DOE/EA--1214-Final

FINAL

EA1214

Environmental Assessment
for
Off-Site Transportation of Low-Level Waste from Four California Sites Under the Management of The U.S. Department of Energy Oakland Operations Office

October 1997

MASTER

FINAL ENVIRONMENTAL ASSESSMENT FOR OFF-SITE TRANSPORTATION OF LOW-LEVEL WASTE TO COMMERCIAL DISPOSAL SITES FROM FOUR CALIFORNIA SITES UNDER THE MANAGEMENT OF THE U.S. DEPARTMENT OF ENERGY OAKLAND OPERATIONS OFFICE

October 1997

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

ALARA	As Low As Reasonably Achievable
CEDE	Committed Effective Dose Equivalent
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
DAW	Dry Active Waste
DOE	U.S. Department of Energy
DOE/OAK	U.S. Department of Energy/Oakland Operations Office
DOT	U.S. Department of Transportation
DR	Disposal Request
EA	Environmental Assessment
EPA	U.S. Environmental Protection Agency
ETEC	Energy Technology Engineering Center, Canoga Park, California
FY	Fiscal Year
GA	General Atomics, San Diego, California
ICRP	International Committee on Radiation Protection
LCF	Latent Cancer Fatality
LBNL	Lawrence Berkeley National Laboratory, Berkeley, California
LLNL	Lawrence Livermore National Laboratory, Livermore, California
LLW	Low-Level Waste
NAS	National Academy of Sciences

LIST OF ACRONYMS (CONTINUED):

NRC	U.S. Nuclear Regulatory Commission
NTS	The Nevada Test Site; Nevada
QF	Quality Factor
SAR	Safety Analysis Report
SLAC	Stanford Linear Accelerator Center, Palo Alto, California
SNL/NM	Sandia National Laboratories, Los Alamos, New Mexico
SNL-EA	Sandia National Laboratories Environmental Assessment, 1996, Los Alamos, New Mexico
TI	Transportation Index
TYP	Ten Year Plan
WAC	Waste Acceptance Criteria

DOE/EA--1214

U.S. Department of Energy (DOE)

Finding of No Significant Impact

Off-Site Transportation of

Low-Level Waste from

Four California Sites under the Management of the

U.S. Department of Energy

Oakland Operations Office

AGENCY: U.S. Department of Energy (DOE)

ACTION: Finding of No Significant Impact (FONSI)

SUMMARY: The U.S. Department of Energy (DOE) has prepared an Environmental Assessment (EA), DOE/EA-1214, evaluating the proposed action to transport low-level waste (LLW) from four DOE sites in California to two commercial off-site locations. Prior to this EA, the off-site transportation of LLW was addressed via Categorical Exclusions (CXs) specific to each project at each of the four sites.

Based upon the information and analyses in the EA, the DOE has determined that the proposed federal action does not significantly affect the quality of the human environment within the meaning of the National Environmental Policy Act of 1969.

DESCRIPTION OF THE PROPOSED WORK:

The proposed action is to ship low-level waste (LLW) from four Department of Energy Oakland Operations Office (DOE/OAK) sites in California which generate LLW, to Nuclear Regulatory Commission (NRC) licensed commercial nuclear waste disposal facilities: Envirocare in Clive, Utah and Chem Nuclear in Barnwell, South Carolina. The four DOE/OAK sites and their locations within California are:

- Lawrence Livermore National Laboratory (LLNL), Livermore, California
- Lawrence Berkeley National Laboratory (LBNL), Berkeley, California
- Energy Technology Engineering Laboratory (ETEC), Canoga Park, California
- Stanford Linear Accelerator Center (SLAC), Palo Alto, California.

ALTERNATIVES:

The only alternative to the proposed action was the no action alternative. Several other alternatives, which are listed below, were considered but eliminated:

- Compact disposal sites - except for the Chem Nuclear Barnwell site, which is included in the proposed action, DOE is precluded from disposing of wastes at these sites.
- DOE sites - DOE will continue to dispose of LLW at the Nevada Test Site (NTS) and the Hanford site, as appropriate. Each site is restricted on the types of LLW that they can accept, resulting in the need for commercial LLW disposal options. The Waste Isolation Pilot Plant (WIPP) is not available for the disposal of LLW.
- Other sites - no other commercial LLW disposal facilities have been approved for use by DOE. Any commercial site used by DOE must meet stringent operational and safety criteria. To date, only the two sites mentioned in the proposed action have met the DOE criteria.

Under the no action alternative, DOE/OAK would not ship and dispose of LLW to commercial sites. LLW would be shipped to DOE-operated disposal facilities. The four DOE/OAK generator sites can generate volumes of LLW that cannot be disposed of at

DOE facilities equal to the rate of generation. When this occurs, the maximum storage capacity at the DOE/OAK generator sites would be reached, leading to the cessation of environmental restoration activities and other operations.

ENVIRONMENTAL IMPACTS:

Transportation Effects: The proposed action was evaluated for both the radiological and non-radiological effects resulting from both incident-free transportation and potential accident scenarios. For both incident-free and accident estimates, radiological effects are characterized by exposure in person-rems and latent cancer fatalities (LCF). Non-radiological effects are characterized by LCF (for incident-free shipments) and Traffic Accident Fatalities (for accident scenarios).

The Region of Influence (ROI) used to determine incident free exposure along transportation corridors for this Environmental Assessment (EA) was assumed to be 800 meters (0.5 miles) on either side of the transportation corridor. For the maximally exposed individual, the distance was assumed to be 30 meters (98 feet) from the exposure source. The analysis for the proposed action indicates the total exposure for the maximally exposed individual along the transport route to Envirocare or Chem Nuclear would not exceed 0.229 mr/yr (versus an NRC public exposure limit of 100 mr/yr). The truck driver exposure would not exceed 1,350 mr/yr (versus an NRC worker exposure limit of 5,000 mr/yr).

For the purpose of evaluating the impacts associated with an accident, the hypothetical worst case accidents are modeled to occur along an urban route that is typical of the most densely populated transportation corridor likely to be encountered along the route from any of the four generating sites to either of the commercial disposal sites. An estimated 6,100 persons reside along the ROI for this transportation corridor (0.5 kilometers on either side of the corridor). Most of the LLW that will be transported emit less than 5 mr/hour; however, the worst-case scenarios assume the transportation of environmental restoration wastes emitting 200 mr/hour contained in Type A packaging, the least robust type of container.

Three accident scenarios were evaluated: one involving no release of radioactive material, one involving the release of 10% of the radioactive material, and one involving the release of 100% of the radioactive material. The accident involving the release of 100% of the radioactive material is estimated to occur once for every million shipments. In all cases, the population at highest risk would be the personnel in the truck. Evacuation of personnel residing within the ROI to safe distances would provide immediate protection from the risk of exposure. The 100% release of radioactive material would be mitigated by the use of response crews and techniques that would ensure the proper removal and disposal of the released material. These conditions would reduce this impact to a level of non-significance.

Air Quality: The largest non-attainment areas on the proposed shipment routes are located in several California Air Basins. This shipping campaign would cause no discernible increase in the daily rate of emissions from truck shipments for these non-attainment areas. The emissions are considered to be *de minimis* and require no formal analysis under EPA's conformity rule (58 FR 63214, November 30, 1993).

Noise: The shipments would minimally increase traffic flow. Because the dominant source of noise along the route is from the passage of vehicles, the noise level would minimally increase over existing ambient noise levels due to the low number of shipments proposed versus present traffic levels. Even if one were to consider that the maximum annual number of shipments for each facility occur in the same year, no noticeable change in common highway noise along any part of the routes between the DOE/OAK sites and Chem Nuclear or Envirocare would be expected.

Cumulative Impacts: Cumulative impacts are those that result from the incremental impact of the proposed action when added to other past, present, and reasonably foreseeable future actions. To calculate cumulative radiological impact, estimated maximum annual doses from the proposed action and from other radioactive waste shipments occurring at the same facilities, along the same routes, and projected to occur concurrently during the proposed action, are added together. This approach neglects the fact that dose fractionation (delivery of a total dose in a number of separate doses spread over time) may reduce the effect of the total cumulative dose. The impacts of the hypothetical worst-case situation of the proposed action, when added to the impact from existing exposures, do not produce a significant impact. The estimated cumulative impact to the maximally exposed individual is 0.247 mr/yr (versus an NRC public limit of 100 mr/yr) and the to the truck crew is 2,220 mr/yr (versus an NRC worker limit of 5,000 mr/yr).

Environmental Justice: Executive Order 12898 requires that all federal agencies evaluate whether proposed actions would cause disproportionate impacts on minority or low income communities. The use of the public highways with the most direct route to interstate highways is the same routes that would be used by any trucks shipping LLW. Therefore, exposure is not limited, restricted, or focused toward any particular population or economically disadvantaged or advantaged group.

DETERMINATION:

Based on the information and analysis in the EA, the DOE has determined that the proposal to transport low-level waste (LLW) from four DOE sites in California to off-site locations does not constitute a federal action significantly affecting the quality of the human environment within the meaning of the National Environmental Policy Act of 1969. Therefore, a FONSI is made and an Environmental Impact Statement is not required.

PUBLIC AVAILABILITY:

Copies of this EA are available from:

Carole Word
U.S. Department of Energy
Office of Public Affairs
1301 Clay Street, 700N
Oakland, CA 94612
(510) 637- 1812

For further information regarding the DOE National Environmental Policy Act (NEPA) process, contact:

Anthony J. Adduci
U.S. Department of Energy
NEPA Compliance Officer
1301 Clay Street, 700N
Oakland, CA 94612
(510) 637-1807

Issued in Oakland, California this 31 day of Oct, 1997.

James M. Turner, Ph.D.
Manager
Oakland Operations Office

EXECUTIVE SUMMARY

Background

The Department of Energy Oakland Operations Office (DOE/OAK) manages sites within California that generate Low Level Waste (LLW) in the course of routine site operations. It is the preference of the DOE to dispose of LLW at federally owned and DOE-operated disposal facilities; however, in some circumstances DOE Headquarters has determined that disposal at commercial facilities is appropriate, as long as the facility meets all regulatory requirements for the acceptance and disposal of LLW, including the passage of a DOE audit to determine the adequacy of the disposal site.

Transportation impacts for shipment of LLW and MLLW from DOE Oakland sites to other DOE sites was included in the impacts identified in the Department's Waste Management Programmatic Environmental Impact Statement (WM-PEIS), published in May, 1997, and determined to be low. The low impacts for shipment to commercial sites identified herein is consistent with the WM-PEIS results.

Purpose and Need

The DOE may need other disposal sites if the DOE Hanford site (Richland, Washington) is unavailable to receive DOE/OAK non-defense LLW, or the Nevada Test Site (NTS) (Las Vegas, Nevada) is unavailable to receive DOE/OAK defense LLW (see Section 2.3) in a sufficiently timely manner so as not to exceed the available on-site storage capacity for LLW. If on-site volumes of LLW exceed site storage capacity, site activities, including site clean up, must be slowed or even stopped until additional storage capacity becomes available. The purpose of this EA is to assess the environmental impacts of different ways of fulfilling this need.

The Proposed Action

The DOE would like to ship LLW from four DOE/OAK sites in California which generate LLW, to NRC-licensed commercial nuclear waste disposal facilities such as Envirocare in Clive, Utah and Chem Nuclear in Barnwell, South Carolina. The four DOE/OAK sites and their locations within California are:

- Lawrence Livermore National Laboratory (LLNL), Livermore, California;
- Lawrence Berkeley National Laboratory (LBNL), Berkeley, California;
- Energy Technology Engineering Center (ETEC), Canoga Park, California;
- Stanford Linear Accelerator Center (SLAC), Palo Alto, California.

The No Action Alternative

DOE/OAK would not ship and dispose of LLW to commercial sites. LLW would be placed in indefinite storage at the DOE/OAK facility that generated the waste until shipped to DOE operated disposal facilities. Disposal at DOE sites can be time consuming. DOE/OAK generator sites can generate volumes of LLW that cannot be disposed of at DOE facilities equal to the rate of generation. When this occurs, the maximum storage capacity at the DOE/OAK generator sites would be reached, leading to the cessation of operations, including environmental restoration.

Summary of Methodology Used to Perform Impacts Analysis

The action being evaluated is the transport of LLW from the gate of the generating site to the gate of the receiving disposal site. Impacts associated with generation and packaging of the LLW are covered under National Environmental Policy Act (NEPA) documentation for each of the generating facilities. Impacts associated with the receipt of the LLW by the disposal sites are covered in the NRC operating licenses for the disposal sites, and their accompanying NEPA documentation.

The methodology employed to determine the impacts associated with the proposed action, is derived from the methodology used in the Sandia National Laboratory, New Mexico (SNL/NM) Environmental Assessment (SNL-EA, 1996). That document estimated the total radiological and non-radiological impacts of transportation to DOE approved commercial disposal facilities upon the following resource areas:

- Exposure and transportation effects, including the risk of accidents along the transport routes from the generating sites to the disposal sites in Clive, Utah and Barnwell, South Carolina.
- Traffic impacts;
- Air quality along the transport routes;
- Noise at the generating sites and along the transport routes;
- Environmental justice;
- Cumulative impacts.

This EA evaluates these same resource areas.

For this EA the potential impacts were estimated for a hypothetical worst-case scenario of approximately 6,228 m^3 of LLW generated by the combined DOE/OAK sites listed above. It was assumed that this total volume would require disposal at commercial sites within a single year. The volume of waste used to estimate the hypothetical worst case scenario represents the maximum volume of LLW present on all four sites, includes an additional margin of safety, and is an overestimate of the actual volumes of LLW anticipated for shipment in any single year from the combined four DOE/OAK sites evaluated in this EA. This volume calculation was used to provide a generous margin of safety for the purposes of this analysis.

Environmental Consequences

The effects incurred by the environmental aspects assessed in this document are minimal based upon the analyses performed. In hypothesizing the most credible accident a conservative approach was taken. This resulted in a rather low probability of accident occurrence with damage and exposures being within established radiological limits.

1.0 PURPOSE AND NEED FOR ACTION

The Department of Energy Oakland Operations Office (DOE/OAK) manages sites within California that generate Low Level Waste (LLW) in the course of routine site operations. [1] The four DOE/OAK sites and their locations within California are:

- Lawrence Livermore National Laboratory (LLNL), Livermore, California;
- Lawrence Berkeley National Laboratory (LBNL), Berkeley, California;
- Energy Technology Engineering Center (ETEC), Canoga Park, California;
- Stanford Linear Accelerator Center (SLAC), Palo Alto, California.

Commercial disposal facilities may be needed if the DOE Hanford site (Richland, Washington) is unavailable to receive DOE/OAK non-defense LLW, or the Nevada Test Site (NTS) (Las Vegas, Nevada) is unavailable to receive DOE/OAK defense LLW (see Section 2.3) in a sufficiently timely manner so as not to exceed the available on-site storage capacity for LLW at any of the DOE/OAK sites listed above.

It is the preference of the DOE to dispose of LLW at federally-owned and DOE-operated disposal facilities; however, in some circumstances DOE Headquarters has determined that disposal at commercial facilities is appropriate as long as such facilities meet all regulatory requirements for the acceptance and disposal of LLW, including the passage of DOE audit to determine the adequacy of the disposal site.

The purpose of this document is to assess the transport of LLW from the gate of the generating site to the gate of the receiving disposal site, and other alternatives. Impacts associated with generation and packaging of the LLW are covered under National Environmental Policy Act (NEPA) Documentation for each of the generating facilities. Impacts associated with the receipt of the LLW by the disposal site are covered in the Nuclear Regulatory Commission (NRC) operating license for the disposal site and their accompanying NEPA documentation.

Consistent with the requirements to manage LLW with public health and safety as a major priority, and to ensure that no legacy waste requiring remedial action remains at the site following DOE operations, DOE/OAK has elected the option to transport its LLW from the four sites listed above for final disposition at either Envirocare and/or Chem Nuclear, or any other DOE approved commercial disposal

[1] It should be noted that "mixed low-level waste" (MLLW) [i.e., any waste containing both a hazardous waste (as defined by the Resource Conservation Recovery Act), and source, special nuclear, or by-product material subject to the Atomic Energy Act of 1954 (42 USC 2011 et seq.)] is not covered under the proposed action.

sites that become available within the transportation corridors analyzed within this EA, should circumstances require such disposal. The purpose of this EA is to assess the environmental impacts of different ways of fulfilling this need. This EA evaluates the proposal for transporting LLW to these commercial disposal sites, and evaluates a no action alternative. Rail transport to the same commercial disposal facilities is included by reference herein, since rail lines and rail distances are comparable to the highway transportation corridors evaluated in this document.

Transportation impacts for shipment of LLW and MLLW from DOE Oakland sites to other DOE sites was included in the impacts identified in the Department's Waste Management Programmatic Environmental Impact Statement (WM-PEIS), published in May, 1997, and determined to be low. The low impacts for shipment to commercial sites identified herein is consistent with the WM-PEIS results.

2.0 THE PROPOSED ACTION AND ALTERNATIVES

2.1 Proposed Action

The Department of Energy (DOE) would like to ship Low-Level Waste (LLW) from four Department of Energy Oakland Operations Office (DOE/OAK) sites in California which generate LLW, to Nuclear Regulatory Commission (NRC) licensed commercial nuclear waste disposal facilities such as Envirocare in Clive, Utah and Chem Nuclear in Barnwell, South Carolina. The four DOE/OAK sites and their locations within California are:

- Lawrence Livermore National Laboratory (LLNL), Livermore, California;
- Lawrence Berkeley National Laboratory (LBNL), Berkeley, California;
- Energy Technology Engineering Center (ETEC), Canoga Park, California;
- Stanford Linear Accelerator Center (SLAC), Palo Alto, California.

2.2 The No Action Alternative

DOE/OAK would not ship and dispose of LLW to commercial sites. LLW would be shipped to DOE operated disposal facilities. Disposal at DOE sites can be time consuming. Further, DOE/OAK generator sites can generate volumes of LLW that cannot be disposed of at DOE facilities equal to the rate of generation. When this occurs, the maximum storage capacity at the DOE/OAK generator sites would be reached, leading to the cessation of operations, including environmental restoration.

2.3 Disposal Alternatives Considered But Eliminated From Further Study

The following alternatives to the proposed action were considered and eliminated. The consideration of alternatives included all disposal sites that accept radioactive wastes.

2.3.1 Compact Disposal Sites

The Low Level Waste Policy Act and Amendments (Act) established a process for states to develop disposal sites for NRC-regulated wastes. The Act encouraged states to form groupings or Compacts, and it required each Compact to open a LLW disposal site. Currently, only two such disposal sites are in operation: the Chem Nuclear site in Barnwell, South Carolina, and the U.S. Ecology site, located on the Hanford Reservation. The Chem Nuclear site is included as a selected disposal site in the proposed action, and the U.S. Ecology site is discussed below.

U.S. Ecology

The privately operated U.S. Ecology site is located on a long-term leased parcel within the Hanford Reservation. It is the disposal site for the Northwest Compact, and as such, it is allowed to accept only certain types of LLW from outside the Compact. The DOE/OAK sites, which are located in the Southwest Compact, can send only naturally-occurring radioactive material (NORM) and accelerator-produced radioactive material (NARM) wastes to U.S. Ecology. Since these waste types constitute only a small fraction of the LLW generated by DOE/OAK facilities, the U.S. Ecology site has been eliminated as a potential alternative to the proposed action.

2.3.2 DOE Sites Eliminated From Further Study

Waste Isolation Pilot Plant

The Waste Isolation Pilot Plant (WIPP) is located near Carlsbad, New Mexico in the southeastern corner of the state. By law, WIPP can accept only defense-related transuranic (TRU) waste. Since the proposed action involves only LLW, WIPP has been eliminated as a potential alternative for the disposal of LLW. To consider this alternative further, DOE policy would have to change and congressional legislation would have to be enacted.

2.3.3 Commercial Sites Not Approved By DOE

DOE policies specify that commercial LLW disposal sites must meet operational and safety criteria, as well as pass a thorough DOE site safety audit. Sites that have not met these DOE criteria are not "qualified" for the purpose of the proposed action. The use of unqualified sites would conflict with standard DOE practices to ensure safety and protect public health, and they have been eliminated as a potential alternative to the proposed action.

2.4 Other Options Considered

Currently, two DOE disposal sites are in operation (the Nevada Test Site and the Hanford Reservation), and another is scheduled to open in December 1997 (the Waste Isolation Pilot Plant). Each site can accept only a specific type of waste.

Defense-Related LLW

The Nevada Test Site (NTS) accepts only defense-related LLW. That is, only DOE programs that receive defense funding can dispose of their LLW at NTS (located north of Las Vegas, Nevada). The NTS will continue to be used for disposal of defense-related LLW, as appropriate.

Non- Defense-Related LLW

The Hanford Reservation (Hanford) accepts only non-defense-related LLW. Only DOE programs that do not receive defense funding can send their wastes to Hanford (which is located near Richland, Washington, in the south central portion of the state). Hanford will continue to be used for disposal of non-defense-related LLW, as appropriate.

