning:

No report found.

Prior Decommissioning Activities Completed:

No report found.

Description of Decommissioning Activities:

No report found.

Reference:

Oswald, Kyle. 2002. Personal Communication. Calculated from data used to build the ROM Model.

TAN-606 Calibration Well

Name:

Test Area North (TAN)-606 Calibration Well

Location:

INEEL

Dates of Activities:

1994 (Oswald, 2002)

Type of Facility:

Other

Total Worker Hours:

3171 (1636 project management) (Oswald, 2002)

Physical Worker Hours:

1535 (215 characterization, 1,320 demolition) (Oswald, 2002)

Total Exposure (Person-Rem):

No data

Person-Rem Per Worker Hour:

No data

Size of Facility (Square Feet):

No data

Level of Facility Radiation:

Low

Complete or Partial Facility:

Partial

Purpose of Facility Prior to Decommissioning:

This well was used in the 1960s to calibrate radiation reading instruments against a radiation source placed in the well (Evans and Perry, 1994).

Prior Decommissioning Activities Completed:

None listed

Description of Decommissioning Activities:

The elevator and drive mechanism was removed, residual contamination was wiped off the wall of the well, the well was filled with pea gravel and capped, and the entry to the area was secured with a dry wall (Evans and Perry, 1994). No final report can be found, this information is from the decommissioning plan.

Reference:

Oswald, Kyle. 2002. Personal Communication. Calculated from data used to build the ROM Model.

Evans, Ted A. and Eugene F. Perry. 1994. *Sampling, Analysis, and Closure Activities for the TAN Building 606 Calibration Well*. EGG-2743. April 1994.

TAN/TSF-3 Concrete Pad

Name:
Test Area North (TAN)/ Technical Support Facility (TSF)-3 Concrete Pad

Location:
INEEL

Dates of Activities:
1983

Type of Facility:
Storage

Total Worker Hours:
1,722 (610 project management)

Physical Worker Hours:
1,112 (demolition and site restoration)

Total Exposure (Person-Rem):
0.09 (6 individuals worked within rad zone and lowest detectable level was 0.015 rem)

Person-Rem Per Worker Hour:
8.1E-5

Size of Facility (Square Feet):
1,575 (35 by 45)

Level of Facility Radiation:
Low

Complete or Partial Facility:
Complete

Purpose of Facility Prior to Decommissioning:
Concrete pad used to store maintenance equipment during the 1950s. During the 1960s some casks stored on the pad leaked radioactive contaminants.

Prior Decommissioning Activities Completed:
None listed

Description of Decommissioning Activities:
Section the concrete pad, remove the concrete sections and all contaminated soil, ship to RWMC for burial, backfill and grade area.

Reference:
Smith, Donald L. and Carla J. Wisler. 1984. *Final Report- Decontamination and Decommissioning of the TAN/TSF-3 Concrete Pad*. EGG-2292. April 1984.

Thermal Source Reactor

Name:
Thermal Source Reactor

Location:
ANL-E
Dates of Activities:
1998
Type of Facility:
Reactor
Total Worker Hours:
No data
Physical Worker Hours:
No data
Total Exposure (Person-Rem):
0.00
Person-Rem Per Worker Hour:
No data
Size of Facility (Square Feet):
No data
Level of Facility Radiation:
Not Ranked
Complete or Partial Facility:
Complete
Purpose of Facility Prior to Decommissioning:
Zero power reactor developed and operated from 1950 to 1989.
Prior Decommissioning Activities Completed:
Defueled in 1982.
Description of Decommissioning Activities:
Removed radioactive and hazardous materials and decontaminated the reactor facility to unrestricted use levels.
Reference:
Fellhauer, Charles, Julie Mathiesen, and Gregory Garlock. 1998. *Decontamination and Decommissioning of the Argonne Thermal Source Reactor at Argonne National Laboratory-East Project Final Report.* ANL/D&D/98-4. December 1998.

TRA-645/751
Name:
ETR Secondary Coolant Pumphouse (TRA-645) and Cooling Tower Basin (TRA-751) (LaBuy, 1997; Schanz, 2001)
Location:
INEEL
Dates of Activities:
1994-98 (Oswald, 2002)
Type of Facility:
Process
Total Worker Hours:
10,157 (2,253 project management) (Oswald, 2002)

Physical Worker Hours:
    7,904 (Oswald, 2002) (382 characterization, 2,242 miscellaneous decommissioning, 767 asbestos removal, 4,513 demolition and site restoration)
Total Exposure (Person-Rem):
    0.00
Person-Rem Per Worker Hour:
    0.00
Size of Facility (Square Feet):
    15,952 (footprint reduction) (Schanz, 2001)
Level of Facility Radiation:
    Medium
Complete or Partial Facility:
    Complete
Purpose of Facility Prior to Decommissioning:
    The secondary coolant pumphouse and cooling tower basin removed heat and returned secondary coolant water to the ETR Heat Exchanger Building (TRA-644) (LaBuy, 1997).
Prior Decommissioning Activities Completed:
    None listed
Description of Decommissioning Activities:
    Removed hazardous, radiological, and waste materials; dismantled equipment; demolished structure; buried concrete foundations; and graded area to match surrounding contours (LaBuy, 1997).
Reference:

LaBuy, S. A. 1997. *Engineering Test Reactor Secondary Coolant Pumphouse (TRA-645) and Cooling Tower Basin (TRA-751) Decommissioning Final Report*. INEEL/EXT-97-01026. October 1997.

