EEG-46

RISK ANALYSIS OF THE TRANSPORT OF CONTACT HANDLED TRANSURANIC (CH-TRU) WASTES TO WIPP ALONG SELECTED HIGHWAY ROUTES IN NEW MEXICO USING RADTRAN IV

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FOREWORD

The purpose of the Environmental Evaluation Group (EEG) is to conduct an independent technical evaluation of the Waste Isolation Pilot Plant (WIPP) Project to ensure protection of the public health and safety and the environment. The WIPP Project, located in southeastern New Mexico, is being constructed as a repository for permanent disposal of transuranic (TRU) radioactive wastes generated by the national defense programs. The EEG was established in 1978 with funds provided by the U. S. Department of Energy (DOE) to the State of New Mexico. Public Law 100-456, the National Defense Authorization Act, Fiscal Year 1989, Section 1433, assigned EEG to the New Mexico Institute of Mining and Technology and provided for continued funding from DOE through a contract (DE-AC04-89AL58309).

EEG performs independent technical analyses of the suitability of the proposed site; the design of the repository, its planned operation, and its long-term integrity; suitability and safety of the transportation systems; suitability of the Waste Acceptance Criteria and the generator sites' compliance with them; and related subjects. These analyses include assessments of reports issued by the DOE and its contractors, other federal agencies and organizations, as they relate to the potential health, safety and environmental impacts from WIPP. Another important function of EEG is independent environmental monitoring of background radioactivity in air, water, and soil, both on-site and in surrounding communities.

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EXECUTIVE SUMMARY

This report analyzes the radiological health effects, and, to a lesser extent, the economic impacts of transporting contact-handled transuranic (CH-TRU) waste from 10 generator sites in the USA to the Waste Isolation Pilot Plant (WIPP). The effects of transporting remote-handled transuranic (RH-TRU) wastes to WIPP are not addressed because the U.S. Department of Energy (DOE) does not have plans to ship this type of waste during the Test Phase. The intent of this report is to place into perspective the risk of radiation from both "incident free" exposure, and exposures resulting from a release of radioactivity from a TRUPACT-II container(s) as a result of a highway accident. only the routes identified in the Supplemental Stipulated Agreement (SSA) between the State of New Mexico and DOE (1982) were analyzed for this report. An adequate database to compare the alternate routes with SSA routes was not available for this analysis.

A different version of this report was originally submitted to the New Mexico Environmental Improvement Board (EIB) on April 9, 1990 in Santa Fe, New Mexico in conjunction with hearings concerning the issue of route designations for the transport of CH-TRU waste in TRUPACT II containers through the State to the WIPP repository near Carlsbad, New Mexico. The current version is an edited, corrected, and re-formatted version for presentation as an Environmental Evaluation Group (EEG) report.

The computer model RADTRAN IV was utilized to calculate radiation doses to persons along the routes. This is the latest version of a model developed by Sandia National Laboratories which is now capable of analyzing dosimetric information for discrete highway segments along the routes. A total of 43 different highway segments within the State were analyzed using this model. As such it is a "first of a kind" intrastate study. The major the routes analyzed. Although EEG has not analyzed alternative routes other than those specified, it appears that the doses received would still be very low compared to natural background.

Economic consequences and risks as a result of CH-TRU transport to WIPP clearly show that maximum consequences for the most severe accidents are greatest in urban areas. A maximum remediation cost of $44 million is estimated for a "severity category eight" accident, involving Los Alamos National Laboratory (LANL) TRU waste, in Artesia, NM. Other estimated costs for a "severity category eight" type of accident include Santa Fe, NM ($26 million) and Roswell, NM ($24 million). Much lower consequential costs are expected for severe accidents occurring in rural areas. The "expected" costs to the State as a result of CH-TRU transport accidents are low ($15,000) as are the costs for emergency response ($10,000) over the life-time of WIPP. Only five accidents involving CH TRU waste are expected statewide throughout the transportation period. Another five accidents are expected with empty transporter trucks.

EEG's recommendations as a result of this analysis are: (1) transport crew members should be monitored closely to insure the allowed 2 mrem/hour exposure rate limit is not exceeded; (2) stopping places should be carefully selected to lower potential exposure rates to individuals at those places, and (3) by-passes around cities should be used when possible in the interest of minimizing health effects and clean-up costs from high consequence, low-probability accidents.

1. INTRODUCTION

on September 18, 1989, the Attorney General of the State of New Mexico advised the State Environmental Improvement Board (EIB) that it should designate preferred transportation routes for the transport of radioactive materials in accordance with DOT Regulations 49 CFR 177.825(l). The immediate concern was designation of routes to the Waste Isolation Pilot Plant (WIPP) in southeastern New Mexico. It was further stipulated that any such designation(s) should be made according to the DOT "Guidelines for Selecting Preferred Highway Routes for Highway Route Controlled Quantity Shipments of Radioactive Materials" (DOT/RSPA/OHMT-89/01, January, 1989). Furthermore, the Attorney General recommended that the EIB should, at a minimum, include those routes identified in Appendix B of the 1982 Supplemental Stipulated Agreement between the State of New Mexico and the United States Department of Energy (DOE). Throughout this report these routes will be referred to as "SSA Identified Routes."

1.1 Background On Decision To Designate Routes

At the August 21, 1989 hearing held by the Radioactive and Hazardous Waste Committee of the New Mexico Legislature, several members of the committee questioned Robert H. Neill, Director of Environmental Evaluation Group (EEG), on the following statement that appeared in EEG-41, "Review of the Draft Supplement Environmental Impact Statement, DOE Waste Isolation Pilot Plant, April 1989,11 July 1989:

> U.S. Department of Transportation Preferred Routes
> While there is agreement on the routes to be followed in New Mexico for the 34,000 truck shipments to WIPP, they are not "Preferred Routes" in the context of regulations issued by the U.S. Department of Transportation (49 CFR 171 and 173) and it is misleading to imply that they fulfill the DOT requirements. (pp. 4-5)

They are not preferred routes, as defined by DOT in 49 CFR 177.825. There are only two conditions which permit states to designate routes, neither of which had been implemented by the Environmental Improvement Board, the only agency in New Mexico authorized to designate routes. Further, they can only become DOT "Preferred Routes" if the state notified DOT by certified mail that they have complied with the provisions of 49 CFR 171.8 as well as 40 CFR 177.825.

DOE acknowledged in a letter to EEG that the contract between DOE and Dawn Trucking did not provide a commitment to the routes. Additionally, the Consultation & Cooperation Agreement between the State of New Mexico and DOE did not require adherence to the routes shown. Consequently, it appeared that the carrier was not legally obligated to adhere to the routes.

The issue was previously raised by EEG on October 26, 1987 to EIB, at hearings held by the New Mexico Radioactive Waste Task Force on April 19, 1989, and in EEG-41, "Review of the DOE Draft Supplement Environmental Impact Statement," July 1989.

Subsequently, the Attorney General was asked to comment and he agreed on September 18, 1989 that it would be necessary for EIB to formally designate the routes in order to insure adherence by the carrier to those routes.

1.2 Participants

An organizational meeting, including state representatives from the Office of the Governor, the Office of the Attorney General, the Energy, Minerals and Natural Resources Department, the Health and Environment Department, the Highway and Transportation Department, and the Environmental Evaluation Group, was held on October 12, 1989 for purposes of planning an analysis of WIPP routes in New Mexico under the conditions specified. other sources of assistance in this endeavor were the University of New Mexico (UNM), Sandia National Laboratory (SNL), DOE, and the U.S. Department of Transportation (DOT).

1.3 Modeling Considerations

The Environmental Improvement Division (EID) announced that the UNM Department of Civil Engineering would provide the technical assistance to the State in implementing a "StateGen/StateNet" menu driven computer model to perform the "figure of merit" transportation analysis according to the DOT guidelines specified above. The model was constructed by modifying the current version of "StateGen/StateNet" to conform more rigorously to the DOT guidelines.

All parties concerned were to provide technical assistance in database development, analysis, and document preparation for use by the Environmental Improvement Division (EID) in planned EIB hearings throughout the State during the second quarter of 1990, and for EIB determination thereafter.

EEG was interested in using other available computer models which could provide dosimetric and health effects information that would not be provided by StateGen/StateNet. EEG's analysis would thus complement the analysis planned by EID. The latest version of the RADTRAN computer model was developed by SNL in 1989. The documentation for RADTRAN IV, has not yet been released. RADTRAN VI possesses many characteristics, including a specific highway segment-by-segment analytical capability not possessed by previous versions of this model. Earlier versions of RADTRAN have been used in preparation of both the Final (FEIS,1980) and Supplemental (SEIS,1990) Environmental Impact Statements for the WIPP. The earlier versions provided a lower resolution or an aggregate analysis which composited rural, suburban, and urban radiological risk impacts of specific waste generator-to-WIPP routes using nationwide accident rates, population densities, etc. Hence, a state-specific analysis which can discriminate between different highway segments having different risk-related characteristics is now available for segments which have a documented database required for execution of the code.

1.4 Previous and Current Role of EEG in Transport Risk

The EEG has been involved in issues of waste transportation to WIPP since 1979 including publishing analyses as well as reviewing DOE reports and testifying before the U.S. Congress and the N.M. Legislature. Three EEG reports have been devoted exclusively to transportation issues. EEG-5, "Calculated Radiation Doses From Deposition of Material Released in Hypothetical Transportation Accidents Involving WIPP-Related Radioactive Wastes" (Channell, 1980), calculated radiation doses from ingestion and direct radiation due to releases from hypothetical transportation accidents. EEG-24, "Potential Problems From Shipment of High-Curie Content Contact-Handled Transuranic (CH-TRU) Waste to WIPP," (Neill and Channell, 1983), evaluated potential problems from gas generation in high-curie contact-handled transuranic (CH-TRU) waste shipments. EEG-33, "Adequacy of TRUPACT-I Design for Transporting Contact-Handled Transuranic Wastes to WIPP" (Channell, Rodgers and Neill, 1986), evaluated the adequacy of TRUPACT-I design for transporting CH-TRU wastes to WIPP. All of these reports had positive results: ingestion doses from transportation accidents are now being considered; gas generation is controlled by venting Type A containers and limiting radionuclide quantities that can be shipped; and the TRUPACT-I and TRUPACT-II rectangular designs were abandoned and a right circular cylinder design, TRUPACT-II, was selected to ship CH-TRU wastes to WIPP incorporating double containment and eliminating venting in the Type B shipping container.

2. SCOPE AND LIMITATIONS OF STUDY

The present report analyzes only the SSA Identified Routes to WIPP because of the availability of highway segment specific data for these routes. The database was summarized in the SEIS, 1990 by Stoller Corporation through the Division of Government Research, IARS, UNM (1989), but were not actually used in SEIS calculations. The UNM document contains the traffic flow and accident analysis data needed to execute RADTRAN IV. Specific limitations and problems encountered in performing this analysis will be discussed as appropriate in other sections of this report.

