REAL DATA FOR REAL ROUTES

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ABSTRACT

Over the last 25 years, methods used to estimate impacts of transporting radioactive materials have improved markedly. Early methods used expert judgment to estimate many of the parameters used in analyses. In addition, because the ability to collect and analyze large amounts of data was constrained by relatively unsophisticated computing technology, analysts in the 1970s and 1980s used characteristics of the transportation environment that have been described as "generic." For example, analysts selected for their analyses route characteristics based on the average characteristics of all routes that might be used. In this regard, the earliest work used national average accident rates to estimate the frequency of transportation accidents that shipments might be involved in, national average travel speeds, and other data that were also averages over the length of a route.

The *Draft Environmental Impact Statement for a Nuclear Waste Repository at Yucca Mountain, Nye County, Nevada* (DEIS) (DOE 1999) estimated impacts from transporting spent nuclear fuel (SNF) and high-level radioactive waste (HLW) from 77 U.S. locations to the Yucca Mountain repository in Nevada. The analysis, which included 10 transportation-implementing alternatives in Nevada (5 rail and 5 heavy-haul truck), used route-specific data to estimate transportation impacts. Examples of route-specific data used include:

1. Origin-specific, real highway and rail routes to Yucca Mountain
2. State-specific accident and fatality rate data.
3. State-specific food transfer factors to estimate ingestion doses.
4. State-specific population density data
5. Population data for the top 20 urbanized areas in the United States

INTRODUCTION

Beginning with estimates of transportation risk presented in NRC's *Final Environmental Impact Statement on the Transportation of Radioactive Material by Air and Other Modes* (NUREG-0170, NRC 1977) and continuing with present-day environmental documents that evaluate risks of transporting radioactive materials, critics have argued that impacts are underrepresented because they are not based on route-specific data. In his 1983 book *The Next Nuclear Gamble*, Dr. Marvin Resnikoff voiced concern that (1) packaging test criteria did not reflect realistic accident conditions, (2) industry did not always follow safety procedures, (3) localities could not exercise sufficient control over routing, and (4) the consequences of an accident could be far more severe than government and industry reports indicated (Resnikoff 1983). In 1999, at a public meeting in Henderson, Nevada, on the Nuclear Regulatory Commission's planned Packaging Performance Study, Robert Halsted, speaking for the Nevada Nuclear Waste Project Office, commented that the "Modal Study Update" should develop a bounding approach to accident probability that considers state-specific data, route-specific data, a range of statistical measures to reflect year-to-year variations, and actual accident/incident rates for historical SNF shipments (Halsted 1999). In June

2001, Mr. Halsted commented to the Governor and Legislature of the State of Nevada "[n]one of DOE's risk assessments consider unique local conditions along specific route segments that could increase the probability or consequences of severe accidents" (Halsted 2001).

The challenge is clear: provide route-specific analysis of transportation risk that considers unique local conditions along specific route segments. However, the focus of this challenge has been more on radiological consequences of the most severe accidents that could occur rather than on the total risks of all possible transportation accidents. As shown in Table 1, radiological accident risks are the smallest of the impact measures reported in the Yucca Mountain DEIS (DOE 1999); estimated nonradiological traffic fatalities are much greater, and the radiological consequences of the maximum reasonably foreseeable accident that was analyzed for rail transportation are the greatest. This is because only the most severe accidents could lead to significant levels of radiation exposure to members of the public and because accidents of such severity are extremely unlikely to occur.

Table 1. Risks of transporting SNF and HLW to a Yucca Mountain repository

Impact[a]	Mostly legal-weight truck	Mostly rail
Incident-free transportation		
Radiological (person-rem/LCF)		
Public	35,000/18	5,000/2.5
Workers	25,000/10	2,300/0.9
Nonradiological (health effect fatalities)	0.6	0.3
Transportation accident risk		
Radiological (person-rem/LCF)	134/0.07	47/0.024
Nonradiological (traffic fatalities)	4	4
Consequences of maximum reasonably foreseeable accident (person-rem/LCF)	9,400/5	61,000/31

a. Impacts are estimates for transporting 70,000 metric tons of SNF and HLW.

