CONTRACTOR REPORT

SAND90–7090
Unlimited Release
UC–721

Preliminary Identification of Scenarios for the Waste Isolation Pilot Plant, Southeastern New Mexico

Robert V. Guzowski
Science Applications International Corporation
2109 Air Park Road SE
Albuquerque, NM 87106

Prepared by Sandia National Laboratories Albuquerque, New Mexico 87185 and Livermore, California 94550 for the United States Department of Energy under Contract DE-AC04-76DP00789

Printed July 1991

Issued by Sandia National Laboratories, operated for the United States Department of Energy by Sandia Corporation.

Printed in the United States of America. This report has been reproduced directly from the best available copy.

Available to DOE and DOE contractors from
Office of Scientific and Technical Information
PO Box 62
Oak Ridge, TN 37831

Prices available from (615) 576-8401, FTS 626-8401

Available to the public from
National Technical Information Service
US Department of Commerce
5285 Port Royal Rd
Springfield, VA 22161

NTIS price codes
Printed copy: A03
Microfiche copy: A01

SAND90-7090
Unlimited Release
Printed July 1991

Distribution
Category UC-721

PRELIMINARY IDENTIFICATION OF SCENARIOS FOR THE WASTE ISOLATION PILOT PLANT, SOUTHEASTERN NEW MEXICO*

Robert V. Guzowski
Science Applications International Corporation
2109 Air Park Road SE
Albuquerque, NM 87106

ABSTRACT

The Waste Isolation Pilot Plant is being evaluated as a location for the disposal of defense-generated transuranic waste. One of the criteria to be used to determine the suitability of the disposal system is compliance with the Containment Requirements established by the U.S. Environmental Protection Agency. One step in determining compliance is to identify the combinations of events and processes (scenarios) defining possible future states of the disposal system that may affect the escape of radionuclides from the repository and transport to the accessible environment.

A list of previously identified events and processes was adapted to a scenario-selection procedure that develops a comprehensive set of mutually exclusive scenarios through the use of a logic diagram. Four events resulted in the development of 16 scenarios. Preliminary analyses indicate that four scenarios result in no releases. Six scenarios consist of combinations of drilling into a waste-filled room, drilling into a room and an underlying brine reservoir, and emplacement of withdrawal wells downgradient from the repository. Six additional scenarios consist of these same six combinations with the addition of potash mining and the associated surface subsidence.

The 12 retained scenarios will be screened based on consequence and/or probability of occurrence. During the course of performance assessment, additional data and information will be used to revise and update these preliminary scenarios where appropriate.

*Work Performed Under Contract No. 63-5621 For Performance Assessment Division (6342), Sandia National Laboratories

PREFACE

This SAND report is a reproduction of the identically titled paper published in:

International Conference on Probabilistic Safety Assessment and Management. 1991. *Probabilistic Safety Assessment and Management: Proceedings of the International Conference on Probabilistic Safety Assessment and Management (PSAM) held February 4-7, 1991 in Beverly Hills, California.* Amsterdam: Elsevier Publishing Company, Inc.

PRELIMINARY IDENTIFICATION OF SCENARIOS FOR THE WASTE ISOLATION PILOT PLANT, SOUTHEASTERN NEW MEXICO*

ROBERT V. GUZOWSKI
Science Applications International Corporation,**
Albuquerque, NM 87185

INTRODUCTION

The Waste Isolation Pilot Plant (WIPP), which is located in southeastern New Mexico, is designed for the disposal of transuranic (TRU) wastes generated by the U.S. Department of Energy's (DOE) nuclear-based defense programs. This location is being evaluated for compliance with Subpart B of the U.S. Environmental Protection Agency's (EPA) *Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes; Final Rule* [1] (the Standard). In order to determine compliance, a performance assessment of the disposal system must be carried out. An integral part of any performance assessment is the identification of the scenarios that are appropriate for the disposal system [2]. The purpose of this paper is to describe the methodology used by the WIPP project for identifying these scenarios and to describe the preliminary results from applying this methodology to the WIPP [3]. These preliminary scenarios are being used to guide the development of the modeling system for compliance calculations and to identify the data needs for performance assessment. As more data and information become available for the WIPP disposal system, and the development of the modeling system progresses, the results of the preliminary scenario development will be revised and updated where appropriate.

REGULATORY BASIS FOR SCENARIOS

Subpart B of the Standard contains the environmental requirements that apply to the disposal system after the waste has been emplaced and the repository/shaft system has been sealed. The Containment Requirements [4] state that cumulative releases of radionuclides to the accessible environment for 10,000 years after disposal from all significant processes and events that may affect the disposal system shall meet certain criteria. By implication, "all significant processes and events" includes all significant combinations of these processes and events. These combinations of processes and events generally are referred to as scenarios.

In addition to the Containment Requirements, the definition of performance assessment [5] refers to an analysis identifying the processes and events that might affect the disposal system. As in the Containment Requirements, this definition implies that the combinations of processes and events also must be considered.

* Work performed for United States Department of Energy under Contract DE-AC04-76DP00789.
** Work performed under Contract 63-5621 for Performance Assessment Division (6342), Sandia National Laboratories, Albuquerque, NM.

REQUIREMENTS OF A PROCEDURE FOR DEVELOPING SCENARIOS

Estimates of the cumulative releases of radionuclides from all significant processes and events in the performance assessment are to be incorporated into a probability distribution of cumulative releases to the extent possible [5]. Although the Standard does not mandate how this probability distribution is to be represented, Appendix B of Subpart B of the Standard is provided as "Guidance for Implementation of Subpart B." This appendix states that the EPA assumes the results of the performance assessment will be assembled into a complementary cumulative distribution function (CCDF).

The procedure for developing scenarios must produce a comprehensive set, so that no important scenarios are omitted. In addition, the scenarios must be mutually exclusive, so that the cumulative releases and the probability of occurrence can be combined in a CCDF.

DESCRIPTION OF SCENARIO-DEVELOPMENT PROCEDURE USED FOR THE WIPP

Much of the past work in identifying scenarios for nuclear-waste disposal systems was based on the use of event trees [6][7][8]. This type of analysis has been used to assess potential accidents at nuclear power plants [9]. Event trees were found not to be suitable for natural systems [10].

Because event trees cannot produce scenarios that adequately address the current formulation of the Standard, the WIPP project has adopted the scenario-development procedure developed by the Waste Management Systems Division of Sandia National Laboratories [11]. The application of this procedure to the WIPP will provide a final comprehensive set of mutually exclusive scenarios that are amenable to both consequence analysis and probability assignment.