Oswald, Kyle. 2002. Personal Communication. Calculated from data used to build the ROM Model.

Schanz, Dennis B. 2001. *Deactivation, Decontamination, and Decommissioning Projects History.* INEEL/EXT-2001-01047. August 2001.

TRA Filter Pit

Name:
    TRA Filter Pit
Location:
    INEEL
Dates of Activities:
    1998 (Oswald, 2002)
Type of Facility:
    Pit/Ponds
Total Worker Hours:
    2,677 (2,371 project management) (Oswald, 2002)

Physical Worker Hours:
Worker hour data incomplete 306 (Oswald, 2002) (294 characterization, 12 asbestos)
Total Exposure (Person-Rem):
No data
Person-Rem Per Worker Hour:
No data
Size of Facility (Square Feet):
No data
Level of Facility Radiation:
Low
Complete or Partial Facility:
Complete
Purpose of Facility Prior to Decommissioning:
The only report found was a draft environmental checklist (Frazee, 1997), so information is limited.
Prior Decommissioning Activities Completed:
None listed.
Description of Decommissioning Activities:
Characterization activities took place for the TRA ETR Filter Pit Area which includes the Filter Pit Building (TRA-755), the Air Intake Building (TRA-655), the Primary Filter Pit (TRA-704), the Secondary Filter Pit (TRA-705), and the Delay Tanks (TRA-706) (Frazee. 1997).
Reference:
Frazee, B. J. 1997. *Draft Environmental Checklists (EC) for TRA-660 Characterization and TRA Filter Pits Characterization*. BJF-09-97 Rev. 0. October 1997.
Oswald, Kyle. 2002. Personal Communication. Calculated from data used to build the ROM Model.

UCLA Boelther Reactor
Name:
University of California- Los Angeles Boelter Research Reactor
Location:
Los Angeles, California
Dates of Activities:
1986-92
Type of Facility:
Reactor
Total Worker Hours:
No data
Physical Worker Hours:
No data
Total Exposure (Person-Rem):
3.87

Person-Rem Per Worker Hour:
No data
Size of Facility (Square Feet):
No data
Level of Facility Radiation:
Not Ranked
Complete or Partial Facility:
Complete
Purpose of Facility Prior to Decommissioning:
100 kW Argonaut type research reactor that operated from 1963-1985 located on the ground floor of Boelter Hall on the UCLA campus.
Prior Decommissioning Activities Completed:
None listed
Description of Decommissioning Activities:
Removed reactor fuel and some reactor components in 1986. From 1989-1992, demolished reactor monolith, removed shield block and process equipment, and decontaminated facility.
Reference:
Abelquist, Eric W., Amir Huda, Scott State, and Joseph Takahashi. 1994. Decommissioning of a University Research Reactor. *Health Physics*. 67(1):80-87.

UHTREX Reactor
Name:
Ultra-High Temperature Reactor Experiment (UHTREX) Facility
Location:
LANL
Dates of Activities:
1988-90
Type of Facility:
Reactor
Total Worker Hours:
No data
Physical Worker Hours:
No data
Total Exposure (Person-Rem):
4.99
Person-Rem Per Worker Hour:
No data
Size of Facility (Square Feet):
12,000 (approximate amount of space available for reuse following decommissioning)
Level of Facility Radiation:
Not Ranked

Complete or Partial Facility:
    Complete
Purpose of Facility Prior to Decommissioning:
    Constructed in the late 1960s to advance high-temperature and gas-cooled reactor technology.
Prior Decommissioning Activities Completed:
    Reactor was shutdown in 1970 and immediately defueled.
Description of Decommissioning Activities:
    Dismantled equipment in building, decontaminated building, removed hazardous materials, removed reactor support structures, and made facility available for future reuse.
Reference:
    Salazar, Miguel and John Elder. 1993. *Decommissioning the UHTREX Reactor Facility at Los Alamos, New Mexico*. LA-12356.

Warehouse
Name:
    CFA-645 Warehouse
Location:
    INEEL
Dates of Activities:
    1994-95
Type of Facility:
    Storage
Total Worker Hours:
    No data
Physical Worker Hours:
    No data
Total Exposure (Person-Rem):
    0.00
Person-Rem Per Worker Hour:
    No data
Size of Facility (Square Feet):
    11,946 (footprint reduction)
Level of Facility Radiation:
    Low
Complete or Partial Facility:
    Complete
Purpose of Facility Prior to Decommissioning:
    Constructed in 1944, used as a Naval warehouse until the early 1950s, then converted to craft operations and gas storage for use by the INEEL.
Prior Decommissioning Activities Completed:
    None listed

Description of Decommissioning Activities:
Removed hazardous constituents, demolished building, excavated foundations and underground piping, and graded area to match surrounding contour.
Reference:
Schanz, Dennis B. 2001. *Deactivation, Decontamination, and Decommissioning Projects History.* INEEL/EXT-2001-01047. August 2001.