2.5 Methodology

This EA evaluates the impacts associated with the transport of LLW from the gate of the DOE/OAK generating site to the gate of the commercial disposal facility. The methodology employed to determine the impacts associated with the proposed action is derived from the methodology used in the Sandia National Laboratory, New Mexico (SNL/NM) Environmental Assessment (SNL-EA, 1996). That document estimated the total radiological and non-radiological impacts of transportation upon the following resource areas:

- Exposure and transportation effects, including the risk of accidents along the transport routes
- Traffic impacts
- Air quality
- Noise
- Environmental justice
- Cumulative effects.

This EA evaluates these same resource areas.

The most direct highway transportation routes were identified from the four DOE/OAK sites to the two representative commercial sites: Envirocare of Utah and Chem Nuclear's Barnwell site. To determine impacts on the subject resource areas, the effects of DOE/OAK shipments were estimated and compared to environmental and population data associated with these routes.

The effects of the DOE/OAK LLW shipments were estimated using the same numerical approach as used by SNL/NM (SNL-EA, 1996). In addition, DOE/OAK data, including distances traveled, quantities and types of wastes being transported, and potentially exposed populations were compared to the SNL/NM situation to determine whether the SNL/NM scenarios were representative of the worst case likely to be encountered in shipping LLW from DOE/OAK facilities.

The impacts associated with highway transportation were assumed to encompass the impacts associated with rail transport, since the distances traveled by rail and the populations encountered along the rail routes are comparable to interstate highways

2.5.1 DOE/OAK Shipment Estimates and Safety Factors

For this EA, the projected number of shipments was derived from the latest disposal projections for LLW from DOE/OAK, including estimates from the latest version of the DOE/OAK Ten Year Plan (TYP, February, 1997). Waste projections were obtained as annual fiscal year (FY) disposal volumes for each site from 1997 to 2006. To be conservative, these LLW projections were doubled for all sites except ETEC (ETEC's TYP projections already included a safety factor of two).

The hypothetical worst-case annual shipping scenario was then calculated. For each site, the single year with the highest LLW shipment volume was identified. For the impact analysis, all the worst-case years for the generator sites were assumed to occur concurrently (6,228 m^3 in one year).

The number of truckloads required to transport this hypothetical worst-case volume then was estimated. It would require 498 truckloads, if packaged in 55-gallon drums, or 329 truckloads, if packaged in steel boxes (4' x 4' x 7'). Table 2.1 shows the breakout of these hypothetical shipments by site and according to packaging type.

Table 2.1 Truckloads Required for Worst-Case Annual Shipments by Site and According to Packaging Type

	Total Truckloads	*LLNL*	*LBNL*	*SLAC*	*ETEC*
Drums	498	84	66	28	318
Boxes	329	56	44	18	209

Appendix A contains supporting details for the waste quantity information contained in Table 2.1. This is the same methodology employed by the SNL-EA (1996) analysis. In that EA, this process is referred to as the "average package" concept because it assumes that all LLW is packaged in a single type of packaging. For example, all 498 truckloads from line 1 in Table 2.1, above, would carry 55-gallon drums. All 329 truckloads from line 2 above would carry steel boxes. The SNL-EA (1996) document also includes a safety factor of two, as does the analysis employed herein.

3.0 AFFECTED ENVIRONMENT

This chapter describes the affected environment for the proposed action. It provides the basis for analyzing the effects of the Proposed Action as discussed in Chapter 4. Information for the chapter is taken from the Environmental Impact Statement/Environmental Impact Report (EIS/EIR) for Continued Operation of Lawrence Livermore National Laboratory (LLNL) and Sandia National Laboratories, Livermore (DOE, 1992), and the Environmental Assessment prepared for disposal of Low Level Waste (LLW) from Sandia National Laboratories, New Mexico (SNL/NM) (DOE/EA-1180), prepared by the U.S. Department of Energy, Kirtland Area Office for the Sandia National Laboratories in New Mexico.

3.1 DOE/OAK Sites Of Origin For LLW

Four DOE/OAK sites that generate LLW are considered under the proposed action. Each is briefly described below.

3.1.1 Lawrence Livermore National Laboratory

LLNL consists of two sites: the Main Site and Site 300. The Main Site occupies approximately one square mile in the Livermore-Amador Valley on the eastern border of the City of Livermore and is located about 50 miles east of San Francisco. Site 300 occupies approximately 11 square miles within Alameda and San Joaquin Counties and is located approximately 10 miles southwest of the City of Tracy. LLNL is a government-owned facility used for nuclear weapon and high-explosives research. LLNL is currently managed by the University of California.

The Livermore Main Site was purchased in 1942 by the U.S. Navy for training and engine service purposes. Nuclear weapons research activities began at the site in 1950 when the Atomic Energy Commission authorized the construction of a materials-test accelerator and established the University of California Radiation Laboratory (the predecessor to the LLNL). Current activities at LLNL include research, testing, and development of national defense and security, energy, nuclear weapons technology, the environment and biomedicine. Planned activities at LLNL include the enhancement of economic competitiveness and science education. Site 300 was purchased in the 1950's for research and testing of non-nuclear high-explosive components for the DOE nuclear weapons program. Planned uses for Site 300 will remain as high-explosives research.

LLNL LLW Storage and Treatment Facilities

The LLW generated at LLNL includes construction debris, equipment, laboratory trash, stabilized waste, and contaminated environmental media (soils, asphalt, gravel, and concrete) from the operations of the major programs. Some solid LLW is generated at Site 300; most originates from the non-nuclear detonation of test assemblies on firing tables. Transport of LLW between Site 300 and the Main Site complies with DOE and Department of Transportation (DOT) packaging requirements (DOE Order 5480.3 and 49 CFR Section 173).

LLNL currently operates four Hazardous Waste Management (HWM) Facilities at its Main Site. Three of these areas are used to store LLW, including the Area 514 and 612 Complexes, and Building 233. At Site 300, LLW is stored in the east firing area in Building 804 before transfer to waste management facilities at the Main Site.

For some LLW, limited treatment is necessary prior to shipping and disposal. LLW treatment that occurs within the HWM facilities primarily includes precipitation and filtration; however, compaction (currently being conducted by some generators) and solidification of some liquid LLW may also occur.

3.1.2 Lawrence Berkeley National Laboratory (LBNL)

The LBNL site is a 134-acre parcel located along the western side of the Berkeley hills in Alameda County adjacent to the University of California, Berkeley campus. The western three-quarters of the site is located within the City of Berkeley and the eastern quarter is located within the City of Oakland. The LBNL site is leased to DOE from the University of California.

LBNL has been operated by the University of California since the early 1930's for a wide range of energy-related research activities including nuclear and high-energy physics, accelerator research and development, materials research, research in chemistry, geology, molecular biology, and biomedical research. LBNL has developed and operated a number of experimental facilities including: three large accelerators, several small accelerators, and radio-chemical laboratories of which the Human Genome Center, the National Tritium Labeling Facility, and the National Center for Electron Microscopy are a part. The future use of the facility is expected to continue to be energy-related research.

LBNL LLW Storage and Treatment Facilities

Various programs at LBNL generate LLW. The waste generated is comprised of miscellaneous debris, equipment, laboratory trash, and scintillation fluids. The waste is primarily contaminated with tritium and Carbon-14. LLW is identified and characterized at the point of generation. Waste characterization must show that the waste meets the Waste Acceptance Criteria (WAC) of the designated facility. Although other LBNL buildings have been used in the past to handle and store LLW, all LLW activities are now conducted in the newly constructed Hazardous Waste Handling Facility (HWHF).

3.1.3 Stanford Linear Accelerator Center (SLAC)

The 426-acre SLAC facility is a high-energy research facility owned and operated by Stanford University under contract to DOE. The site is located on the San Francisco Peninsula between San Francisco and San Jose. SLAC was established in 1962 as a research facility for high-energy particle physics. The Center's four major experimental facilities are the Linear Accelerator, the Positron Electron Project Storage Ring, the Stanford Positron Electron Asymmetric Ring, and the Stanford Linear Accelerator Center Linear Collider.

SLAC LLW Storage and Treatment Facilities

SLAC primarily generates LLW from accelerator operations, and it includes items such as large pieces of equipment activated during accelerator runs and maintenance activities. Some LLW consists of corrosion products, such as copper, that accumulate in resin beds. LLW is also generated when pipe and other metal pieces from the accelerator are replaced.

LLW is currently managed at two different SLAC facilities: the Radioactive Materials Storage Yard (RMSY) and the Radioactive Waste Storage Area (RWSA). The RWSA is used for most of SLAC's LLW handling and storage. Occasionally, the RMSY is used to prepare wastes for storage and disposal; however, as its name implies, the RMSY is primarily a storage area for radioactive materials.

3.1.4 Energy Technology Engineering Center (ETEC)

The ETEC site is located just west of the city of Canoga Park, approximately 30 miles northwest of Los Angeles in the Simi Hills of Ventura County. ETEC consists of property owned by the U.S. Government and property owned by

Boeing North American Corporation (Boeing). The ETEC facilities occupy a portion (90 acres) of the Santa Susana Field Laboratory (SSFL), also owned and operated by Boeing. Boeing and predecessor organizations, have conducted nuclear reactor development and testing programs for DOE at the SSFL since the early 1950's. ETEC was formed in the mid-1960's as a DOE laboratory for the development of liquid metal heat transfer systems in support of the Liquid Metal Fast Breeder Reactor Program.

ETEC LLW Storage and Treatment Facilities

Presently, the bulk of the decontamination and decommissioning (D&D) waste being generated at ETEC, and the bulk projected for the future, is LLW resulting from environmental restoration (ER) activities; no ongoing research and development (R&D) operations are taking place. All DOE D&D work at ETEC is scheduled to end by Fiscal Year (FY) 2006.

ETEC's Radioactive Materials Handling Facility (RMHF) is used in support of D&D activities and contains a decontamination facility and temporary storage areas for LLW. Limited forms of treatment may be necessary to prepare wastes for shipment. If required, they are conducted within the confines of the RMHF; treatment options include evaporation and compaction.

3.2 Resources Considered But Not Analyzed

This Environmental Assessment (EA) evaluates the impacts of the shipment and transport of Low Level Waste (LLW) from the gate of the generating facility to the gate of the disposal facility. Resources and resource topics considered for this EA, but not analyzed in detail because they were not areas that would be potentially impacted by the transportation of LLW along interstate highways, include the following:

- Seismicity
- Climate
- Land Use
- Topography
- Archeological resources
- Historical resources
- Socioeconomics
- Threatened and endangered species
- Water resources
- Biodiversity

These resources were not included in the discussion of impacts because the proposed action does not involve excavation/construction activities, discharges that would affect water quality, job creation or elimination, or an activity that could affect the natural and cultural resources at any of the subject DOE/OAK sites.

3.3 Resources Selected For Analysis

Resources selected for analysis for the proposed action include:

- Exposure and transportation effects, including the risk of accidents along the transport routes;
- Traffic impacts;
- Air quality;
- Noise;
- Environmental justice;
- Cumulative impacts.

Each resource area is discussed in summary below for the four sites potentially impacted by the proposed action.

3.3.1 Exposure And Transportation Effects

LLW is transported in containers that are approved by the DOT, NRC, and the DOE, and that meet the requirements of the waste receiver. The proposed action would adhere to these requirements.

If the waste is transported by commercial truck, the waste would be transported along interstate or other primary highways well suited to cargo truck transport. The highway routes from the four subject DOE/OAK sites to the Envirocare and Chem-Nuclear Sites are provided in Table 3.1, and illustrated in Figures 3.1 through 3.4.

The proposed action may result in exposure to the general public and workers involved in the transportation of the LLW.

Workers

Personnel routinely working with the materials described by this action may receive low-levels of external exposure to radiation (gamma and x-ray). The dose and impact estimates of LLW storage and processing are contained in the *Final Environmental Impact Statement and Environmental Impact Report for Continued Operation of Lawrence Livermore National Laboratory and Sandia National Laboratories,* *Livermore* (DOE/EIS-0157, U.S. Department of Energy and University of California, August, 1992). For personnel involved with transport of LLW (e.g., truck crews), the dose rates in the cabs of tractor trucks carrying radioactive waste are required by regulations to be less than 2 mrem/hr (49 CFR 173).

General Public

During routine transportation operations, individuals near the shipping containers could receive low-levels of external exposure to radiation (gamma and x-ray). No internal exposures would be received since the LLW would be contained within the shipping containers. Members of the general public who could potentially be at risk from routine operations resulting from overland transportation include the following (guidelines for allowable exposure to members of the public and for the truck crew in mrem/year are presented in table 4.2):

- *Persons Along the Transportation Route*: This group, often referred to as the off-link population, generally receives the smallest dose. Population doses to persons within 800 meters (0.5 miles) on each side of the transport route are estimated.

- *Persons Sharing the Transportation Route:* Population doses to persons in vehicles traveling in the same direction (including passing vehicles) and in the opposite direction (collectively referred to as the on-link population) are estimated, although their doses are expected to be very small.

- *Persons at Stops:* Population doses to persons at fuel and rest stops, tire inspection stops, etc., along the route are estimated. In this analysis the stop time was derived by using 0.011 hr/km (0.018 hr/mile) as the stop rate for truck shipments (based on national trucking data for long haul shipments). The general public population exposed during each stop was estimated at 50 persons, and the average exposure distance for these persons was 20 meters (65 feet).

Estimates of exposures and the methodologies used to derive these values are discussed in Section 4.3, Impacts Associated with the Proposed Action, and presented in Appendix Section B.

3.3.2 Air Quality

The Clean Air Act, Section 176(c), requires the Environmental Protection Agency (EPA) to establish rules to ensure that actions by federal agencies conform with State Implementation Plans (SIPs). These plans are designed to eliminate or reduce the severity and number of violations of the National Ambient Air Quality Standards (NAAQS). As a result, the EPA promulgated the "General Conformity" rule (58 FR 63214-63259) in November of 1993. This rule applies in areas that are considered "non-attainment" or "maintenance" areas for any of six criteria air pollutants (ozone, carbon monoxide, sulfur dioxide, nitrogen dioxide, particulate matter, and lead). A non-attainment area is one in which the air quality in an area exceeds the allowable NAAQS for one or more pollutants, while a maintenance area is one that has been reassigned from non-attainment to attainment. The conformity rule covers both direct and indirect emissions of criteria pollutants that are caused by federal actions and which exceed the threshold emission levels shown in 40 CFR 93.153(b). Each affected State is required by Section 176(c) of the 1990 Clear Air Act amendments to devise a SIP, which is designed to achieve the NAAQS.

DOE has integrated the requirements of the conformity rule with those of its NEPA process wherein, for actions not exempted, the total emissions from the proposed action are evaluated to determine if they are above *de minimus* thresholds, and if they are regionally significant.

The California Clean Air Act of 1988 requires air pollution control districts and air quality management districts to develop air quality management plans for meeting state ambient air quality standards for ozone, carbon monoxide, sulfur dioxide and nitrogen dioxide. The state Air Resources Board (ARB) is responsible for developing a plan for meeting state PM_{10} standards. California designates non-attainment areas on the basis of the state standards, which are more stringent than federal standards in some cases.

The non-attainment areas for the transportation routes described in this section are listed in Tables 3.2 through 3.9, located at the end of this chapter. These tables include the State of California non-attainment areas for the segments of the transportation routes that lie in the state.

3.3.3 Noise

Noise sources in the vicinity of the DOE/OAK sites can be categorized into two major groups: transportation and stationary sources. Stationary sources are not affected by the proposed action. Transportation sources are associated with moving vehicles that generally result in producing fluctuating noise levels above the ambient noise level for a short period of time. Transportation sources include those of aircraft, motor vehicles, and rail operations. Non-fluctuating noise levels can result from transportation sources such as a busy highway heard from a distance, which sounds like a constant low hum.

3.3.4 Environmental Justice

On Feb. 11, 1994 President Clinton issued the "Executive Order on Federal Actions to Address Environmental Justice, in Minority and Low Income Populations." This order requires that the relative impacts of any federal actions on minority and/or low income populations be addressed to avoid the placement of a disproportionate share of the burden of the adverse impacts of federal policies and actions on these groups. For the purposes of the proposed action, populations considered are those which reside within 0.5 miles on either side of the highways where transport of LLW will occur and people using the highways and/or stopping at rest stops. It is expected that the number and proportion of minority or low-income households would vary along the highway routes for the proposed action, and no group would be disproportionately represented over the course of the transportation corridors analyzed herein.

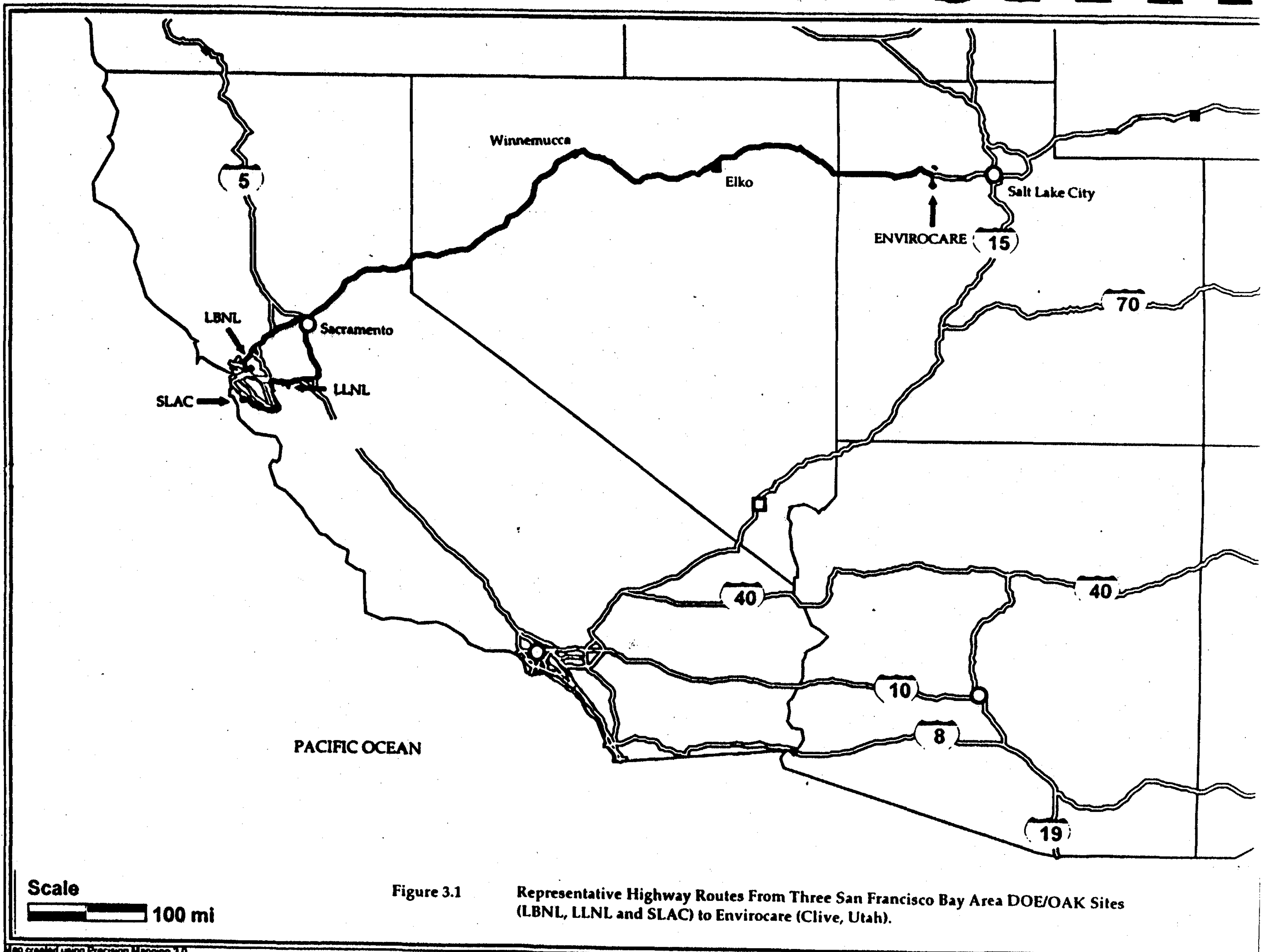
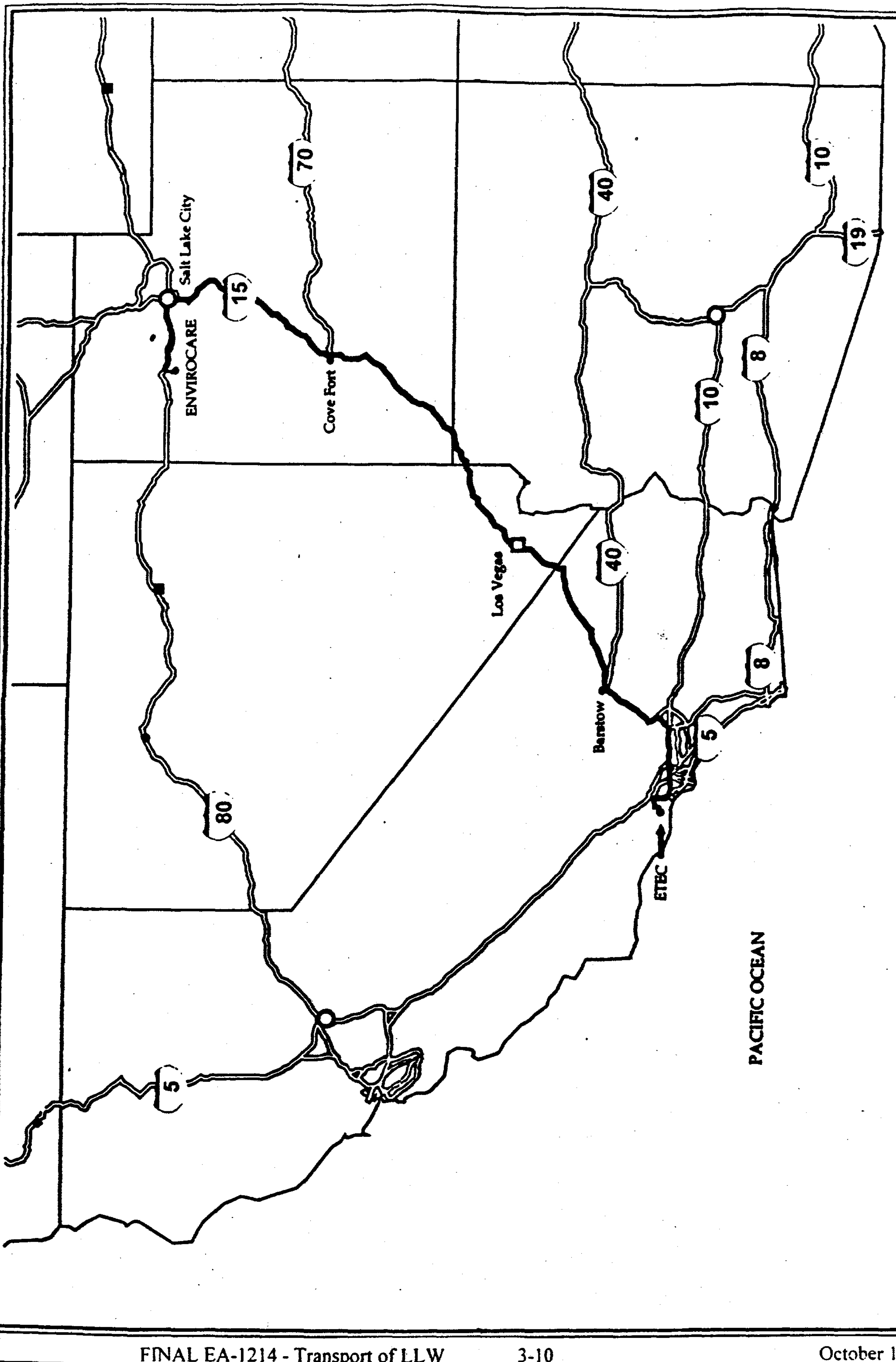