In Cranwell and others [11], scenarios are defined as sets of naturally occurring and human-induced events and processes that represent realistic future changes to the repository, geologic, and hydrologic systems that may affect the escape and transport of radionuclides. The scenario-development procedure consists of five basic steps.

In the first step, the events and processes that may affect the escape of radionuclides from the waste panels and/or the transport of radionuclides to the accessible environment are identified. A panel of experts may be used to identify these events and processes, or an existing list of nonsite-specific events and processes compiled by panels of experts for previous studies can be used. Table 1 is the list from Cranwell and others [11].

The second step consists of classifying the events and processes in the comprehensive list into various categories as an aid in determining the completeness of the list. This step is organizational, and certain classification schemes can be beneficial to the modeling efforts.

In the third step, the events and processes are screened to eliminate those that are not pertinent to the specific disposal system being investigated or do not contribute to the integrated release to the accessible environment. Three screening criteria can be used: physical reasonableness, probability of occurrence, and consequence. In addition to these screening criteria, Appendix B of the Standard limits the severity of human intrusion into the disposal system to exploratory drilling for resources.

TABLE 1. Potentially disruptive events and processes by category [after 11].

Natural Events and Processes	Human-Induced Events and Processes
Celestial Bodies	**Inadvertent Intrusions**
Meteorite Impact	Explosions
Surficial Events and Processes	Drilling
Erosion/Sedimentation	Mining
Glaciation	Injection Wells
Pluvial Periods	Withdrawal Wells
Sea-Level Variations	**Hydrologic Stresses**
Hurricanes	Irrigation
Seiches	Damming of Streams or Rivers
Tsunamis	**Waste- and Repository-Induced Events and Processes**
Regional Subsidence or Uplift (also applies to subsurface)	Subsidence and Caving
Mass Wasting	Shaft and Borehole Seal Degradation
Flooding	Thermally Induced Stress/Fracturing in Host Rock
Subsurface Events and Processes	Excavation-Induced Stress/Fracturing in Host Rock
Diapirism	
Seismic Activity	
Volcanic Activity	
Magmatic Activity	
Formation of Dissolution Cavities	
Formation of Interconnected Fracture Systems	
Faulting	

The fourth step in the procedure is the construction of scenarios by combining the events and the processes that survive the screening process. A logic diagram is used to construct the scenarios. Figure 1 is an example of a logic diagram for what were classified as hypothetical release and transport events and processes. No temporal relationship is implied by the sequence of events and processes across the top of the diagram or within the constructed scenarios. At each junction within the diagram, a yes/no decision is made as to whether the next event or process across the top of the diagram is added to the scenario. The pathway defined by "no" decisions at all of the branch points leads to the base-case scenario, which is the undisturbed performance of the disposal system. The time at which an event or process occurs relative to the other events and processes in the scenario is a variable for consequence modeling. This time of occurrence can be sampled during the uncertainty analysis.

Screening the scenarios is the last step in the procedure. In a strict mathematical approach, no scenarios can be eliminated from inclusion in the construction of a CCDF, because the summation of the probabilities of occurrence of all the scenarios in the logic diagram must be equal to 1. In a practical approach, some scenarios can be identified as having so little effect on the shape and location of the CCDF that consequence modeling of the scenarios is not necessary, although these scenarios should be considered when evaluating overall compliance of the disposal system to the Standard.

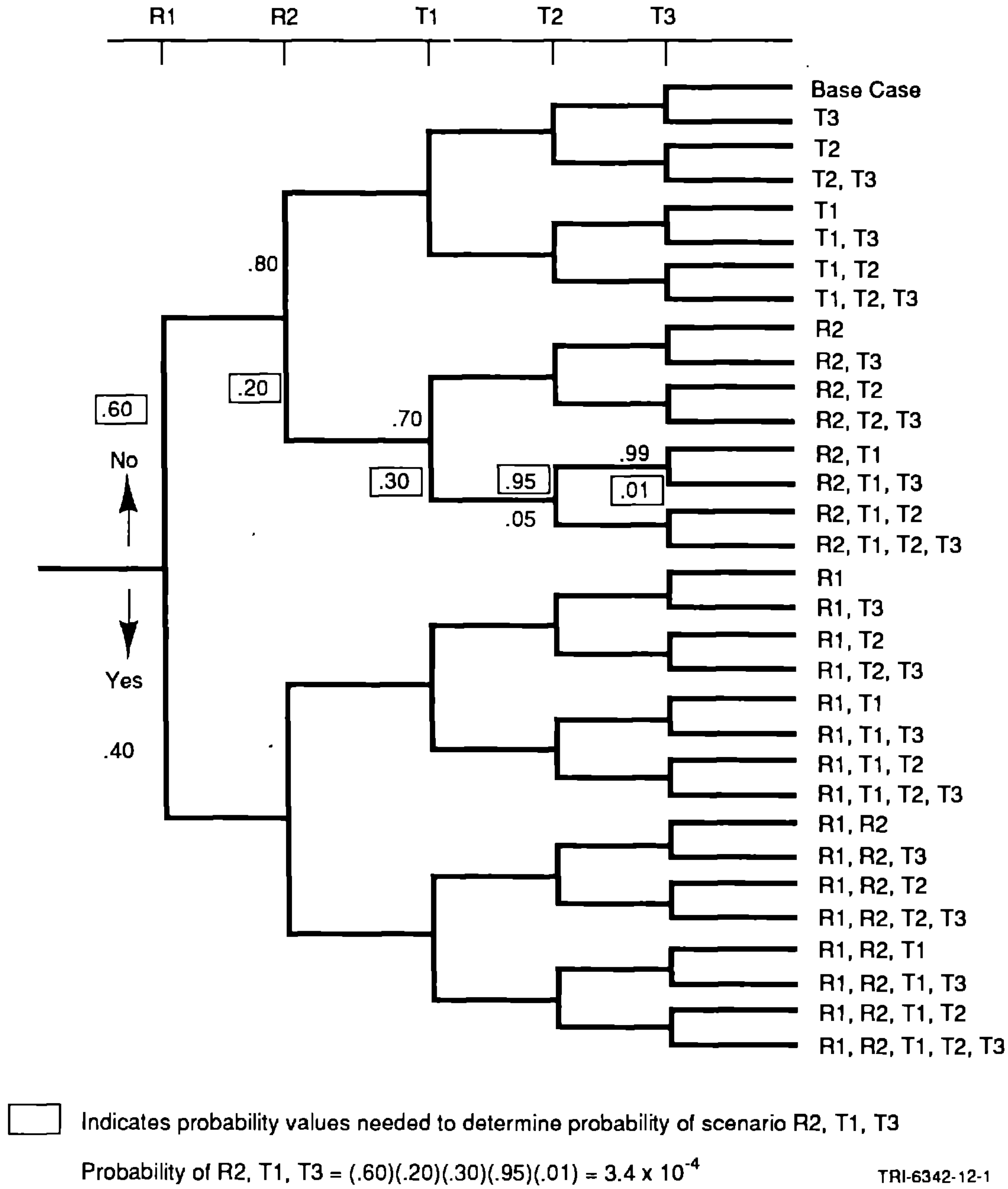


FIG. 1. Demonstration logic diagram for the construction of scenarios for hypothetical events and processes [after 11].