USING ROUTE-SPECIFIC DATA TO IMPROVE ESTIMATES OF RADIOLOGICAL ACCIDENT RISK

Taking the factors one at a time, we address the issue of how, and whether, route-specific analysis could improve the estimates of radiological accident risk to the public and also improve the estimates of consequences of severe accidents in communities. Here, we define radiological accident risk as the product of the radiological consequences of an accident of a particular severity and the frequency that we would expect the severe accident to occur. When we add up the products of consequences and frequency of occurrence for all of the different kinds of severe accidents that could occur on a particular section of highway or railroad, we call this the radiological accident risk for that particular section of route.

To estimate the frequency of occurrence of an accident on a particular segment of route, the ideal would be to use historical accident data for the route and for the mode of transportation on that route. The Yucca Mountain DEIS (DOE 1999) approach to this ideal was first to use state-specific accident and fatality rate data compiled for railroads and interstate heavy-combination trucks from U.S. Department of Transportation data (DOT) sources (Saricks and Tompkins 1999). The analysis also used distances shipments were projected to travel on specific highway and rail routes through states. The routes for the analysis (see Figures 1 and 2) were selected using the HIGHWAY

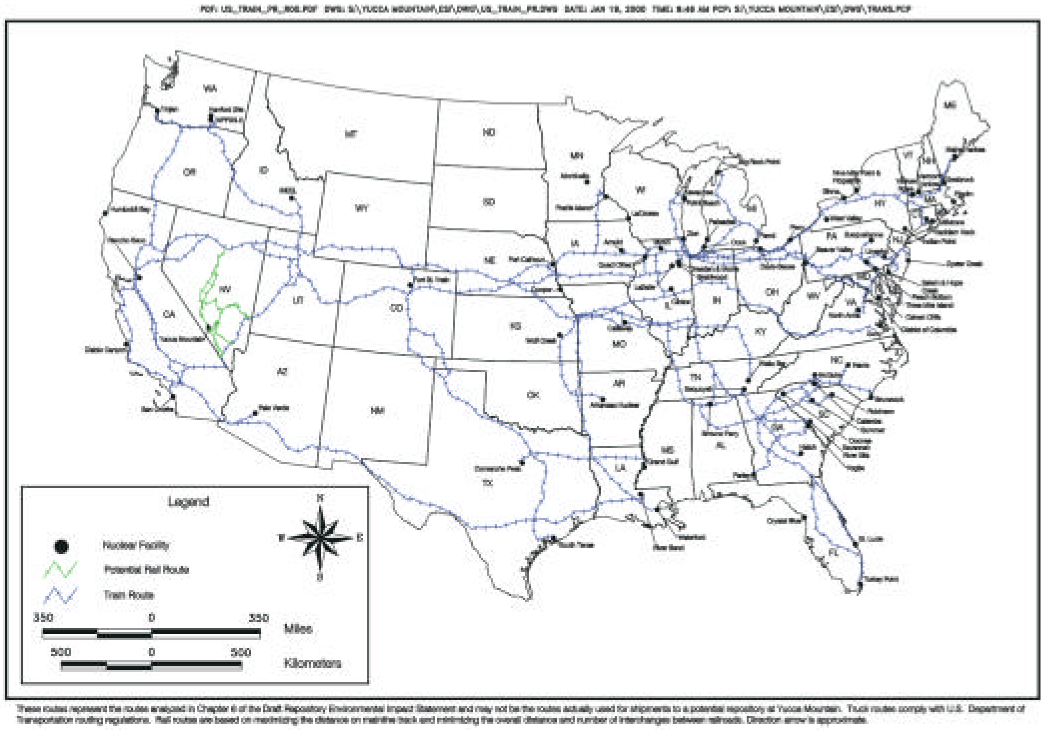

Figure 1. Potential train routes for shipping SNF and HLW to a Yucca Mountain repository.

