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INTRODUCTION

The Waste Isolation Pilot Plant (WIPP) is an authorized U.S. Department of Energy (DOE) research and development facility constructed near the city of Carlsbad in southeastern New Mexico. The facility is intended to demonstrate the safe disposal of transuranic (TRU) radioactive waste resulting from U.S. defense activities. Under the WIPP Land Withdrawal Act of 1992 (LWA), federal lands surrounding the WIPP facility were withdrawn from all public use and the title of those lands was transferred to the Secretary of Energy. The DOE's TRU waste is stored, and in some cases is still being generated, at 10 large-quantity and 13 small-quantity sites across the United States. After applicable certification requirements have been met, the TRU waste at these sites will be sent to the WIPP to initiate the disposal phase of the facility, which according to current planning is projected to last for approximately 35 years.

The LWA required that a transportation study be performed comparing the shipment of TRU waste to the WIPP both by truck and by rail. In response to this requirement, the DOE issued a report in 1994 entitled *Comparative Study of Waste Isolation Pilot Plant (WIPP) Transportation Alternatives* (DOE 1994). The baseline for that report was the WIPP transportation study that was part of the final *Supplemental Environmental Impact Statement for WIPP* (DOE 1990). The analyses presented in the 1994 report demonstrated that while DOE could safely transport TRU waste to the WIPP, the study should not be utilized as the sole basis for selecting a transportation option. The report also indicated that DOE was committed to further study of the WIPP transportation system and that additional analyses would be presented as they became available.

In 1997, DOE directed Argonne National Laboratory-East (ANL-E) to prepare a revised transportation report utilizing the Laboratory's demonstrated expertise in transportation risk and cost analysis. The scope of the revised report (DOE 1998) was to take a new, updated look at the comparative risks and costs associated with the transportation of TRU waste as part of the evolving process of selecting a transportation method, or combination of methods, for the shipment of waste to the WIPP. The report focused specifically on the risks and costs associated with transporting TRU waste to the WIPP. The report incorporated DOE waste management programmatic developments since the 1994 transportation report (DOE 1994) and normal economic changes that had taken place in the transportation industry (truck and rail) since that time. The report also explored, in greater detail than the 1994 report, possible routes for the rail option with regard to both regular and dedicated trains. The planning basis for this newer report was to be the most current revision of the *National Transuranic Waste Management Plan* (NTWMP) (DOE 1997a). The NTWMP reflects the latest information on TRU waste inventories, number of projected shipments, and other factors, and it is integrated into waste management planning at the DOE Headquarters level.

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This paper summarizes the results of the revised report, which was completed in September 1998 and is entitled *WIPP Transportation Assessment Update — Comparative Cost and Risk Assessments* (DOE 1998). The details on the analytical approach, as well as the supporting data, are contained in the report itself and are not included in this paper. The 1998 report focused on the 10 large-quantity sites. DOE subsequently requested an addendum to the report that will provide a comparative assessment of the risks and costs for transporting TRU waste from the 13 small-quantity sites to the WIPP. While analysis of the small-quantity sites has not yet been completed, preliminary results suggest that the total risks and costs from these sites constitute a small percentage compared with those from the large-quantity sites.

TRANSPORTATION OPTIONS

Table 1 shows the 10 large-quantity sites and their respective volumes of TRU waste. TRU waste shipments by truck will use the currently projected routes shown in Figure 1. These routes benefit from the newer transportation corridors developed by DOE since the 1994 report and have been coordinated with various oversight groups such as the Western Governors Association and the Southern States Energy Board. In the 1998 report, Argonne researchers developed representative rail routes with a computer-based rail routing model. The rail routes for the 10 large-quantity sites are shown in Figure 2. The rail routes are considered representative because they have not yet been selected or planned by the DOE. They do, however, provide a rational basis for comparing the impacts and costs of transporting TRU waste by rail relative to those of the truck option. The rail-related costs pertain only to the shipment costs and do not include such programmatic costs as establishing the rail transportation corridors and the emergency response planning and training costs along these corridors.