The criteria for screening scenarios to identify which scenarios do not require consequence modeling are physical reasonableness, probability of occurrence, and consequence. Physically incompatible events and processes can be virtually eliminated from scenario development by not allowing specific parameter values or specific locations of occurrence to define events and processes. Scenarios with probabilities of occurrence less than some value will have a minimal impact on the CCDF. As with the individual events and processes, the probability for scenarios was assumed to be less than one chance in 10,000 in 10,000 years. To determine the probabilities of the scenarios, the probability of occurrence and nonoccurrence of each event and process is assigned to the appropriate "yes" and "no" legs at each junction in the logic diagram (Figure 1).

The final screening criteria is consequence. At this stage of the procedure, consequence means release of radionuclides to the accessible environment within 10,000 years. In the screening process, calculations may be used to determine whether releases occur.

PRELIMINARY IMPLEMENTATION OF SCENARIO-SELECTION PROCEDURE

The steps of the Cranwell and others [11] scenario-selection procedure have not been rigorously applied to the scenario-development efforts for the WIPP performance assessment. Events and processes originally identified for use in event trees had to be adapted for use in a logic diagram.

Identified Events and Processes

As a starting point in the identification of events and processes, Hunter [12] used a list of events and processes that had been considered for studies in support of waste disposal sites in bedded salt in southeastern New Mexico and elsewhere [6][11][13][14]. A total of 24 events and processes were evaluated as to their pertinence to the WIPP. Because of the geologic stability of the region, tectonic, volcanic, and plutonic events and processes were eliminated as potentially disruptive events and processes. Hunter identified "...normal flow of ground water, climatic change, the drilling of exploratory boreholes, solution mining, seal performance, the effects of drilling into a brine reservoir beneath the repository, leaching of the solid waste, nuclear criticality, waste/rock interactions, and waste effects" [15]. Waste/rock interactions and waste effects were considered applicable to all scenarios. The remaining 14 events and processes were determined to be of no significance to the WIPP.

Evaluation and Adaptation of Events and Processes to Scenario-Selection Procedure

Some of the events and processes retained by Hunter [12] are expected to occur and therefore are part of the base-case scenario. These events and processes contribute to the undisturbed conditions that define the base-case scenario and are not appropriate for use in the logic diagram to develop additional scenarios.

Events and processes that are part of the base-case scenario are normal flow of ground water, climatic change, seal performance, and leaching of solid waste. Remaining events are modified from the drilling of exploratory boreholes to drilling into a waste-filled room or drift; from solution mining to potash mining outside the WIPP boundary; and from the effects of drilling into a brine pocket beneath the repository to drilling through a room or drift and into an underlying brine reservoir. The emplacement of withdrawal wells downgradient was added as an event, because these wells can provide alternate pathways for radionuclides to reach the accessible environment. Nuclear criticality is being evaluated separately, and if this process turns out to be feasible for the WIPP inventory and the disposal system, the scenario-development step in this procedure will be revised.

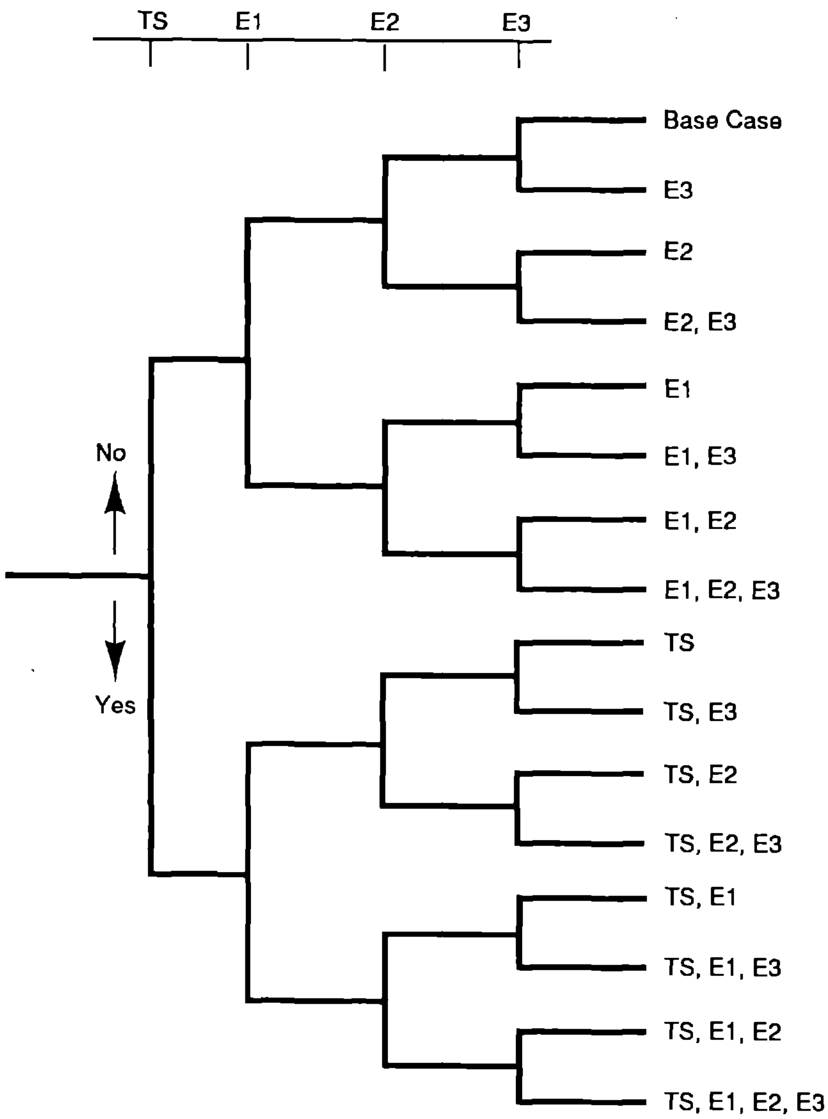
Development of Scenarios

The next step in the scenario-selection procedure is the development of scenarios by the use of a logic diagram. This diagram produces 2^n scenarios, where n is the number of events and processes incorporated in the diagram. With the four events retained for the WIPP, 16 scenarios are developed in the logic diagram (Figure 2). A separate task will determine the number of intrusions of each type of intrusion event. In addition, the location, the time of the intrusions, and the duration of pumping for withdrawal wells will be variables in the model(s) used for consequence analysis.