Figure 3.1 Representative Highway Routes From Three San Francisco Bay Area DOE/OAK Sites (LBNL, LLNL and SLAC) to Envirocare (Clive, Utah).



Scale 100 mi

Figure 3.2 Representative Highway Route From One Los Angeles Area DOE/OAK Site (ETEC) to Envirocare (Clive, Utah).

Map created using Precision Mapping 3.0

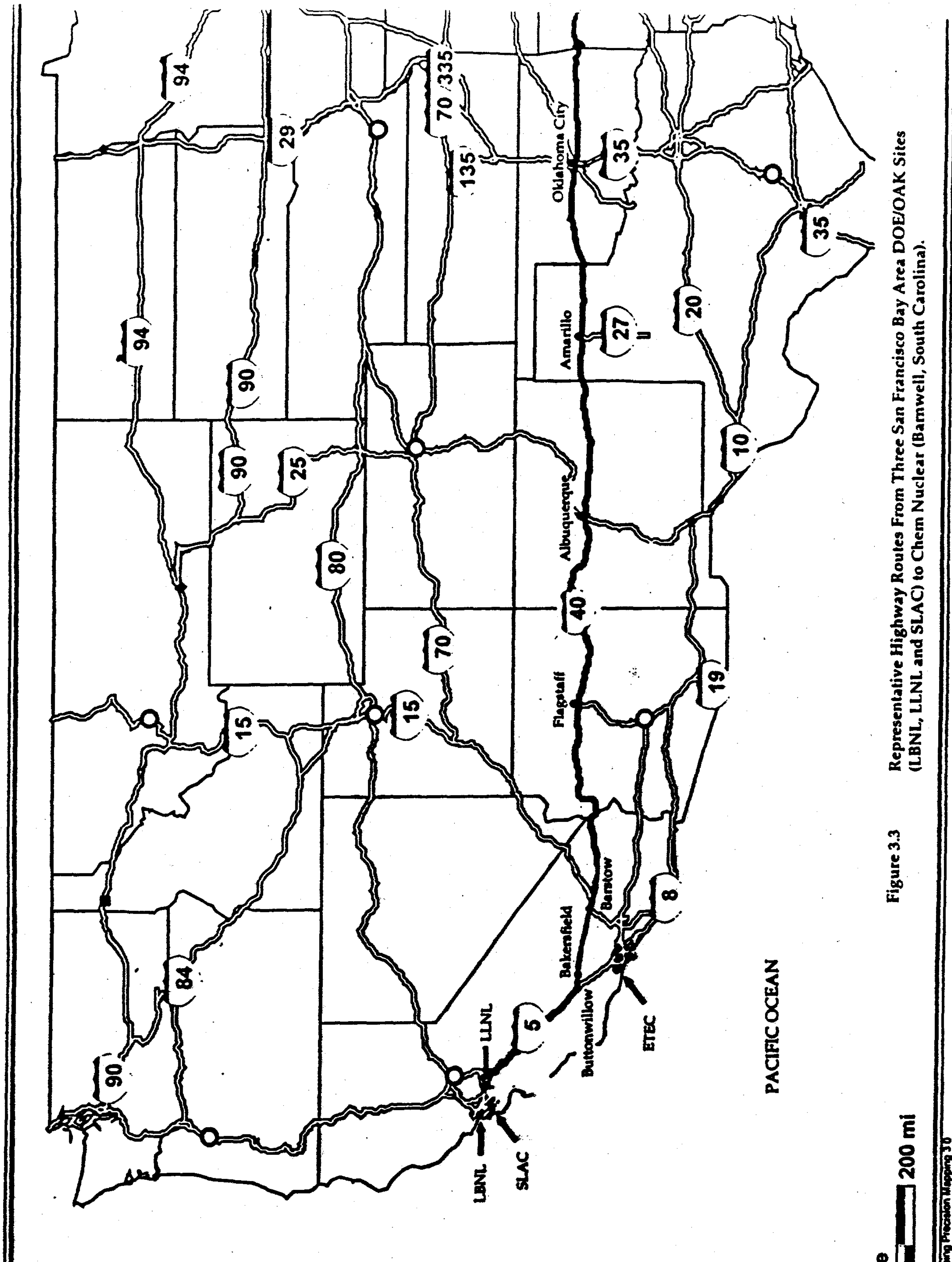


Figure 3.3 Representative Highway Routes From Three San Francisco Bay Area DOE/OAK Sites (LBNL, LLNL and SLAC) to Chem Nuclear (Barnwell, South Carolina).

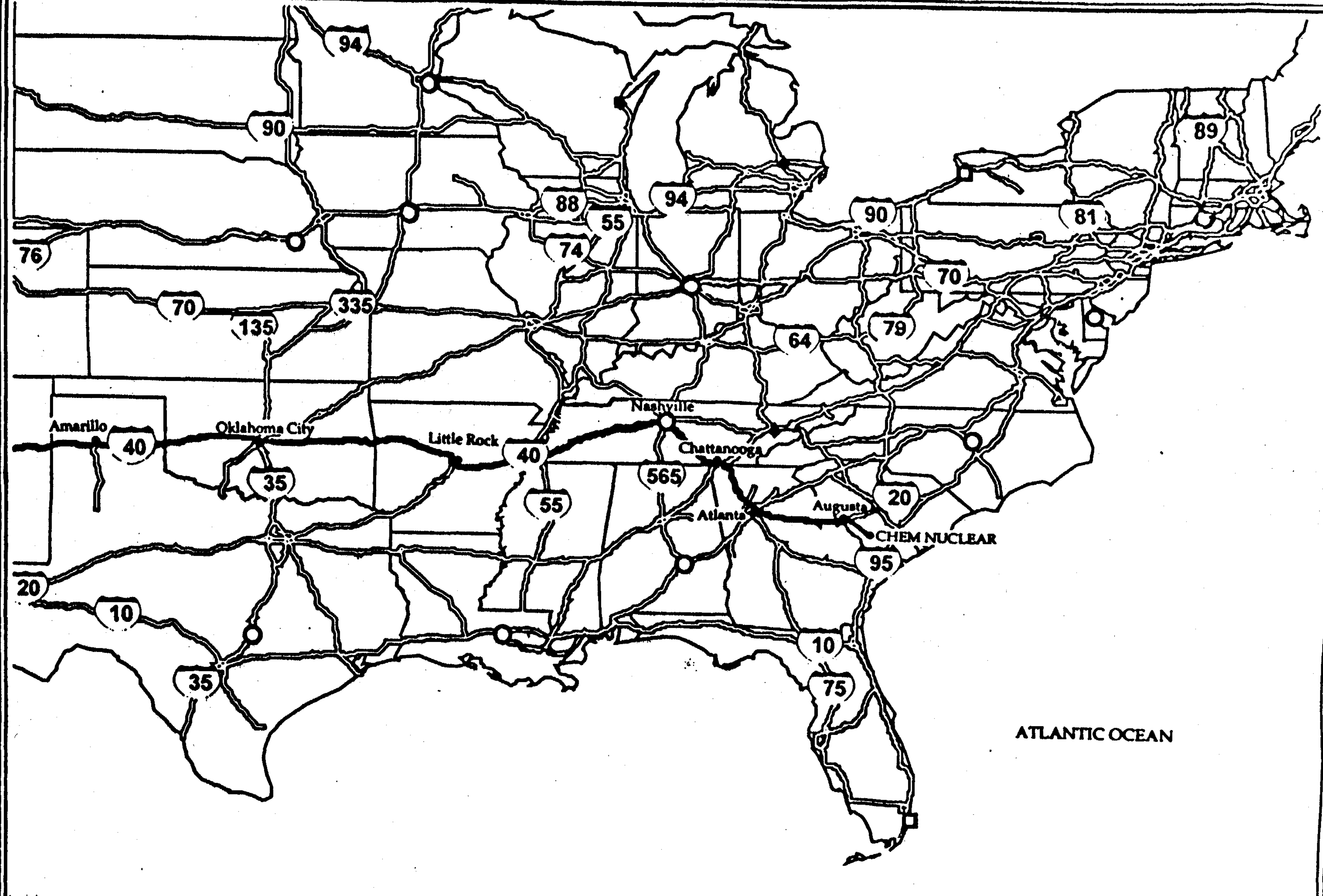


Figure 3.3 (continued) Representative Highway Routes From Three San Francisco Bay Area DOE/OAK Sites (LBNL, LLNL and SLAC) to Chem Nuclear (Barnwell, South Carolina).

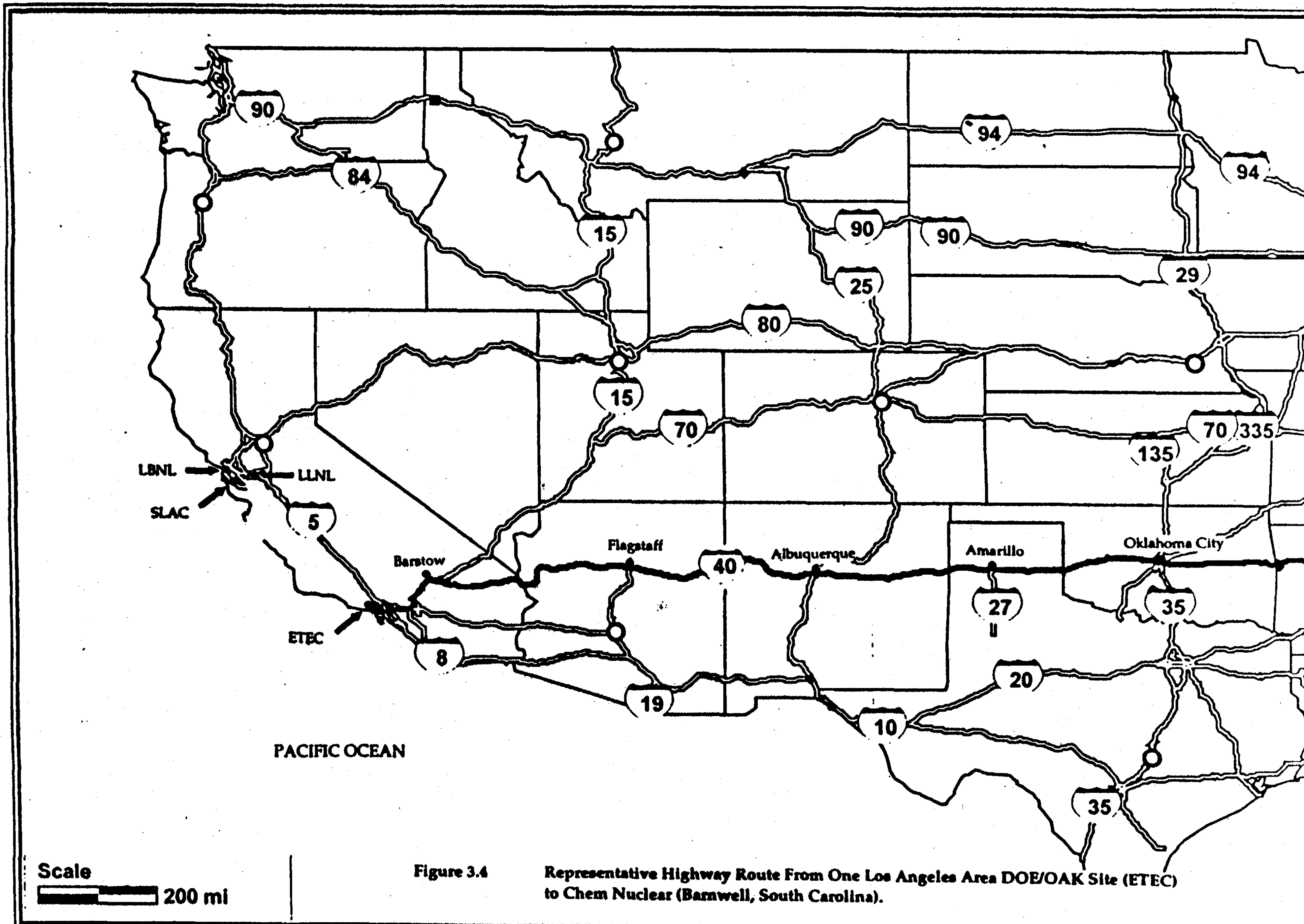


Figure 3.4 **Representative Highway Route From One Los Angeles Area DOE/OAK Site (ETEC) to Chem Nuclear (Barnwell, South Carolina).**

Map created using Precision Mapping 3.0

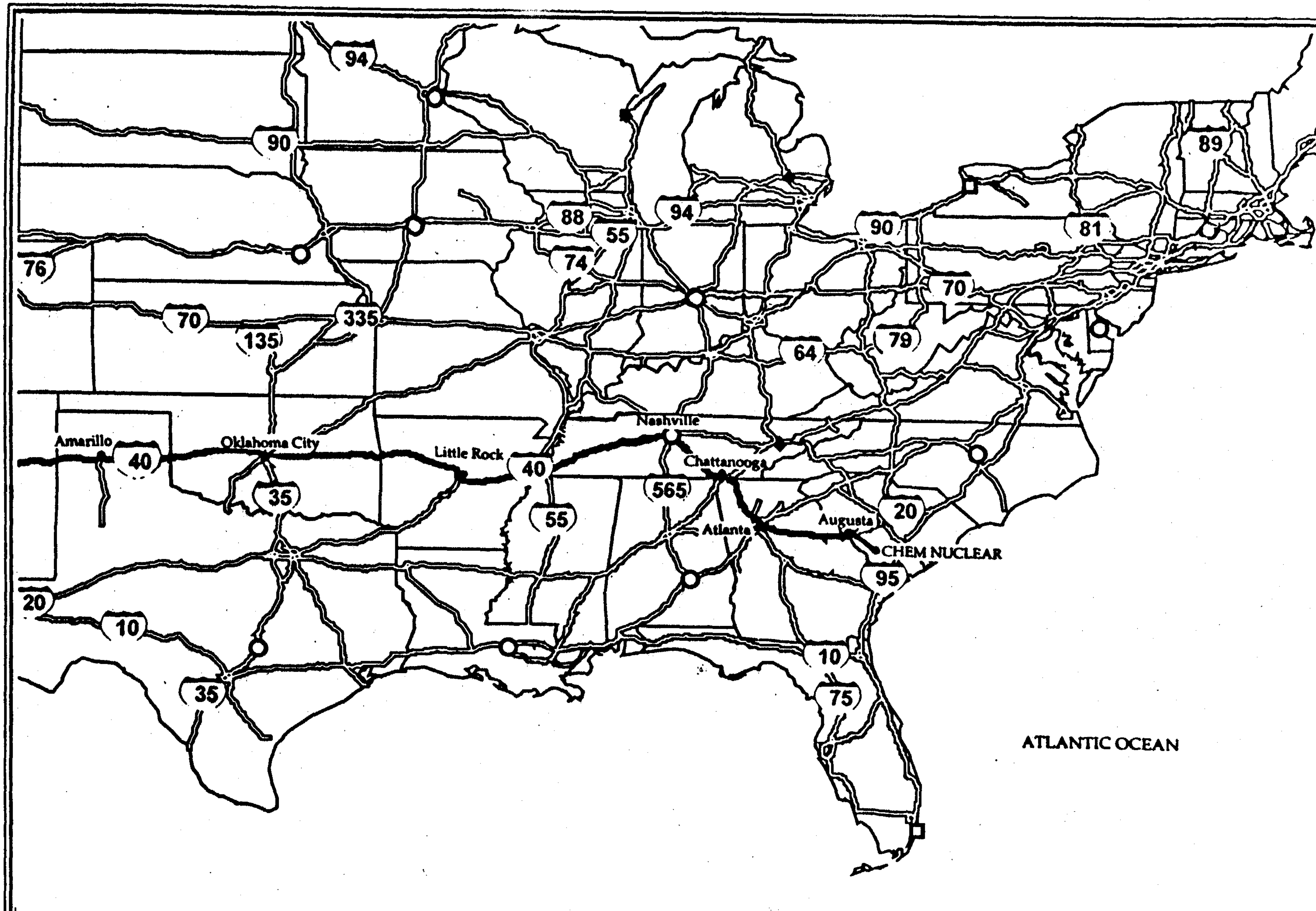


Figure 3.4 (continued) Representative Highway Route From One Los Angeles Area DOE/OAK Site (ETEC) to Chem Nuclear (Barnwell, South Carolina).

Map created using Precision Mapping 3.0

Table 3.1 Routes from DOE/OAK Facilities to Disposal Sites

Facility	Disposal Site	
	Envirocare	**Chem Nuclear**
ETEC	State Highway 118 to I-405 to U.S. Highway 101 to I-10 to I-15 to I80 to Exit 49 near Clive, Utah and local roads to Knolls, Utah.	State Highway 118 to I-405 to U.S. Highway 101 to I-10 to I-15 to I-40 to I-24 to U.S. Highway 74 to I-75 to I-20 to South Carolina State Highway 230 to South Carolina State Highway 125 to site.
LBNL	Cyclotron Road to Hearst Street to Oxford Street to University Avenue to I-80 to Exit 49 near Clive Utah and local roads to Knolls, Utah.	Cyclotron Road to Hearst Street to Oxford Street to University Avenue to I-80 to I-580 to I-5 to California State Highway 58 to I-40 to I-24 to U.S. Highway 74 to I-75 to I-20 to South Carolina State Highway 230 to South Carolina State Highway 125 to site.
LLNL	Vasco Road to I-580 to I-5 to I-80 to Exit 49 near Clive , Utah and local roads to Knolls, Utah.	Vasco Road to I-580 to I-5 to California State Highway 58 to I-40 to I-24 to U.S. Highway 74 to I-75 to I-20 to South Carolina State Highway 230 to South Carolina State Highway 125 to site.
SLAC	Sand Hill Road to I-280 to I-680 to I-580 to I-5 to I-80 to Exit 49 near Clive , Utah and local roads to Knolls, Utah.	Sand Hill Road to I-280 to I-680 to I-580 to I-5 to California State Highway 58 to I-40 to I-24 to U.S. Highway 74 to I-75 to I-20 to South Carolina State Highway 230 to South Carolina State Highway 125 to site.