Table 1 TRU Waste Storage Locations and Volumes (m^3)

		Contact-Handled TRU Waste		Remote-Handled TRU Waste	
Site	Location	Stored[a]	Projected through 2033[b]	Stored[a]	Projected through 2033[b]
Argonne National Laboratory-East	Argonne, IL	94	109	0	0
Hanford Reservation	Richland, WA	16,127	7,305	200	1,582
Idaho National Engineering and Environmental Laboratory	Idaho Falls, ID	64,575	15,009	86	53
Lawrence Livermore National Laboratory	Livermore, CA	297	835	0	0
Los Alamos National Laboratory	Los Alamos, NM	8,255	8,544	101	128
Mound Plant	Miamisburg, OH	241	6	0	0
Nevada Test Site	Nevada	618	19	0	0
Oak Ridge National Laboratory	Oak Ridge, TN	917	180	1,268	100
Rocky Flats Environmental Technology Site	Golden, CO	1,505	6,988	0	0
Savannah River Site	Aiken, SC	11,725	17,811	1	21

[a] Volumes prior to treatment and repackaging.

[b] Projected volumes include estimates from environmental restoration, decontamination and decommissioning, and future DOE missions, for example, the disposition of weapons-useable plutonium at the Savannah River Site.

Source: DOE (1997a).