This initial study is limited to an evaluation of risks involving radioactive waste transportation to the WIPP site along the SSA Identified Routes. The availability of demographic data along all of the proposed routes is not in a refined stage, and only approximate population densities can be obtained for some segments. An excellent reference for this type of information was located in the first and second editions of "New Mexico in Maps" (Williams and McAllister, 1979 and Williams, 1986). Also, this study is heavily dependent on the SEIS for specific waste volumes, radionuclide concentrations, shipping, and other characteristics required for RADTRAN IV operation. In addition, many parameters involved in the calculation of radiation doses and specific health effects are integral parts of the RADTRAN IV code, and the reader is advised to review RADTRAN III documentation (Madsen et al, 1986) as reference material on these parameters pending the availability of RADTRAN IV documentation. Thus, the analysis presented here should not be viewed as a final documentation of radiological risk, but as a preliminary exercise which must await refinement of the database and perhaps the model itself for greater sensitivity.

3. SPECIFIC ROUTES SELECTED FOR ANALYSIS

3.1 Route Description

The specific routes selected for this analysis consist of four highway extensions into New Mexico involving Interstates 1-40 (east and west entrances), 1-25 (north entrance), and US-285 (southern entrance), and one intrastate route from Los Alamos National Laboratory (LANL) to WIPP. The CH-TRU waste entering the state from the west on 1-40 will originate at Lawrence Livermore National Laboratory (LLNL) and the Nevada Test Site (NTS). The waste entering the state from the east on 1-40 will originate at Oak Ridge National Laboratory (ORNL), Mound Laboratory (ML), and the Argonne National Laboratory (ANL). The Rocky Flats Plant (RFP), Idaho National Engineering Laboratory (INEL), and Hanford Plant (HP) waste will enter the state from the north on 1-25. Waste entering New Mexico from the south via I-20/US-285 will originate at Savannah River Site (SRS). These national routes are shown on Figure 1 and the New Mexico routes on Figure 2. With the exception of waste originating at SRS, all routes will converge on US-285 near Vaughn, New Mexico, and thereafter will share a common route to WIPP. Each of these routes within the state have been subdivided into segments or "links" to allow comparison of specific dosimetric values and health effects. The route convergence scheme for all waste origins to their point of convergence with other waste sources entering the state and their final progression to WIPP is presented in Table 1, along with other specific characteristics required for execution of the computer code employed in this analysis.

TABLE 1 - CH-TRU Waste Route Integration- Scheme

No.	Description of Link	Length Km	Persons per Km2	Vehicles per hr	Accidents per Km
	------- LANL to US285 Interchange (Lamy) -------				
1	NM4(Pajarito Road) NM502 interchange	7.88	57.6	88.8	2.45E-07
2	NM502 interchange US84/285 interchange	19.6	12.6	237.	3.48E-07
3	US84/285 interchange Santa Fe, north limit	20.3	3.51	434.	2.67E-07
4	Santa Fe, north limit 1-25, Santa Fe, south	11.0	580.	592.	1.64E-06
5	1-25, Santa Fe, south US285 interchange	12.7	3.51	231.	1.45E-07
	------ HP, RFP, and INEL to US285 Interchange (Lamy) -----				
6	1-25, Colorado border US64 interchange south	22.1	529.	118.	1.22E-07
7	US64 interchange south Springer south interch.	55.7	1.16	65.7	2.64E-07
8	Springer south interch. Las Vegas north limit	101.	1.85	66.0	2.70E-07
9	Las Vegas north limit US84 interchange	11.9	1286.	66.0	2.70E-07
10	US84 interchange US285 interchange	79.7	3.86	121.	2.82E-07
	---- US285 interchange (Lamy) to 1-40 (Clines Corners) ---(LANL, RFP, INEL, HP composite)				
11	US285 interchange- 1-40 interchange	66.5	3.51	22.9	5.24E-07

No.	Description of Link	Length Km	Persons per Km2	Vehicles per hr	Accidents per Km
	--LLNL and NTS to I-40/US285 interchange (Clines Corners)--				
12	1-40, Arizona border Gallup western limit	46.4	2.74	237.	3.16E-07
13	Gallup western limit Gallup eastern limit	8.21	615.	237.	1.61E-07
14	Gallup eastern limit NM371 interchange	43.8	2.74	237.	1.61E-07
15	NM371 interchange NM53 interchange	46.0	2.74	300.	1.45E-07
16	NM53 interchange Grants eastern limit	5.47	345.	295.	1.93E-07
17	Grants eastern limit West Central interch.	98.6	6.77	295.	1.93E-07
18	West Central interch. Rio Grande Blvd. intch.	11.9	1340.	652.	4.87E-07
19	Rio Grande Blvd. intch. 1-25/1-40 interchange	3.86	1340.	1910.	8.73E-07
20	1-25/1-40 interchange- San Mateo Blvd. interch.	3.86	1340.	2640.	5.86E-07
21	San Mateo Blvd. intch. Tramway Blvd. interch.	9.18	1340.	1650.	4.13E-07
22	Tramway Blvd. interch. I-40/US285 interchange	81.5	50.5	339.	2.17E-07
	--I-40/US285 interchange (Clines Corners) to US285 (Vaughn)-(LANL, RFP, INEL, HP, LLNL, and NTS composite)				
23	I-40/US285 interchange US60 interchange	43.5	0.73	29.5	5.24E-07
24	US60 interchange US54/US60 intch.	22.87	0.73	38.8	2.88E-07
25	US54/US60 intch. US285 south	6.28	0.85	66.2	1.37E-07

No.	Description of Link	Length Km	Persons per Km2	Vehicles per hr	Accidents per Km
	---- ORNL, ML, and ANL To US285 south (Vaughn) ---				
26	1-40 Texas border				
	Tucumcari east intch.	63.0	1.43	168.	1.27E-07
27	Tucumcari east intch.				
	Tucumcari west intch.	4.60	484.	168.	1.27E-07
28	Tucumcari west intch.				
	US84 south interchange	84.3	0.87	213.	1.37E-07
29	US84 south interchange				
	Santa Rosa west limit	5.47	44.0	408.	2.33E-07
30	Santa Rosa west limit				
	US54/US285 south	59.8	0.58	15.1	2.51E-07
	--- US285 south (Vaughn) to US62/US285 north (Carlsbad) ---				
	(LANL, RFP, INEL, HP, LLNL, NTS, ORNL, ML, and ANL composite) 31 US54/US285 south				
31	US70 east	142.	0.66	28.2	1.96E-07
32	US70 east				
	Roswell north limit	2.58	522.	375.	9.93E-08
33	Roswell north limit				
	US70 west	5.80	576.	375.	2.19E-06
34	US70 west				
	Roswell south limit	6.76	522.	229.	2.84E-06
35	Roswell south limit				
	Artesia north limit	55.6	3.86	82.1	4.65E-07
36	Artesia north limit				
	US82 interchange	2.57	1146.	216.	6.64E-07
37	US82 interchange				
	Artesia south limit	2.90	1146.	198.	2.48E-07
38	Artesia south limit				
	Carlsbad north limit	48.8	2.32	64.4	3.26E-07
39	Carlsbad North limit				
	US62/US285 north	5.64	469.	225.	2.55E-06

No.	Description of Link	Length Km	Persons per Km2	Vehicles per hr	Accidents per Km
	------ SRS to US62/US285 north (Carlsbad) --				
40	US285 Texas border- US62/US285 south	50.7	4.40	42.4	4.91E-07
41	US62/US285 south US62/US285 north	3.22	469.	365.	1.77E-06
	---- US62/US285 north (Carlsbad) to WIPP--- (LANL, RFP, INEL, HP, LLNL, NTS, ORNL, ML, ANL, and SRS total)				
42	US62/US285 north Carlsbad east limit	1.77	469.	150.	1.28E-06
43	Carlsbad east limit US62/north Access WIPP	44.8	1.12	49.1	1.55E-07

The one exception to the preferred routes used in the analysis involves LANL transport on the Pajarito road route through White Rock instead of the preferred truck route on East Jemez Road. Data was not available for the latter. Also, the route from Santa Rosa to Vaughn via US-54 was not included in the Stoller Corporation report, however, unofficial data on this link was made available for this study through personal communication with the Highway and Transportation Department and is included in the analysis.

3.2 Velocities. Traffic Density and Accident Rates

The only rural and urban segments were considered in the analysis in order to be consistent with the Stoller report. It was assumed that a highway segment through any major city or town along the routes was urban, but only the segments traversing Albuquerque were considered as urban freeway. The velocity of the transport trucks and all other traffic was assumed to be 88.6 Km/hr (55 mph) on all rural segments, and some urban segments where the interstate highway allowed this velocity on the bypass and/or freeway, such as for Albuquerque. The vehicle velocity through a city, such as Santa Fe, Roswell, and Artesia, was assumed to be 24.2 km/hr (15 mph) on the average, allowing for stops at traffic lights, etc. Traffic flow density and dependent crash rates were based on one-way traffic or one-half of the average daily two-way traffic (ADT) and crash rates reported by Stoller before conversion to the metric system. Fatality crash statistics were not considered because the accident severity classification employed by RADTRAN IV was assumed to take into effect both fatal and non-fatal incidents in its operation. Truck crash statistics were not employed because of the uncertainty of truck traffic percentages along many of the segments, and their effect on the overall crash rates was not clear. It was thus assumed that the probability of auto-auto, auto-truck, truck-truck, and individual truck accidents were represented by the overall crash rate for a given segment in the direction of WIPP.

3.3 Population

The estimates of population densities along the route segments were made upon consideration of the 800 m (0.5 mile) boundary from the center line of a highway utilized for incident free dosimetric calculations in the code, and for the radial distances employed for accidental releases of radionuclides. Williams (1986) presents population densities for significant cities and towns in each county in addition to mean county density estimates. He also presented a population density map of New Mexico illustrating the clustering of people along major highway routes (see Figure 3). The assumption used in this analysis was to consider the city or town population densities when specific route segments traversed these areas, and to use mean county densities or densities adjusted for major towns between communities. In some cases it was necessary to weight densities from different counties when segments crossed such boundaries. The total population along the route calculated, from Table 1, is 170,000. Partial verification of the densities was accomplished by comparison with the density map alluded to earlier. Every effort was made in this analysis to utilize individual segment(s) for the major communities along the routes by subdividing the specifically larger segments provided in the Stoller report where necessary and possible.

4. CH-TRU WASTE AND WASTE TRANSPORT

The final SEIS is the main source of CH-TRU waste characteristics utilized in this analysis; other information of this type is also available from RADTRAN III documentation (Madsen et al, 1986).

4.1 CH-TRU Shipments

The projected number of shipments (SEIS, 1990) utilized in this analysis are presented in Table 2, along with radioactivity shipment data.

TABLE 2-- Projected Number of CH-TRU Shipments To WIPP By Truck And Curie Loadings

Facility	Total Shipments	Curies/Shipment
INEL	4046	103
RFP	7608	153
HP	3103	646
SRS	2640	1890
LANL	2065	1250
ORNL	228	310
NTS	80	6.6
ANL	14	55.5
LLNL	969	96.2
ML	150	1.4
total	20903	

This analysis will consider the effects of all CH-TRU shipments to WIPP independent of the actual number of years required to transport the entire inventory. Hence, the results of the analysis are based on the total impact of these wastes and not on an annual shipment basis. Once the actual number of years required to transport the CH-TRU waste from the specific generator sites is more firmly established, annual contributions may be estimated as required by partitioning the total inventory on a year-by-year basis.