Waste Ion Exchange
Name:
Waste Ion Exchange Facility
Location:
ANL-E
Dates of Activities:
1995-1998
Type of Facility:
Process
Total Worker Hours:
No data
Physical Worker Hours:
No data
Total Exposure (Person-Rem):
0.00
Person-Rem Per Worker Hour:
No data
Size of Facility (Square Feet):
640 (building size 20 by 32)
Level of Facility Radiation:
Not Ranked
Complete or Partial Facility:
Complete
Purpose of Facility Prior to Decommissioning:
The Waste Ion Exchange Facility was used to process waste fluids from a collecting lagoon. The facility has been non-functional for over 30 years.
Prior Decommissioning Activities Completed:
The facility was shutdown, but there were no records of what took place at that time.
Description of Decommissioning Activities:
Removed radioactive and hazardous materials, dismantled Waste Ion Exchange equipment, decontaminated and demolished the building, and restored the site.
Reference:
Wiese, Edward C. 1998. *Decontamination and Dismantlement of the Building 594 Waste Ion Exchange Facility at Argonne National Laboratory-East Project Final Report*. ANL/D&D/98-3. November 1998.

Water Boiler Reactor
Name:
TA-2 Water Boiler Reactor
Location:
LANL
Dates of Activities:
1989-1990
Type of Facility:
Reactor
Total Worker Hours:
No data
Physical Worker Hours:
No data
Total Exposure (Person-Rem):
4.35
Person-Rem Per Worker Hour:
No data
Size of Facility (Square Feet):
No data
Level of Facility Radiation:
Not Ranked
Complete or Partial Facility:
Complete
Purpose of Facility Prior to Decommissioning:
This reactor was used primarily as a source of neutrons.
Prior Decommissioning Activities Completed:
External structures and underground piping associated with the gaseous effluent line were removed in 1985-1986.
Description of Decommissioning Activities:
Dismantled the Water Boiler Reactor and decontaminated the room to provide reusable space.
Reference:
Montoya, Gilbert M. 1991. *Final Project Report TA-2 Water Boiler Reactor Decommissioning Project*. LA-12049.

WCF
Name:
Waste Calcination Facility CPP-633
Location:
INEEL
Dates of Activities:
1995-99
Type of Facility:
Process
Total Worker Hours:
No data

Physical Worker Hours:
    No data
Total Exposure (Person-Rem):
    3.6
Person-Rem Per Worker Hour:
    No data
Size of Facility (Square Feet):
    7,560 (footprint reduction)
Level of Facility Radiation:
    High
Complete or Partial Facility:
    Complete
Purpose of Facility Prior to Decommissioning:
    Used the calcinations conversion process to convert highly radioactive, liquid waste to a stable dry sand-like radioactive material, more suitable for long-term interim storage.
Prior Decommissioning Activities Completed:
    None listed.
Description of Decommissioning Activities:
    Entombed the facility in concrete to meet RCRA closure to landfill standards.
Reference:
    Schanz, Dennis B. 2001. *Deactivation, Decontamination, and Decommissioning Projects History.* INEEL/EXT-2001-01047. August 2001.

WMO and AEF-603
Name:
    Waste Management Office (WMO) Buildings 601/601A and Argonne Experimental Facility (AEF-603)
Location:
    INEEL
Dates of Activities:
    1995-96
Type of Facility:
    Storage (WMO) and Reactor Support (AEF, control building for BORAX)
Total Worker Hours:
    No data
Physical Worker Hours:
    No data
Total Exposure (Person-Rem):
    0.00
Person-Rem Per Worker Hour:
    No data
Size of Facility (Square Feet):
    11,000 (footprint reduction)

Level of Facility Radiation:

Low

Complete or Partial Facility:

Complete

Purpose of Facility Prior to Decommissioning:

WMO-601 was used to house the Zero Power Reactor (ZPR-III). The ZPR-III was decommissioned in 1974 and the WMO was converted to storage area. WMO-601A was added for office space. AEF-603 housed the control building for BORAX.

Prior Decommissioning Activities Completed:

In 1974 the ZPR-III was decommissioned.

Description of Decommissioning Activities:

Dismantled and removed septic systems, a metal shed containing auxiliary generator attached to WMO-601, a buried fuel tank, a concrete transformer pad, a concrete pad, a concrete shield, a valve access pit, and demolished the buildings.

Reference:

Schanz, Dennis B. 2001. *Deactivation, Decontamination, and Decommissioning Projects History.* INEEL/EXT-2001-01047. August 2001.