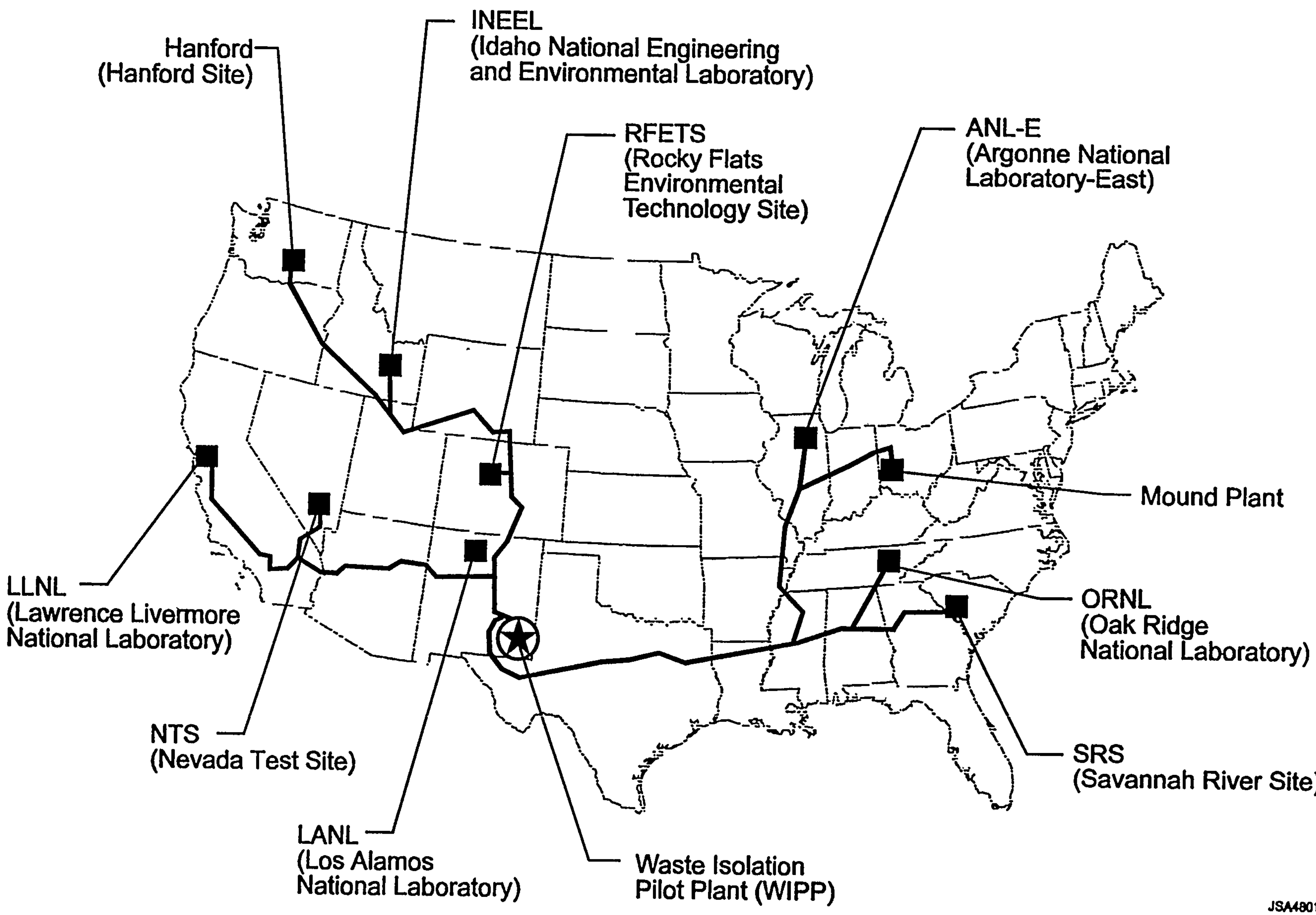

FIGURE 1 Routes for Truck Options

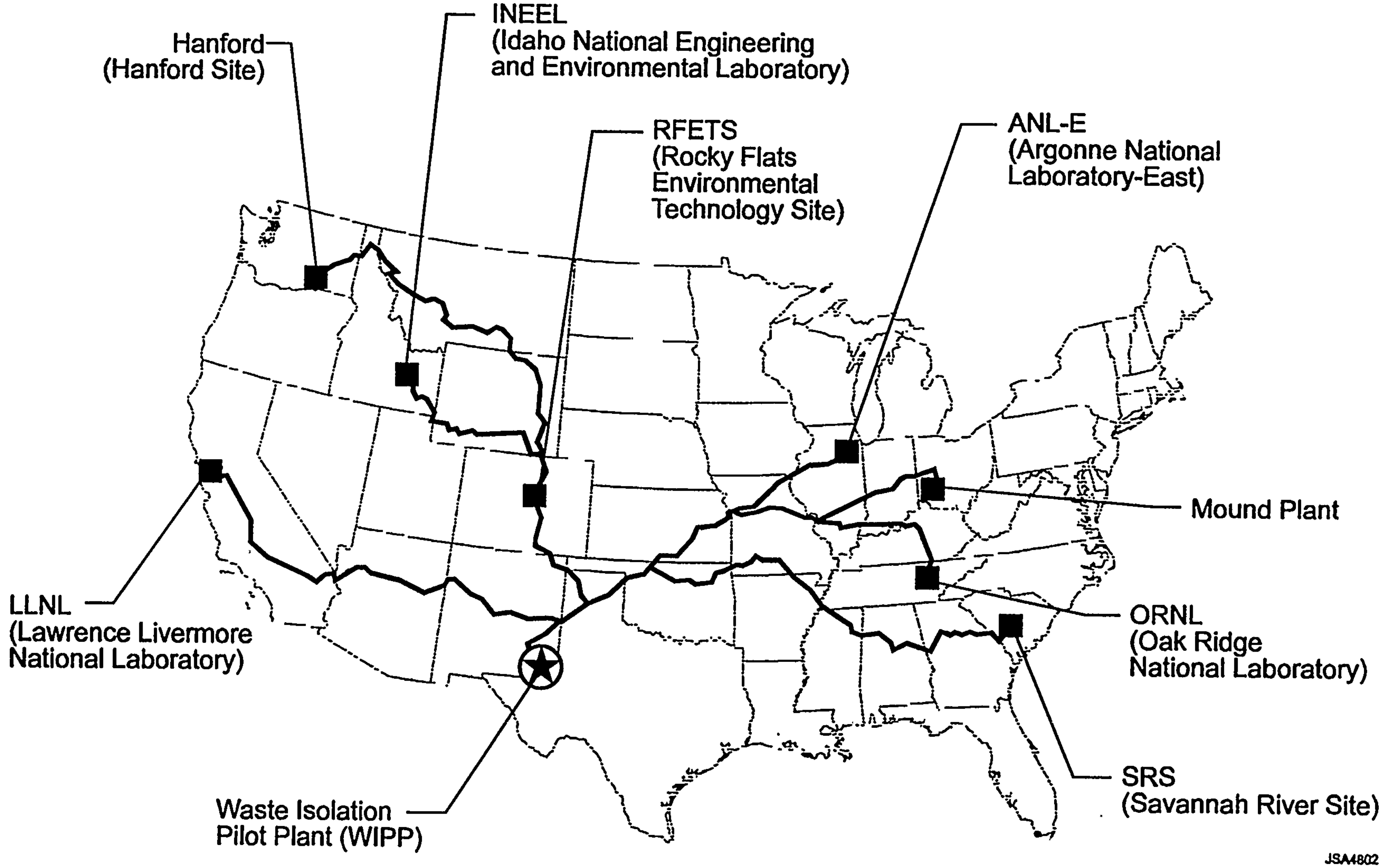

FIGURE 2 Representative Routes for Train Options

The following transportation options were evaluated as bounding the transportation options currently available to DOE:

- Truck shipments, with each shipment consisting of a tractor and trailer and carrying up to three TRUPACT-II casks for contact-handled (CH) TRU waste or one RH-72B cask for remote-handled (RH) TRU waste.

- Regular commercial train shipments consisting of up to three railcars containing up to six TRUPACT-II casks or two RH-72B casks per railcar on a train carrying general freight. Buffer cars are placed in front of and behind the cars containing the TRU waste.

- Dedicated train shipments configured similar to the regular train shipments except that the train carries only the TRU waste, the buffer cars, and, a caboose or passenger car carrying emergency response personnel.

Neither Los Alamos National Laboratory (LANL) nor the Nevada Test Site (NTS) has easily accessible rail facilities; therefore, the TRU waste from these two sites would be shipped by truck, even under the two rail options.

The number of shipments to the WIPP for the disposal period was taken from the NTWMP (DOE 1997a). The overall number of shipments from the 10 large-quantity sites decreased from that given in the 1994 transportation report (DOE 1994). This is primarily because of the refinement in the waste inventory data shown in the NTWMP compared with the data that formed the basis of the 1994 report. A total of approximately 18,223 and 5,000 CH- and RH-TRU waste shipments, respectively, are anticipated by truck. Under the rail options, a total of approximately 10,214 and 2,629 railcar shipments of CH- and RH-TRU waste, respectively, would be expected.

ESTIMATION OF COMPARATIVE OCCUPATIONAL AND PUBLIC IMPACTS

The TRU waste at the generator and storage sites contains a small component of hazardous chemical waste. The chemical risks, however, from this TRU waste during intersite transportation have been previously assessed in *the Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement* (DOE 1997b) and have been found to be negligible. Consequently, chemical risks associated with transporting TRU waste were not considered further in the 1998 report (DOE 1998).