Table 3.2 Non-attainment Areas Along Representative Highway Route from ETEC to Envirocare

Air Districts	Counties	Federal Criteria Pollutants			California Criteria Pollutants		
		Carbon Monoxide	Ozone	PM10	Carbon Monoxide	Ozone	PM10
CALIFORNIA							
South Central Coast	Ventura		X			X	X
South Coast	Los Angeles	X	X	X	X	X	X
South Coast	San Bernadino	X	X	X	X	X	X
Mojave Desert	San Bernadino		X	X		X	X
NEVADA							
NWNIAQCR	Clark	X		X			
UTAH							
WFIAQCR	Utah	City of Provo		X			
WFIAQCR	Salt Lake	Salt Lake City	X	X			

Key to Air Districts

A-MRGIAQCR	Albuquerque-Mid Rio Grande Intrastate Air Quality Control Region
CIAQCR	Chattanooga Interstate Air Quality Control Region
MAIAQCR	Metropolitan Atlanta Intrastate Air Quality Control Region
MMIAQCR	Metropolitan Memphis Interstate Air Quality Control Region
MTIAQCR	Middle Tennessee Intrastate Air Quality Control Region
M-YIAQCR	Mojave-Yuma Intrastate Air Quality Control Region
NGIQCR	Northeast Georgia Intrastate Air Quality Control Region
NWNIAQCR	Northwest Nevada Intrastate Air Quality Control Region
WFIAQCR	Wasatch Front Intrastate Air Quality Control Region
WTIAQCR	Western Tennessee Intrastate Air Quality Control Region

Table 3.3 EPA Non-attainment Areas Along Representative Highway Route from ETEC to Chem Nuclear

Air Districts	Counties	Federal Criteria Pollutants			California Criteria Pollutants		
		Carbon Monoxide	Ozone	PM10	Carbon Monoxide	Ozone	PM10
CALIFORNIA							
South Central			X			X	X
South Coast		X	X	X	X	X	X
South Coast		X	X	X	X	X	X
Mojave Desert			X	X		X	X
ARIZONA							
M-YIAQCR	Mojave			X			
NEW MEXICO							
A-MRGIAQCR	Bernalillo	X					
TENNESSEE							
MMIAQCR	Shelby	X		X			
WTIAQCR	Fayette			X			
MTIAQCR	Williamson			X			
MTIAQCR	Davidson			X			
MTIAQCR	Sumner			X			
MTIAQCR	Wilson			X			
MTIAQCR	Rutherford			X			
CIAQCR	Hamilton			X			
GEORGIA							
CIAQCR	Cherokee			X			
CIAQCR	Paulding			X			
NGIAQCR	Forsyth			X			
MAIAQCR	Cobb			X			
MAIAQCR	Douglas			X			
MAIAQCR	Gwinnet			X			
MAIAQCR	Clayton			X			
MAIAQCR	De Kalb			X			
MAIAQCR	Coweta			X			
MAIAQCR	Fulton			X			
MAIAQCR	Fayette			X			
MAIAQCR	Rockdale			X			
MAIAQCR	Henry			X			

Table 3.4 Non-attainment Areas Along Representative Highway Route from LLNL to Envirocare

Air Districts	Counties	Federal Criteria Pollutants			California Criteria Pollutants		
		Carbon Monoxide	Ozone	PM10	Carbon Monoxide	Ozone	PM10
CALIFORNIA							
S.F. Bay Area	Alameda	Urban Areas				X	X
San Joaquin Valley	San Joaquin		X	X		X	X
Sacramento Valley	Sacramento	X	X	X	X	X	X
	Placer		X	X		X	X
Mountain Counties	Placer		X	X		X	X
	Nevada					X	X
NEVADA							
NWNIAQCR	Washoe	X	X	X			

Table 3.5 EPA Non-attainment Areas Along Representative Highway Route from LLNL to Chem Nuclear

Air Districts	Counties	Federal Criteria Pollutants			California Criteria Pollutants		
		Carbon Monoxide	Ozone	PM10	Carbon Monoxide	Ozone	PM10
CALIFORNIA							
S.F. Bay Area	Alameda	Urban				X	X
San Joaquin	San Joaquin		X	X		X	X
San Joaquin	Stanislaus		X	X		X	X
San Joaquin	Merced		X	X		X	X
San Joaquin	Fresno		X	X		X	X
San Joaquin	Kings		X	X		X	X
San Joaquin	Kern	Bakersfield	X	X		X	X
Mojave Desert	Kern		X	X		X	X
Mojave Desert	San'		X	X		X	X
ARIZONA							
M-YIAQCR	Mojave			X			
NEW MEXICO							
A-MRGIAQCR	Bernalillo	X					
TENNESSEE							
MMIAQCR	Shelby	X	X				
WTIAQCR	Fayette		X				
MTIAQCR	Williamson		X				
MTIAQCR	Davidson		X				
MTIAQCR	Sumner		X				
MTIAQCR	Wilson		X				
MTIAQCR	Rutherford		X				
CIAQCR	Hamilton		X				

Table 3.5 EPA Non-attainment Areas Along Representative Highway Route from LLNL to Chem Nuclear (continued)

Air Districts	Counties	Federal Criteria Pollutants			California Criteria Pollutants		
		Carbon Monoxide	Ozone	PM10	Carbon Monoxide	Ozone	PM10
GEORGIA							
CIAQCR	Cherokee		X				
CIAQCR	Paulding		X				
NGIAQCR	Forsyth		X				
MAIAQCR	Cobb		X				
MAIAQCR	Douglas		X				
MAIAQCR	Gwinnet		X				
MAIAQCR	Clayton		X				
MAIAQCR	De Kalb		X				
MAIAQCR	Coweta		X				
MAIAQCR	Fulton		X				
MAIAQCR	Fayette		X				
MAIAQCR	Rockdale		X				
MAIAQCR	Henry		X				

Table 3.6 Non-attainment Areas Along Representative Highway Route from LBNL to Envirocare

Air Districts	Counties	Federal Criteria Pollutants			California Criteria Pollutants		
		Carbon Monoxide	Ozone	PM10	Carbon Monoxide	Ozone	PM10
CALIFORNIA							
S.F. Bay Area	Alameda	Urban Areas				X	X
S.F. Bay Area	Contra Costa	Urban Areas				X	X
Sacramento Valley	Sacramento	X	X	X	X	X	X
Sacramento Valley	Placer		X	X		X	X
Mountain Counties	Placer		X	X		X	X
Mountain Counties	Nevada					X	X
NEVADA							
NWNIAQCR	Washoe	X	X	X			

Table 3.7 EPA Non-attainment Areas Along Representative Highway Route from LBNL to Chem Nuclear

Air Districts	Counties	Federal Criteria Pollutants			California Criteria Pollutants		
		Carbon Monoxide	Ozone	PM10	Carbon Monoxide	Ozone	PM10
CALIFORNIA							
S.F. Bay Area	Alameda	Urban		X		X	X
San Joaquin	San Joaquin		X	X		X	X
San Joaquin	Stanislaus		X	X		X	X
San Joaquin	Merced		X	X		X	X
San Joaquin	Fresno		X	X		X	X
San Joaquin	Kings		X	X		X	X
San Joaquin	Kern	Bakersfield	X	X		X	X
Mojave Desert	Kern		X	X		X	X
Mojave Desert	San		X	X		X	X
ARIZONA							
	Mojave			X			
NEW MEXICO							
	Bernalillo	X					
TENNESSEE							
MMIAQCR	Shelby	X	X				
WTIAQCR	Fayette		X				
MTIAQCR	Williamson		X				
MTIAQCR	Davidson		X				
MTIAQCR	Sumner		X				
MTIAQCR	Wilson		X				
MTIAQCR	Rutherford		X				
CIAQCR	Hamilton		X				

Table 3.7 EPA Non-attainment Areas Along Representative Highway Route from LBNL to Chem Nuclear (continued)

Air Districts	Counties	Federal Criteria Pollutants			California Criteria Pollutants		
		Carbon Monoxide	Ozone	PM10	Carbon Monoxide	Ozone	PM10
GEORGIA							
CIAQCR	Cherokee		X				
CIAQCR	Paulding		X				
NGIAQCR	Forsyth		X				
MAIAQCR	Cobb		X				
MAIAQCR	Douglas		X				
MAIAQCR	Gwinnet		X				
MAIAQCR	Clayton		X				
MAIAQCR	De Kalb		X				
MAIAQCR	Coweta		X				
MAIAQCR	Fulton		X				
MAIAQCR	Fayette		X				
MAIAQCR	Rockdale		X				
MAIAQCR	Henry		X				

Table 3.8 Non-attainment Areas Along Representative Highway Route from SLAC to Envirocare

Air Districts	Counties	Federal Criteria Pollutants			California Criteria Pollutants		
		Carbon Monoxide	Ozone	PM10	Carbon Monoxide	Ozone	PM10
CALIFORNIA							
S.F. Bay Area	San Mateo	Urban Areas				X	X
S.F. Bay Area	Santa Clara	Urban Areas				X	X
S.F. Bay Area	Alameda	Urban Areas				X	X
San Joaquin Valley	San Joaquin		X	X		X	X
Sacramento Valley	Sacramento	X	X	X	X	X	X
Sacramento Valley	Placer		X	X		X	X
Mountain Counties	Placer		X	X		X	X
Mountain Counties	Nevada					X	X
NEVADA							
NWNIAQCR	Washoe	X	X	X			

Table 3.9 EPA Non-Attainment Areas Along Representative Highway Route from SLAC to Chem Nuclear

Air Districts	Counties	Federal Criteria Pollutants			California Criteria Pollutants		
		Carbon Monoxide	Ozone	PM10	Carbon Monoxide	Ozone	PM10
CALIFORNIA							
S.F. Bay Area	San Mateo	Urban				X	X
S.F. Bay Area	Santa Clara	Urban				X	X
S.F. Bay Area	Alameda	Urban				X	X
San Joaquin	San Joaquin		X	X		X	X
San Joaquin	Stanislaus		X	X		X	X
San Joaquin	Merced		X	X		X	X
San Joaquin	Fresno		X	X		X	X
San Joaquin	Kings		X	X		X	X
San Joaquin	Kern	Bakersfield	X	X		X	X
Mojave Desert	Kern		X	X		X	X
Mojave Desert	San		X	X		X	X
ARIZONA							
M-YIAQCR	Mojave			X			
NEW MEXICO							
A-MRGIAQCR	Bernalillo	X					
TENNESSEE							
MMIAQCR	Shelby	X	X				
WTIAQCR	Fayette		X				
MTIAQCR	Williamson		X				
MTIAQCR	Davidson		X				
MTIAQCR	Sumner		X				
MTIAQCR	Wilson		X				
MTIAQCR	Rutherford		X				
CIAQCR	Hamilton		X				

Table 3.9 EPA Non-Attainment Areas Along Representative Highway Route from SLAC to Chem Nuclear (continued)

Air Districts	Counties	Federal Criteria Pollutants			California Criteria Pollutants		
		Carbon Monoxide	Ozone	PM10	Carbon Monoxide	Ozone	PM10
GEORGIA							
CIAQCR	Cherokee		X				
CIAQCR	Paulding		X				
NGIAQCR	Forsyth		X				
MAIAQCR	Cobb		X				
MAIAQCR	Douglas		X				
MAIAQCR	Gwinnet		X				
MAIAQCR	Clayton		X				
MAIAQCR	De Kalb		X				
MAIAQCR	Coweta		X				
MAIAQCR	Fulton		X				
MAIAQCR	Fayette		X				
MAIAQCR	Rockdale		X				
MAIAQCR	Henry		X				

4.0 ENVIRONMENTAL CONSEQUENCES

4.1 Overview and Summary

This chapter presents the environmental effects associated with the proposed action and the no-action alternative. Under the National Environmental Policy Act (NEPA) of 1969, a determination of environmental effects of a proposed action requires an analysis of both the context of an action and its intensity (40 CFR 1508.27). This Chapter should be cross referenced with Chapter 3, which describes the existing environment of the proposed action.

The effects incurred by the environmental aspects assessed in this document are minimal based upon the analyses performed. In hypothesizing the most credible accident a conservative approach was taken. This resulted in a rather low probability of occurrence with damage and exposures being within established radiological limits.

4.2 Proposed Action

The DOE would like to ship LLW from four DOE/OAK sites in California which generate LLW, to Nuclear Regulatory Commission (NRC) licensed commercial nuclear waste disposal facilities such as Envirocare in Clive, Utah and Chem Nuclear in Barnwell, South Carolina. The four DOE/OAK sites and their locations within California are:

- Lawrence Livermore National Laboratory (LLNL), Livermore, California;
- Lawrence Berkeley National Laboratory (LBNL), Berkeley, California;
- Energy Technology Engineering Center (ETEC), Canoga Park, California;
- Stanford Linear Accelerator Center (SLAC), Palo Alto, California.

4.3 Impacts Associated With The Proposed Action

4.3.1 Transportation Effects

Following the methodology used by the Sandia National Laboratories, New Mexico Environmental Assessment (SNL-EA, 1996), the proposed action was evaluated for both the radiological and non-radiological effects resulting from both incident-free transportation and potential accident scenarios. For both incident-free and accident estimates, radiological effects are characterized by exposure in person-rems and latent cancer fatalities (LCF). Non-radiological effects are characterized by LCF (for incident-free shipments) and Traffic

Accident Fatalities (for accident scenarios). Appendix B has a detailed discussion of the methodology employed to derive these results.

Incident-Free Exposures Along Transportation Corridors

The Region of Influence (ROI) used to determine incident free exposure along transportation corridors for this Environmental Assessment (EA) was assumed to be 800 meters (0.5 miles) on either side of the transportation corridor. For the maximally exposed individual the distance was assumed to be 30 meters (98 feet) from the exposure source.

The following criteria were used to evaluate the potential for the proposed project to have an adverse cumulative radiological impact on potentially exposed populations along the transportation route in the absence of traffic accidents involving the release of radiological materials:

- The annual dose limit in mrem/yr for the maximally exposed individual is not to exceed 100 [NRC Public Exposure Guidelines]

- The annual dose limit for the truck crew is not to exceed 5,000 mrem/yr (NUREG-0170).

Incident-free impacts are approximately the same for radiological and non-radiological health risks. The non-radiological incident-free impacts are associated with truck emissions from the shipping campaign.

Based upon the impact analysis for the proposed action the total exposure for the maximally exposed individual along the transport route to Envirocare in Clive, Utah or Chem Nuclear in Barnwell, South Carolina would not exceed 0.229 mrem/yr, under the hypothetical worst case scenario projected for this analysis. The total estimated hypothetical exposure for the truck crew would not exceed 1,350 mrem/yr (see column 1 in Table 4.2). Exposure assumptions are based upon Department of Transportation (DOT) and NRC regulations dealing with packaging of materials for overland transportation. A package shipped overland in exclusive use closed transport vehicles may not exceed the following radiation levels as provided in 49 CFR 173.441 (b):

- 1,000 mrem/hr on the external package surface;

- 200 mrem/hr at any point on the outer surface of the vehicle;

- 10 mrem/hr at any point 2 meters (6.6 feet) from the vertical planes projected by the outer lateral surfaces of the vehicle; and

- 2 mrem/hr in any normally occupied position in the vehicle.

Exposure scenarios and lengths of exposure used to estimate the maximally exposed individuals are given in Section B-5 of the Appendix to this document.

Accident-Based Exposures Along Transportation Corridors

Radiation exposure to the total exposed population, including both the general public and the truck crew, over each of the complete shipping routes has been estimated for exposure associated with traffic accidents. The probability for highway accidents to occur was first estimated (see Table A.2, Appendix). The potential exposure to populations was then estimated, based upon the estimated severity of the accident, the behavior of the radioactive material packaging and the release fractions of the radioactive materials.

The following criterion was used to evaluate the potential for the proposed project to have an adverse radiological impact on potentially exposed populations along the transportation route in the event of traffic accidents involving the release of radiological materials:

- The annual dose limit in mrem/yr for the maximally exposed individual is not to exceed 100 (NRC Public Exposure Guidelines)

Fatality estimates from non-radiological accidents are approximately two orders of magnitude higher than the radiological accident risk estimates. Non-radiological fatalities can occur even in very low severity accidents. In addition, since the methodology employed in this EA includes the return trip in its risk estimates, the non-radiological health risks are estimated over twice the distance compared to that of radiological risks.

Hypothetical Worst Case Accident Scenarios

For the purpose of this EA, the hypothetical worst case accidents are modeled to occur along an urban route that is typical of the most densely populated transportation corridor likely to be encountered along the route from any of the four generating sites to either of the commercial disposal sites. An estimated 6,100 persons reside along the ROI for this transportation corridor (0.5 kilometers on either side of the corridor).

A typical LLW shipment from the generating sites emits less than 5 mrem/hour. Environmental restoration (ER) activities can generate wastes that emit as much as 200 mrem/hour.

It is assumed that the truck involved in the hypothetical accident is carrying Type A containers, the least robust of container types in which

LLW is transported. The waste material is assumed to be ER related LLW materials that have been removed from a radioactive source area in the course of ER activities. These materials would weigh 2,963 pounds, and if released from their container, are assumed to emit 200 mrems per hour of radiation at the source.

Three accident scenarios were evaluated:

- Category 1 severity, resulting in the release of no radioactive material into the environment. (One in 142 shipments in an urban environment).

- Category 3 severity, resulting in the release of 10% of the radioactive material from failed packages. (One in 2976 shipments in an urban environment).

- Category 5 severity, resulting in the release of 100% of the radioactive materials from failed packages. (One in one million shipments in an urban environment).

In the event of a Category 1 accident, no radioactive materials would be released to the environment.

In the event of a Category 3 accident, 10% of the radioactive materials, or approximately 296 pounds of material could be released to the environment. Under this scenario, the annual dose in mrem/hour for the maximum exposed individual adjacent to the source would be reached in approximately five hours.

In the event of the Category 5 accident, 100% of the materials, or 2,963 pounds could be released. Under this scenario, the annual dose in mrem/hour for the maximum exposed individual adjacent to the source would be reached in one-half hour .

Three factors bear upon the risk of exposure to radiation: shielding, distance, and time. In the event of an accident, the shielding of some or all of the material being transported would be removed. Therefore, distance and time become critical factors. The population at highest risk would be the personnel in the truck. Evacuation of personnel to safe distances provides immediate protection from the risk of exposure.

Although the likelihood of an accident occurring and resulting in the release of radioactive materials is improbable (see Tables A-2 and A-3, Appendix), if such an accident were to occur clean up crews would be required to respond to the accident and contaminated materials, including soil, would require removal. While this would be a significant impact, response crews would be trained and equipped to avoid radiological impacts, and techniques exist to remove and properly dispose of contaminated materials. These conditions would reduce this impact to a level of non-significance.

It should be noted that the accident scenarios presented above deviate from the worst case scenario used in the SNL-EA (1996), which was otherwise used as the basis for all analyses presented in this EA. An LLW waste type typical of DOE/OAK sites was used for this analysis and three accident scenarios were developed, whereas only one worst case scenario was used in the SNL-EA (1996). Furthermore, the risk factors used in this EA are more conservative, since the SNL-EA (1996) used a category 8 accident per RADTRAN 4 (one accident in 120,000,000 shipments).

4.3.2 Air Quality

In Chapter 3, the non-attainment areas associated with the representative highway routes are listed in tables for each of the proposed disposal options. The largest non-attainment areas on the proposed routes are located in several California Air Basins. All of the non-attainment areas lie along interstate highways. This shipping campaign would cause no discernible increase on the daily rate of truck shipments for these non-attainment areas.

An analysis was undertaken to determine the impact of the proposed shipments relative to the threshold emission levels in non-attainment areas described by the EPA in its air conformity regulations (40 CFR 93.153 [b][1]). The EPA's general conformity rule (58 FR. 63214, November 30, 1993) requires Federal agencies to prepare a written conformity analysis and determination for proposed activities only in those cases where the total emissions of an activity exceed the threshold emission levels. Where it can be demonstrated that emissions from a proposed new activity fall below the thresholds, these emissions are considered to be *de minimus* and require no formal analysis.

The air emissions within all non-attainment areas along the proposed shipment routes would be well below the threshold emission levels established by the EPA, and thus would require no formal conformity analysis.

4.3.3 Noise

The proposed action would minimally increase traffic flow. Because the dominant source of noise along the route is from the passage of vehicles, the noise level would minimally increase over existing ambient noise levels. Even considering that the maximum annual number of shipments for each facility occurs in the same year, no noticeable change in common highway noise along any part of the routes between the DOE/OAK sites and Chem Nuclear or Envirocare would be expected.

4.3.4 Cumulative Impacts

Cumulative impacts are those that result from the incremental impact of the proposed action when added to other past, present, and reasonably foreseeable future actions (see 40 CFR § 1508.7 and CEQ, 1978).