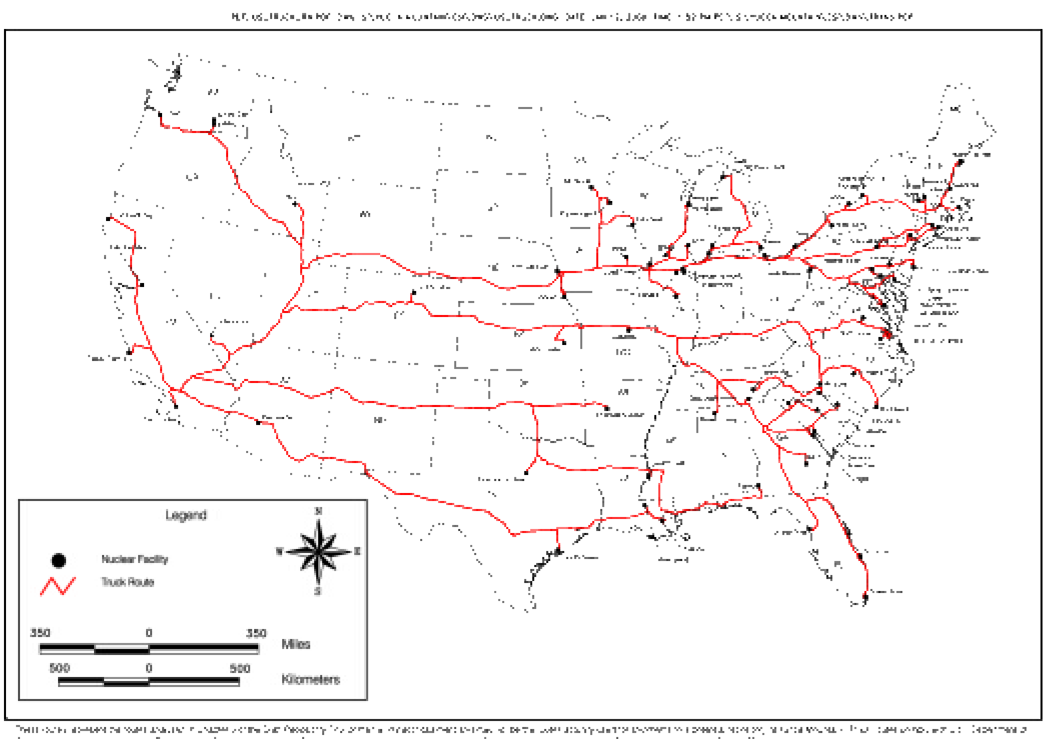

Figure 2. Potential truck routes for transporting SNF and HLW to a Yucca Mountain repository

(Johnson et al. 1993a) and INTERLINE (Johnson et al. 1993b) computer programs and routing assumptions based on DOT regulations and historic rail industry practices.

Accident rate data for individual highways in states or for segments of highways are not available from a source that is consistent for all states and therefore were not collected. In fact, data provided to DOT by some states are insufficient to determine rates for highway types (interstate, primary highway, other roads and highways) and therefore are sufficient only to estimate average rates for all highways in a state. Saricks and Tompkins (1999) report that "[s]everal states either do not furnish location-specific information (rendering assignment to highway type impossible) or provide it in a coded manner unintelligible to the general user."

Nonetheless, in 1993 state law enforcement organizations began reporting motor carrier accidents to the DOT SAFETYNET System (Saricks and Tompkins, 1999) using a uniform reporting system recommended by the National Governors Association. Rail accidents and fatalities by state are compiled by the Federal Railroad Administration's *Accident/Incident Bulletin*, also using standardized criteria for reportable rail accidents. Such standardized reporting of accidents, coupled with commodity flow information from the Bureau of Transportation Statistics and Association of American Railroads, permits accident and fatality rates for each state to be determined. For highway transportation, the data are sufficient to permit estimating rates for accidents and fatalities for the three highway types: interstate, primary, and other roads and highways.

Because state-specific rate data used in the Yucca Mountain DEIS analysis are based on actual accident counts and commodity flow survey data that collect all commerce for a state, risk estimates using the data can be expected to encompass the risks in affected locales in the state. The available data are not sufficient to consistently estimate accident rates in every individual locale along specific segments of highway or railroad that might be used by shipments. Nonetheless, even though risks associated with a specific hazard of a particular section of interstate near a community may not be explicitly analyzed, the fact that all hazards along the route are encompassed by the analysis helps ensure that impacts unique to the community are addressed. In fact, because a local impact cannot be greater than the sum of all local impacts, impacts in a community along a route through a state would be smaller than the estimated total impacts for the state. Thus, the need to determine individual local data is less important if the overall risk for a state, and thus for all of the communities in the state, is found to be low. As shown in Table 2, estimated impacts that would occur in the State of Nevada from transporting 70,000 metric tons of SNF and HLW would be small. For this reason, the impacts in communities along the transportation routes in Nevada would also be small.