The impacts to human health from both vehicle- and cargo-related causes were assessed for crew members and members of the general public. Occupational and public risks and exposures were evaluated as follows:

- *Radiological health impacts* — Radiological risks from potential exposure to radiation during routine (incident-free) transportation and to radioactive material released during potential accidents for occupational workers and members of the general public.

- *Nonradiological health impacts* — Nonradiological risks for transport vehicle emissions and for injuries and fatalities resulting from accidents as a direct result of physical trauma.

Table 2 is a summary of the total radiological incident-free transportation impacts for the disposal phase. The total dose values and latent cancer fatalities (LCFs) shown include the nonoccupational and occupational doses for the general public and transportation crews.

Approximately 1.5 million members of the general public live or work along these shipment routes. On average, an exposed member of the public could be expected to receive a dose of approximately 0.0032 rem or less if the same 1.5 million people were present along the routes for the entire 35-year shipping campaign. This estimate is based on the total nonoccupational public dose of 4,900 person-rem for truck shipments out of the total dose of 7,600 person-rem for the public and the crews combined. Such a dose is 100 times *less* than the annual average dose of approximately 0.360 rem in background radiation that an individual normally receives from natural and man-made sources. This projected population dose of 4,900 person-rem would have the potential of causing two LCFs in the general public (out of the total of three LCFs shown in Table 2) for the entire shipping campaign. For perspective, in a population of 1.5 million, approximately 350,000 people would be expected to die from cancer resulting from all causes.