To calculate cumulative radiological impact, estimated maximum annual doses from the proposed action and from other radioactive waste shipments occurring at the same facilities, along the same routes, and projected to occur concurrently during the proposed action, are added together. This approach neglects the fact that dose fractionation (delivery of a total dose in a number of separate doses spread over time) may reduce the effect of the total cumulative dose (Ullrich et al., 1987; Miller et al., 1989).

Table 4.2 contains a summary of the potential cumulative dose estimates to individuals of specific impact groups for two potential sources; the total of all four DOE/OAK facility LLW shipments to Chem Nuclear (the highest impact proposed action of this EA) and the NUREG-0170 risk assessment, which was a comprehensive study of radiation exposure from existing shipments conducted by the NRC in 1977. The table indicates that the impacts of the hypothetical worst-case situation of the proposed action, when added to the impact from existing exposures (NUREG-0170), do not produce a significant impact.

Table 4.2 Cumulative Individual Annual Permitted Radiation Dose for Impact Group Individuals

Maximally Exposed Individual Doses (mrem/year)				
Impact Group	LLW to Chem Nuclear	NUREG-0170	Total Annual Dose	Annual Dose Limit[1]
Public (MEI)	0.229[2]	0.018	0.247	100
Truck Crew	1,350	870[3]	2,220	5,000

1 NRC Radiation Worker dose limits - 5,000 mrem/yr -- NRC public exposure guidelines - 100 mrem/yr.

2 Assumes all worst-case shipments in the same year and maximally exposed individual (MEI) is exposed to all 498 shipments.

3 These values are the sum for truck and van maximally exposed individual crew members from Table 4-8 in NUREG-0170. Estimated worker dose assumes same individual drives all shipments during a given year.

4.3.5 Environmental Justice

Executive Order 12898 requires that all federal agencies evaluate whether proposed actions would cause disproportionate impacts on minority or low income communities. The dominant radiological risk associated with incident-free transportation of LLW is the exposure to the public during rest stops, followed by exposure to the truck crew. The use of the public highways, interstate highways and rest stops that would be used by trucks shipping LLW, is not limited or restricted to any particular population group, economically disadvantaged or advantaged. Although it is expected that the percentage of total population comprised of minority or low-income households would vary along the highway routes for the proposed action, the impacts from LLW shipments is estimated to be negligible, as cited in Section 4.3.1. There is, therefore, no disproportionate impact to those minority or low-income households residing or along the transportation corridors or routes.

4.4. Impacts Associated with the No Action Alternative

The no action alternative would have impacts due to the accumulation of LLW on the sites of generation, and the slow-down or curtailment of site activities, including clean-up actions.. Further, activities that would be performed at the various storage sites would result in some additional radiation exposures to DOE/OAK and site personnel due to higher volumes of LLW in storage. These activities include weekly inspections of storage areas to identify deteriorating or leaking containers and to confirm inventories, the placement of new waste, the replacement of labels degraded by exposure to the sun and inclement weather, the repackaging of waste as containers degrade, the checking of radiation monitors, and the replacement of warning signs. If a leak or spill were to occur, additional doses would most likely be received by responding personnel. Any increase in worker exposures would result in an increase in cancer risk to workers. As inventories increase, it will become more difficult to maintain acceptable exposure levels of less than 5 mrem/hr at one foot.

4.5 Environmental Consequences

The effects incurred by the environmental aspects assessed in this document are minimal based upon the analyses performed. In hypothesizing the most credible accident a conservative approach was taken. This resulted in a rather low probability of accident occurrence with damage and exposures being within established radiological limits.

James M. Turner, Ph.D.
Manager

5.0 PERSONS AND AGENCIES CONTACTED

David Marshall
Bay Area Air Quality Management District
939 Ellis Street, 5th Floor
San Francisco, CA 94109-7799
(415) 749-4678

Doug Thompson
California Air Resources Control Board
Office of Air Quality and Transportation Planning
2020 L Street
P.O. Box 2815
Sacramento, CA 95812
(916) 322-8279

Greg Tholen
Sacramento Valley Air Quality Management District
8411 Jackson Road, Suite 230
Sacramento, CA 95826
(916) 386-7025

Bunny Margison
San Joaquin Valley Unified Air Pollution Control District
1999 Tuolumne Street, Suite 200
Fresno, CA 93721
(209) 497-1000

Alvin DeSavin
Mojave Desert Air Quality Management District
15428 Civic Drive, Suite 200
Victorville, CA 92392
(760) 245-1661

Tod Nishikawa
Placer Air Pollution Control District
11454 B Avenue
Auburn, CA 95603
(916) 889-7130

Daniel Nakahara
Deputy Director
Waste Management Division
Oakland Operations Office
U.S. Department of Energy
Oakland, CA 94612
(510) 637-1640

Ravnesh Amar
Energy Technology Engineering Center
Rocketdyne Division
Boeing Corporation
M/S T-038
6633 Canoga Park, CA 91304
(818) 586-5243

Mark Hammond
Public Affairs
Nuclear Regulatory Commission
1450 Maria Lane, Suite 3000
Walnut Creek, CA 94596
(510) 975-0254

Kevin Fuller
Project Manager
Envirocare of Utah, Inc.
46 West Broadway, Suite 240
Salt Lake City, UT 84101
(801) 532-1330

Mike Mohundro
Chem-Nuclear Systems, Inc.
P.O. Box 726
Columbia, SC 29210
(803) 256-0450

Scott Johnson
Ventura Air Pollution Control District
702 County Square Drive
Ventura, CA 93003
(805) 645-1400

6.0 LIST OF PREPARERS

Uribe and Associates

Muriel Waller
EA Role: Project Coordinator

Ed Kilduff
EA Role: LLW Management Issues

Brian Wines
EA Role: Transport Risk Assessment

Laura Frost
EA Role: Transport Risk Assessment

David Montgomery
EA Role: Draft Review

Kevin Fudge
EA Role: Environmental Scientist

7.0 REFERENCES

ASME, 1994	American Society of Mechanical Engineers, *Quality Assurance Requirements for Nuclear Facility Applications*, ASME NQA-Q, New York, NY, 1994.
CEQ, 1978	Council on Environmental Quality, "Regulations on Implementing NEPA Procedures," Part 1500-1508, 43 FR 5-5990, Washington, D.C., 1978.
DOE, 1990	United States Department of Commerce, Bureau of the Census, 1990 *Census of Population: General Population Characteristics, New Mexico, 1990* CP-1-33, 1990.
DOE, 1988a	United States Department of Energy (DOE) Headquarters to Manager, Albuquerque Operations Office, memorandum, 18 March 1988, "Cessation of Low-Level Waste (LLW) Disposal Operations at the Sandia National Laboratories-Albuquerque."
DOE, 1988b	United States Department of Energy (DOE), to P.M. Stanford, Controller, Sandia National Laboratories-Albuquerque, memorandum, 29 November 1988, "Cessation of Low-Level Waste (LLW) and Mixed Waste Operations at SNLA."
DOE, 1993	United States Department of Energy (DOE), *Environmental Assessment for the Radioactive and Mixed Waste Management Facility at the Sandia National Laboratories, Albuquerque*, DOE/EA-0466, Albuquerque, New Mexico, June 1993.
DOE, 1994a	United States Department of Energy (DOE), Transuranic Waste Integration Program, *Lexicon*, Third Edition, prepared by Los Alamos Technical Associates, Inc., February 1994.
DOE, 1994c	United States Department of Energy (DOE), *Interim Report Waste Management Facilities Cost Information for Mixed Low-Level Waste*, Idaho National Engineering Laboratory, Idaho Falls, Idaho, March 1994.

DOE, 1994d	Department of Energy (DOE), "NEPA Environment Checklists, DOE Control SNA-94-034, Sandia National Laboratories, April 5, 1994.
DOE, 1995a	United States Department of Energy, Office of Environmental Policy Assistance to Distribution, 3 February 1995, *Analysis-Clean Air Act (CAA) Final Rule Requiring That Federal Actions Conform to Applicable State Implementation Plans, U.S. Office of Environmental Policy Assistance.*
DOE, 1995	United States Department of Energy (DOE), The Environmental Impact Statement for the Savannah River Site, October 1995.
DOE, 1996a	United States Department of Energy (DOE), The Environmental Impact Statement for the Nevada Test Site and Offsite Locations for the State of Nevada, DOE/EIS-0243, August 1996.
ERDA, 1975	United States Energy Research and Development Agency (ERDA), *Final Environmental Statement, Waste Management Operations, Hanford Reservation, Richland, Washington*, ERDA-1538, December 1975.
Ex Ent, 1989	Executive Enterprises, Inc., *Environmental Acronyms, Abbreviations, and Glossary of Terms*, Executive Enterprises, Inc., New York, 1989.
EPA, 1991	Environmental Protection Agency, "Risk Assessment Guidance For Superfund, Volume I, Human Health Evaluation Manual," EPA/540/1-80/002, December 1989.
EPA, 1991b	Environmental Protection Agency, Air Quality Designations and Classification; Final Rule, November 6, 1995, *Federal Register* 56694.
Finley, 1988	N.C. Finley, J.D. McClure, P.C. Reardon, *An Analysis of the Risks and Consequences of Accidents Involving Shipments of Multiple Type A Radioactive Material Packages*, SAND88-1915, Sandia National Laboratories, Albuquerque, New Mexico, August 1988.
Fischer, 1987	Fischer, L.E., et al., *Shipping Container Response to Severe Highway and Railway Accident Conditions*, NUREG/CR-4829, USNRC, Washington, D.C., 1987.

Foley, 1974 — Foley, J.T., et al., "Qualitative Characterization of the Environment Experienced by Cargo in Motor Carrier Accidents," *Proceedings of the 4th International Symposium on Packaging and Transportation of Radioactive Materials*, Miami Beach, Florida, September 22-27, 1974.

Goel, 1991 — Goel, S., *Impact of Carbon Monoxide Mitigation Programs in Albuquerque,* (Research Paper: University of New Mexico), Albuquerque, New Mexico, December 1991.

Hallenbeck, 1986 — Hallenbeck, W.H. and K.M. Cunningham, *Quantitative Risk Assessment for Environmental and Occupational Health*, Lewis Publications, Chelsea, Missouri, 1986.

Helton, 1991 — Helton, J.C., *Performance Assessment Overview, in Preliminary Comparison with 40 CFR Part 191, Subpart B for the Waste Isolation Pilot Plant, December 1991*, SAND91-0893, Sandia National Laboratories, Albuquerque, New Mexico, 1991.

ICRP, 1991 — International Committee on Radiological Protection (ICRP), 1990, *Recommendations of the International Commission on Radiation Protection*, ICRP Publication 60, Oxford, United Kingdom, 1991.

Larson, 1975 — Larson, D.W., et al., *Severities of Transportation Accidents, Volume IV-Train*, SLA74-001, Sandia National Laboratories, Albuquerque, New Mexico, September 1975.

Miller, 1989 — Miller, A.B., G.R. Howe, et al., "Mortality from Breast Cancer After Irradiation During Fluoroscopic Examinations in Patients Being Treated for Tuberculosis," *New England Journal of Medicine.* 321 (1285-1289), 1989.

Mills, 1994 — Mills, G.S. and K.S. Newhauser, "Cumulative Dose to Members of the Public from Routine Highway Transportation of RAM," *Waste Management '94*, University of Arizona, Tuscon, Arizona, 1994.

NAS, 1990 — National Academy of Sciences (NAS) Committee on the Effects of Ionizing Radiations, *Health Effects of Exposure to Low Levels of Ionizing Radiation (*BEIR V), National Academy of Sciences, Washington, D.C., 1990.

Neuhauser, 1991 K.S. Neuhauser and F.L. Kanipe, RADTRAN4 - Volume II: *Technical Manual*, DRAFT SAND89-2370, Sandia National Laboratories, Albuquerque, New Mexico, June 1991.

Neuhauser, 1992 K.S. Neuhauser and F.L. Kanipe, RADTRAN4 - Volume III: *User Guide*, SAND89-2370, Sandia National Laboratories, Albuquerque, New Mexico, June 1991.

NRC, 1977 United States Nuclear Regulatory Commission (NRC), *Final Environmental Statement of the Transportation of Radioactive Material by Air and Other Modes*, NUREG-0170, Vol. 1, December 1977.

NRC, 1991 Nuclear Regulatory Commission (NRC), *Preamble to Standards for Protection Against Radiation*, May 21, 1991, 56 *Federal Register* 23363.

NVO, 1991a United States Department of Energy (DOE), Nevada Operations Office, *Waste Management Plan for the Nevada Test Site*, July 1991.

NVO, 1991b United States Department of Energy (DOE), Nevada Field Office, *Environmental Restoration and Waste Management Site Specific Plan*, DOE/NV-336, August 1991.

ORNL, 1992a P. Johanson, *Highway 5.0 - An Expanded Highway Routing Model: Program Description, Methodology and Revised User's Manual*, ORNL/TM-12124, Oak Ridge National Laboratory, Oak Ridge, Tennessee, 1992.

ORNL, 1992b P. Johanson, Oak Ridge National Laboratory, *INTERLINE 5.0 - An Expanded Railroad Routing Model: Program Description, Methodology, and Revised User's Manual*, ORNL/TM-12090, Oak Ridge National Laboratory, Oak Ridge, Tennessee, 1992.

Parker, 1989 S.P. Parker, ed., *McGraw-Hill Dictionary of Scientific and Technical Terms*, 4th ed. McGraw-Hill Book Company, 1989.

RLO, 1989 United States Department of Energy, Richland Office, *Hanford Site Waste Management Plan*, DOE/RL 89-32, December 1989.

RLO, 1991	United States Department of Energy, Richland Office, Environmental Restoration and Waste Management Site-Specific Plan for the Richland Operations Office: Hanford Site Five-Year Plan Fiscal Years 1993-1997, DOE/RL-91-25, September 1991.
Shleien, 1992	B. Shleien, *The Health Physics and Radiological Health Handbook*, Revised Edition, Scinta, Inc., Silver Spring, Maryland, 1992.
SNL, 1993	Sandia National Laboratories, *Sandia National Laboratories, New Mexico, Environmental Baseline Update*, SAND92-7339, January 1993.
Ullrich, 1987	Ullrich, R.L., M.C. Jernigan, et al., "Radiation Carcinogenesis: Time-Dose Relationships," *Radiation Research.* 111 (179-184), 1987.
USAF, 1990	United States Department of the Air Force (USAF), Headquarters, Military Aircraft Command, *Environmental Assessment of the Realignment of Units at Kirtland Air Force Base, New Mexico*, Scott Air Force Base, Illinois, April 1990.
USNRC 1977	USNRC (U.S. Nuclear Regulatory Commission), "Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes," NUREG4170, Vols. I and II, Office of Standards Development, USNRC, Washington, D.C., 1977.

8.0 GLOSSARY

Absorbed Dose	The energy imparted to matter by ionizing radiation pr unit mass of irradiated material at the place of interest. The unit of absorbed dose is the rad.
Accelerator	See Particle Accelerator.
Activity	See Radioactivity.
Average Annual Daily Traffic(AADT)l	The total number of vehicles traveling in one direction on a defined rod segment pr year divided by 365. If multiple counts exist for an area, the smallest count is reported in this EA. This procedure helps to ensure a conservative estimate of the impacts of the proposed action on local vehicle traffic and emissions.
Biological Dose Conversion Factor	See Dose Conversion Factor.
Characterization	A term applied to waste and to the procedure by which it is sampled, categorized, and labeled for and before processing, storage, or transport.
Ci, μCi, nCi	Curie, microcurie, and nanocurie; special unit of radioactivity. One Ci is 3.7×10^{10} nuclear transformations per second. One μCi equals 10^{-6} Ci, while one nCi equals 10^{-9} Ci; 10 nCi/g equals one part per million.
Committed Dose Equivalent	Dose Equivalent is the product of absorbed does measured in rad [or measured in gray (Gy)] in tissue and a quality factor. It is expressed in units of rem or sievert. Committed Dose Equivalent is the predicted total dose equivalent to a tissue or organ over a 50-year period after a known intake of a radionuclide into the body. It does not include contributions from external dose.
Committed Effective Dose Equivalent	The sum of the committed dose equivalents to various tissues in the body, each multiplied by the appropriate weighting factor. It is expressed in units of rem (or sievert) (WHC, 1994).

Compaction	Reduction of waste volumes by hydraulic press, in the cases where such reduction would not itself cause a hazard.
Decibel	(1) The unit for measurement of the intensity of sound, one decibel representing the faintest sound that can be heard by the human ear; (2) the unit which expresses the difference in power between two acoustic or electrical signals, equal to one-tenth the common logarithm of the ratio of the two levels (Williams, 1991).
Decontamination	The removal of unwanted material (typically radioactive material) from facilities, soils, or equipment by washing, chemical action, mechanical cleaning, or other techniques.
Dose	The quantity of radiation absorbed, per unit mass, by the body or by any portion of the body [10CFR 20.4(a)].
Dose Conversion Factor	Dose in the units of concern. Frequently used as the factor that expresses the *committed effective dose equivalent* to a person from the intake (inhalation or ingestion) of a unit activity of a given radionuclide (Schlein, 1992)
Dose Equivalent	The product of absorbed dose in tissue, a quality factor, and other modifying factors. Absorbed dose (expressed in units of rad) is the energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest in that material. A quality factor is the principal modifying factor used to calculate the dose equivalent from the absorbed dose. Dose equivalent is expressed in units of rem.
Dose Rate	The radiation dose delivered per unit of time measured, for example in rem per hour (Schleien, 1992).
Effects	Synonymous with impacts. Includes ecological, aesthetic, historic, cultural, economic, social, or health impacts, whether direct, indirect, or cumulative. Under NEPA, the effects of beneficial, as well as detrimental, actions must be considered (DOE, 1994b).
Environmental Restoration	Measures taken to clean up and stabilize or restore a site that has been contaminated with hazardous substances (DOE, 1994b).

Gamma Rays	Electromagnetic radiation emitted in the process of nuclear transition or radioactive decay.
General Public	The general populace; does not include radiation workers.
Generator	Any person, by site location, whose act or process produces hazardous waste identified or listed in 40 CFR 261 (RCRA, Sections 144.2; 146.3; 270.2)
Hazardous Materials	Any substance or material that poses a risk to health, safety, and/or property.
Hot Cell	A heavily shielded compartment containing remote handling equipment for highly radioactive materials (DOE, 1994b).
Impacts	See Effects.
Latent Cancer Fatality	A fatal malignancy that may occur after 10 years or more and that has a probability of occurrence that increases with exposure.
Low-Level Waste	Waste that contains radioactivity and is not classified as high-level waste, transuranic waste, or spent nuclear fuel, or by-product material. Test specimens of fissionable material irradiated for research and development may be regarded as LLW only if the concentration of transuranics is less than 100 nCi/gm.
Maximally Exposed Individual	An individual member of the public who is modeled as living beside the highway route and who is exposed to every shipment at a distance of 30 meters.
Mixed Waste	Waste containing both hazardous and radioactive constituents.
Neutron Generator	A piece of equipment that enhances a nuclear chain reaction in a nuclear warhead through the electrical acceleration of ions onto a target of fissionable material.
Non-Attainment Area	Geographic area that does not meet one or more of the National Ambient Air Quality Standards for the criteria pollutants designated in the Clean Air Act (Ex Ent, 1989)

Off-Site — Anything, such as roads, buildings, streams, and people, located outside or beyond the restricted public access boundaries. Any site that is not on site.

Particle Accelerator — A device that accelerates electrically charged atomic or subatomic particles, such as electrons, protons, or ions, to high energies. Also known as accelerator (Parker, 1989).

Person-Rem — Unit of estimating dose from radiation exposure to a population. Equal to the average individual dose times the number of people in the population exposed.

Population Dose — Population dose is expressed in person-rem and is used in estimating possible effects to a human population exposed to known hazardous materials, such as radioactivity. Equal to the average individual dose (in rems) times the number of people exposed.

Probability — The annual probability of occurrence of a single accident or event sequence.

Quality Factor — The ratio of dose equivalent (rem or mrem) to absorbed energy (rad or mrad) is called the quality factor (QF).

Rad Radioactivity — The unit of absorbed dose equal to 100 ergs/gm (0.01 J/kg) in any medium. (1) The spontaneous nuclear decay of a material with a corresponding release of energy in the form of particles and/or electromagnetic radiation. (2) The property characteristic of radioactive material to spontaneously "disintegrate" with the emission of energy in the form of radiation. The unit of radioactivity is the curie (or becquerel) (DOE, 1994b).

Radiation Worker — An individual who works with or around radiation or who, in the course of completing a task, may be exposed to radiation.

Radioactive Waste — Solid, liquid, or gaseous materials of negligible economic value that contain radionuclides in excess of threshold quantities except for radioactive material from post-weapons test activities.

