

Walk the Line: The Development of Route Selection Standards for Spent Nuclear Fuel and High-level Radioactive Waste in the United States - 13519

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ABSTRACT

Although storage facilities for spent nuclear fuel (SNF) and high-level radioactive waste (HLRW) are widely dispersed throughout the United States, these materials are also relatively concentrated in terms of geographic area. That is, the impacts of storage occur in a very small geographic space. Once shipments begin to a national repository or centralized interim storage facility, the impacts of SNF and HLRW will become more geographically distributed, more publicly visible, and almost certainly more contentious. The selection of shipping routes will likely be a major source of controversy.

This paper describes the development of procedures, regulations, and standards for the selection of routes used to ship spent nuclear fuel and high-level radioactive waste in the United States. The paper begins by reviewing the circumstances around the development of HM-164 routing guidelines. The paper discusses the significance of *New York City versus the Department of Transportation* and application of HM-164. The paper describes the methods used to implement those regulations. The paper will also describe the current HM-164 designated routes and will provide a summary data analysis of their characteristics. This analysis will reveal the relatively small spatial scale of the effects of HM 164.

The paper will then describe subsequent developments that have affected route selection for these materials. These developments include the use of “representative routes” found in the Department of Energy (DOE) 2008 Supplemental Environmental Impact Statement for the formerly proposed Yucca Mountain geologic repository. The paper will describe recommendations related to route selection found in the National Academy of Sciences 2006 report Going the Distance, as well as recommendations found in the 2012 Final Report of the Blue Ribbon Commission on America's Nuclear Future. The paper will examine recently promulgated federal regulations (HM-232) for selection of rail routes for hazardous materials transport. The paper concludes that while the HM 164 regime is sufficient for certain applications, it does not provide an adequate basis for a national plan to ship spent nuclear fuel and high-level radioactive waste to centralized storage and disposal facilities over a period of 30 to 50 years.

INTRODUCTION

Transporting radioactive materials has created tensions between State and Federal Governments. The first regulations related to route selection for highway shipments resulted in a court case, *New York City v. United States Department of Transportation* 1983, in which the Federal regulations were challenged and upheld. That controversy led to three decades of policy discussions about route selection for spent nuclear fuel (SNF) and high-level radioactive waste (HLRW) shipments.

DEVELOPMENT OF ROUTING GUIDELINES

In the late 1970's, the nuclear power industry was beset by a series of crises. The Three Mile Island accident disrupted plans for a major national expansion of nuclear generating capacity. The US nuclear fuel reprocessing plant at West Valley, New York had gone bankrupt, (Jacob, 1991), President Carter had signed a ban on nuclear fuel reprocessing (Baum, 1984), the "California Nuclear Laws" prohibited the construction of new nuclear power plants until the problem of spent fuel was solved (Jacob, 1991). Finally, many US cities passed ordinances prohibiting the transportation of radioactive materials through their jurisdictions (Rainey, 1986). These blanket prohibitions could prevent the further development of nuclear power and cripple the completion of many nuclear power plants.

If uranium fuel rods could not be transported to nuclear power plants, then the plants would have to close. If the spent nuclear fuel generated by the operation of the plants could not be shipped off-site, then the plants could not operate (Jacob, 1991). If public opposition to the transportation of radioactive materials remained high and could not be circumvented through the legal system, nuclear power had no future.

New York City v. the Department of Transportation

In the midst of these controversies, the City of New York amended its health code to restrict the movement of certain kinds of radioactive material through the city. One of the primary reasons for this change to the health code was ongoing shipments in and out of New York City's JFK airport. The quantities of these air shipments often exceeded 100 pounds of plutonium with activities in excess of 500,000 curies (Solon, 1984). Concern about these shipments prompted the change to the health code, but this change also effectively prohibited the transportation of high-level radioactive waste through New York City by highway. This affected operations of the high flux beam reactor at the Brookhaven National Laboratory on Long Island. There is no rail access to move spent nuclear fuel away from Brookhaven. The only two available modes of transportation were truck and barge.