4.2 Waste Characterization

A CH-TRU trailer contains 3 TRUPACT-II packages, each containing 14 55-gallon drums or two Standard Waste Boxes. The average radioactivity in one shipment for each generator site is given in Table 3.

TABLE 3 -Average Radioactivity Per Shipment by Radionuclides

Curies

isotope	ANL	HP	INEL	LANL	LLNL
Th-232	O.OOE+O	O.OOE+O	5.17E-5++	O.OOE+O	O.OOE+O
U-233	O.OOE+O	O.OOE+O	1.53E-1	2.95E-2	O.OOE+O
U-235	O.OOE+O	O.OOE+O	5.79E-6+	8.37E-5+	O.OOE+O
U-238	O.OOE+O	O.OOE+O	9.72E-6+	3.61E-4	O.OOE+O
Np-237	9.65E-4+	O.OOE+O	O.OOE+O	O.OOE+O	O.OOE+O
Pu-238	5.39E+O	3.08E+O	1.08E+l	1.67E+2	3.42E-1
Pu-239	3.41E+O	3.30E+l	5.89E+O	8.86E+l	8.23E+O
Pu-240	1.56E+O	1.18E+l	1.44E+O	2.04E+l	2.36E+O
Pu-241	3.10E+l	5.98E+2	4.55E+l	6.88E+2	7.84E+l
Pu-242	O.OOE+O	2.66E-3+	O.OOE+O	4.OOE-3	1.29E-4
Am-241	1.41E+l	O.OOE+O	3.89E+l	2.90E+2	6.81E+O
Cm-244	O.OOE+O	O.OOE+O	O.OOE+O	O.OOE+O	O.OOE+O
Cf-252	O.OOE+O	O.OOE+O	O.OOE+O	O.OOE+O	O.OOE+O

isotope	NL	NTS	ORNL	RFP	SRS
Th-232	O.OOE+O	O.OOE+O	4.26E-4++	O.OOE+O	O.OOE+O
U-233	O.OOE+O	O.OOE+O	3.85E+l	O.OOE+O	O.OOE+O
U-235	O.OOE+O	O.OOE+O	1.15E-3+	O.OOE+O	O.OOE+O
U-238	O.OOE+O	O.OOE+O	4.59E-3+	O.OOE+O	O.OOE+O
Np-237	O.OOE+O	O.OOE+O	O.OOE+O	O.OOE+O	4.09E-3
Pu-238	1.36E+O	3.82E-2	5.75E+l	5.37E-1	1.83E+3
Pu-239	1.18E-2	6.46E-1	1.24E+2	1.82E+l	2.20E+O
Pu-240	3.10E-3	1.53E-1	O.OOE+O	4.15E+O	8.81E-1
Pu-241	1.19E-3	5.76E+O	O.OOE+O	1.29E+2	6.61E+l
Pu-242	O.OOE+O	O.OOE+O	O.OOE+O	3.70E-4+	7.19E-4+
Am-241	O.OOE+O	O.OOE+O	1.04E+O	8.62E-1	1.81E-1
Cm-244	O.OOE+O	O.OOE+O	6.90E+l	O.OOE+O	O.OOE+O
Cf-252	O.OOE+O	O.OOE+O	1.10E+l	O.OOE+O	O.OOE+O

Notes for Table 3:

+ radionuclides listed in SEIS, but quantities not considered significant enough to include in analyses based on uncertainty of estimates for other radionuclides present in

++ Thorium-232 was not included in the analyses where present because radiation characteristics are not included in the RADTRAN IV library, and because of the relatively small quantities involved.

4.3 Radionuclide Characteristics

The CH-TRU waste is classified as "lung type 311 which indicates that the waste consists of alpha-emitting long half-lived radionuclides, and the waste itself is categorized as "type [5,11] designating it as solid, dispersible, sintered waste containing "small" size loose powder. In addition, each radionuclide present in the waste has specific radiological transport and dosimetric characteristics which are specified by the analyst or the RADTRAN code itself (see Table 4).

TABLE 4 - Radiological Characteristics Of Specific Radionuclides

Isotope	1	2	3	4+	5+	6
U-233	5.79E+07	1.31E-0	3.70E-05	3.40E-04	1.70E-02	1.OE-02
NP-237	7.82E+08	3.43E-02	3.65E-03	3.60E-06	9.20E-02	1.OE-02
U-238	1.03E+12	1.36E-03	1.65E-05	3.40E-04	1.70E-02	1.OE-02
PU-238	3.20E+04	1.82E-03	1.40E-05	1.OOE-06	1.40E-02	1.OE-02
PU-239	8.79E+06	7.96E-04	1.30E-05	1.OOE-06	1.40E-02	1.OE-02
PU-240	2.39E+06	1.73E-06	1.37E-05	1.OOE-06	1.40E-02	1.OE-02
PU-241	5.26E+03	2.54E-06	O.OOE+00	1.OOE-06	1.41E-02	1.OE-02
PU-242	1.37E+08	1.44E-03	1.16E-05	1.OOE-06	1.40E-02	1.OE-02
AM-241	1.58E+05	3.24E-02	3.01E-03	3.60E-06	4.20E-02	1.OE-02
CM-244	6.61E+03	1.70E-03	1.33E-05	3.60E-06	1.60E-02	1.OE-02
CF-252	9.64E+02	1.20E-03	1.19E-05	3.60E-06	1.60E-02	1.OE-02

1 = physical half-life, days 2 = photon energy, MeV/dis

3 = cloud dose, rem-m3/Ci-sec 4 = food transfer frac, Ci/Ci

5 = soil transfer frac, Ci/Ci 6 = deposition velocity, m/sec

note:
\+ supplied by user; others supplied by code

4.4 Dose Conversion Factors

Dose factors which convert both inhaled and ingested radionuclides to a specific organ or tissue dose with either a 1-year or 50-year integration period are required as RADTRAN input for estimating doses received by the population and the resulting health effects. This information was obtained from several sources as were the user supplied parameters in Table 4 (Till and Meyer, 1983; Brodsky, 1982; U.S. Department of Energy, 1988; Dunning, *1985*). Table 5 presents rem/Ci inhaled or ingested conversion factors for selected organs and tissues in the adult human body.

TABLE 5 - Rem/Ci Conversion Factors For Specific Organs And Tissues From Inhalation And Ingestion Of Specific Radionuclides

L = via inhalation G - via ingestion

Isotope	1	2	3	4	5	6	7	8
U-233	***	*******	*******	*******	*******	*******	*******	*******
L	4.OOE+8	5.30E+3	2.82E+4	3.90E+4	2.82E+4	1.10E+7	5.99E+7	7.92E+5
G	5.90E+3	2.88E+4	3.93E+2	6.30E+4	3.86E+2	8.70E+5	3.86E+2	1.09E+4
NP-237								
L	1.OOE+8	1.50E+7	1.14E+8	4.90E+4	3.81E+4	1.70E+9	5.96E+7	7.07E+8
G	4.80E+2	1.30E+6	9.10E+8	7.90E+4	3.02E+3	1.40E+6	8.77E+3	5.66E+7
U-238								
L	3.50E+8	3.90E+3	2.48E+4	3.40E+4	2.48E+4	9.60E+6	4.60E+7	7.33E+5
G	5.20E+3	2.60E+4	3.77E+2	5.50E+4	3.40E+2	7.70E+5	3.41E+2	1.01E+4
PU-238								
L	4.50E+8	9.90E+5	1.03E+8	4.50E+4	1.70E+1	2.70E+9	1.80E+S	6.51E+S
G	3.08E-1	1.50E+3	8.62E+3	7.30E+4	1.45E-3	6.80E+5	3.21E-2	5.44E+4
PU-239								
L	4.20E+8	1.10E+6	1.17E+8	4.10E+4	1.61E+1	3.20E+8	1.70E+8	7.29E+8
G	2.88E-l	1.40E+3	9.77E+3	6.70E+4	1.70E-3	7.90E+5	1.94E-2	6.11E+4
PU-241								
L	3.60E+5	1.30E+3	2.52E+6	8.70E+2	5.51E+1	6.40E+7	1.50E+5	1.51E+7
G	1.50E-4	1.30E+O	2.09E+2	1.40E+3	4.59E-3	1.70E+4	2.41E-2	1.26E+3
PU-242								
L	4.OOE+8	8.80E+5	1.11E+8	4.OOE+8	1.09E+1	3.OOE+9	1.70E+8	6.96E+8
G	3.50E-1	1.40E+3	9.29E+3	6.50E+4	1.24E-2	7.30E+5	8.73E-2	6.85E-1

Isotope	1	2	3	4	5	6	7	8
AM-241								
L	1.20E+S	1.70E+7	1.20E+S	4.60E+4	2.78E+3	1.OOE+9	6.OOE+9	7.50E+8
G	1.80E+1	7.60E+4	5.OOE+5	7.40E+4	1.14E+1	8.20E+5	6.36E+1	3.12E+6
CM-244								
L	1.20E+8	1.70E+7	5.88E+7	4.70E+4	2.31E+1	5.90E+8	7.14E+7	3.85E+8
G	1.68E+1	7.90E+4	2.45E+5	7.60E+4	9.25E-2	4.80E+5	9.55E-1	1.61E+6
CF-252								
L	2.40E+S	3.10E+7	2.OOE+7	5.OOE+5	6.03E+4	1.79E+9	1.38E+8	1.44E+8
G	1.10E+3	1.60E+5	1.14E+5	5.OOE+5	3.70E+2	7.66E+6	1.05E+3	6.22E+5

Legend:

1 - lung, 1 year integration

2 = bone marrow, 1 year integration

3 = gonads, 50 year integration

4 = lower large intestine, 50 year integration

5 = thyroid, 50 year integration

6 = bone (endosteal), 50 year integration

7 = lung, 50 year integration

8 = bone marrow, 50 year integration

5. HEALTH EFFECTS OF BOTH EXTERNAL AND INTERNAL EXPOSURE TO IONIZING RADIATION UTILIZED IN RADTRAN IV

The "expected" latent effects of ionizing radiation in producing either cancer mortalities or genetic effects used for this analysis are based on the United States Nuclear Regulatory Commission (NRC) publication, "An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants" (U.S. Nuclear Regulatory Commission, 1975), and are used for this analysis. However, updating the code to more current estimates of these parameters is planned by SNL in the near future. It is estimated that the conversion factors used in this study may be low by a factor of 3.3 to 6.6 if BEIR V values are universally accepted. Table 6 lists the latent effects parameters that were obtained (Madsen et al, 1986) for this study.

TABLE 6 - Expected Latent Effects Per Person-Rem Of Exposure

Exposed organ or tissue	Latent cancers/person-Rem
Bone marrow (leukemia)	2.8E-05 fatalities
Lung	2.2E-05 fatalities
Lower large intestine	3.OE-06 fatalities
Bone	7.OE-06 fatalities
All other	2.2E-05 fatalities
gonads	1.7E-04 genetic effects

It is expected that the thyroid latent cancer induction rate of 1. 34E-04 per person-rem will prove fatal in 10% of the cases. Also, the whole body induction rate is based on external exposure to penetrating radiation. Finally, the genetic effects conversion factor is applied to both low and high linear energy transfer (LET) radiation involving both internal and external exposures.