The exception to this would be if the proportions of accidents in locations along routes were not the same as the proportions of flows of commodities (traffic) in the same locations. For example, if more accidents occurred on low-use highways in a state than on high-use highways, the use of state average statistics would underestimate accident rates on the low-use highways and overestimate rates for high-use highways. This potential shortcoming in using aggregate data is the fundamental basis for Robert Halsted's argument that analysis of impacts "should develop a bounding approach to accident probability which considers: state specific data [and] route specific data."

Table 2. Risks in Nevada of transporting SNF and HLW to a Yucca Mountain repository

Impact[a]	Mostly legal-weight truck	Mostly rail	
		Heavy-haul trucks	Branch rail line
Incident-free transportation			
Radiological (person-rem/LCF)			
Public	2,800/1.4	1,040/0.4	430/0.2
Workers	1,600/0.63	1,600/0.8	470/0.2
Nonradiological (health effect fatalities)	0.005	0.005	0.01
Transportation accident risk			
Radiological (person-rem/LCF)	0.5/0.0003	0.72/0.0004	0.15/0.00008
Nonradiological (traffic fatalities)	0.5	0.7	0.2

a. Impacts are estimates for transporting 70,000 metric tons of SNF and HLW.

To address the issue, the Yucca Mountain DEIS analysis used information reduced by Saricks and Tompkins in two key ways. First, for highway transportation, the accident rates in states were estimated based on statistics for interstate transportation carriers who use interstate highways for their long-haul transportation. Second, the data were collected and reported separately for interstate, primary, and other highways in the state. Through this reduction of the data, the analysis provided accident and fatality rates that reflect what could be expected for interstate trucking of SNF from generator sites to a Yucca Mountain repository.

In contrast, a report for the City of North Las Vegas to analyze risks for populations along the planned North Las Vegas Beltway of transporting SNF to a Yucca Mountain repository (Louis Berger Group 2000) used a bounding approach and local data—an approach consistent with that recommended by Robert Halsted. The study, which used accident rate data for urban freeways obtained from the State of Nevada, stated that the accident rate on urban freeways in Nevada is 17 times that used for Nevada highways in the Yucca Mountain DEIS. However, the report did not acknowledge data submitted to DOE by the State, and reported in the Yucca Mountain DEIS, wherein the State reported an accident rate for interstate trucks on all Nevada highways that was 4 times, not 17 times, higher than the rate provided by Saricks and Tompkins (1999). The report also failed to review an analysis in the DEIS that estimated that the rate reported to DOE by Nevada was about 1.6 times higher than reported by Saricks and Tompkins when the State's accident reporting requirements were reconciled with DOT reporting requirements. Nonetheless, although the report used a high estimate for the accident rate and DOE's highest estimate for the number of legal-weight truck shipments that could be expected, it concluded that the risk of a release of radioactive materials in an accident on the 21-kilometer (13-mile)-long North Las Vegas Beltway would be small (Louis Berger Group, page 98)—a 1 in 90 chance over 24 years (page 58). This conclusion is not surprising when one reviews the overall accident risks for transportation in Nevada (Table 2).

USING COMMUNITY-SPECIFIC DATA TO IMPROVE ESTIMATES OF RADIOLOGICAL ACCIDENT RISK

In addition to his criticisms of DOE for failing to consider unique local hazard conditions in analyzing transportation risks, Robert Halsted has also criticized a failure to consider unique characteristics of populations in communities through which shipments would pass. He has mentioned special, so-called at-risk populations such as children in schools along routes, the elderly in nursing homes, and the infirm in hospitals. He has also identified specific places along routes where houses inhabited by real people are close to a highway that might be used for shipments. The thrust of the comments has been that an analysis of risks understates impacts if it does not specifically consider the members of society who are arguably most vulnerable or most at risk.

The Yucca Mountain DEIS used U.S. Census data to estimate the number of people in the general population who would live near the highway and rail routes that were selected for analysis. However, it was not possible or practical to identify each special population that would be in each of the thousands of Census blocks crossed by the routes analyzed. But, the use of Census data for populations along real routes selected for the analysis ensured that estimated impacts would be calculated for the health and safety of real people—not generic populations along generic routes. Because populations resident in care facilities for the elderly are included in Census data, the analysis includes the impacts to these populations. Furthermore, impacts to temporary occupants of schools and hospitals that would be near routes and whose temporary occupancy is not included in Census data are included in the analysis, because the analysis assumes that adults, children, and hospital patients are present in their homes when every shipment passes. Thus, while it is certain that the approach of using Census data to estimate the number of people who would be exposed to passing shipments leaves some uncounted, it is also certain that the analysis counts some who would not be affected. For the purpose of estimating health and safety risks to populations along routes, the approach provides reasonable estimates and does not exclude special populations.