Associated Universities Incorporated (AUI), a coalition of Brookhaven facility users, applied to the Department of Transportation for an "inconsistency" determination. A determination of this type would declare the City of New York's action preempted because it conflicted with the provisions Federal law, especially the Hazardous Materials Transportation Act (HMTA) (Solon, 1984). The DOT decided that the New York health code amendment was not preempted because the Secretary of Transportation had not exercised the authority-granted in HMTA to make rules for designating hazardous materials routes. However, the conflict prompted the DOT to begin the

rulemaking process that culminated in HM-164 (Rainey, 1986). The timeline of events is below:

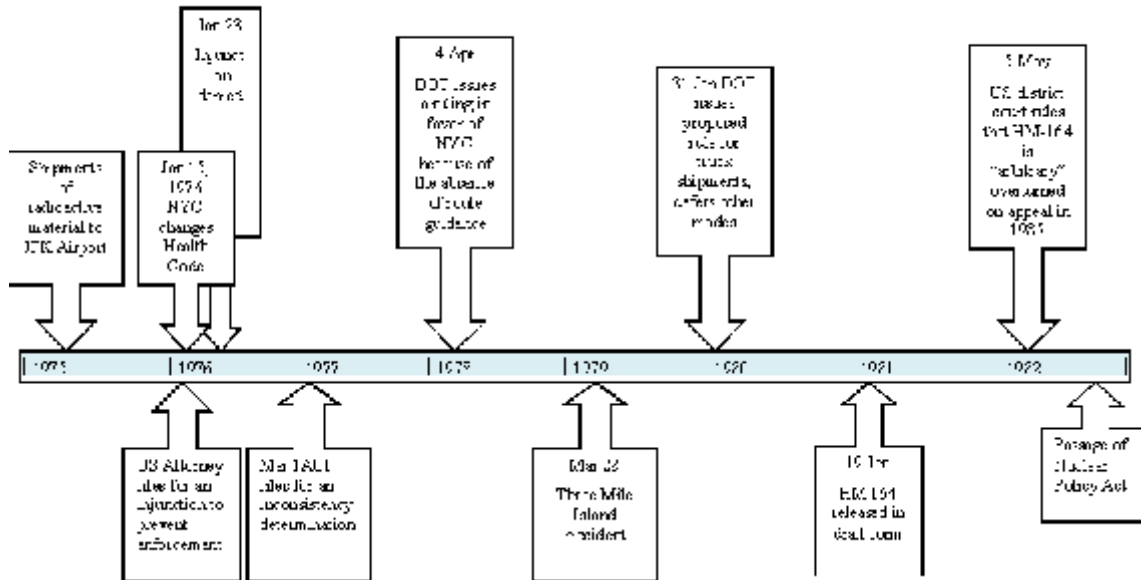


Figure 1 Timeline of litigation

The HM-164 rules applied only to truck transportation. The absence of any alternative mode (i.e. barge) meant that spent fuel would travel by truck through mid-town Manhattan. Figure 1 depicts the routes used through New York City (Resnikoff, 1983).