6. CH-TRU WASTE TRANSPORT MODE CHARACTERISTICS

The transport of CH-TRU waste by truck assumes that two crew members are present at a distance of 4 meters from the nearest TRUPACT II container, and that they are not exposed to doses greater than 2 mrem/hour while operating the vehicle. A further assumption is that a maximum of 50 people are exposed to gamma radiation at each stopping place at an exposure distance of 20 meters from the TRUPACT containers. The assumed stop time in hours/kilometer traveled for all carriers is set at 0.011, whereas, the minimum stop time (hrs) is set to 0. 0. A transportation accident is rated in terms of its severity. In this analysis eight severity classes were assumed where 46.2, 30.2, 17.6, 4.03, 1.18, 0.65, 0.057, and 0.011 percent of accidents occurred in rural areas for classes 1 thru 8, respectively. Thus, about 98% of the accidents are in severity classes 1 thru 4, of which 94% occur in the first three severity classes. For urban areas the respective percentages are 58.3, 38.2, 2.78, 0.63, 0.074, 0.014, 0.0011, and 0.0001, where 99% of all accidents are in the first three severity classes. An intermediate set of numbers is obtained for suburban areas, but they are not used in this analysis. The fraction of the radioactivity released during an accident varies according to severity where 0.0, 0.0, 0.0001, 0.001, 0.01, 0.10, 1.0, and 10 percent for severity classes 1 thru 8, respectively. It is further assumed that 10% of the released material (type 5) is aerosolized for any accidental release, and that 5% of the resulting aerosol contains particles below 10 μm aerodynamic equivalent diameter (AED). Thus, in a class 8 accident, 0.1 x 0.1 x 0.05z 5 x 10-4 or 1 part in 2,000 of the contents would be aerosolized and respirable. Details on the inhalation and ingestion of radionuclides resulting from releases and dispersion in accidents can be found in the RADTRAN III documentation (Madsen et al, 1986).

7. RESULTS

Both the incident free and accidental exposure of the New Mexico population (other than that to be described as "societal" by Madsen et al (1986)) may be divided into 5 major groupings for purposes of analysis. These groups consist of CH-TRU waste generators which share identical routes within the state as described earlier:

1. RFP, INEL, HP - which mutually share highway segments 6 thru 10 exclusively.

2. LLNL, NTS which mutually share highway segments 12 thru 22 exclusively.

3. ORNL ,MP, ANL - which mutually share highway segments 26 thru 30 exclusively.

4. SRS - which has exclusive use of highway segments 40 and 41.

5. LANL - which has exclusive use of highway segments 1 thru 5.

In addition, four subgroups may be identified where the five major groups mutually share highway segments with each other:

la. groups 1 and 5 mutually share highway segment 11 exclusively.

2a. groups 1, 2, and 5 mutually share highway segments 23 thru 25 exclusively.

3a. groups 1, 2, 3, and 5 mutually share highway segments 31 thru 39 exclusively.

4a. all groups mutually share highway segments 42 and 43.

7.1 Incident Free Exposure

Incident free radiation exposure involves external whole body exposure by penetrating (gamma and associated x-rays) radiation emitted from the TRUPACT container equally in all directions (isotropic). Some shielding by buildings along urban freeways is assumed in this analysis (building dose factor = 0.0086, Madsen et al, 1986), however, no shielding is assumed along rural routes. Only three highway segments in the State (1-40 thru Albuquerque) were of the urban freeway class where this building dose factor was considered. The resulting person-rem exposure dose to individuals along the transportation routes by grouping are presented in Table 7.

TABLE 7 - Population Exposure by Generator

highway grouping CEDE	population person-rems	expected latent cancer fatalities	percent of LCF	max. individual dose, mrems
1	157	0.0188	24.4	0.722
2	20	0.0025	3.1	0.020
3	12	0.0014	1.9	0.109
4	13	0.0016	2.0	0.292
5	20	0.0025	3.1	0.346
la	54	0.0065	8.4	1.068
2a	60	0.0072	9.3	1.088
3a	254	0.0305	39.5	1.197
4a	53	0.0063	8.2	1.489
totals	643	0.0773	99.9	

It should be noted that almost 50% of the maximum individual dose is contributed by the first highway grouping (RFP,INEL,HP), and that both group 4 (SRS) and group 5 (LANL) are major contributors. Grouping 1 is also a major contributor to the latent cancer fatality rate. The expected genetic effects in the population from external exposure is estimated as 0.1 for all shipments of all CH-TRU wastes from the generators.

A similar table showing the contribution of each CH-TRU generator to the accident free incidental dose is presented in Table 8.

TABLE 8 - Population Exposure By Individual Generators

generator	population person-rems CEDE	expected latent cancer fatalities	percent of LCF	max. individual dose, mrems
LANL	133	0.016020.6	20.6	0.346
SRS	24	0.00293.7	3.7	0.292
INEL	99	0.011915.4	15.4	0.166
RFP	278	0.033443.2	43.2	0.467
HP	53	0.00648.2	8.2	0.089
LLNL	21	0.00253.3	3.3	0.016
NTS	5	0.00060.8	0.8	0.004
ML	1	0.00010.2	0.2	0.002
ANL	1	0.00010.2	0.2	0.004
ORNL	28	0.00344.4	4.4	0.103
totals	643	0.0773100.0	100.0	1.489

Note: LCF based on 1.2E-4 LCF/rem; SEIS (1990) used 2.8E-4, and BEIR V (1990) suggests 4 to SE-4 LCF/rem

The dose to the maximum individual of 1.489 mrem would be in a location where all transport trucks used a common route (highway segments 42 and 43) within the city of Carlsbad and east to the WIPP site. Shipments from LANL, SRS, INEL, RFP, and HP contribute over 90% of the total; grouping 1 alone contributes almost 50% of this external dose. Higher maximum individual doses would be expected to occur at stops along the route. For example, EEG-41 suggested a maximum dose greater than or equal to 110 mrem while the SEIS projected values as high as 480 mrem. SRS, INELI RFP, and HP also contribute almost 70% of the expected latent fatal cancers and genetic effects; LANL is the only other major contributor to these risks.

Table 9 shows the partitioning of exposure dose for these groups. This analysis partitions the external exposure of the population into doses received by the crew (2 persons), residents along the route, persons traveling along the route during transport, and individuals (50 persons assumed) exposed at transport truck stopping locations.

TABLE 9 - Exposure Dose Partitioning Among Individuals During CH-TRU Transport Within New Mexico

generator	fraction of dose: crew members	residents	passengers	stops	dose frac
LANL-rural	0.47	0.0003	0.009	0.53	0.87
-urban	0.26	0.0990	0.340	0.30	
SRS-rural	0.55	0.0003	0.005	0.45	0.93
-urban	0.35	0.0750	0.280	0.29	
INEL-rural	0.54	0.0030	0.004	0.45	0.94
-urban	0.36	0.1000	0.240	0.30	
RFP-rural	0.55	0.0030	0.004	0.40	0.94
-urban	0.36	0.1000	0.230	0.30	
HP-rural	0.55	0.0030	0.004	0.45	0.94
-urban	0.37	0.1000	0.240	0.30	
LLNL-rural	0.54	0.0009	0.010	0.45	0.96
-urban	0.43	0.0590	0.160	0.35	
NTS-rural	0.54	0.0009	0.010	0.45	0.96
-urban	0.43	0.0590	0.160	0.35	
ML-rural	0.55	0.0005	0.006	0.45	0.93
-urban	0.36	0.1000	0.240	0.30	
ANL-rural	0.32	0.0007	0.008	0.67	0.92
-urban	0.18	0.1280	0.300	0.38	
ORNL-rural	0.25	0.0008	0.009	0.75	0.91
-urban	0.13	0.1370	0.320	0.41	
mean-rural	0.49	0.0010	0.007	0.51	0.93
mean-urban	0.32	0.0960	0.250	0.32	

7.2 Accidental Exposure Analysis

7.2.1 Methodology

Both external and internal exposures to ionizing radiation may result from accidents of trucks carrying CH-TRU waste if the accident is severe enough to cause a release of radioactivity. The actual release fraction, the fraction of accidents, the aerosolized fraction, and the fraction of aerosols below 10µm by the eight severity classes utilized in this analysis have been discussed previously. Also, the expected latent fatal cancer and genetic effects rates have been presented. Early fatality and morbidity effects rates are excluded from this report as the expected doses resulting from accidental releases from TRUPACT II containers are far below those required for such occurrences. A discussion of early fatality and morbidity effects is presented in Madsen et al, 1986.

The exposure as a result of an accident is divided into two groups depending on whether the accident is severe enough to cause a release of radioactivity from the waste containers. As noted earlier the most probable accidents (severity 1 and 2) do not have postulated releases, and severity class 3 would involve a release equal to one-millionth of the content of the TRUPACT containers. Hence, most of the accidents will be of the nonrelease type for urban (96.5t), and rural (76.4%) areas; only 1.9% of all rural accidents will have releases exceeding onemillionth of the contents. In the case of a non-release accident, persons within a radial distance between 3.05 to 305 meters are assumed to be exposed to external radiation from the stationary containers. Population exposures from a release accident are calculated for an area of 1.35E+09m2 (520 square miles) in the 22.50 downwind sector. The maximum distance of this exposure would be about 30 miles from the TRUPACT. Radiation doses to the exposed population are computed for inhalation from the contaminated cloud and from resuspension, for external radiation from cloudshine and groundshine, and from ingestion of contaminated food. The inhalation and external radiation exposures are covered in section 7.2.3 and the *ingestion pathway* is discussed in section 7.2.4. Madsen, et al (1984) *contains more* detail on the computational procedure.

Accidents occurring in the predominantly rural settings of the State are assumed to be 50% under cultivation for estimating exposure doses due to ingestion of contaminated food. RADTRAN IV does not consider the ingestion pathway in urban areas. The *ingestion pathway* is discussed in more detail in section 7.2.4.

The total exposure dose received from the release of radioactivity in accidents ranging from severity 3 thru. 8 is highway segment specific (severity accidents 1 and 2 do not release radioactivity), and is dependent on the origin of CH-TRU waste involved in the accident. A given highway segment may receive waste from 1 to 10 waste generator sites, depending on its location, and the expected number of accidents will be additive. The expected number of accidents for all shipments by highway segment are listed below taking into account the major transport groupings outlined earlier and one-way traffic (while carrying wastes) toward WIPP.