Two groups of scenarios can be delineated in the scenarios in Figure 2. One set consists of the various combinations of the intrusion events (E1 and E2) with the withdrawal well (E3), and the other set contains these same combinations with the addition of potash mining (TS).

STATUS OF SCENARIO SCREENING

Preliminary consequence modeling indicates that radionuclides only reach the accessible environment for those scenarios that include at least one event resulting in penetration of a room or drift. Because of these results, the base-case scenario and scenarios E3, TS, and TSE3 can be eliminated from further consideration. The assumptions made for these analyses will be reviewed and revised as needed for the final performance assessment. An additional effort to determine the probabilities of the events in the scenarios is in progress.



TS - Potash Mining Outside the WIPP Boundary
E1 - Drilling Through Room or Drift and Into Brine Reservoir
E2 - Drilling into a Room or Drift
E3 - Emplacement of Withdrawal Well Downgradient From Repository

TRI-6342-259-0

FIG. 2. Preliminary scenarios developed with a logic diagram for WIPP disposal system [3].

REFERENCES

1. United States Environmental Protection Agency (U.S. EPA), 40 CFR Part 191, Federal Register 50, p. 38066-38089 (1985).
2. R. M. Cranwell, J. E. Campbell, J. C. Helton, R. L. Iman, D. E. Longsine, N. R. Ortiz, G. E. Runkle, and M. J. Shortencarier, SAND81-2573 (NUREG/CR-2452) (Sandia National Laboratories, Albuquerque, NM, 1982, rev. 1987).
3. R. V. Guzowski, SAND89-7149 (Sandia National Laboratories, Albuquerque, NM, 1990).
4. U.S. EPA, 40 CFR 191.13, Federal Register 50, p. 38086.
5. U.S. EPA, 40 CFR 191.12(q), Federal Register 50, p. 38086.
6. F. W. Bingham and G. E. Barr, SAND78-1730 (Sandia National Laboratories, Albuquerque, NM, 1979).
7. R. L. Hunter, SAND 83-1342 (NUREG/CR-3353) (Sandia National Laboratories, Albuquerque, NM, 1983).
8. R. L. Hunter, G. E. Barr, and F. W. Bingham, SAND82-1277 (Sandia National Laboratories, Albuquerque, NM, 1983).
9. U.S. Nuclear Regulatory Commission, WASH-1400 (NUREG-75/014) (1975).
10. H. C. Burkholder in Scientific Basis for Nuclear Waste Management, 2, p. 689-702 (New York, Plenum Press, 1980).
11. R. M. Cranwell, R. V. Guzowski, J. E. Campbell, and N. R. Ortiz, SAND80-1429 (NUREG/CR-1667) (Sandia National Laboratories, Albuquerque, NM, 1990).
12. R. L. Hunter, SAND89-2546 (Sandia National Laboratories, Albuquerque, NM, 1989).
13. H. C. Claiborne and F. Gera, ORNL-TM-4639 (Oak Ridge National Laboratories, Oak Ridge, TN, 1974).
14. Arthur D. Little, Inc., EPA 520/4-79-007D (U.S. EPA, 1980).
15. R. L. Hunter, 1989, p. 31.

Distribution

FEDERAL AGENCIES

U. S. Department of Energy (6)
Office of Environmental Restoration
and Waste Management
Attn: Leo P. Duffy, EM-1
Jill E. Lytle, EM-30
Mark Duff, EM-34
Steve Schneider, EM-34
Clyde Frank, EM-50
Lynn Tyler, EM-50
Washington, DC 20585

U.S. Department of Energy (5)
WIPP Task Force
Attn: Mark Frei (2)
G. H. Daly
Sandi Fucigna
Jay Rhoderick
12800 Middlebrook Rd.
Suite 400
Germantown, MD 20874

U.S. Department of Energy (4)
Office of Environment, Safety and
Health
Attn: Raymond P. Berube, EH-20
Carol Borgstrum, EH-25
Ray Pelletier, EH-231
Kathleen Taimi, EH-232
Washington, DC 20585

U. S. Department of Energy (6)
Albuquerque Operations Office
Attn: Bruce G. Twining
J. E. Bickel
K. A. Griffith
D. Krenz
G. Runkle
C. Soden
P.O. Box 5400
Albuquerque, NM 87185-5400

U. S. Department of Energy (10)
WIPP Project Office (Carlsbad)
Attn: A. Hunt (4)
M. McFadden
V. Daub (4)
K. Hunter
P.O. Box 3090
Carlsbad, NM 88221-3090

U. S. Department of Energy, (5)
Office of Civilian Radioactive Waste
Management
Attn: Deputy Director, RW-2
Associate Director, RW-10
Office of Program
Administration and
Resources Management
Associate Director, RW-20
Office of Facilities
Siting and
Development
Associate Director, RW-30
Office of Systems
Integration and
Regulations
Associate Director, RW-40
Office of External
Relations and Policy
Office of Geologic Repositories
Forrestal Building
Washington, DC 20585

U. S. Department of Energy
Attn: National Atomic Museum Library
Albuquerque Operations Office
P.O. Box 5400
Albuquerque, NM 87185

U. S. Department of Energy
Research & Waste Management Division
Attn: Director
P.O. Box E
Oak Ridge, TN 37831

U. S. Department of Energy (2)
Idaho Operations Office
Fuel Processing and Waste
Management Division
785 DOE Place
Idaho Falls, ID 83402

U.S. Department of Energy
Savannah River Operations Office
Defense Waste Processing
Facility Project Office
Attn: W. D. Pearson
P.O. Box A
Aiken, SC 29802

U.S. Department of Energy (2)
Richland Operations Office
Nuclear Fuel Cycle & Production
Division
Attn: R. E. Gerton
825 Jadwin Ave.
P.O. Box 500
Richland, WA 99352

U.S. Department of Energy (3)
Nevada Operations Office
Attn: J. R. Boland
D. Livingston
P. K. Fitzsimmons
2753 S. Highland Drive
Las Vegas, NV 87183-8518

U.S. Department of Energy (2)
Technical Information Center
P.O. Box 62
Oak Ridge, TN 37831

U.S. Department of Energy (2)
Chicago Operations Office
Attn: J. C. Haugen
9800 South Cass Avenue
Argonne, IL 60439

U.S. Department of Energy
Los Alamos Area Office
528 35th Street
Los Alamos, NM 87544