The total potential radiological impacts from postulated transportation accidents are summarized in Table 3. The highest collective population dose risk (11 person-rem) is associated with truck shipments of CH-TRU waste. This dose, however, is several orders of magnitude lower than the incident-free population doses shown in Table 2. The lower radiological accident risk is a result of the protection afforded by the Type B containers (i.e., the TRUPACT-II cask and the RH-72B cask) and the low probability of severe accidents capable of breaching those containers. Although a severe radiological accident is not expected during the disposal phase, no acute fatalities to the public would be expected even if a severe accident involving the most hazardous CH- and RH-TRU wastes should occur.

Table 4 summarizes the total nonradiological transportation impacts. The total vehicle-related impacts summarized in the table consider both CH- and RH-TRU waste shipments. These impacts refer to the potential for fatalities resulting from vehicle emissions and for transportation accidents that result in injuries and/or fatalities resulting from physical trauma. These impacts are not related to the cargo in the shipment. They are inherent in the transportation options considered and would be expected even if the transport vehicle was empty but had to make the number of shipments predicted over the disposal phase. The total impacts shown in Table 4 for the *entire* shipping campaign for truck or rail shipments are approximately 0.1% of the *annual* national average impacts for each mode of transport. The accident impacts for truck transport are slightly higher than those for rail transport, primarily because of the greater number of truck shipments involved.

Table 2 Total Radiological, Incident-Free, Transportation Impacts for 1998–2033

	Public and Transportation Crew	
Transportation Mode	Dose (person-rem)	Latent Cancer Fatalities
Truck	7,600	3
Regular train	1,450	0.7
Dedicated train	670	0.3

Table 3 Total Radiological Accident Transportation Impacts for 1998–2033

Transportation Mode	Cumulative Dose Risk (person-rem)	Latent Cancer Fatalities
Truck	11	0.005
Regular train	0.46	0.0002
Dedicated train	0.46	0.0002

Table 4 Total Nonradiological Transportation Impacts for 1998–2033

Transportation Mode	Fatalities From Vehicle Emissions	Accidents	
		Injuries	Fatalities
Truck	0.1	31	3.5
Regular train	0.09	31	1.5
Dedicated train	0.09	31	1.5

A comparison of Tables 2, 3, and 4 yielded several noteworthy observations. Predicted LCFs from incident-free radiological impacts are higher for the truck option than for the rail options because of the greater number of truck shipments and the closer proximity of the truck shipments to the public and workers. Incident-free radiological impacts are more than 100 times greater than the radiological accident impacts. However, the dominant impacts for all three transportation options are the nonradiological impacts, which result simply from transporting cargo regardless of its contents. As noted above, these nonradiological impacts for shipping TRU waste represent only a small fraction of the annual national average impacts for each mode of transport. The overall impacts for the truck option are slightly higher (because of the greater number of shipments involved) than for either rail option; however, the difference is within the range of uncertainty involved in computing the risks for each option. Thus, from an impact perspective, neither the truck nor the rail option has a clear advantage over the other.

ESTIMATION OF COMPARATIVE COSTS

Comparative costs for transporting TRU waste to the WIPP for the disposal phase (1998–2033) were also estimated. These costs include the loading costs at each site of origin and the unloading costs at the WIPP. Unloading costs do not include the cost of emplacing waste into the repository itself (i.e., a waste disposal fee), which will be a programmatic operating cost borne by the Carlsbad Area Office. Truck transportation costs are reported for LANL and NTS as part of the train options, and additional loading and unloading intermodal costs are included in the train-option estimates for ANL-E, Lawrence Livermore National Laboratory (LLNL), and Oak Ridge National Laboratory (ORNL). These adjustments account for the fact that neither LANL nor NTS have rail spurs within a reasonable distance of the site and that ANL-E, LLNL, and ORNL, while not having rail spurs on-site, have rail spurs within a reasonable distance from the site. Costs are reported in 1998 dollars.

Table 5 Summary of Impacts and Costs for the Disposal Phase for 1998–2033

Transportation Option	Injuries/Fatalities	Cost (million $)
Truck	31/3.5	393
Regular train	31/1.5	494
Dedicated train	31/1.5	829

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