Release Fraction — The fraction of the total inventory of radioactive or hazardous particulate or vapor released to the atmosphere during an accident.

rem	See Roentgen Equivalent Man.
Risk	A measure of the product of the probability and the consequences of an accident expressed in either qualitative or quantitative terms.
Roentgen Equivalent Man (rem)	(1) Unit used to express human biological doses as a result of exposure to various types of ionizing radiation. (2) Unit of radiation that charges atoms, equal to the amount that produces the same damage to humans as 1 roentgen of high-voltage x-rays. The relation of the rem to other dose units depends on the biological effect under consideration and on the conditions/type of irradiation 9DOE, 199b).
Site	The land area that a facility occupies. The area of land owned or controlled by the DOE for the principal purpose of constructing and operating a facility and limited by the site boundary.
"Traffic Jam" Maximally Exposed Individual	An individual member of the public who is sharing the highway with the LLW conveyance during a traffic stoppage resulting in traffic jam conditions. The exposure to this individual is modeled with a 2-hour traffic stoppage with an exposure distance of 2 meters (6.5 feet). This dose estimate is performed for a single truck shipment to establish an estimate of a potential dose resulting from a realistic traffic situation.
Transportation Index (TI)	A dimensionless number (rounded up to the nearest first decimal place) displayed on the label of a package to designate the degree of control to be exercised by the carrier during transportation (10 CFR 71.4). For this EA, the TI is the number expressing the maximum radiation level in millirem per hour to be measured at 1 meter (3.25 feet) from the external surface of the outermost package on a conveyance.
Waste Streams	Typical and average quantities of waste by category produced by a facility or an organization annually.

FINAL ENVIRONMENTAL ASSESSMENT FOR OFF-SITE TRANSPORTATION OF LOW-LEVEL WASTE TO COMMERCIAL DISPOSAL SITES FROM FOUR CALIFORNIA SITES UNDER THE MANAGEMENT OF THE U.S. DEPARTMENT OF ENERGY OAKLAND OPERATIONS OFFICE

APPENDICES

October 1997

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

ALARA	As Low As Reasonably Achievable
CEDE	Committed Effective Dose Equivalent
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
DAW	Dry Active Waste
DOE	U.S. Department of Energy
DOE/OAK	U.S. Department of Energy/Oakland Operations Office
DOT	U.S. Department of Transportation
DR	Disposal Request
EA	Environmental Assessment
EPA	U.S. Environmental Protection Agency
ETEC	Energy Technology Engineering Center, Canoga Park, California
FY	Fiscal Year
GA	General Atomics, San Diego, California
ICRP	International Committee on Radiation Protection
LCF	Latent Cancer Fatality
LBNL	Lawrence Berkeley National Laboratory, Berkeley, California
LLNL	Lawrence Livermore National Laboratory, Livermore, California

LIST OF ACRONYMS (CONTINUED):

LLW	Low-Level Waste
NAS	National Academy of Sciences
NRC	U.S. Nuclear Regulatory Commission
NTS	The Nevada Test Site; Nevada
QF	Quality Factor
SAR	Safety Analysis Report
SLAC	Stanford Linear Accelerator Center, Palo Alto, California
SNL/NM	Sandia National Laboratories, Los Alamos, New Mexico
SNL-EA	Sandia National Laboratories Environmental Assessment, 1996, Los Alamos, New Mexico
TI	transportation index
TYP	Ten Year Plan
WAC	Waste Acceptance Criteria

APPENDIX A - INPUT PARAMETERS FOR TRANSPORTATION RISK ANALYSIS

A.1 Waste Stream Inventories

The estimated waste inventories used to estimate the impact of the proposed action are presented in Table A.1. The estimated volumes of low-level waste (LLW) are listed by site for a single year of shipping. The estimated volumes have either been taken from the DOE/OAK February 28, 1997 Ten Year Plan (TYP) or have been provided by Department of Energy/Oakland Operations Office (DOE/OAK) Environmental Restoration Site Program Managers. The single Fiscal Year (FY) represents the FY estimated to have the largest volume of LLW that will be prepared (characterized and packaged) for shipping between 1997 and 2006. For the purpose of this Environmental Assessment (EA), the FY included in Table A.1 is considered to represent each site's worst-case annual shipping scenario. The volumes in Table A.1 were doubled for all sites, except ETEC, to obtain the data for Table 2.1 in the EA.

Table A.1 - DOE/OAK Forecasted Shipments of LLW

Site	Defense Sites	Non-Defense Sites			Totals
	LLNL	LBNL	SLAC	ETEC	
Fiscal Year [1]	1999	1997	1997	1998	
Volume (m^3) [2]	520.0	411.0	170.0	4,000.0	5,114.0
Number of Drums [3]	2,477	1,958	810	19,048	24,355
Number of Boxes [4]	163	129	54	1,250	1,600
Number of Drum Shipments [5]	42	33	14	318	408
Number of Box Shipments [6]	28	22	9	209	269

Notes:
1. Fiscal Year for a given site represents the largest estimated volume to be shipped in a single year between 1997 through 2006.
2. LLW volume data collected from DOE/OAK February 28, 1997 Ten Year Plan.
3. One 55-gallon steel drum = 0.21 m^3/drum.
4. One 4.0' x 4.0' x 7.0' steel box = 3.2 m^3/box.
5. Number of drums per shipment = 60/truck.
6. Number of boxes per shipment = 6/truck.

A.2 Accident Severity Category Data

The following discussion explains the accident severity categories used in the SNL-EA, 1996. The present EA for DOE/OAK incorporates the results of the SNL/NM analysis, as explained in Section B.1 of Appendix B.

Figure A.1 presents a two-dimensional representation of the spectrum of severe environments that could result from a trucking accident [Nuclear Regulatory Commission (NRC), 1977]. The full range of credible accident outcomes are encompassed by the accident severity categories: from "fender benders" to horrific, violent accidents that subject the conveyances and cargoes to extreme physical stresses (via crush or puncture forces), or extreme thermal stresses (via intense and prolonged fire), or a combination of both types of stresses. The mapping of the spectrum of all credible accident outcomes into a two-dimensional space defined by two-accident parameters (physical force versus thermal stress) is synonymous to the development of accident scenarios for risk assessment of fixed facilities (such as nuclear power plants or waste disposal sites). This "accident spectrum" approach to modeling accident outcomes is used for transportation risk assessment rather than the "accident scenario" approach that is commonly used for the risk analysis of fixed facilities. See Section B.6 for a discussion on the transportation accident analysis method used in this analysis.

The likelihood that any given accident would result in a particular accident environment is modeled by assigning conditional probabilities to each of the accident severity categories. A conditional probability is defined as the probability that an accident, given that it occurs, would be of a certain severity. The Department of Energy (DOE) has endorsed the use of conditional probabilities developed by the NRC for the eight accident severity category schemes used in this EA (NRC, 1977). These probabilities are listed in Table A.2.

The severity categories for truck accidents are shown in Figure A.2. The ordinate in Figure A.2 is crush force. Research has shown that the dominant factors in the determination of motor carrier accident severity are crush force, fire duration, and puncture (Foley, 1974). The severity categories include all accidents with a probability of occurrence of one in a million or greater for an entire campaign of up to 45 shipments, a probability well within the levels found acceptable by the U.S. Environmental Protection Agency (EPA) and other agencies (Hallenbeck, 1986).

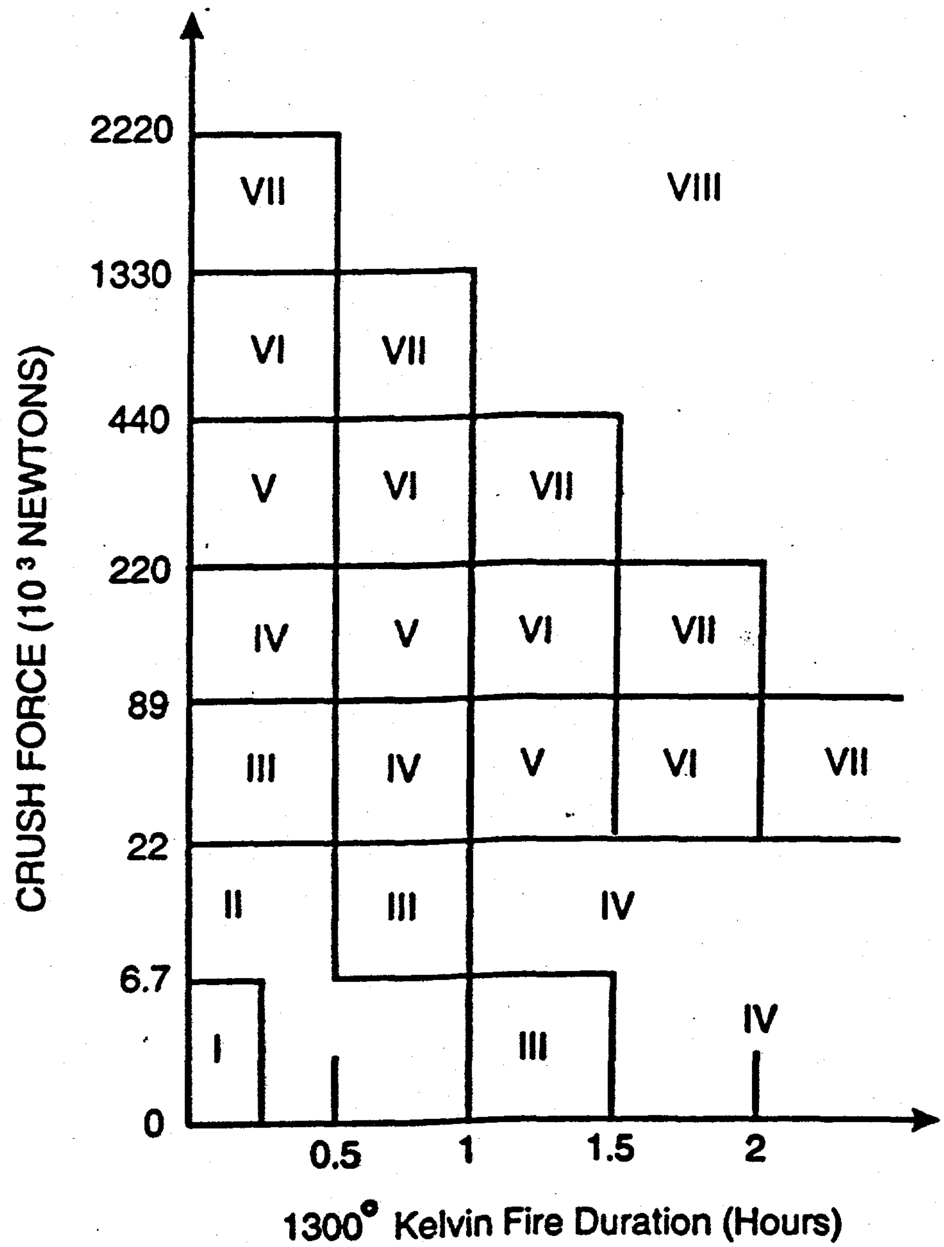


Figure A-1 Accident Severity Category Classification Scheme - Motor Trucks

Table A.2 *RADTRAN 4* Accident Probability Data by Truck

RADTRAN 4 Input Parameter	Truck	
Conditional Probability of Accident Severity Category 1	Urban	0.583
	Suburban	0.435
	Rural	0.462
Conditional Probability of Accident Severity Category 1	Urban	0.382
	Suburban	0.285
	Rural	0.302
Conditional Probability of Accident Severity Category 3	Urban	0.0278
	Suburban	0.221
	Rural	0.176
Conditional Probability of Accident Severity Category 4	Urban	0.00636
	Suburban	0.05060
	Rural	0.04030
Conditional Probability of Accident Severity Category 5	Urban	7.24E-04
	Suburban	0.00664
	Rural	0.01180
Conditional Probability of Accident Severity Category 6	Urban	1.46E-4
	Suburban	0.00174
	Rural	0.00647
Conditional Probability of Accident Severity Category 7	Urban	1.13E-5
	Suburban	6.72E-5
	Rural	5.71E-4
Conditional Probability of Accident Severity Category 8	Urban	9.94E-7
	Suburban	5.93E-6
	Rural	1.13E-4

Other researchers have used six-category (Wilmot, 1981) and twenty-category schemes (Fischer, 1987) to describe the same spectrum of highway accidents. All schemes give approximately the same results when applied to similar problems and are essentially interchangeable (Fischer, 1990; Whitlow, 1992). Consistent with the general principles of probabilistic risk assessment, extremely low probability events (Helton, 1991) are not considered reasonably foreseeable, and therefore are not included among the accident-severity categories. Thus, for example, a maximum credible accident, although physically possible, has a probability so remote (i.e., improbable) as to render its occurrence not reasonably foreseeable.

Given that an accident of a particular accident severity occurs, the behavior of the radioactive material packaging and of the radioactive material in the accident environment is modeled by the use of release fractions (see Section B.6.1, Appendix B). The release fractions used in this analysis were developed by the DOE for the purpose of modeling the behavior of radioactive material shipments involving multiple Type A packages (Finley, 1988). These release fractions are shown in Table A.3. The meaning of the release fractions can be illustrated by example.

Should a truck accident occur with sufficient force or fire to result in a Category 1 severity environment, then the Type A packages on the shipment would not fail (release fraction = 0.0) and none of the radioactive material would be released into the environment. Should a truck accident of severity 3 occur, then ten percent (10%) of the radioactive material in the shipment would escape through failed packages (release fraction = 0.1). Should a truck accident of severity 5 or higher occur, then one hundred percent (100%) of the radioactive material in the shipment would be released (release fraction = 1.0).

Table A.3 RADTRAN 4 Accident Severity Material Release Fractions

	Accident Severity Category							
Mode	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Truck	0.0	0.02	0.1	0.1	1.0	1.0	1.0	1.0

Finley, 1988

APPENDIX B - IMPACT AND RISK ASSESSMENT METHODOLOGY

B.1 Methodology Used To Extrapolate The Results Of The SNL-EA

B.1.1 Introduction

This Environmental Assessment (EA) for disposal of LLW from four Department of Energy, Oakland Operations Office (DOE/OAK) sites in California is based on the EA prepared for disposal of LLW from Sandia National Laboratories, New Mexico (SNL/NM) (DOE/EA-1180).

Two software packages/databases were used to estimate risk to the public and truck crew members for the SNL-EA. One of the databases, *Highway 5.0 - Expanded Highway Routing Model* (ORNL, 1992), provided estimates of population densities along proposed shipping routes. The other software package/database, *RADTRAN 4* modeling software (Neuhauser, 1991, 1992), used the input from the first database and the projected quantity of LLW waste to estimate dose risks and latent cancer fatalities (LCF) for affected populations. The risk assessment component of the EA prepared for disposal of LLW generated at SNL/NM was based on two major inputs to the software used for the assessments.

- Quantity of LLW requiring disposal.
- Populations exposed to LLW during disposal shipments.

Quantity Of LLW

The SNL-EA evaluated the mrems/hr of exposure associated with truckloads of waste shipped in either 55-gallons drums or 4' x 4' x 7' boxes. The SNL-EA assumed that trucks were either loaded with 60 drums or six boxes. Risks were estimated for two bounding cases; all LLW transported in shipments of 60 drums per truck or all LLW transported in shipments of six boxes per truck. Shipments in drums provided an upper bound on exposure because more shipments were required, while shipments in boxes provide the lower bound for the risk estimate. The present EA for DOE/OAK disposal uses the same bounding cases.

Populations Exposed To LLW Shipments

Populations evaluated in the SNL-EA included: Public Off-Link; Public On-Link; Public Stops; Truck Crew; and Maximally Exposed Individuals. Public On-Link, Public Stops, and Truck Crew exposures are primarily functions of travel distance to the disposal site. The Maximally Exposed Individuals are a subset of the Public Off-Link populations, as defined in Section 4.2.1.

The Public Off-Link Exposure is a function of the population living within one-half mile of the route used to transport LLW to the disposal site. To obtain the exposed population in the Public Off-Link Setting, the SNL-EA used the *Highway 5.0 - Expanded Highway Routing Model* (ORNL, 1992); this database provides estimates of route-specific densities for rural, suburban, and urban transportation segments.

Performance Of Risk Assessment Calculations

Risk assessment calculations in the SNL-EA were performed using the *RADTRAN 4* modeling software (Neuhauser, 1991, 1992). Inputs to the software included the transportation route and exposed populations values obtained from the *Highway 5.0* database, and the per truckload radiation exposure for each mode of shipment. The *RADTRAN 4* modeling software was also used to model accident risks for highway shipments of wastes.

B.1.2 Approach To Preparing This EA

For disposal routes that are approximately equal in length, the variable that has the greatest impact on the calculated risks is the number of truckloads of LLW shipped to the disposal site in a given year. The risk associated with LLW shipments from the DOE/OAK sites has been estimated by multiplying the per shipment (truckload) risks calculated in the SNL-EA by the number of shipments of LLW to be disposed of from the DOE/OAK sites.

Transportation Routes and Exposed Populations

The SNL-EA provides data for the four proposed transportation routes to disposal facilities. For each route, the exposed population (Public Off-Link) was calculated as a function of the population densities alongside the proposed transportation route. For each of these four routes the percentage of the total travel in rural, suburban, and urban areas were individually calculated from the *Expanded Highway Routing Model database* (ORNL, 1992). Table B.1 presents these travel distances and population density classes as derived for the SNL-EA and also presents similar data for a disposal EA prepared for the General Atomics (GA) facility in San Diego, California (*Final Environmental Assessment for Decontaminating and Decommissioning the General Atomics Hot Cell Facility*; US DOE, August 1995).

Table B.1 Travel Distances and Population Density Classifications for Highway Routes from DOE Facilities to Disposal Sites

Route	Population Classification			
	Distance (miles)	Percent Rural	Percent Suburban	Percent Urban
From SNL/NM (Albuquerque) EA				
SNL/NM to U.S. Ecology (Hanford, WA)	1,602	89.0	8.7	1.4
SNL/NM to Nevada Test Site (Las Vegas, NV)	643	91.0	6.6	2.4
SNL/NM to Chem Nuclear (Barnwell, SC)	1,646	80.2	17.8	2.0
SNL/NM to Envirocare (Clive, UT)	1,068	89.0	9.1	1.9
From GA (San Diego) EA				
GA to Envirocare (Clive, UT)	821	80.7	15.7	3.6

Because GA has already prepared an EA that addresses waste transportation, it was intentionally not included in the DOE/OAK EA. However, the transportation route analysis for transport of waste from the GA site in northern San Diego to the Envirocare facility in Clive, Utah includes the Interstate 5 - Highway 163 interchange in the central urban area of San Diego; this route has been included in Table B.1 to assess the significance of the high population densities in major urban and suburban areas in California (the San Francisco Bay Area for LBNL, LLNL and SLAC, and the Los Angeles area for ETEC), relative to the population densities in the states evaluated as transportation routes in the SNL-EA for LLW disposal from Albuquerque.

The route in the SNL-EA that is most similar to the population distribution along the route in the GA/EA is the route from SNL/NM (Albuquerque) to Chem Nuclear (Barnwell, SC). The most significant difference in the relative percentages is the percentage of travel through urban population densities, which are 2 percent and 3.6 percent for the Albuquerque to Chem Nuclear and GA to Envirocare routes, respectively. However, the travel distance from Albuquerque to Chem Nuclear (1,646 miles) is twice the travel distance from GA to Envirocare (821 miles). Therefore, the total exposed urban populations are approximately equivalent, as demonstrated by the following calculation.

The urban populations in the SNL/NM route from Albuquerque to Chem Nuclear were determined to have a mean density of 3,861 persons/km^2 (1,490 persons/mile^2) (see Table 3.5 in the SNL-EA). From Albuquerque to Chem Nuclear, the exposed urban population is the product of the length of the route, a one-mile wide exposure corridor (the Public Off-Link), the percentage of the route in urban areas, and the population density. These parameters are applied in the following calculations:

(1,646 miles) x (1 miles) x (2 %) x (1,490 persons/mile^2) = 49,050 persons

Similarly from the GA site to Envirocare, the exposed urban populations was determined to be:

(821 miles) x (1 miles) x (3.6 %) x (1,490 persons/mile^2) = 44,040 persons

Therefore, the route from GA to Envirocare has approximately 10 percent fewer exposed persons in urban environments compared to the route from Albuquerque to Chem Nuclear. The same calculations for the suburban and rural areas can be made using mean population densities of 719 persons/km^2 (278 persons/mile^2) and 6 persons/km^2 (2.3 persons/mile^2), respectively (see Table 3.5 in the SNL-EA).

Table B.2 Comparison of Exposed Populations Along Two Transport Routes

Population Classification	GA to Envirocare (821 miles) (persons)	SNL/NM to Chem Nuclear (1,646 miles) (persons)
Urban	44,040	49,050
Suburban	35,833	81,450
Rural	1,524	3,036
Total	*81,397*	*133,536*

Use of the SNL/NM to Chem Nuclear route to model public exposure along the GA to Envirocare route would overestimate the exposed population by approximately 60 percent.

To provide simple, conservative estimates of risk for LLW disposal from the DOE/OAK sites, the DOE/OAK EA has used the public exposure calculated along the route from Albuquerque to Chem Nuclear as a worst-case upper bound for public exposure for transport from any of the four DOE/OAK facilities in California to the Envirocare facility. For transport from the California sites to Chem Nuclear, twice the exposure from Albuquerque to Chem Nuclear has been used as an upper bound on exposure. Note that for the four DOE/OAK sites the route to Chem

Nuclear from California passes through Albuquerque, and that from Albuquerque to Chem Nuclear the route is identical to the route used in the SNL-EA.