U.S. Department of Energy (3)
Rocky Flats Area Office
Attn: W. C. Rask
Gary Huffman
Tom Lukow
P.O. Box 928
Golden, CO 80402-0928

U.S. Department of Energy
Dayton Area Office
Attn: R. Grandfield
P.O. Box 66
Miamisburg, OH 45343-0066

U.S. Department of Energy
Attn: Edward Young
Room E-178
GAO/RCED/GTN
Washington, DC 20545

U.S. Environmental Protection
Agency (2)
Office of Radiation Protection Programs
(ANR-460)
Attn: Richard Guimond (2)
Washington, D.C. 20460

U.S. Nuclear Regulatory Commission (4)
Division of Waste Management
Attn: N. Eisenberg
B. J. Youngblood
S. Copland
R. Ballard
Mail Stop 4-H-3
Washington, DC 20555

U.S. Nuclear Regulatory Commission (4)
Advisory Committee on Nuclear Waste
Attn: Dade Moeller
Martin J. Steindler
Paul W. Pomeroy
William J. Hinze
7920 Norfolk Avenue
Bethesda, MD 20814

Defense Nuclear Facilities Safety Board
Attn: Dermot Winters
600 E. Street NW
Suite 675
Washington, DC 20004

Katherine Yuracko
Energy and Science Division
Office of Management and Budget
725 17th Street NW
Washington, DC 20503

U.S. Geological Survey
Conservation Division
Attn: W. Melton
P.O. Box 1857
Roswell, NM 88201

U.S. Geological Survey (2)
Water Resources Division
Attn: Cathy Peters
Suite 200
4501 Indian School, NE
Albuquerque, NM 87110

STATE AGENCIES

Bureau of Land Management
101 E. Mermod
Carlsbad, NM 88220

Bureau of Land Management
New Mexico State Office
P.O. Box 1449
Santa Fe, NM 87507

Environmental Evaluation Group (5)
Attn: Robert Neill
Suite F-2
7007 Wyoming Blvd., N.E.
Albuquerque, NM 87109

New Mexico Bureau of Mines
and Mineral Resources (2)
Attn: F. E. Kottlowski, Director
J. Hawley
Socorro, NM 87801

New Mexico Department of Energy &
Minerals
Attn: Kasey LaPlante, Librarian
P.O. Box 2770
Santa Fe, NM 87501

New Mexico Radioactive Task Force (2)
(Governor's WIPP Task Force)
Attn: Anita Lockwood, Chairman
Chris Wentz, Coordinator/Policy
Analyst
2040 Pacheco
Santa Fe, NM 87505

Bob Forrest
Mayor, City of Carlsbad
P.O. Box 1569
Carlsbad, NM 88221

Chuck Bernard
Executive Director
Carlsbad Department of Development
P.O. Box 1090
Carlsbad, NM 88221

Robert M. Hawk (2)
Chairman, Hazardous and Radioactive
Materials Committee
Room 334
State Capitol
Sante Fe, NM 87503

Kirkland Jones (2)
Deputy Director
New Mexico Environmental Improvement
Division
P.O. Box 968
1190 St. Francis Drive
Santa Fe, NM 87503-0968

ADVISORY COMMITTEE ON NUCLEAR FACILITY SAFETY

John F. Ahearne
Executive Director, Sigma Xi
99 Alexander Drive
Research Triangle Park, NC 27709

James E. Martin
109 Observatory Road
Ann Arbor, MI 48109

Dr. Gerald Tape
Assoc. Universities
1717 Massachusetts Ave. NW
Suite 603
Washington, DC 20036

DOE BLUE RIBBON PANEL

Thomas Bahr, Director
New Mexico State University
New Mexico Water Resources Research
Institute
Box 3167
Las Cruces, NM 88001

Robert Bishop
Nuclear Management Resources Council
1776 I Street, NW
Suite 300
Washington, DC 20006-2496

Arthur Kubo
BDM Corporation
7915 Jones Branch Drive
McLean, VA 22102

Leonard Slosky
Slosky & Associates
Bank Western Tower
Suite 1400
1675 Broadway
Denver, CO 80202

Newal Squyres
Holland & Hart
P.O. Box 2527
Boise, ID 83701

WIPP PANEL OF NATIONAL RESEARCH COUNCIL'S BOARD ON RADIOACTIVE WASTE MANAGEMENT

Charles Fairhurst, Chairman
Department of Civil and
Mineral Engineering
University of Minnesota
500 Pillsbury Dr. SE
Minneapolis, MN 55455

John O. Blomeke
Route 3
Sandy Shore Drive
Lenoir City, TN 37771

John D. Bredehoeft
Western Region Hydrologist
Water Resources Division
U.S. Geological Survey (M/S 439)
345 Middlefield Road
Menlo Park, CA 94025

Karl P. Cohen
928 N. California Avenue
Palo Alto, CA 94303

Fred M. Ernsberger
250 Old Mill Road
Pittsburgh, PA 15238

Rodney C. Ewing
Department of Geology
University of New Mexico
200 Yale, NE
Albuquerque, NM 87131

B. John Garrick
Pickard, Lowe & Garrick, Inc.
2260 University Drive
Newport Beach, CA 92660

Leonard F. Konikow
U.S. Geological Survey
431 National Center
Reston, VA 22092

Jeremiah O'Driscoll
505 Valley Hill Drive
Atlanta, GA 30350

Christopher Whipple
Clement International Corp.
160 Spear St.
Suite 1380
San Francisco, CA 94105-1535

National Research Council (3)
Board on Radioactive
Waste Management
Attn: Peter B. Myers, Staff Director (2)
Dr. Geraldine J. Grube
2101 Constitution Avenue
Washington, DC 20418

PERFORMANCE ASSESSMENT PEER REVIEW PANEL

G. Ross Heath
College of Ocean
and Fishery Sciences
583 Henderson Hall
University of Washington
Seattle, WA 98195

Thomas H. Pigford
Department of Nuclear Engineering
4153 Etcheverry Hall
University of California
Berkeley, CA 94720

Thomas A. Cotton
JK Research Associates, Inc.
4429 Butterworth Place, NW
Washington, DC 20016

Robert J. Budnitz
President, Future Resources
Associates, Inc.
2000 Center Street
Suite 418
Berkeley, CA 94704

C. John Mann
Department of Geology
245 Natural History Bldg.
1301 West Green Street
University of Illinois
Urbana, IL 61801

Frank W. Schwartz
Department of Geology and Mineralogy
Ohio State University
Scott Hall
1090 Carmack Rd.
Columbus, OH 43210

FUTURES SOCIETIES EXPERT PANEL

Theodore S. Glickman
Resources for the Future
1616 P St., NW
Washington, DC 20036