TABLE 10 - Expected Accidents For All Shipments Of CH-TRU Waste By Highway Segment And Grouping

highway seg/grp	severity classes 1	2	3	4	5	6	7	8	%
1/5	1.8E-3	1.2E-3	7.OE-4	1.6E-4	4.7E-5	2.6E-5	2.3E-6	4.5E-7	.08
2/5	6.5E-3	4.3E-3	2.5E-3	5.7E-4	1.7E-4	9.1E-5	S.OE-6	1.6E-6	.30
3/5	5.2E-3	3.4E-3	2.OE-3	4.5E-4	1.3E-4	7.2E-5	6.4E-6	1.3E-6	.24
4/5	2.2E-2	1.4E-2	1.OE-3	2.4E-4	2.8E-5	5.4E-6	4.2E-7	3.7E-8	.79
5/5	1.8E-3	1.2E-3	6.7E-4	1.5E-4	4.5E-5	2.5E-5	2.2E-6	4.3E-7	.08
6/1	3.3E-2	2.1E-2	1-2E-2	2.9E-3	8.4E-4	4.5E-4	4.OE-5	8.OE-5	1.5
7/1	1.OE-1	6.6E-2	3.OE-2	8.8E-3	2.6E-3	1.4E-3	1.2E-4	2.5E-5	4.5
8/1	1.9E-1	1.2E-1	7.1E-2	1-6E-2	4.7E-3	2.6E-3	2.3E-4	4.5E-5	8.6
9/1	2.2E-2	1.4E-2	8.3E-3	1.9E-3	2.7E-3	4.4E-4	2.7E-5	5.4E-6	1.0
10/1	1.5E-1	1.OE-1	5.SE-2	7.5E-3	2.2E-3	1.2E-3	1.9E-4	3.7E-5	6.7
11/1a	2.7E-1	1.8E-1	1.OE-1	2.4E-2	6.9E-3	3.SE-3	3.3E-4	1AE-4	12.
12/2	7.1E-3	4.6E-3	2.7E-3	6.2E-4	1.SE-4	9.9E-5	8.8E-6	1.7E-6	.33
13/2	6.4E-4	4.2E-4	2.4E-4	5.6E-5	1.6E-5	9.OE-6	7.9E-7	1.6E-7	.03
14/2	3.4E-3	2.2E-3	1.3E-3	3.OE-4	8.7E-5	4.8E-5	4.2E-6	8.4E-7	.15
15/2	3.2E-3	2.1E-3	1-2E-3	2.8E-4	8.3E-5	4.5E-5	4.OE-6	7.9E-7	.15
16/2	5.1E-3	3.3E-3	1.9E-3	4.5E-4	1.3E-4	7.2E-5	6.3E-6	1.3E-6	.23
17/2	9.2E-2	6.OE-2	3.5E-2	8.OE-3	8.OE-3	1.3E-3	1.1E-4	2.3E-5	4.3
18/2	3.5E-3	2.3E-3	1.7E-4	3.9E-5	4.5E-6	8.9E-7	6.9E-8	6.OE-9	.12
19/2	2.1E-3	1AE-3	9.8E-5	2.3E-5	2.6E-6	5.2E-7	4.OE-8	3.5E-9	.08
20/2	1.4E-3	9.1E-4	6.8E-5	1.5E-5	1.8E-6	3.5E-7	2.7E-8	2.4E-9	.19
21/2	2.3E-3	1.5E-3	1.1E-4	2.5E-5	3.OE-6	5.SE-7	4.5E-8	4.OE-9	.08
22/2	8.6E-3	5.6E-3	3.3E-3	7.5E-4	2.2E-4	1.2E-4	1.1E-5	2.1E-6	.39
23/2a	1.9E-1	1.2E-1	7.2E-2	1.4E-2	2.8E-3	1.5E-3	1.9E-4	3.8E-5	8.6
24/2a	4.5E-2	3.6E-2	2.1E-2	4.SE-3	1.6E-3	8.7E-4	6.2E-5	1.3E-5	2.3
25/2a	7.1E-3	4.6E-3	2.7E-3	6.2E-4	1.8E-4	1.OE-4	B.SE-6	1.7E-6	.33
26/3	1AE-3	9.5E-4	5.5E-4	1.3E-4	1.6E-4	2.OE-5	1.8E-6	3.5E-7	.07
27/3	1.1E-4	6.9E-5	4.OE-5	9.2E-6	2.7E-6	1.5E-6	1.3E-7	2.3E-8	.01
28/3	2.1E-3	1.4E-3	8.OE-4	1.8E-4	5.4E-5	2.9E-5	2.6E-6	5.1E-7	.10

severity classes

highway seg/grp	1	2	3	4	5	6	7	8	%
29/3	2.3E-4	1.5E-4	S.SE-5	2.OE-5	5.9E-6	3.2E-6	2.9E-7	5.6E-8	.01
30/3	2.7E-3	1.8E-3	1.OE-3	2AE-4	6.9E-5	3.8E-5	3AE-6	6.7E-7	.12
31/3a	2.3E-1	1.5E-1	8.9E-2	2.OE-2	6.OE-3	3.3E-3	2.9E-4	5.7E-5	11.
32/3a	2.7E-3	1.8E-3	1.3E-4	7.5E-5	3.2E-6	6.8E-7	6AE-7	4.9E-9	.11
33/3a	1AE-1	8.9E-2	7.3E-3	1.5E-3	1.7E-4	3AE-5	2.6E-6	2.3E-7	5.0
34/3a	2.OE-1	1.3E-1	9.7E-3	2.2E-3	2.6E-4	5.1E-5	5.5E-6	2.3E-7	7.2
35/3a	2.1E-1	1AE-1	8.3E-2	1.9E-2	5.6E-3	8.6E-4	2.7E-4	5.3E-5	9.9
36/3a	1.SE-2	1.2E-2	8.7E-4	1.1E-3	2.3E-5	4.8E-6	3.5E-7	3.1E-8	.68
37/3a	7.7E-3	1.3E-3	3.2E-4	7.1E-5	9.7E-6	1.9E-6	2.1E-6	1.3E-8	.44
38/3a	1.3E-1	8.SE-2	5.1E-2	1.2E-2	3AE-3	1.5E-3	1.7E-4	3.3E-5	6.1
39/3a	1.5E-1	1.OE-1	7.3E-3	1.7E-3	1.9E-4	3.8E-5	3.OE-6	2.6E-7	5.6
40/4	3.OE-2	2.OE-2	1.2E-2	2.7E-3	7.8E-4	4.3E-4	3.8E-5	7AE-6	1.4
41/4	8.8E-3	5.8E-3	4.2E-4	9.6E-5	1.1E-5	2.2E-6	1.7E-7	1.5E-8	.33
42/4a	2.8E-2	1.8E-2	1.3E-3	2.7E-4	6.1E-5	6.9E-6	5AE-7	4.7E-8	1.0
43/4a	6.7E-2	4AE-2	2.6E-2	4.7E-3	1.7E-3	8.2E-4	8.3E-5	1.5E-5	3.1
tots.	2.4E+O	1.6E+O	7.2E-1	1.6E-1	4.8E-2	3.2E-2	2.3E-3	5.8E-4	
%	48.	32.	15.	3.	1.	1.	<0.1	<0.1	

7.2.2 Expected Number of Accidents

The number of expected truck transport accidents (see Table 10), involving CH-TRU waste over the entire life-time of the WIPP, are about five with only one (20%) involving a release of radioactivity. There is about a 75% chance that the expected accident releasing radioactivity will be in severity class 3 (1/1,000,000 of the contents are released), and less than a 9% chance that the accident will be equal to or greater than severity class 5 where the release would be greater than 1/10,000 of the contents. About 30% of all the accidents are expected to occur in urban areas with the majority expected to occur in Roswell (12%), Carlsbad (7%), and Artesia (1%). About 1% percent of the accidents are expected to occur in the urban areas of Albuquerque and Santa Fe with the rest scattered among other communities along the routes, such as Raton, Las Vegas, Tucumcari, Santa Rosa, Gallup, Grants, and Vaughn. Furthermore, about 1.5% of the five predicted accidents are expected between LANL and the southern urban limit of Santa Fe. The initial segment for this route (through White Rock) that is evaluated here is not the preferred route by the State (Jemez Road has been designated for this purpose) but the effect on the overall calculations is not expected to be significant.

The expected accidents in rural areas (about three and one-half) over the life-time of WIPP are distributed in a pattern which reflects the projected number of shipments traversing the highway segment, the specific accident rate, the average daily traffic volume, and the length of the segment. The expected accident percentages by segment groupings described earlier are presented in Table 11.

TABLE 11 - Expected Percentage Of Accidents by Highway Grouping In Rural Areas

highway grouping	percent of accidents	approximate description of grouping
5	0.7	Los Alamos to Lamy cutoff
1	19.8	Raton to Lamy cutoff
la	12.0	Lamy cutoff to Clines Corners
2	5.3	Gallup to Clines Corners
2a	10.9	Clines Corners to Vaughn
3	0.3	Tucuncari to Vaughn
3a	16.0	Vaughn to Carlsbad
4	1.4	US-285 south to Carlsbad
4a	3.1	Carlsbad to WIPP
total	69.5	

7.2.3 Latent Cancer Fatalities from Accidents

The total exposure dose received from the release of radioactivity in accidents ranging from severity 3 thru 8 are highway segment specific and are dependent on the source of CH-TRU waste involved in the accident. A given highway segment may involve only one, or all waste generator types, depending on its location within the routing scheme, and the expected accident rates are also additive in this respect. The expected number of accidents for all shipments by highway segment are listed in Table 12. These accidents are only for one-way transportation to WIPP when the TRUPACTS are carrying waste.

It should be emphasized that the latent cancers in Table 12 depict the consequences of accidents occurring within a given severity class, and not the actual expected risks involved from such accidents. An illustration of this difference can be shown with respect to segment 4 (Santa Fe urban area) where:

* consequent latent cancer fatalities = 2.7
(Table 12, accident involving LANL waste, segment

*probability of severity 8 type accident = 3.7E-08
(Table 10, all shipments, segment 4)

The expected latent cancer fatalities or risk is estimated as the product:

ELCF = 2.7(CLCF) X 3.7E-08 (PS8A) = 1.OE-7, where

ELCF = expected latent cancer fatalities or “risk”

CLCF = consequent latent cancer fatalities

PSBA = probability of severity 8 type accident.