Table B.3 Selection of Routes from the SNL-EA that are Appropriate To Use To Model Disposal for the Four DOE/OAK Sites

Route	Actual Distance (miles)	Modeled as Albuquerque to Chem Nuclear (miles)	Modeled as Twice the Exposure from Albuquerque to Chem Nuclear (miles)
S.F. Bay Area[1] to Chem Nuclear	2,746	---	3,292
ETEC to Chem Nuclear	2,457	---	3,292
S.F. Bay Area to Envirocare	675	1,646	---
ETEC to Envirocare	766	1,646	---

Note:
1. S.F. Bay Area includes three DOE/OAK sites: LBNL, LLNL, and SLAC.

Adjustments for the Number of Shipments/Truckloads Required for DOE/OAK LLW Disposal

In the SNL-EA, estimates were made for disposal volumes for three successive years following the preparation of the EA. Because the present DOE/OAK EA is based on conservative interpolations from the SNL-EA, one "worst-case" number of shipments per-year was estimated for each of the four DOE/OAK sites. The worst-case shipment volume for each site was based on LLW volume data presented in the DOE/OAK February 28, 1997 Ten Year Plan (TYP) for three of the facilities (ETEC, LBNL and LLNL) and from DOE/OAK Environmental Restoration Program Managers for SLAC

(see Section A.2 of Appendix A).

In Chapter 4 of the SNL-EA, the risks for disposal are evaluated in terms of "Person-rem" and "Latent Cancer Fatalities (LCF)" for scenarios with unique numbers of waste shipments. For the DOE/OAK EA, the SNL/NM risk analysis has been used to calculate the following four factors for the SNL/NM to Chem Nuclear disposal route: "Person-rem/shipment as drums", "Person-rem/shipment as boxes", "LCF/shipment as drums", and "LCF/shipment as boxes" (the split columns in Tables B.4 and B.5 represent the same impact represented two different ways). The SNL/NM to Chem Nuclear route is the route that has been selected as most appropriate for modeling the DOE/OAK disposal shipment routes.

Table B.4 Maximum Annual Incident-Free Impacts for Highway Shipment of DOE/OAK LLW to Envirocare (modelled as 1646 mile trip from SNL/NM to Chem Nuclear)

Incident-Free Impacts - Total Dose Estimates for All Highway Shipments											
Risk Group	Packaging	Per Shipment		LLNL		LBLNL		SLAC		ETEC	
				Drums: 84 Shipments		Drums: 66 Shipments		Drums: 28 Shipments		Drums: 318 Shipments	
				Boxes: 56 Shipments		Boxes: 44 Shipments		Boxes: 18 Shipments		Boxes: 209 Shipments	
		Person-rem	LCF	Person-rem	LCF	Person-rem	LCF	Person-rem	LCF	Person-rem	LCF
Public Off-Link	Drums	2.80E-03	1.42E-06	2.35E-01	1.19E-04	1.85E-01	9.37E-05	7.84E-02	3.98E-05	8.90E-01	4.52E-04
	Boxes	3.00E-03	1.50E-06	1.68E-01	8.40E-05	1.32E-01	6.60E-05	5.40E-02	2.70E-05	6.27E-01	3.14E-04
Public On-Link	Drums	1.50E-02	7.50E-06	1.26E+00	6.30E-04	9.90E-01	4.95E-04	4.20E-01	2.10E-04	4.77E+00	2.39E-03
	Boxes	1.55E-02	7.83E-06	8.68E-01	4.38E-04	6.82E-01	3.45E-04	2.79E-01	1.41E-04	3.24E+00	1.64E-03
Public Stops	Drums	2.20E-01	1.10E-04	1.85E+01	9.24E-03	1.45E+01	7.26E-03	6.16E+00	3.08E-03	7.00E+01	3.50E-02
	Boxes	2.33E-01	1.17E-04	1.30E+01	6.55E-03	1.03E+01	5.15E-03	4.19E+00	2.11E-03	4.87E+01	2.45E-02
Total Public	Drums	2.40E-01	1.20E-04	2.02E+01	1.01E-02	1.58E+01	7.92E-03	6.72E+00	3.36E-03	7.63E+01	3.82E-02
	Boxes	2.50E-01	1.23E-04	1.40E+01	6.89E-03	1.10E+01	5.41E-03	4.50E+00	2.21E-03	5.23E+01	2.57E-02
Crew	Drums	8.00E-02	3.20E-05	6.72E+00	2.69E-03	5.28E+00	2.11E-03	2.24E+00	8.96E-04	2.54E+01	1.02E-02
	Boxes	8.33E-02	3.33E-05	4.66E+00	1.86E-03	3.67E+00	1.47E-03	1.50E+00	5.99E-04	1.74E+01	6.96E-03
Total (Public and Crew)	Drums	3.20E-01	1.63E-04	2.69E+01	1.37E-02	2.11E+01	1.08E-02	8.96E+00	4.56E-03	1.02E+02	5.18E-02
	Boxes	3.33E-01	1.63E-04	1.86E+01	9.13E-03	1.47E+01	7.17E-03	5.99E+00	2.93E-03	6.96E+01	3.41E-02
Maximally Exposed Individual	Drums	2.30E-07	1.14E-10	1.93E-05	9.58E-09	1.52E-05	7.52E-09	6.44E-06	3.19E-09	7.31E-05	3.63E-08
	Boxes	2.35E-07	1.18E-10	1.32E-05	6.61E-09	1.03E-05	5.19E-09	4.23E-06	2.12E-09	4.91E-05	2.47E-08

Table B.5 Maximum Annual Incident-Free Impacts for Highway Shipment of DOE/OAK LLW to Chem Nuclear (modelled as twice the 1,646 mile transport from SNL/NM to Chem Nuclear)

Incident-Free Impacts - Total Dose Estimates for All Highway Shipments											
Risk Group	Packaging	Per Shipment		LLNL		LBLNL		SLAC		ETEC	
				Drums: 84 Shipments		Drums: 66 Shipments		Drums: 28 Shipments		Drums: 318 Shipments	
				Boxes: 56 Shipments		Boxes: 44 Shipments		Boxes: 18 Shipments		Boxes: 209 Shipments	
		Person-rem	LCF	Person-rem	LCF	Person-rem	LCF	Person-rem	LCF	Person-rem	LCF
Public Off-Link	Drums	5.60E-03	2.84E-06	4.70E-01	2.39E-04	3.70E-01	1.87E-04	1.57E-01	7.95E-05	1.78E+00	9.03E-04
	Boxes	6.00E-03	3.00E-06	3.36E-01	1.68E-04	2.64E-01	1.32E-04	1.08E-01	5.40E-05	1.25E+00	6.27E-04
Public On-Link	Drums	3.00E-02	1.50E-05	2.52E+00	1.26E-03	1.98E+00	9.90E-04	8.40E-01	4.20E-04	9.54E+00	4.77E-03
	Boxes	3.10E-02	1.57E-05	1.74E+00	8.77E-04	1.36E+00	6.89E-04	5.58E-01	2.82E-04	6.48E+00	3.27E-03
Public Stops	Drums	4.40E-01	2.20E-04	3.70E+01	1.85E-02	2.90E+01	1.45E-02	1.23E+01	6.16E-03	1.40E+02	7.00E-02
	Boxes	4.66E-01	2.34E-04	2.61E+01	1.31E-02	2.05E+01	1.03E-02	8.39E+00	4.21E-03	9.74E+01	4.89E-02
Total Public	Drums	4.80E-01	2.40E-04	4.03E+01	2.02E-02	3.17E+01	1.58E-02	1.34E+01	6.72E-03	1.53E+02	7.63E-02
	Boxes	5.00E-01	2.46E-04	2.80E+01	1.38E-02	2.20E+01	1.08E-02	9.00E+00	4.43E-03	1.05E+02	5.14E-02
Crew	Drums	1.60E-01	6.40E-05	1.34E+01	5.38E-03	1.06E+01	4.22E-03	4.48E+00	1.79E-03	5.09E+01	2.04E-02
	Boxes	1.67E-01	6.66E-05	9.33E+00	3.73E-03	7.33E+00	2.93E-03	3.00E+00	1.20E-03	3.48E+01	1.39E-02
Total (Public and Crew)	Drums	6.40E-01	3.26E-04	5.38E+01	2.74E-02	4.22E+01	2.15E-02	1.79E+01	9.13E-03	2.04E+02	1.04E-01
	Boxes	6.66E-01	3.26E-04	3.73E+01	1.83E-02	2.93E+01	1.43E-02	1.20E+01	5.87E-03	1.39E+02	6.81E-02
Maximally Exposed Individual	Drums	4.60E-07	2.28E-10	3.86E-05	1.92E-08	3.04E-05	1.50E-08	1.29E-05	6.38E-09	1.46E-04	7.25E-08
	Boxes	4.70E-07	2.36E-10	2.63E-05	1.32E-08	2.07E-05	1.04E-08	8.46E-06	4.25E-09	9.82E-05	4.93E-08

Table B.6 Maximum Annual Accident Risk Estimates for Highway Shipment of DOE/OAK LLW to Proposed Sites

Accident Risk Estimates - Total Dose Estimates for All Highway Shipments												
Disposal Site Option	Packaging	Per Shipment		LLNL		LBLNL		SLAC		ETEC		
				Drums: 84 Shipments		Drums: 66 Shipments		Drums: 28 Shipments		Drums: 318 Shipments		
				Boxes: 56 Shipments		Boxes: 44 Shipments		Boxes: 18 Shipments		Boxes: 209 Shipments		
		Person-rem	LCF	Person-rem	LCF	Person-rem	LCF	Person-rem	LCF	Person-rem	LCF	
Envirocare (modeled as 1,646 miles)	Drums	1.05E-03	5.20E-07	8.82E-02	4.37E-05	6.93E-02	3.43E-05	2.94E-02	1.46E-05	3.34E-01	1.65E-04	
	Boxes	1.60E-03	8.00E-07	8.96E-02	4.48E-05	7.04E-02	3.52E-05	2.88E-02	1.44E-05	3.34E-01	1.67E-04	
Chem Nuclear (modeled as 3,292 miles)	Drums	2.10E-03	1.04E-06	1.76E-01	8.74E-05	1.39E-01	6.86E-05	5.88E-02	2.91E-05	6.68E-01	3.31E-04	
	Boxes	3.20E-03	1.60E-06	1.79E-01	8.96E-05	1.41E-01	7.04E-05	5.76E-02	2.88E-05	6.69E-01	3.34E-04	

The estimated maximum number of shipments of LLW forecasted for any one year for each of the four subject DOE/OAK sites is presented in Table 4.1 of the EA. The maximum number of shipments for each site was multiplied by the appropriate per shipment factors to calculate the "Person-rem" and "LCF" values for each disposal route for DOE/OAK LLW disposal to Envirocare and Chem Nuclear (see B.4 and B.5).

The procedure described in the preceding two paragraphs also was used to estimate annual accident risk estimates for disposal from the DOE/OAK sites using the values presented in the SNL-EA for transportation to Envirocare and the Chem Nuclear facility (see Table B.6).

B.1.3 Worst-Case Accident

Hypothetical Worst Case Accident Scenarios

For the purpose of this EA, the hypothetical worst case accidents are modeled to occur along an urban route that is typical of the most densely populated transportation corridor likely to be encountered along the route from any of the four generating sites to either of the commercial disposal sites. An estimated 6,100 persons reside along the ROI for this transportation corridor (0.5 kilometers on either side of the corridor).

A typical LLW shipment from the generating sites emits less than 5 mrem/hour. Environmental restoration (ER) activities can generate wastes that emit as much as 200 mrem/hour.

It is assumed that the truck involved in the hypothetical accident is carrying Type A containers, the least robust of container types in which LLW is transported. The waste material is assumed to be ER related LLW materials that have been removed from a radioactive source area in the course of ER activities. These materials would weigh 2,963 pounds, and if released from their container, are assumed to emit 200 mrems per hour of radiation at the source.

Three accident scenarios were evaluated:

- Category 1 severity, resulting in the release of no radioactive material into the environment. (One in 142 shipments in an urban environment).

- Category 3 severity, resulting in the release of 10% of the radioactive material from failed packages. (One in 2976 shipments in an urban environment).

- Category 5 severity, resulting in the release of 100% of the radioactive materials from failed packages. (One in one million shipments in an urban environment).

In the event of a Category 1 accident, no radioactive materials would be released to the environment.

In the event of a Category 3 accident, 10% of the radioactive materials, or approximately 296 pounds of material could be released to the environment. Under this scenario, the annual dose in mrem/hour for the maximum exposed individual adjacent to the source would be reached in approximately five hours.

In the event of the Category 5 accident, 100% of the materials, or 2,963 pounds could be released. Under this scenario, the annual dose in mrem/hour for the maximum exposed individual adjacent to the source would be reached in one-half hour .

Three factors bear upon the risk of exposure to radiation: shielding, distance, and time. In the event of an accident, the shielding of some or all of the material being transported would be removed. Therefore, distance and time become critical factors. The population at highest risk would be the personnel in the truck. Evacuation of personnel to safe distances provides immediate protection from the risk of exposure.

Although the likelihood of an accident occurring and resulting in the release of radioactive materials is improbable (see Tables A-2 and A-3, Appendix), if such an accident were to occur clean up crews would be required to respond to the accident and contaminated materials, including soil, would require removal. While this would be a significant impact, response crews would be trained and equipped to avoid radiological impacts, and techniques exist to remove and properly dispose of contaminated materials. These conditions would reduce this impact to a level of non-significance.

It should be noted that the accident scenarios presented above deviate from the worst case scenario used in the SNL-EA (1996), which was otherwise used as the basis for all analyses presented in this EA. An LLW waste type typical of DOE/OAK sites was used for this analysis and three accident scenarios were developed, whereas only one worst case scenario was used in the SNL-EA (1996). Furthermore, the risk factors used in this EA are more conservative, since the SNL-EA (1996) used a category 8 accident per RADTRAN 4 (one accident in 120,000,000 shipments).

B.2 Representative Transportation Campaign - Current LLW Inventory

In order to minimize doses under accident-free (incident-free) conditions to the public (along the highways and at stops) and to the truck crew (two drivers), loading of trucks transporting the various wastes addressed in this shipping campaign would take advantage of the fact that mainly containers in the outer layer of the cargo would measurably contribute to the dose rate at one-meter from the truck (Finley, 1988). In general, the containers would be loaded so that packages (drums or boxes) with the lower package dose rates would surround containers with higher package dose rates. The Transportation Index (TI) for each truck load is calculated on the basis of the average package dose rate per package in the outer layer. It is assumed that drums are not stacked and that the dose rate of a row of 20 drums is calculated to be 4.6 times the average dose rate for all waste drums.

B.3 Shipping Campaign For Transportation Risk Assessment - "Average" Waste

Two specific shipping campaigns were developed to establish the number of shipments that would be required at each of the four DOE/OAK sites. One campaign is based on all of the average waste being packaged and shipped in 55-gallon drums, and the other is based on all of the average waste being shipped in 4' x 4' x 7' boxes [Department of Transportation (DOT) 7A steel containers]. The number of drums or boxes that would be required was estimated by allowing for 0.21 m^3/drum (7.4 ft^3/drum) and 3.2 m^3/box (111 ft^3/box) for waste packaging (Shleien, 1992). The volumetric projections of maximum annual LLW shipment rates at each DOE/OAK facility is listed in Table 2.1 of the EA.

In the SNL-EA, the forecasted inventory of LLW was incorporated into the transportation risk assessment as presented in Chapter 4.0 of the SNL-EA. The SNL/NM transportation risk assessment conservatively doubled the number of shipments needed to dispose of the existing LLW inventory. This was done to establish an upper estimate for transportation impacts that bounds the uncertainty associated with the generation of forecasted wastes.

The DOE/OAK EA has followed the same rationale by doubling the forecasted "worst year" waste volumes for three of the four sites. An exception was made for ETEC, because the LLW volume identified for the site in Table A.1 already incorporated a conservative uncertainty factor of two.

B.4 Measurements Of Radiation Exposure

An individual may be exposed externally to ionizing radiation from a radioactive source outside the body, and/or internally, from ingesting or inhaling radioactive material. In calculating an external dose, one may assume that the dose is distributed uniformly over the body. An external dose is delivered only during the actual time of exposure to the radiation source. However, when radionuclides are deposited in various body tissues and organs, the dose and effects are not uniform. A few organs in the body may receive a large dose; others may receive none. An internal dose continues to be delivered as long as the radioactive source is in the body, although both radioactive decay and elimination of the radionuclide by ordinary metabolic processes decreases the dose rate with the passage of time. An internal dose is calculated for 50 years following the initial exposure, and the result is expressed as the committed effective dose equivalent (CEDE). The effective dose is the sum of the external dose and the committed effective dose from internal sources.

Potential radiological impacts are measured by estimating the highest radiation exposure any single person might receive, as well as the collective exposure to a particular population (e.g., all those living in the vicinity of a transportation route). Two primary units of radiation measurement are used in this EA to estimate these impacts, the rem and person-rem. The rem (roentgen equivalent man) is a measure of radiation damage to biological tissue. Specifically, it is the amount of damage done when 1 gram of biological tissue absorbs 100 ergs of x-ray (or gamma-ray) energy. Absorbed radiation energy is measured directly in rad (radiation absorbed dose); one rad is the absorption of 100 ergs of energy by 1 gram of absorbing substance. Thus, one rem is the biological damage done when one rad of x-ray or gamma rays is absorbed. Rems and rads are quite large, so radiation doses are usually measured in millirems (mrem, or 1/1000 of a rem) or millirads (mrad, or 1/1000 of a rad).

The concept of dose equivalent accounts for the differing amounts of biological damage done by various types of ionizing radiation (alpha, gamma, etc.). The ratio of dose equivalent (rem or mrem) to absorbed energy (rad or mrad) is called the quality factor (QF). For gamma radiation and x-rays, the QF is 1.0; thus, the dose equivalent in mrem is equal to the dose in mrad.

In the SNL-EA, dose equivalents from incident-free transportation activities are the basis for quantifying incident-free impacts. For brevity, incident-free dose equivalents are referred to as "doses." Doses would have no probabilistic contributions to the likelihood of their occurrence. That is, the incident-free doses are not modeled as functions of random events. The activities that contribute to the estimation of doses are modeled as occurring with no uncertainty.

Accident risk is based on the mathematical combination of a probabilistic model of the random occurrence of accident events and expected doses for a given set of accidents. Risk analyses are calculated as CEDE risks. For brevity, the CEDE risks are referred to as "dose risks."

The maximum annual allowable radiation exposure from operational activities established by the DOE, as well as by the NRC, to protect individual members of the general public is 100 mrem (DOE Order 5400.5, 1993). It is estimated that the average individual in the United States receives a dose of about 360 mrem per year from all sources, including natural and medical sources of radiation (NAS, 1990). For perspective, a modern chest x-ray results in an approximate dose of 8 mrem, while a diagnostic hip x-ray results in an approximate dose of 83 mrem (Shleien, 1992). For further perspective, an individual must receive an acute exposure of approximately 600 rem (600,000 mrem) before there is a high probability of near-term death (NAS, 1990).

Radiation exposure to a population or a group of persons is measured in person-rem. The total population exposure — all the persons-rems — is derived by adding up all the individual doses in the exposed group. This measurement is particularly important when trying to take into account the potential impacts of very small doses on very large populations (e.g., all those living along the transportation routes).

Health effects may be calculated from doses by multiplying the dose by an appropriate conversion factor, known as a risk factor. This risk factor has the dimensions of health effect per unit dose per person and may include a time factor. The National Academy of Sciences (NAS) study on the biological effects of ionizing radiation includes a number of examples of such risk factors (NAS, 1990). These risk factors have been developed from epidemiological studies of health effects in populations exposed to ionizing radiation, primarily the Atomic Bomb Survivors Life Study (NAS, 1990) and occupational exposure studies.

Thus, with such a conversion, the estimated exposures can be converted into estimated numbers of health effects. Because the exposures predicted in this study are far below those known to cause immediate fatality, or even illness, only delayed health effects are estimated. A delayed effect is measured in latent cancer fatalities (LCFs), defined as a fatal malignancy that may occur after 10 years or more and that has a probability of occurrence that increases with exposure. The conversion factor used in this EA is 0.0005 LCFs/person-rem for the general public and 0.0004 LCFs/person-rem for workers (NRC, 1991). Worker groups tend to be healthy adults and do not represent as broad a spectrum of susceptible people (e.g., children) as does the general population. Applying the conversion factor to the general population, a collective dose of 2,000 person-rem is estimated to result in one additional LCF.