Norman Rosenberg
Resources for the Future
1616 P St., NW
Washington, DC 20036

Max Singer
The Potomac Organization, Inc.
5400 Greystone St.
Chevy Chase, MD 20815

Maris Vinovskis
Institute for Social Research
Room 4086
University of Michigan
426 Thompson St
Ann Arbor, MI 48109-1045

Gregory Benford
University of California, Irvine
Department of Physics
Irvine, CA 92717

Craig Kirkwood
College of Business Administration
Arizona State University
Tempe, AZ 85287

Harry Otway
Health, Safety, and Envir. Div.
Mail Stop K-491
Los Alamos National Laboratory
Los Alamos, NM 87545

Martin J. Pasqualetti
Department of Geography
Arizona State University
Tempe, AZ 85287-3806

Michael Baram
Bracken and Baram
33 Mount Vernon St.
Boston, MA 02108

Wendell Bell
Department of Sociology
Yale University
1965 Yale Station
New Haven, CT 06520

Bernard L. Cohen
Department of Physics
University of Pittsburgh
Pittsburgh, PA 15260

Ted Gordon
The Futures Group
80 Glastonbury Blvd.
Glastonbury, CT 06033

Duane Chapman
5025 S. Building, Room S5119
The World Bank
1818 H Street NW
Washington, DC 20433

Victor Ferkiss
Georgetown University
37th and O Sts. NW
Washington, DC 20057

Dan Reicher
Senior Attorney
Natural Resources Defense Council
1350 New York Ave. NW, #300
Washington, DC 20005

Theodore Taylor
P.O. Box 39
3383 Weatherby Rd.
West Clarksville, NY 14786

NATIONAL LABORATORIES

Argonne National Labs
Attn: A. Smith, D. Tomasko
9700 South Cass, Bldg. 201
Argonne, IL 60439

Battelle Pacific Northwest Laboratories (6)
Attn: D. J. Bradley
J. Relyea
R. E. Westerman
S. Bates
H. C. Burkholder
L. Pederson
Battelle Boulevard
Richland, WA 99352

Lawrence Livermore National Laboratory
Attn: G. Mackanic
P.O. Box 808, MS L-192
Livermore, CA 94550

Los Alamos National Laboratory
Attn: B. Erdal, CNC-11
P.O. Box 1663
Los Alamos, NM 87544

Los Alamos National Laboratories (3)
HSE-8
Attn: M. Enoris
L. Soholt
J. Wenzel
P.O. Box 1663
Los Alamos, NM 87544

Los Alamos National Laboratories (2)
HSE-7
Attn: A. Drypolcher
S. Kosciewiscz
P.O. Box 1663
Los Alamos, NM 87544

Oak Ridge National Labs
Martin Marietta Systems, Inc.
Attn: J. Setaro
P.O. Box 2008, Bldg. 3047
Oak Ridge, TN 37831-6019

Oak Ridge National Laboratory (2)
Attn: R. E. Blanko
E. Bondietti
Box 2008
Oak Ridge, TN 37831

Savannah River Laboratory (6)
Attn: N. Bibler
E. L. Albenisius
M. J. Plodinec
G. G. Wicks
C. Jantzen
J. A. Stone
Aiken, SC 29801

Savannah River Plant (2)
Attn: Richard G. Baxter
Building 704-S
K. W. Wierzbicki
Building 703-H
Aiken, SC 29808-0001

CORPORATIONS/MEMBERS OF THE PUBLIC

Arthur D. Little, Inc.
Attn: Charles R. Hadlock
Acorn Park
Cambridge, MA 02140-2390

Benchmark Environmental Corp. (3)
Attn: John Hart
C. Frederickson
K. Lickliter
4501 Indian School Rd., NE
Suite 105
Albuquerque, NM 87110

Deuel and Associates, Inc.
Attn: R. W. Prindle
7208 Jefferson, NE
Albuquerque, NM 87109

Disposal Safety, Inc.
Attn: Benjamin Ross
Suite 314
1660 L Street NW
Washington, DC 20006

E G & G Idaho (3)
1955 Fremont Street
Attn: C. Atwood
C. Hertzler
T. I. Clements
Idaho Falls, ID 83415

In-Situ, Inc. (2)
Attn: S. C. Way
C. McKee
209 Grand Avenue
Laramie, WY 82070

INTERA Technologies, Inc. (3)
Attn: G. E. Grisak
J. F. Pickens
A. Haug
Suite #300
6850 Austin Center Blvd.
Austin, TX 78731

INTERA Technologies, Inc.
Attn: Wayne Stensrud
P.O. Box 2123
Carlsbad, NM 88221

IT Corporation (3)
Attn: R. F. McKinney (2)
P. Drez
Regional Office - Suite 700
5301 Central Avenue, NE
Albuquerque, NM 87108

IT Corporation
R. J. Eastmond
825 Jadwin Ave.
Richland, WA 99352

IT Corporation (2)
Attn: D. E. Deal
P.O. Box 2078
Carlsbad, NM 88221

Pacific Northwest Laboratory
Attn: Bill Kennedy
Battelle Blvd.
P.O. Box 999
Richland, WA 99352

RE/SPEC, Inc. (7)
Attn: L. L. Van Sambeek
D. B. Blankenship
G. Callahan
T. Pfeifle
J. L. Ratigan
P.O. Box 725
Rapid City, SD 57709

Reynolds Elect/Engr. Co., Inc.
Building 790, Warehouse Row
Attn: E. W. Kendall
P.O. Box 98521
Las Vegas, NV 89193-8521

Roy F. Weston, Inc.
CRWM Tech. Supp. Team
Attn: Clifford J. Noronha
955 L'Enfant Plaza, S.W.
North Building, Eighth Floor
Washington, DC 20024

Science Applications International Corporation
Attn: Howard R. Pratt, Senior Vice President
10260 Campus Point Drive
San Diego, CA 92121

Science Applications International Corporation
Attn: Michael B. Gross Ass't. Vice President
Suite 1250
160 Spear Street
San Francisco, CA 94105

Science Applications International Corporation (2)
Attn: George Dymmel
Chris G. Pflum
101 Convention Center Dr.
Las Vegas, NV 89109

Southwest Research Institute
Center for Nuclear Waste Regulatory Analysis (4)
Attn: P. K. Nair (3)
B. Sagar (1)
6220 Culebra Road
San Antonio, Texas 78228-0510

Systems, Science, and Software (2)
Attn: E. Peterson
P. Lagus
Box 1620
La Jolla, CA 92038