TABLE 12 - Total Latent Cancer Fatalities From Transportation Accidents Arranged by Highway Segment Grouping and Severity Class +

highway seg/grp+++	severity classes 3	4	5	6	7	8	
1/5	1.4E-6	1.4E-5	1.3E-4	1.2E-3	1.OE-2	7.7E-2	
2/5	1.4E-6	1.4E-5	1.3E-4	1.2E-3	1.OE-2	7.7E-2	
3/5	1.4E-6	1AE-5	1.3E-4	1.2E-3	1.OE-2	7.7E-2	
4/5	2.8E-5	2.8E-4	2.SE-3	2.8E-2	2.8E-1	2.7E+O	
----------							1++
5/5	1.4E-6	1.4E-5	1.3E-4	1.2E-2	1.OE-2	7.7E-2	
6/1	2.OE-7	2.OE-6	2-OE-5	1.9E-4	1.7E-3	1.3E-2	
7/1	2.OE-7	2.OE-6	2.OE-5	1.8E-4	1.7E-3	1.3E-2	
8/1	2.OE-7	2.OE-6	2.OE-5	1.9E-4	1.7E-3	1.3E-2	
9/1	2.OE-7	2.OE-6	2.2E-5	1.9E-4	1.7E-3	1.3E-2	
10/1	2.OE-7	2.2E-6	2.OE-5	1.9E-4	1.7E-3	1.3E-2	
11/1a	1.6E-6	1.6E-5	1.6E-4	1.4E-3	1.2E-2	9.OE-2	
12/2	3.3E-8	3.3E-7	3.3E-6	3.3E-5	3.OE-4	2.3E-3	
13/2	3.3E-8	3.3E-7	3.3E-6	3.3E-5	3.OE-4	2.6E-3	
14/2	3.3E-8	3.3E-7	3.3E-6	3.3E-5	3.3E-4	2.3E-3	
15/2	3.3E-8	3.3E-7	3.3E-6	3.3E-5	3.OE-4	2.3E-3	
16/2	3.3E-8	3.3E-7	3.3E-6	3.3E-5	3.OE-4	2.3E-3	
17/2	3.3E-8	3.3E-7	3.3E-6	3.3E-5	3.OE-4	2.3E-3	
18/2	2.2E-6	2.2E-5	2.2E-4	2.2E-3	2.2E-2	2.2E-1	
----------							2
19/2	2.2E-6	2.2E-5	2.2E-4	2.2E-3	2.2E-2	2.2E-1	
----------							2
20/2	2.2E-6	2.2E-5	2.2E-4	2.2E-3	2.2E-2	2.2E-1	
----------							2
21/2	2.2E-6	2.2E-5	2.2E-4	2.2E-3	2.2E-2	2.2E-1	
----------							2
22/2	3.3E-8	3.3E-7	3.3E-6	3.3E-5	3.OE-4	2.3E-3	

severity classes

highway

seg/grp..................	3	4	5	6	7	8	
23/2a	1.6E-6	1.6E-5	1.6E-4	1.5E-3	1.2E-2	9.3E-2	
24/2a	1.6E-6	1.6E-5	1.6E-4	1.5E-3	1.2E-2	9.3E-2	
25/2a	1.6E-6	1.6E-5	1-6E-4	1.5E-3	1.2E-2	9.3E-2	
26/3	1.5E-7	1.5E-6	1.5E-5	1.5E-4	1.3E-3	1.1E-2	
27/3	1.6E-7	1.6E-6	1.6E-5	1.5E-4	1.5E-3	1.1E-2	
28/3	1.5E-7	1.5E-6	1.6E-5	1.5E-4	1.3E-3	1.1E-2	
29/3	1.5E-7	1.5E-6	1.6E-5	1.5E-4	1.3E-3	1.1E-2	
30/3	1.5E-7	1.5E-6	6.7E-5	1.5E-4	1.3E-3	1.1E-2	
31/3a	1.8E-6	1.SE-5	1.7E-4	1.6E-3	1.3E-2	1.OE-1	
32/3a	4.2E-5	4.2E-4	4.2E-3	4.2E-2	4.OE-1	4.2E+O	
	----------	----------	----------	----------	----------	----------	3
33/3a	4.7E-5	4.7E-4	4.7E-3	4.7E-2	4.7E-1	4.7E+O	
	----------	----------	----------	----------	----------	----------	3
34/3a	4.2E-5	4.2E-4	4.2E-3	4.2E-2	4.2E-1	4.2E+O	
	----------	----------	----------	----------	----------	----------	3
35/3a	1.8E-6	1.SE-5	1.7E-4	1.6E-3	1.3E-2	1.OE-1	
36/3a	9.3E-5	9.3E-4	9.3E-3	9.3E-2	9.3E-1	9.3E+O	
	----------	----------	----------	----------	----------	----------	4
37/3a	9.3E-5	9.3E-4	9.3E-3	9.3E-2	9.3E-1	9.3E+O	
	----------	----------	----------	----------	----------	----------	4
38/3a	1.6E-6	1.6E-5	1.6E-4	1.5E-3	1.2E-2	9.3E-2	
39/3a	3.8E-5	3.8E-4	3.8E-3	3.8E-2	3.SE-1	3.8E+O	
	----------	----------	----------	----------	----------	----------	5
40/4	2.8E-8	2.8E-7	2.8E-6	2.3E-5	2.OE-4	1.5E-3	
41/4	6.7E-5	6.7E-4	6.7E-3	6.7E-2	6.7E-1	6.7E+O	
	----------	----------	----------	----------	----------	----------	5
42/4a	1.OE-4	1.OE-3	1.OE-2	1.OE-1	1.OE+O	1.OE+l	
	----------	----------	----------	----------	----------	----------	5
43/4a	1.8E-6	2.1E-5	1.7E-4	1.6E-3	1.4E-2	1.OE-1	

Notes for Table 12:

values shown are composited according to the number of waste generators traversing the specific highway segment. They reflect the cumulative consequence where accident(s) from each generator(s) are assumed to occur independently of the others within a given segment and severity class. For example, segments 1-5 show the consequence of varying severities involving only LANL CH-TRU waste, whereas segments 42-43 show the combined consequences of 10 independent waste generators, etc. The maximum consequences for single category 8 accidents are 2.7 LCF in Roswell, 5.5 LCF in Artesia, and 6.7 LCF in Carlsbad.

Underlined segments were considered urban; only Albuquerque was considered urban freeway. Segments not underlined were considered to be rural:

1=Santa Fe, 2=Albuquerque, 3=Roswell, 4=Artesia, 5=Carlsbad.

Ingestion mode not considered in urban areas.

7.2.4 Doses from Ingestion Pathway

The RADTRAN IV model was used to compute population doses from crops that would be contaminated from releases of transuranic radionuclides from TRUPACT II accidents in rural areas. The RADTRAN IV code assumes that 50% of all rural land is under cultivation. Actually New Mexico lands are devoted mostly to grazing and the amount under cultivation is much less than 50%. Since a much lower fraction of radionuclides moving through the grass - steer - meat pathway actually is ingested by humans in meat than in cultivated crops, this assumption results in ingestion dose calculations being conservative (higher than the most likely value). However, some of this conservatism would be offset by two assumptions that are not necessarily conservative: (1) apparently, contamination on exposed plant surfaces from resuspension and deposition of contaminated soils was not considered (this can be an important mechanism in arid environments); and (2) transfer coefficients appear to assume that transuranics are in the (less soluble) oxide form. The expected values of population risks in terms of latent cancer fatalities from all pathways are presented by waste origin in Table 13.

TABLE 13 - Expected Values of Population Risk In Latent Cancer Fatalities By Waste Origin

Origin	Group	Ground	Inhaled	Resuspd	Cloudsh	Ingestion
LANL-rural	5	2.3E-9	3.9E-7	1.SE-6	2.OE-14	8.1E-6
-urban		2.4E-9	3.6E-7	1.6E-6	1.8E-14	
RFP -rural	1	7.OE-10	8.9E-7	4.OE-6	3.3E-15	1.7E-7
-urban		3.7E-11	4.4E-8	2.OE-7	1.6E-16	
INEL-rural	1	1.OE-8	1.OE-6	4.8E-6	7.4E-14	3.3E-6
-urban		5.6E-10	5.2E-8	2.4E-7	3.7E-15	
HP-rural	1	2.7E-10	8.3E-7	3.8E-6	2.9E-16	3.3E-8
-urban		1.5E-11	4.1E-8	1.9E-7	1.5E-17	
LLNL-rural	2	1.1E-9	2.2E-7	9.8E-7	7.7E-15	1.4E-6
-urban		3.7E-11	7.1E-9	3.2E-8	2.5E-16	
NTS -rural	2	3.6E-13	8.8E-10	4.OE-9	3.4E-19	1.6E-10
-urban		1.2E-14	2.9E-11	1.3E-10	1.1E-20	
ORNL-rural	3	9.9E-12	1.6E-8	7.3E-8	2.OE-17	4.3E-8
-urban		7.1E-12	1.1E-8	4-SE-8	1.4E-17	
ANL -rural	3	9.2E-13	1.2E-10	5.3E-10	6.6E-18	3.3E-8
-urban		6.4E-13	7.7E-11	3.5E-10	4.4E-18	
ML-rural	3	5.OE-14	6.5E-11	2.9E-10	3.2E-20	2.1E-11
-urban		3.3E-14	4.3E-11	1.9E-10	2.1E-20	
SRS -rural	4	1.9E-10	3.4E-07	1.5E-06	1.7E-16	8.2E-8
-urban		8.6E-11	1.3E-07	6.OE-07	6.8E-17	
total-rural		1.5E-8	3.6E-6	1.8E-5	1.1E-13	(1.3E-5)+
total-urban		3.1E-9	6.5E-7	2.9E-6	2.2E-14	
sub-totals		1.8E-8	4.3E-6	2.1E-5	1.3E-13	(2.5E-5)++

notes:

+ = grand total due to ingestion

++ = grand total due to all other modes of exposure

The expected latent cancers resulting from the weighing of severity group consequences with the severity occurrence accident probabilities show an expected fatal cancer production which is over two orders of magnitude lower than that expected from incident-free external exposures described earlier in this report. The expected number of fatal cancers due to ingestion of radionuclides is equal to about 50% of those expected from all other modes of exposure during an accident, but the assumed conservative assumptions probably yield an overestimate of this fraction. Also, ingestion doses are not directly comparable to the other exposures because they are "societal" in nature, that is, they are incurred by a much larger number of individuals than those who live along the routes to WIPP in New Mexico.

The expected latent cancer death contribution from urban areas accounts for only about 13% of the total averaged over all routes and waste origins excluding the ingestion pathway. Thus, the accidental exposure pathway appears, like incident-free exposures, to be relatively insensitive to higher urban population densities in New Mexico. The major contribution to the overall exposure dose from both incident-free and accidental exposure comes from rural highway segments along routes leading to WIPP.

8. EXPECTED GENETIC EFFECTS

The expected values of population risk in genetic effects, as a result of CH-TRU waste shipments to WIPP, are presented in Table 14 for the ingestion mode and for the combined groundshine, inhalation, resuspension, and cloudshine exposure modes.

TABLE 14 - Expected Values Of Population Risk In Genetic Effects by Waste Origin From Transportation Accidents

origin	Group	Ingestion +	All other modes
LANL	5	7.6E-7	3.8E-7
RFP	1	1.6E-8	4.SE-7
INEL	1	3.3E-7	5.7E-7
HP	1	2.3E-9	4.4E-7
LLNL	2	1.4E-7	1.2E-7
NTS	2	1.1E-11	4.6E-10
ORNL	3	3.7E-9	1.3E-8
ANL	3	2.3E-12	1.OE-10
ML	3	2.1E-11	5.9E-10
SRS	4	7.4E-9	2.2E-7
totals		1.3E-6	2.OE-6

Note:

\+ This genetic effects component considered to be societal; all other modes of exposure assumed to be shared by individuals along the transportation routes.

About 85% of the expected latent cancer fatalities and genetic effects due to the ingestion mode are produced by LANL and INEL waste streams. This is undoubtedly due to the higher Am-241 content of these wastes. The expected genetic effects due to modes of exposure excluding ingestion are caused primarily by inhalation and resuspension processes; that due to cloudshine is negligible relative to the other components. The effects by all modes of exposure are small when compared to exposures attributable to natural background radiation levels.

9. ECONOMIC CONSEQUENCES AND EXPECTED ECONOMIC

The cost of environmental restoration of contaminated land surface due to the release of CH-TRU waste as a result of a transportation accident ranges in value depending on accident severity and the particular highway segment affected. The expected economic risk factors in the probability of accident severity were applied in its formulation. Table 15 presents the range of economic consequences, identifies their location, and presents the total expected costs along the route for a specific waste generator.