Genetic effects in subsequent generations are another type of health effect that may occur as a result of low-level radiation exposure, such as that associated with the proposed action in this EA. The conversion factor is smaller, and the uncertainty is greater than for LCFs. The International Committee on Radiation Protection (ICRP) has recommended a conversion factor about five times lower than that used to estimate cancer fatalities (ICRP, 1991). For comparison with the latter, in a general population, a collective dose of 10,000 person-rem is estimated to result in one additional genetic effect in all subsequent generations.

B.5 Incident-Free Highway Transportation

The transportation risk analysis for the SNL-EA was performed using the *RADTRAN 4* database (Neuhauser, 1992). *RADTRAN 4* models were developed to provide very conservative estimates of impact. For example, *RADTRAN 4* postulated that, in the event of an accident, people would not be evacuated for 24 hours. In actuality, people would probably be evacuated sooner, thereby reducing the time of exposure. In addition, the *RADTRAN 4* accident dispersal characteristics of SNL/NM combustible materials were used to yield conservative estimates of accident dose risk.

Detailed information regarding the route and population distribution for the transportation routes to Envirocare and Chem Nuclear were required for the *RADTRAN 4* modeling that was performed by SNL/NM. This information was obtained using the *Highway 5.0* database (ORNL, 1992a). *Highway 5.0* is essentially a computerized atlas that was used to minimize a combination of distance and driving time for highway routes between two points while maximizing the use of interstate highways. This feature allowed SNL/NM to establish baseline routes for shipments of radioactive wastes that conform to DOT routing regulations (which require that interstate system highways be used to the maximum extent possible). The population density distribution was calculated for several segments of highway routes, segments representing rural, suburban, and urban population densities. Population densities incorporated in the *Highway 5.0* database were determined using 1990 Federal Census Bureau data. The Census Bureau updates the census data every 10 years. There is no other national database available for population densities. SNL/NMs use of the Census Bureau's decennial data is consistent with the government's and private industries' practice of using this data to model population characteristics.

Routes that might ultimately be taken for waste shipments cannot be predicted with 100-percent precision because of routing variables due to conditions such as weather, road construction or repair, or accidents involving other vehicles. Moreover, if routes are consistent with DOT regulations, State authorities can change the route that must be used for transportation. The representative routes analyzed in this EA, based on conformity with general DOT criteria, provide a basis for comparing potential impacts associated with using two different commercial disposal sites for the DOE/OAK waste. These routes are described in Chapter 3 of the EA.

During routine transportation operations, individuals passing near the shipping containers could receive levels of external exposure to radiation (gamma and x-rays). No internal exposures would be received since the LLW would be contained within the shipping containers. Population exposure models are described in detail in the *RADTRAN 4* technical manual (Neuhauser, 1991). The various groups of persons potentially at risk from routine operations resulting from overland transportation would be the truck crew and the general public.

The following are definitions of terms commonly used when addressing transportation-related radiation exposure.

Conveyance: Dose rates in the cabs of tractor trucks carrying radioactive waste are required by regulation to be less than 2 mrem/hr (49 CFR 173). All trucks are modeled as having two-person crews.

Persons Along the Transportation Route: This group, often referred to as the off-link population, generally receives the smallest doses. Population doses to persons within 800 meters (0.5 miles) on each side of the transport route are estimated.

Persons Sharing the Transportation Route: Population doses to persons in vehicles traveling in the same direction (including passing vehicles) and in the opposite direction (collectively referred to as the on-link population) are estimated, although their doses, if existent at all, are also usually very small.

Persons at Stops: Population doses to persons at fuel and rest stops, tire inspection stops, etc., along the route are estimated. In this analysis the stop time was derived by using 0.011 hour/kilometer (0.018 hour/mile) as the stop rate for truck shipments (based on national trucking data for long-haul shipments). The general public population exposed during each stop was estimated at 50 persons, and the average exposure distance for these persons was 20 meters (65 feet).

Maximally Exposed Individual: This term refers to an individual member of the public who is modeled as living beside the highway route and who is exposed to every shipment at a distance of 30 meters (98 feet).

"Traffic Jam" Maximally Exposed Individual: This term refers to an individual member of the public who is sharing the highway with the LLW conveyance during a traffic stoppage resulting in traffic jam conditions. The exposure to this individual is modeled with a 2-hour traffic stoppage with an exposure distance of 2 meters (6.5 feet). This dose estimate is calculated for a single truck shipment to establish an estimate of a potential dose resulting from a realistic traffic situation.

B.6 Highway Accidents

B.6.1 Methodology

Risk analysis of potential accidents differs from calculations for incident-free transportation because the analyst must account for the probability of an accident occurring. In the incident-free scenario, some exposure is expected from radiation emitted from the casks. In the case of accidents, the probability of exposure is only an estimate of a hypothetical event. Probabilities are derived from published accident rates for truck transportation.

The DOE has developed a method for analyzing the risks associated with the transportation of radioactive material that does not employ the use of specific accident scenarios. Transportation accident analysis presents a very different risk assessment problem than fixed site facility accident analysis, such as those for nuclear power plants, for which the concept of accident scenario analyses are appropriate. Transportation accidents can happen at any point along the transportation route and the specifics that would define a particular accident scenario (e.g., weather, velocity, traffic, location, interaction with other vehicles and pedestrians) must be modeled in a generic, stochastic fashion. *RADTRAN 4* uses a model that employs an accident severity category approach for modeling severe accident environments rather than specific accident scenarios. Accident environments are modeled as a set of "accident severity categories" (see Section A.2 of Appendix A). The full range of credible accident outcomes are encompassed by the accident severity categories: from "fender benders" to horrific, violent accidents that could subject the conveyances and cargo's to extreme physical stresses (via crush or puncture forces), or extreme thermal stresses (via intense and prolonged fire), or a combination of both types of stresses. The mapping of the spectrum of all credible accident outcomes into a two-dimensional space defined by two accident parameters (physical force vs. thermal stress) is synonymous to the development of accident scenarios for risk assessment of fixed facilities (such as nuclear power plants or waste disposal sites). The severity categories include all accidents with a probability of occurrence of one-in-a-million or greater for the entire campaign of truck shipments, a figure well within the levels found acceptable by the EPA and other agencies (Hallenbeck, 1986).

The likelihood that any given accident would result in a particular accident environment is modeled by assigning conditional probabilities to each of the severity categories (NRC, 1977). Conditional probabilities are assigned to each category (see Section A.2 and Table A.3 in Appendix A). A conditional probability is defined as the probability that an accident, given that it occurs, would be of a certain severity. These conditional probabilities, when combined with specific accident frequency rates and the number of shipments in a campaign, establish an estimate of the frequency of the accident severity categories. These frequencies are then combined with the *RADTRAN 4* accident consequence analysis to yield estimates of accident risk. For truck shipments, the accident frequency rates are based on accident statistics for Federal, State, and local road types for each State and for each population density regime (urban, rural, and suburban). The appropriate accident frequencies outlined in each segment of the truck routes used by SNL/NM were derived from the *Highway 5.0* database (ORNL, 1992a).

The behavior of the packages and the radioactive materials during accident environments is modeled by assigning release fractions to each accident severity category (see Appendix A). Release fractions for shipments of multiple Type A packages, such as for 55-gallon drums and 4' x 4' x 7' boxes modeled for the shipping campaigns of the proposed action, have been estimated by the DOE (Finley, 1988) for each of the eight accident severity categories used in this analysis. Release fractions represent a statement of belief regarding the quantity of radioactive material that would be released into the environment given an accident environment of a particular severity. These release fractions are combined with other accident analysis parameters (e.g., accident frequencies, and accident severity category probabilities) to develop the expected release of radioactive material into the environment.

Atmospheric dispersion is usually the primary mechanism for dispersing any radioactive material that might be released in a severe accident. Weather conditions cannot be predicted far in advance with any certainty, and transportation analyses must consider the fact that weather may vary from one point to another on a given route. Therefore, national average weather conditions are used when transporting by highway.

B.6.2 Waste Packaging Performance

The performance of the package in each accident severity category is accounted for in the SNL/NM analysis. "Type A" waste containers such as a 55-gallon steel drums or 4' x 4' x 7' steel boxes (DOT 7A) are intended to provide a safe, economic means for transporting relatively small quantities of radioactive wastes. These containers are expected to retain their integrity under the kinds of abuse considered "normal," or likely to occur during transport; e.g., falling from vehicles or being dropped from similar heights; being exposed to rain; being struck by a sharp object that may penetrate their surface; or being positioned under other heavy containers. They must be designed to satisfy all of the requirements imposed on "Strong, Tight Containers." They must also satisfy stringent additional dimensional, ambient environment, internal pressure, and containment specifications. It is assumed that Type A packages would fail to contain the contents in a severe accident, creating a potential pathway for the release of contents. The regulations therefore prescribe units on the maximum amounts of radionuclides that can be transported in such packages. These limits ensure that in the event of a release, the consequences from external radiation or contamination are minimized, or are below recognized thresholds.

Federal regulations require that all Type A packages used be certified by the appropriate agency. The DOE proposes to use only DOT-certified packagings for this proposed action. The certification process for a package design includes extensive documentation that the package can pass certain performance-based test criteria. Passing is defined as the package's ability to maintaining specified shielding and containment capabilities after being subjected to appropriate test conditions. Type A packages must be able to withstand test conditions that simulate the stress of normal, non-accident conditions of transport. The test standards for Type A packages as established in Title 49 Code of Federal

Regulations (CFR), Parts 173.463 through 173.469 (49 CFR 173.463 through 173.469) are as follows:

- Withstanding a water spray for one hour;
- Withstanding a free-fall drop of the package onto a flat surface from a height of 1.2 meters (4 feet), if the package weighs 11,000 pounds or less;
- Withstanding compression five times the package's weight for 24 hours; and
- Withstanding a free-fall drop of a 5.9 kilogram-bar (13 pound-bar) on end onto the package from a height of 1 meter (3.3 feet).

An NRC certificate is issued as evidence that a specific type of package and its contents will meet applicable Federal regulations. The certificate is issued on the basis of a Safety Analysis Report (SAR) on the packaging design. Type B packaging must survive certain severe hypothetical accident conditions of impact, puncture, fire, and immersion. The tests are not intended to duplicate accident environments, but rather to produce damage equivalent to extreme accidents. The complete accident sequence is described 10 CFR 71.73 and is summarized in Section B.6.3.

B.6.3 Test Sequence For Type B Packaging

The effects on a package during testing may be evaluated either by subjecting a scale-model sample package to the test, or by other methods acceptable to the NRC. The NRC Regulatory Guide 7.9 allows assessment of package performance by analysis, proto-type testing, model testing, or comparison to a similar package. To be judged as surviving, the packaging must not exceed allowable releases defined in 10 CFR 71.51. The dose rate outside the packaging must not exceed 1 rem/hour at a distance of 1 meter (3.3 ft) from the packaging surface. The first three tests must be performed on the same package in this order: drop test; puncture test; and thermal test (with an immersion test following for fissile material packagings only).

The drop test consists of a 9-meter (30-foot) drop onto a flat, essentially unyielding, horizontal surface, striking the surface in the position for which maximum damage is expected. The puncture test consists of a 1-meter (40-inch) drop onto the upper end of a 15-centimeter (6-inch) solid, vertical, cylindrical bar of mild steel mounted on an essentially unyielding surface. The top of the bar must be horizontal and its edge rounded to a radius of not more than 6 millimeters (.25 inches). An essentially unyielding surface is one that absorbs very little of the energy of impact, which means that the energy of impact is absorbed almost entirely by the test object (box or drum). Unyielding surfaces are constructed of a monolithic concrete base, reinforced by Re-bar and covered with a plate of battleship armor.

In a thermal test, the packaging must be exposed for not less than 30 minutes to a heat flux not less than that of a radioactive environment of 800°C (1475°F) with an emissivity coefficient of at least 0.9. The surface absorptivity must be either the value that the package may be expected to possess if exposed to a fire, or 0.8, whichever is greater. When it might be significant, convective heat input must be included on the basis of still, ambient air. The packaging may not be artificially cooled after external heat input ceases, and any combustion of packaging materials must be allowed to proceed until it terminates naturally.

Fissile materials packaging for which water in-leakage has not been assumed for criticality analysis must be subjected to submersion under a head of water of at least 0.9 meters (3 feet) for not less than 8 hours and in the attitude for which the maximum leakage is expected. All packages must be subjected to a separate test in which an undamaged container is submerged under a head of water of at least 15 meters (50 feet) for not less than 8 hours.

Although spent fuel (a radioactive waste not covered in this EA) casks have been involved in several accidents, their integrity has never been compromised. The regulatory tests are structured to place an upper bound on the kinds of damage seen in actual severe transportation accidents. Furthermore, after completion of this series of performance qualification tests, Type B packagings are further subjected to a post-accident, leak-rate performance test (10 CFR 71.51). In this test, no escape of radioactive material is allowed that exceeds an A2 amount within one week of testing. The A2 amount of an isotope is the maximum activity of that isotope in a potentially dispersible form that is allowed to be shipped in a Type A packaging, which is non-accident resistant. Safety Series No. 6 lists A2 values for all commonly transported isotopes.

The use of an essentially unyielding target makes the regulatory certification tests extremely demanding. Real targets are much more yielding. For example, a lead-shield steel cask was dropped 610 meters (2,000 feet) from a helicopter onto undisturbed soil (NRC, 1977). Impact velocity was 396 kilometers per hour (235 miles per hour). The cask entered 2.4 meters (8 feet) into the hard soil but suffered no measurable deformation. An identical cask dropped 9 meters (30 feet) onto an essentially unyielding surface during regulatory testing suffered considerably more deformation (Yoshimura, 1978). More recent research has expanded the study of yielding targets (e.g., concrete surfaces) and their comparison with the regulatory surface.

B.6.4 Transportation Regulations - Overland Carriage

Overland shipments by truck are regulated by a variety of DOT and NRC regulations dealing with packaging, notification, escorts, and communication.

When provisions are made to secure a package so that its position within the transport vehicle remains fixed during transport, with no loading or unloading between the beginning and end of transport, a package shipped overland in exclusive-use closed transport vehicles may not exceed the following radiation levels as provided in 49 CFR 173.441(b):

- 1,000 mrem/hour on the external package surface;
- 200 mrem/hour at any point on the outer surface of the vehicle;
- 10 mrem/hour at any point 2 meters (6.6 feet) from the vertical planes projected by the outer lateral surfaces of the vehicle; or, in the case of an open vehicle, at any point 2 meters from the vertical planes projected from the outer edges of the vehicle; and
- 2 mrem/hour in any normally occupied position in the vehicle. However, this provision does not apply to private motor carriers when the personnel are operating under the auspices of a radiation protection program and are wearing radiation-exposure monitoring devices.

The shipper of record must comply with the requirements of 10 CFR 71.5 and 73.37. Section 71.5 provides that all overland shipments must be in compliance with DOE and NRC regulations.

B.6.5 Truck Carriage

For carriage by truck, the carrier will use interstate highways or state-designated preferred routes for movements of radioactive wastes in conformity with the DOE rule-making known as Docket HM-164. These regulations, found in 49 CFR 397.101, establish routing and driver training requirements for highway carriers of packages containing "highway-route-controlled quantities" of radioactive wastes (spent fuel shipments would constitute such quantities). DOT rules make those routes designated by appropriate State agencies enforceable by the Federal government according to DOT's own determination that such route designations, when accompanied by an adequate safety analysis, are likely to result in further reduction of radiological risk.

B.6.6 Accident Risks During Overland Transportation

The radiological accident risks in the SNL-EA were calculated assuming that a specific population of people were exposed to a contaminated plume that might result from an accident. The number of persons potentially exposed varied by route segment and was based on the segment population density and downwind travel of the radioactive cloud (plume). In the event of a severe transportation accident and fire within an urban area, the radioactive cloud is assumed to travel over the urban area to a distance of 80 kilometers (50 miles) of the accident site. In reality, the plume would be subject to prevailing winds and might disperse from populated areas. In addition, although the urban population is typically much greater than the population in surrounding outlying areas, the accident model treats the urban population density as constant over the 80 kilometers (50 miles). Another conservative assumption incorporated into the risk assessment is that the entire population remains in the area for 24 hours and therefore is exposed to the greatest extent possible of radioactive waste deposited on the ground from the plume. In reality, individuals close to an accident would probably be evacuated in less than 24 hours.

B.7 Non-Radiological Health Effects And Risks

A series of unit-risk factors (that is, risk per kilometer traveled) have been developed based on national statistics for accident-related deaths for highway transportation (Wilmot, 1983). These factors, shown in Table B.4, have been used to calculate the expected numbers of non-radiological fatalities associated with highway transportation of the DOE/OAK LLW shipments to each of the two options for the proposed action.

The non-radiological impacts were estimated only for a truck shipment campaign using 55-gallon drums to package the waste. This establishes an upper bound on the potential non-radiological risks. If the 4' x 4. x 7' boxes were used to package the waste, then fewer shipments would be required than for those utilizing drums. The primary non-radiological impact is death from mechanical causes in traffic accidents. Traffic accidents also may cause non-fatal injuries. In general, approximately 98 percent of traffic-related injuries in urban areas and 94 percent in rural areas are non-fatal. However, no estimate of the expected number of injuries was made in the SNL/NM or in the DOE/OAK analysis.

Health effects related to vehicle emissions from the truck shipments are estimated in terms of LCFs. Recovery rates for cancer are far more variable and dependent upon the location of the cancer. In part due to the large variation in relative incidence of non-fatal health effects, fatalities are the only measure of harm that allows direct comparison between radiological and non-radiological consequences. An estimate of consequences of incident-free transportation (LCFs associated with release of pollutants by trucks in urban areas) were presented in the SNL-EA for completeness. These estimates included very large uncertainties. The incident-free estimates were calculated with published non-radiological risk factors (Rao, 1982) used in combination with the truck transportation distances associated with each SNL/NM LLW disposal option. The non-radiological impact estimates included the contribution from the return trip of the truck to Albuquerque.

B.8 Cumulative Impacts

Cumulative impacts are those that result from the incremental impact of the proposed action when added to other past, present, and reasonably foreseeable future actions [see 40 CFR §1508.7. (CEQ, 1978)]. To calculate the cumulative radiological impact, maximum annual doses from the proposed action and from other projections for radioactive waste transportation to the same facilities, along the same routes and during the same time as the proposed action, are added (see Table B.8). This approach neglects the fact that dose fractionation (delivery of a total dose in a number of separate doses spread over time) may reduce the effect of the total cumulative dose (Ulrich, 1987; Miller, 1989).

The following discussion describes the results of the *"Final Environmental Statement on the Transportation of Radioactive material by Air and Other Modes,"* NUREG-0170 (NRC, 1977).

Table B.7 Cumulative Impacts

NON-RADIOLOGICAL UNIT FACTORS FOR TRUCK TRANSPORTATION			
	Rural	**Suburban**	**Urban**
Normal Non-occupational (latent cancers/km)	---	---	1.0×10^{-7}
Accident Non-occupational (fatalities/km)	5.3×10^{-8}	1.3×10^{-8}	7.5×10^{-9}
Accident Occupational (fatalities/km)	1.5×10^{-8}	3.7×10^{-9}	2.1×10^{-9}

The proposed action is similar in many respects to that of other radioactive waste transportation that is taking place in the same locations and along similar routes. The transportation of radioactive wastes and shipments of spent nuclear fuel to support the fuel cycle, in particular, were assessed in NUREG-0170 (NRC, 1977). This Environmental Statement considered the risk of transporting various types of packages of radioactive waste along transportation corridors, such as the ones that would be used for the proposed DOE/OAK action, and determined that the total annual incident-free and accident risk was minimal. Recent studies of radioactive waste shipments indicate that no substantial changes in the number of shipments or in their characteristics have occurred over the intervening years that would invalidate the general results of NUREG-0170 (Weiner, 1991). For individuals residing near principal transportation routes, NUREG-0170 estimated that the average annual individual dose from radioactive waste transportation activities was about 0.09 mrem. Recently it was estimated that a maximal exposed individual member of the public would not receive more than 0.14 mrem if exposed to the in-transit passage of all of the 1,611,443 radioactive materials packages shipped in the United States in a single year (Weiner, 1991). This is, of course, not a realistic scenario, but it does place an upper bound on the individual in-transit dose from other shipments.

It was also estimated that the individual in-transit dose for a person located 30 meters (98 ft) from an average route segment is only 0.00009 mrem (Mills, 1994). NUREG-0170 used annual shipment levels for the United States as a whole to obtain maximally exposed individual dose estimates. The class of shipment that can be used to conservatively model traffic in the vicinities of the Envirocare and Chem Nuclear facilities is secondary transport. Secondary transport is the shipment by light-duty vehicles of consignments of a large variety of packages (DOT Type A and small Type B packages) in cities and suburbs along secondary roadways and city streets. NUREG-0170 estimated that the dose to an individual living 30 m (98 ft) from a roadway would be no more than 0.009 mrem from secondary transport. The maximum annual dose to a person exposed to local highway traffic in the vicinity of either Envirocare or Chem Nuclear is unlikely to exceed 0.009 mrem. Therefore, the average annual individual dose remains valid for considering the cumulative impacts associated with the proposed action.