TASC
Attn: Steven G. Oston
55 Walkers Brook Drive
Reading, MA 01867

Tech. Reps., Inc. (4)
Attn: Janet Chapman
T. Cameron
D. Marchand
J. Stikar
5000 Marble NE
Suite 222
Albuquerque, NM 87110

Tolan, Beeson, and Assoc.
Attn: T. Tolan
2320 W. 15th Ave.
Kennewick, WA 99337

TRW Environmental Safety Systems (TESS)
Attn: Ivan Saks
10306 Eaton Place
Suite 300
Fairfax, VA 22030

Westinghouse Electric Corporation (7)
Attn: Library
L. Trego
W. P. Poirier
L. Fitch
V. F. Likar
R. Cook
R. F. Kehrman
P.O. Box 2078
Carlsbad, NM 88221

Westinghouse Hanford Company
Attn: Don Wood
P.O. Box 1970
Richland, WA 99352

Westinghouse/Hanford
Attn. K. Owens
2401 Stevens Road
Richland, WA 99352

Weston Corporation
Attn: David Lechel
5301 Central Avenue, NE
Albuquerque, NM 87108

Western Water Consultants
Attn: D. Fritz
P.O. Box 3042
Sheridan, WY 82801

Western Water Consultants
Attn: P. A. Rechard
P.O. Box 4128
Laramie, WY 82071

Neville Cook
Rock Mechanics Engineering
Mine Engineering Dept.
University of California
Berkeley, CA 94720

Dennis W. Powers
Star Route Box 87
Anthony, TX 79821

UNIVERSITIES

University of Arizona
Attn: J. G. McCray
Department of Nuclear Engineering
Tucson, AZ 85721

University of California
Mechanical, Aerospace, and
Nuclear Engineering Department (2)
Attn: W. Kastenberg
D. Browne
5532 Boelter Hall
Los Angeles, CA 90024

University of Hawaii at Hilo
Attn: S. Hora
Business Administration
Hilo, HI 96720-4091

University of New Mexico (2)
Geology Department
Attn: D. G. Brookins
Library
Albuquerque, NM 87131

University of New Mexico
Research Administration
Attn: H. Schreyer
102 Scholes Hall
Albuquerque, NM 87131

Pennsylvania State University
Materials Research Laboratory
Attn: Della Roy
University Park, PA 16802

Texas A&M University
Center of Tectonophysics
College Station, TX 77840

University of Wyoming
Department of Civil Engineering
Attn: V. R. Hasfurther
Laramie, WY 82071

University of Wyoming
Department of Geology
Attn: J. I. Drever
Laramie, WY 82071

University of Wyoming
Department of Mathematics
Attn: R. E. Ewing
Laramie, WY 82071

LIBRARIES

Thomas Brannigan Library
Attn: Don Dresp, Head Librarian
106 W. Hadley St.
Las Cruces, NM 88001

Hobbs Public Library
Attn: Marcia Lewis, Librarian
509 N. Ship Street
Hobbs, NM 88248

New Mexico State Library
Attn: Ingrid Vollenhofer
P.O. Box 1629
Santa Fe, NM 87503

New Mexico Tech
Martin Speere Memorial Library
Campus Street
Socorro, NM 87810

New Mexico Junior College
Pannell Library
Attn: Ruth Hill
Lovington Highway
Hobbs, NM 88240

Carlsbad Municipal Library
WIPP Public Reading Room
Attn: Lee Hubbard, Head Librarian
101 S. Halagueno St.
Carlsbad, NM 88220

University of New Mexico
General Library
Government Publications Department
Albuquerque, NM 87131

NEA/PSAC USER'S GROUP

Timo K. Vieno
Technical Research Centre of Finland (VTT)
Nuclear Engineering Laboratory
P.O. Box 169
SF-00181 Helsinki
FINLAND

Alexander Nies (PSAC Chairman)
Gesellschaft f r Strahlen- und
Institut f r Tieflagerung
Abteilung f r Endlagersicherheit
Theodor-Heuss-Strasse 4
D-3300 Braunscheweig
FEDERAL REPUBLIC OF GERMANY

Eduard Hofer
Gesellschaft f r Reaktorsicherheit (GRS)
MBH
Forschungsgel nde
D-8046 Garching
FEDERAL REPUBLIC OF GERMANY

Takashi Sasahara
Environmental Assessment Laboratory
Department of Environmental Safety
Research
Nuclear Safety Research Center,
Tokai Research Establishment, JAERI
Tokai-mura, Naka-gun
Ibaraki-ken
JAPAN

Alejandro Alonso
C tedra de Tecnolog a Nuclear
E.T.S. de Ingenieros Industriales
Jos Guti rrez Abascal, 2
E-28006 Madrid
SPAIN

Pedro Prado
CIEMAT
Instituto de Tecnolog a Nuclear
Avenida Complutense, 22
E-28040 Madrid
SPAIN

Miguel Angel Cu ado
ENRESA
Emilio Vargas, 7
E-28043 Madrid
SPAIN

Francisco Javier Elorza
ENRESA
Emilio Vargas, 7
E-28043 Madrid
SPAIN

Nils A. Kjellbert
Swedish Nuclear Fuel and Waste Management
Company (SKB)
Box 5864
S-102 48 Stockholm
SWEDEN

Bj rn Cronhjort
Swedish National Board for Spent Nuclear
Fuel (SKN)
Sehlsedtsgatan 9
S-115 28 Stockholm
SWEDEN

Richard A. Klos
Paul-Scherrer Institute (PSI)
CH-5232 Villingen PSI
SWITZERLAND

Charles McCombia
NAGRA
Parkstrasse 23
CH-5401 Baden
SWITZERLAND

Brian G. J. Thompson
Department of the Environment
Her Majesty's Inspectorate of Pollution
Room A5.33, Romney House
43 Marsham Street
London SW1P 2PY
UNITED KINGDOM

Trevor J. Sumerling
INTERA/ECL
Chiltern House
45 Station Road
Henley-on-Thames
Oxfordshire RG9 1AT
UNITED KINGDOM

Richard Codell
U.S. Nuclear Regulatory Commission
Mail Stop 4-H-3
Washington, D.C. 20555

Norm A. Eisenberg
Division of High Level Waste Management
Office of Nuclear Material Safety and
Safeguards
Mail Stop 4-H-3
Washington, D.C. 20555

Paul W. Eslinger
Battelle Pacific Northwest Laboratories (PNL)
P.O. Box 999, MS K2-32
Richland, WA 99352

Budhi Sagar
Center for Nuclear Waste Regulatory
Analyses (CNWRA)
Southwest Research Institute
Post Office Drawer 28510
6220 Culebra Road
San Antonio, TX 78284

Andrea Saltelli
Commission of the European Communities
Joint Resarch Centre od Ispra
I-21020 Ispra (Varese)
ITALY