The analysis in the Yucca Mountain DEIS also analyzed the consequences of maximum reasonably foreseeable transportation accidents. DOE guidance (DOE 2000) states that "risk should augment and not substitute for the presentations of both the probability of occurrence and the consequences of the accident." The guidance also observes that "[a]lthough such methods [probabilistic risk analysis] typically consider the full range of potential accident severity classes, including the most severe, these methods do not present consequences for a particular accident scenario that may be of interest, such as a maximum reasonably foreseeable accident." The guidance advises analysts to consider accidents in a specific location using an accident scenario postulated to have an estimated occurrence of 10^{-6} to 10^{-7} per year.

For estimating public health and safety consequences from severe transportation accidents, the Yucca Mountain DEIS used data from the U.S. Census for highly populated urban areas. We then assumed that an accident could occur in the center of such a populated area, because some of the real routes selected pass through parts of urban areas. We estimated the potential for a severe accident in an urban area using state-specific accident rate data (Saricks and Tompkins 1999), data from the Modal Study (Fischer et al. 1987) that describes the distribution of severe accidents, and the number of kilometers that shipments were estimated to travel through urban areas. The analysis then assumed that evacuation or other likely actions to mitigate potential health and safety consequences would not occur. Even though responsible actions would ensure that such situations did not occur, this assumption is the same as assuming school children would not be evacuated to safety, that they would not be sheltered in their schools, or that the elderly in care homes or persons in hospitals would not be sheltered, or evacuated if necessary. For the severe rail cask accident analyzed, we estimated its likelihood of occurring in an urban area to be on the order of twice in

10 million years. We estimated that 31 latent cancer fatalities could result in an affected urban population if this accident occurred and if there were no evacuation or other mitigation. More severe accidents with greater consequences would not be reasonably foreseeable.

It has been said that the focus of attention on accidents in urban areas ignores the greater likelihood of an accident in rural areas along routes. In comments at public hearings, citizens from small communities have expressed concern for the potential consequences of an accident in their communities and therefore expressed the need to know what routes would be used. Special concern has been expressed that small communities do not have the resources to respond to a severe transportation accident and that a lack of effective response would make consequences greater. The State of Nevada has argued that each community along the routes that would be used to ship SNF and HLW is at risk of a catastrophic accident without ability to respond.

However, the analysis of maximum reasonably foreseeable accidents in urban areas provides evidence that significant health and safety consequences would not occur if an accident occurred in a small community. In fact, the low population density in rural areas, which have population densities 500 times less than highly urbanized areas, suggests that no latent cancer fatalities would be expected to occur in such an area following a maximum reasonably foreseeable rail accident. Nonetheless, in its proposed policy and procedures for implementing Section 180(c) of the Nuclear Waste Policy Act (Federal Register 1998), DOE commits to provide technical assistance and funding to train officials of state, tribal, and local governments through whose jurisdictions routes would pass in procedures for safe routine transportation and emergency response. Furthermore, state and DOE emergency response resources, if requested, would be quickly dispatched to an accident scene and would work with local officials to limit any impacts that might occur. The emergency response resources would be immediately aware of an accident because shipments would be tracked by satellite.

CONCLUSIONS

The analysis approach employed in the *Draft Environmental Impact Statement for a Nuclear Waste Repository at Yucca Mountain, Nye County, Nevada* to estimate impacts of transporting 70,000 metric tons of SNF and HLW from 77 generator sites is a route-specific analysis that evaluated impacts along real routes. The analysis used the best available information to estimate the radiological and nonradiological impacts that could occur in each state along the routes. The results of the analyses provide substantial information that is useful for evaluating impacts that could occur in communities along potential highway and rail routes. Furthermore, the information provides strong evidence that the radiological risks of incident-free transportation and accidents would be low for every community along potential routes and for special populations that reside in those communities. The consequences of severe transportation accidents that might occur are based on route-specific analyses and encompass consequences that could be expected for such accidents in any community along the potential routes.

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