TABLE 15 - Economic Consequences And Expected Risks Involving CH-TRU Waste by Generator In 1980 Dollars

origin	Minimum+ Consequence	Segment Location	Maximum++ Consequence	Segment Location	Exp. Risk All Segments
LANL	$ 2.7E+02	all	$ 4.4E+07	36-37	$ 1.5E+03
RFP	2.7E+02	all	4.1E+06	36-37	2.7E+03
INEL	2.7E+02	all	S.OE+06	36-37	6.6E+03
HP	2.7E+02	all	1.9E+07	36 37	1.9E+03
LLNL	2.7E+02	all	3.2E+06	18-21	1.7E+03
NTS	2.7E+02	all	8.2E+04	18-21	1.3E+02
ORNL	2.7E+02	all	8.1E+06	36-37	6.3E+02
ANL	2.7E+02	all	9.8E+05	36-37	1.9E+00
ML	2.7E+02	all	1.6E+04	36-37	1.6E+01
SRS	2.7E+02	all	2.6E+07	41-42	1.8E+02

total expected costs $ 1.5E+04

Notes:

+ assumes accident of severity 1 occurs

++ assumes accident of severity 8 occurs

The total expected costs to the State as a result of accidents involving the transport of CH-TRU waste to WIPP is estimated at about $15,000 over the entire transportation period. According to the model the maximum consequential cost ($44,000,000) to the State would involve an accident of severity 8 from a truck carrying LANL waste on segments 36-37 (between the northern and southern urban limits of Artesia). The maximum consequence remediation costs from waste originating at RFP, INEL, HP, ORNL, ANL, and ML also occurs at this location. Two of the maximum costs occur in Albuquerque (segments 18-21) involving wastes from LLNL and NTS, and one maximum remediation cost involving waste from SRS occurs in Carlsbad (segments 41-42). Maximum consequence remediation costs for the City of Santa Fe (segment 4), resulting from a severity 8 accident involving LANL CH-TRU wastes, are estimated at $26,000,000 and a maximum cost of about $24,000,000 is projected for remediation in Roswell (segments 33-34) from the same source. These results indicate that maximum cost consequence accidents will occur in urban areas with 70% of them expected within the City of Artesia which has one of the higher urban densities in the State (1,146 persons/km2, Williams, 1986), and exceeds the population densities of Roswell and Carlsbad. Also, all transport of CH-TRU waste, with the exception of SRS waste, traverses this city.

Other expected costs involve initial response costs and on-scene costs which vary from as low as $200 to a high estimate approaching $10,000 depending on the severity of release, but these are nominal costs compared to those incurred with high severity accident remediation costs.

10. DISCUSSION AND CONCLUSIONS

10.1 RADTRAN IV Model

This analysis was conducted with the best available data that EEG could obtain to execute the RADTRAN IV code, and the results obtained are derived exclusively from the output of this model. The four versions of this model attest to the efforts of SNL in trying to both improve and extend the capabilities of users involved in transportation analysis. EEG is actively scrutinizing the "hard-wired" parameters and assumptions utilized in the model, and has had positive interaction with SNL personnel actively involved in developing and maintaining the model for outside users. Many default values present in the code were accepted for the analysis, pending a more detailed study by EEG of site-specific input for future uses of this code. While we are questioning some of these assumptions, it was not our intention in this report to concentrate on model operation, but to organize and analyze the output resulting from our interaction in terms of input parameters. The limitations of database development on EEG's part has already been documented in this report.

10.2 Incident-Free

The inference from incident-free exposures is that the risk is practically independent of population density, traffic, and accident rates because crew members and individuals surrounding stopping places receive the major fraction of the dose (Table 9) primarily in rural areas which account for over 90% of the total exposure. Urban areas, however, are more affected by traffic density, but their contribution to the total exposure by this means is less than 10%.

Since the miles of urban roadway on the main routes to WIPP are only 5 - 7% of the total mileage, it is not surprising that most of the total population dose occurs in rural areas. However, the real fraction of the dose that occurs in urban areas may be greater then indicated in Table 9 for several reasons: (1) the stop time parameter used (0.011 hrs/km) appears to be excessive for rural areas in New Mexico; (2) the assumed number of people (50) surrounding stopping places may also be conservative for rural areas; (3) the dose to crew members in urban areas (relative to rural areas) should be directly related to the fraction of the total transit times spent in urban areas but the volumes in Table 9 appear to be low by factors of 3-5; and (4) similarly, the urban doses to residents and at stops appear to be low by factors of 1.1 to 2. The effect of the above factors may lead to an urban dose fraction of as much as 15%.

The overall contribution to the incident-free exposure by individual generators is quite variable (Table 8) with wastes from RFP, INEL, and HP contributing over 60%, and LANL contributing over 20% of the total population dose. The maximum individual dose partitioning follows a similar pattern, but depends on the location of the individual along the route. With respect to preferred routing strategies, the effect of major contributors to the incident-free dose should be given primary consideration. For example, the selection of routes for wastes from RFP, INEL, HP, and LANL will have a major effect on the overall exposure of individuals along the routes, while the final selection of routes for waste originating at NTS and LLNL may have relatively small overall radiological health impact.

10.3 Exposure From Transportation

Whereas incident-free exposure of individuals along the routes carrying CH-TRU waste in New Mexico can be assessed in a deterministic manner, the exposure from releases of radioactive materials as a result of a transportation accident either assumes the accident occurs (consequential), or factors in the probability of occurrence or expectation (risk). Expected accidents involving CH-TRU waste will not occur with equal frequency along the routes (Table 11), and will differ by severity of accident (Table 10) and by the total number of shipments traversing the specific segment. The analysis indicates that about five transportation accidents involving CH-TRU waste will occur in the State over the entire transportation period, and that about one of these accidents will involve the release of radioactive waste. The probability of this one accident aerosolizing more than 1/1000 of the cargo radioactivity is less than 1%, and there is a 75% chance that only 1/10,000,000 of the radioactive content will be aerosolized for inhalation exposure. It is noted that release fractions as a function of accident severity by the model are significantly lower than the assumed release fractions used in the RADTRAN II analyses for the SEIS (1990), but EEG agrees that the lower estimates are more reasonable, albeit less conservative. Finally, the analysis indicates that about 70% of the accidents will occur in rural area highway segments in the routes to WIPP. Of those accidents which will occur in urban areas (about 30%), 12% are expected to occur in Roswell, and 7% in Carlsbad with the remaining 11% distributed among other communities in the state.

The consequence of an accident that does occur along the transport routes to WIPP, will depend on a number of factors (Table 12): waste origin, highway segment, number of shipments traversing the segment, population density, severity of accident, etc. The major consequences in terms of latent cancer fatalities would involve an accident in an urban area even when exposure from ingestion of radionuclides is included for rural areas. The maximum consequence of about seven latent cancer fatalities for a severity 8 accident (with a probability of about 1 in 66 million) is shown for the urban area of Carlsbad. About three latent cancer fatalities would result in Roswell, five in Artesia, and three in Santa Fe as a result of a severity 8 accident within these urban areas; only 0.2 deaths would result from a similar accident in Albuquerque.

The expected values of population risk as a result of accidents is very small (Table 13) where about 0.00003 latent cancer fatalities are expected statewide as a result of transportation accidents excluding the ingestion pathway. The expected population risk due to ingestion of released radioactivity is even smaller (0.00001 latent cancer fatalities) and, in addition, considers a much larger population as described for societal risk. Genetic effects from accidents follow a similar pattern and are relatively insignificant (Table 14).

The wide divergence between consequences and expected risks is clearly evident in this analysis, and the importance of a consequence is dependent on its probability of occurrence and its magnitude. However, consequences can be utilized to bound risks, and to encourage alternative actions when potential harm is significant. The risk can be either health and safety related or economic in nature.

10.4 Economic Consequences And Risks

The economic consequences and risks resulting from a release of radioactive materials as a result of a transportation accident are presented in Table 15. A maximum of $44,000,000 would be required to remediate a release of radioactivity as a result of a severity 8 accident in the city of Artesia, and lesser but significant amounts in other urban areas of the state. Cities along the southern portion of the route to WIPP, particularly Artesia and Roswell appear to show maximum consequences for both radiological health related and economic consequences. The maximum economic consequences contributed by waste from LANL from a maximum severity accident in Santa Fe is $24,000,000. All maximum economic consequence occurrences are within urban areas with higher population densities. The expected costs, however, are trivial (about $15,000 for all accidents over the transportation period), and are not of great concern.

Additional costs involving initial response activities range from about $200-$10,000 depending on accident severity, and also appear to be of little economic concern.

11. SUMMARY OF CONCLUSIONS RECOMMENDATIONS

11.1 Conclusions

The results of this analysis clearly indicate the expected exposure of New Mexico residents as a result of accidents involving the transport of CH-TRU waste to WIPP is less than 0.1% of the expected dose due to incident-free shipments that do not involve accidents or releases of radioactivity. The incident-free dose is partitioned among truck crew, persons surrounding stopping places, passengers of automobiles along the routes, and residents surrounding the highway routes approximately as:

* crew-314 person-rems
* persons at stopping places - 314 person-rems
* residents and passengers along routes - 16 person-rems.

If one assumes a 25-year transportation period, 60 total crew members, 10 stopping places in New Mexico at 50 persons exposed per stopping place, and 170,000 residents and passengers exposed on all the routes, then the following dose rates may be estimated as:

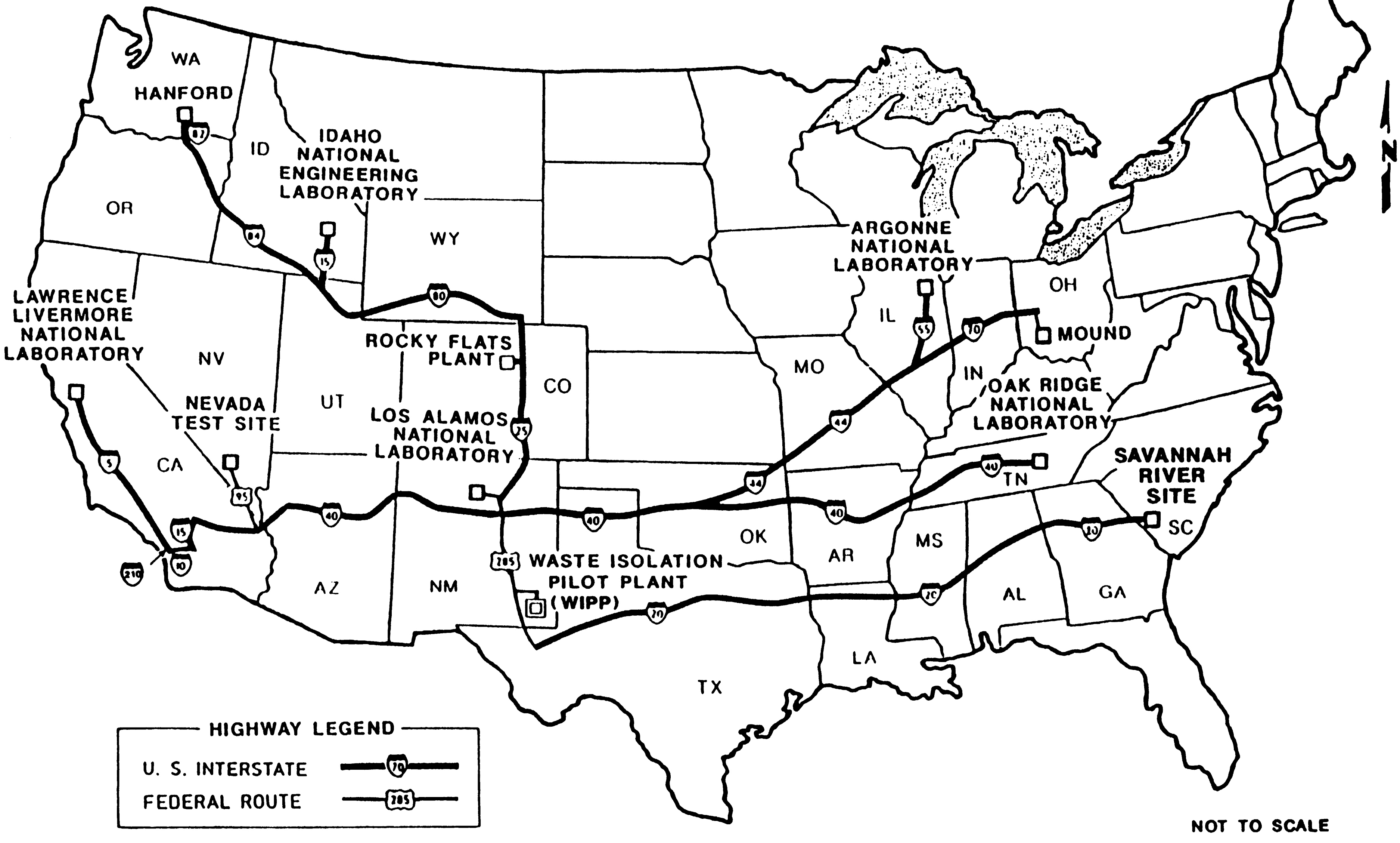
* crew - 0.2 rem/crew member/year
* persons at stopping places - 0.025 rem/person/year
* residents and passengers along the routes - 3.7E-06 rems/person/year.

When compared to natural background exposures of 0.3 rems/year/person and variations between locations in the U.S., only crew member exposures appears significant. The attendant expected latent cancer fatalities as a result of these exposures would not be expected to be statistically significant compared to the normal cancer incidence. The calculated dose to persons at stopping places (25 mrem/y) is not trivial since it is equal to the allowable dose to members of the public from most fixed nuclear facilities (including WIPP). However, as stated above, we believe this calculated dose is quite conservative. Based on this analysis, the currently identified routes do not pose a statistically significant health risk to New Mexico residents, and it is not expected that any other routes which may be so designated for this purpose will pose a significant health risk.

11.2 Recommendations

We recommend that crew members should be closely monitored to assure that the 2 mrem/hour maximum exposure limit is not exceeded. Also, the selection of truck stopping places should be carefully studied, both in number and location, to minimize unnecessary exposures as much as possible. Finally, in the interests of minimizing health effects and clean-up costs in cities from high consequence, low-probability accidents, it is recommended that by-passes around communities should be used when possible.

PROPOSED TRU WASTE TRUCK TRANSPORTATION ROUTES



With Permission
U.S. Department of Energy, 1990. Final Supplement Environmental Impact Statement: Waste Isolation Pilot Plant.

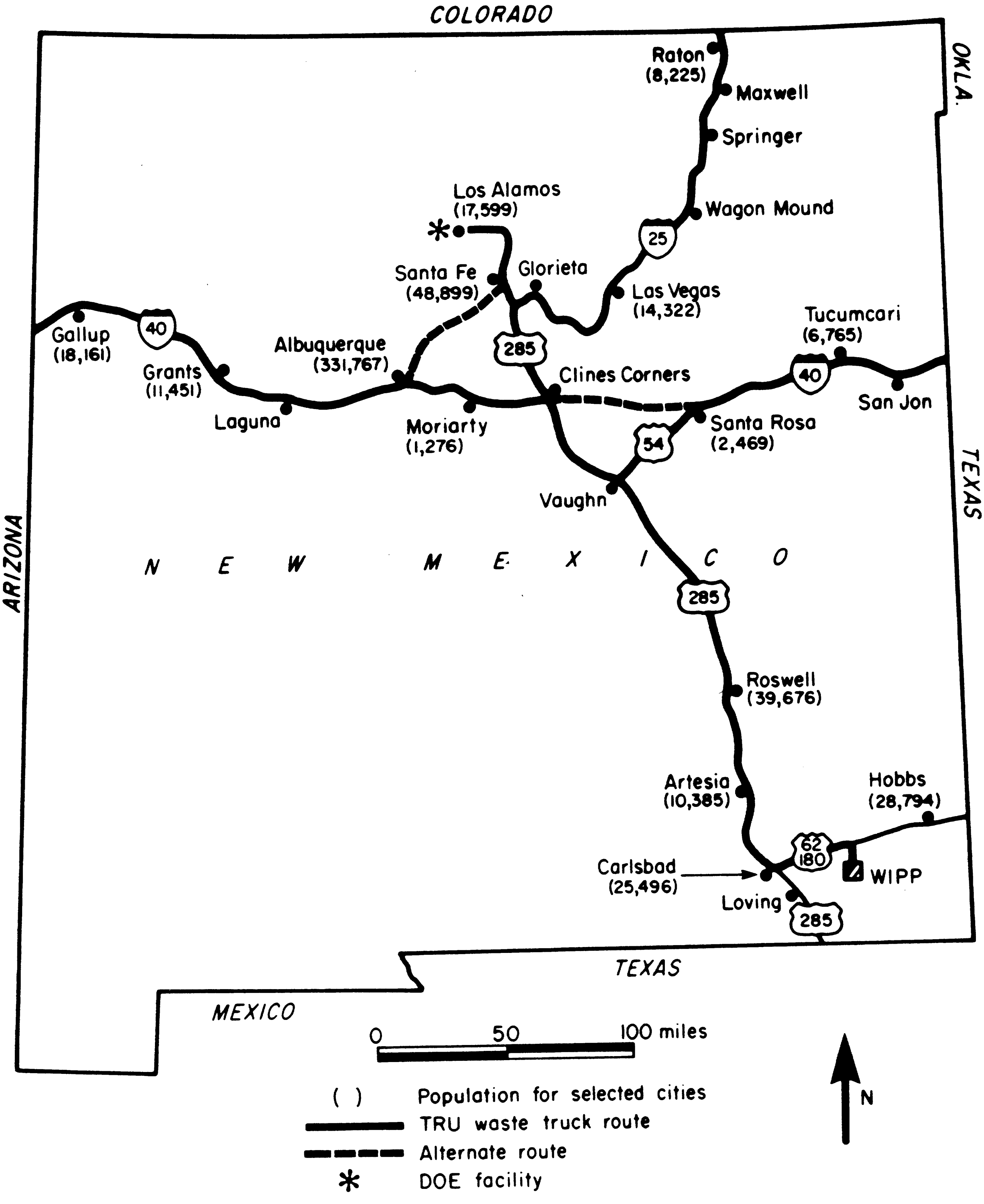
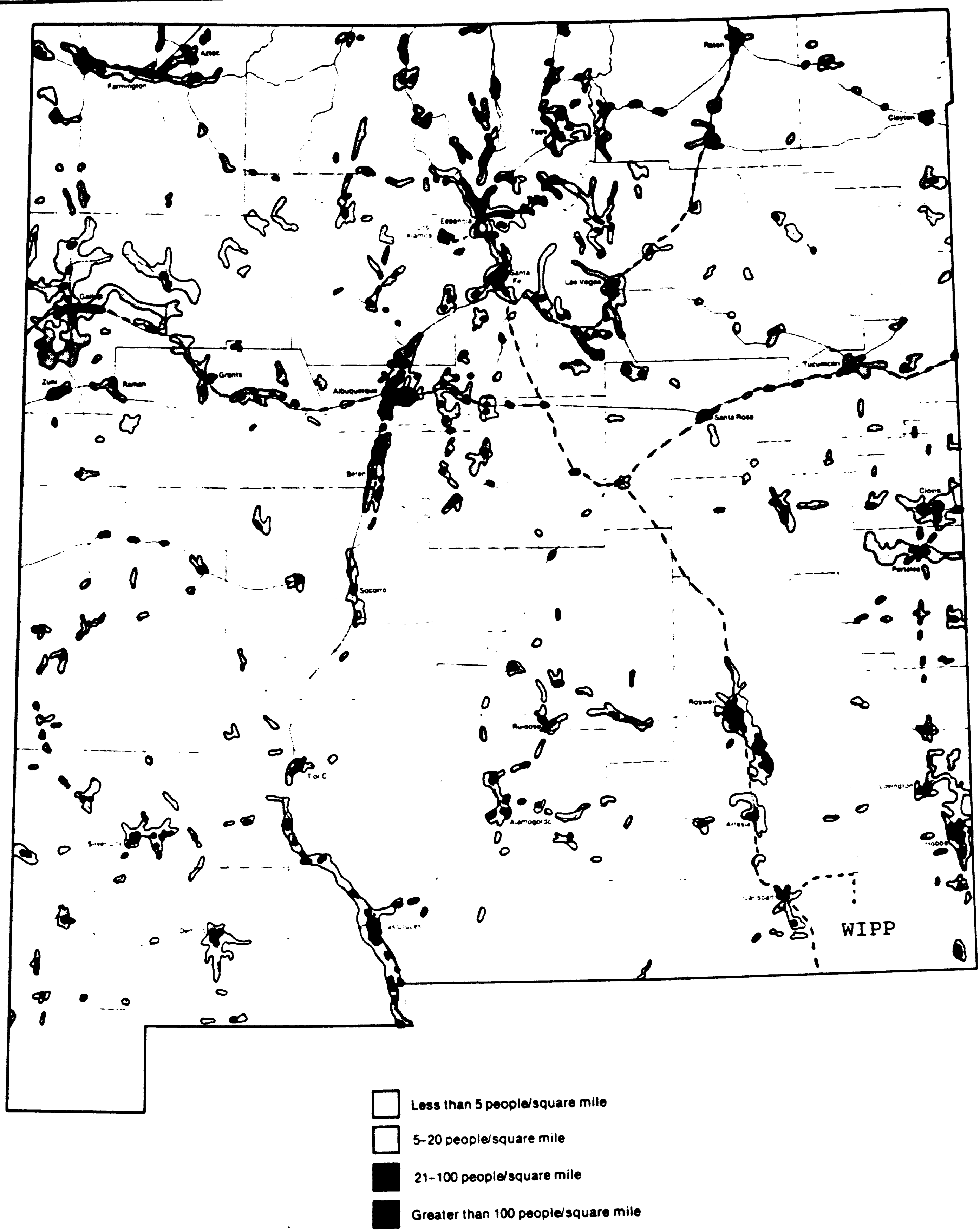


Figure 2 : ROUTES TO WIPP IDENTIFIED IN THE SUPPLEMENTAL STIPULATED AGREEMENT

State WIPP Routes Enhanced for Clarification



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