Shaheed Hossain
Division of Nuclear Fuel Cycle and Waste
Management
International Atomic Energy Agency
Wagramerstrasse 5
P.O. Box 100
A-1400 Vienna
AUSTRIA

Daniel A. Galson
Division of Radiation Protection and Waste
Management
38, Boulevard Suchet
F-75016 Paris
FRANCE

FOREIGN ADDRESSES

Studiecentrum Voor Kernenergie
Centre D'Energie Nucleaire
Attn: A. Bonne
SCK/CEN
Boeretang 200
B-2400 Mol
BELGIUM

Atomic Energy of Canada, Ltd. (4)
Whiteshell Research Estab.
Attn: Peter Haywood
John Tait
Michael E. Stephens
Bruce W. Goodwin
Pinewa, Manitoba, CANADA
ROE 1L0

D. K. Mukerjee
Ontario Hydro Research Lab
800 Kipling Avenue
Toronto, Ontario, CANADA
M8Z 5S4

Ghislain de Marsily
Lab. G ologie Appliqu
Tour 26, 5 tage
4 Place Jussieu
F-75252 Paris Cedex 05, FRANCE

Jean-Pierre Olivier
OECD Nuclear Energy Agency (2)
38, Boulevard Suchet
F-75016 Paris, FRANCE

D. Alexandre, Deputy Director
ANDRA
31 Rue de la Federation
75015 Paris, FRANCE

Claude Sombret
Centre D'Etudes Nucleaires
De La Vallee Rhone
CEN/VALRHO
S.D.H.A. BP 171
30205 Bagnols-Sur-Ceze
FRANCE

Bundesministerium fur Forschung und
Technologie
Postfach 200 706
5300 Bonn 2
FEDERAL REPUBLIC OF GERMANY

Bundesanstalt fur Geowissenschaften
und Rohstoffe
Attn: Michael Langer
Postfach 510 153
3000 Hannover 51
FEDERAL REPUBLIC OF GERMANY

Hahn-Mietner-Institut fur Kernforschung
Attn: Werner Lutze
Glienicker Strasse 100
100 Berlin 39
FEDERAL REPUBLIC OF GERMANY

Institut fur Tieflagerung (4)
Attn: K. Kuhn
Theodor-Heuss-Strasse 4
D-3300 Braunschweig
FEDERAL REPUPLIC OF GERMANY

Kernforschung Karlsruhe
Attn: K. D. Closs
Postfach 3640
7500 Karlsruhe
FEDERAL REPUBLIC OF GERMANY

Physikalisch-Technische Bundesanstalt
Attn: Peter Brenneke
Postfach 33 45
D-3300 Braunschweig
FEDERAL REPUBLIC OF GERMANY

D. R. Knowles
British Nuclear Fuels, plc
Risley, Warrington, Cheshire WA3 6AS
1002607 GREAT BRITAIN

Shingo Tashiro
Japan Atomic Energy Research Institute
Tokai-Mura, Ibaraki-Ken
319-11 JAPAN

Netherlands Energy Research Foundation
ECN (2)
Attn: Tuen Deboer, Mgr.
L. H. Vons
3 Westerduinweg
P.O. Box 1
1755 ZG Petten, THE NETHERLANDS

Johan Andersson
Statens K rnkraftinspektion
SKI
Box 27106
S-102 52 Stockholm, SWEDEN

Fred Karlsson
Svensk Karnbransleforsorjning AB
SKB
Box 5864
S-102 48 Stockholm, SWEDEN

INTERNAL

1	A. Narath
20	O. E. Jones
1511	D. K. Gartling
1520	L. W. Davison
1521	J. G. Arguello
1521	H. S. Morgan
3151	S. M. Wayland
3200	N. R. Ortiz
6000	V. L. Dugan, Acting
6232	W. R. Wawersik
6233	J. C. Eichelberger
6233	J. L. Krumhansl
6300	T. O. Hunter, Acting
6310	T. E. Blejwas, Acting
6311	A. L. Stevens
6312	G. E. Barr
6312	F. W. Bingham
6313	L. E. Shephard
6315	P. C. Kaplan
6316	R. P. Sandoval
6317	S. Sinnock
6320	J. E. Stiegler
6340	W. D. Weart
6340	S. Y. Pickering
6341	J. M. Covan
6341	D. P. Garber
6341	R. C. Lincoln
6341	Sandia WIPP Central Files (20)
6342	D. R. Anderson
6342	L. S. Gomez
6342	M. Gruebel
6342	R. Guzowski (5)
6342	R. D. Klett
6342	M. G. Marietta
6342	D. Morrison
6342	A. C. Peterson
6342	R. P. Rechard
6342	P. Swift
6342	K. M. Trauth
6342	B. L. Baker*
6342	J. Bean*
6342	J. Berglund*
6342	W. Beyeler*
6342	R. Blaine*
6342	T. Blaine*
6342	K. Brinster*
6342	K. Byle*
6342	L. Clements*
6342	J. Garner*
6342	A. Gilkey*
6342	A. Hsia*
6342	H. Iuzzolino*
6342	J. Logothetis*
6342	R. McCurley*
6342	J. Orona*
6342	J. Rath*
6342	P. Roache*
6342	D. Rudeen*
6342	J. Sandha*
6342	J. Schreiber*
6342	J. Tauxe*
6342	P. Vaughn*
6343	T. M. Schultheis
6344	R. L. Beauheim
6344	P. B. Davies
6344	S. J. Finley
6344	E. Gorham
6344	A. M. LaVenue
6344	C. F. Novak
6344	S. W. Webb
6345	R. Beraun
6345	L. Brush
6345	B. M. Butcher, Acting
6345	A. R. Lappin
6345	M. A. Molecke
6346	B. L. Ehgartner
6346	D. E. Munson
6346	E. J. Nowak
6346	J. R. Tillerson
6346	T. M. Torres
6350	R. L. Hunter
6400	D. J. McCloskey
6413	J. C. Helton
6415	J. Campbell
6415	R. M. Cranwell
6415	R. L. Iman
6415	M. Tierney
6416	E. Bonano
6416	M.S.Y. Chu
9300	J. E. Powell
9310	J. D. Plimpton
9320	M. J. Navratil
9325	J. T. McIlmoyle
9325	R. L. Rutter
9330	J. D. Kennedy
9333	O. Burchett
9333	J. W. Mercer
8523	R. C. Christman
3141	S. A. Landenberger (5)
3145	Document Processing (8) for DOE/OSTI
3151	G. C. Claycomb (3)

*U.S. GOVERNMENT PRINTING OFFICE 1991-0-574-038/44053