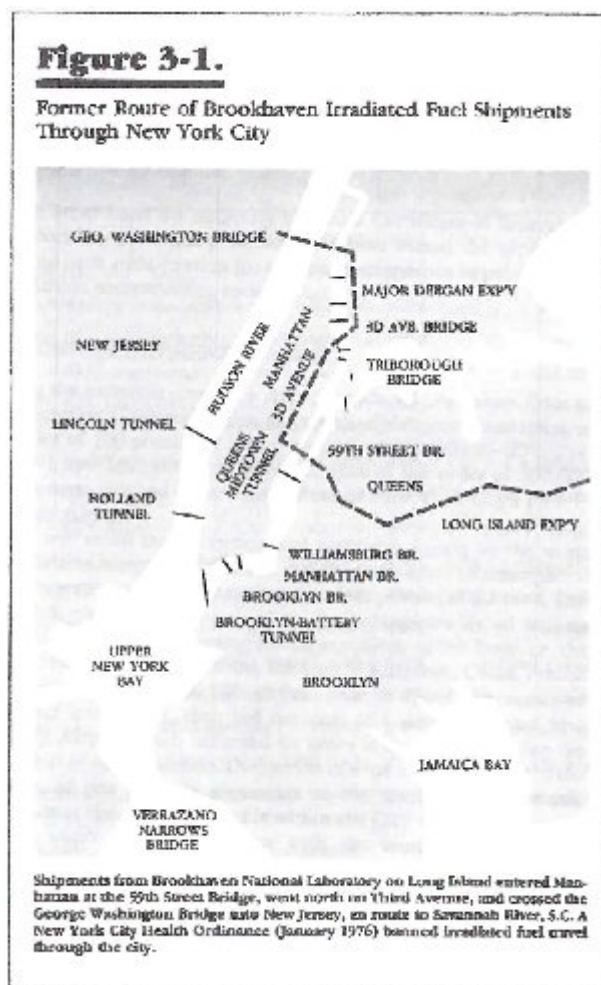


Figure 2 former route of Brookhaven irradiated fuel shipments through New York City

In comments to the DOT's Environmental Assessment (EA) of the transportation program, the City highlighted barge shipments as a safer, less risky alternative to truck transportation (Rainey, 1986). The DOT responded that HMTA allowed the Secretary of Transportation to set allowable safety levels for each mode of transportation and that HMTA did not require risk comparisons between the modes. As a practical matter, the DOT argued that the truck HM-164 rules were the only immediate response possible by the DOT.

HMTA includes a "non-preemption" procedure that allows states, which are in the best position to know the safest local routes, to supplement the preferred route system, the interstate highway system, with better alternative routes. The City argued that the HMTA non-preemption process was not realistic for New York City because all of the available roads traveled through downtown New York City. There was no better alternative road choice. The DOT acknowledged in its EA that an alternative road could probably not be found under the HMTA non-preemption process. The City argued that the only way to reduce the risk of a catastrophic accident was to use a different mode-barge (Rainey, 1986).

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The DOT relied exclusively on two documents: NUREG 0170 (Office of Standards Development, Nuclear Regulatory Commission, 1977) and Transportation of Radionuclides in Urban Environs: Draft Environmental Assessment 73, by Sandia National Laboratory, in order to make an informed decision about whether or not HM-164 was “significant” under NEPA (Sandia National Laboratories, 1980). NUREG-0170 sought to quantify the risks of transporting radioactive materials by different modes. In fact, the study sought to do what the Circuit Court decided was unnecessary-it compared the risks of transporting radioactive materials between alternative modes of transportation. The Sandia Report was broader in scope and examined the problem of transporting radioactive waste through urban areas. Both reports are controversial and strong arguments can be made that DOT did not make an “informed” decision (Audin, 1993).

MILESTONES IN THE DEVELOPMENT OF ROUTE SELECTION

National Research Council (Green Book) 1984

The National Research Council (NRC) prepared a report on the social consequences of spent nuclear fuel disposal in 1984. The report, sometimes referred to as the “green book” because of the color of its cover, is strikingly prescient and demonstrates that the complexity and impacts of transporting these materials have been well understood since at least the 1980’s. The report contains a very powerful discussion and images that depict the concentration of impacts along particular routes P 52.

This network of [transportation] activities can be viewed as a “waste funnel” in which spent fuel from widely dispersed power plants is transported via waste corridors to one or more storage sites. The effects of this activity are thinly distributed at the network’s many origins at the outer range (i.e., the wide end) of the funnel but increase rapidly as the fuel moves toward depots, heavily traveled routes, and repositories at the mouth of the funnel.

HM-164 Application

The route selection process described in the Guidelines enables states to choose the “best” route by applying three criteria to each potential alternate route. The three criteria are:

- Normal radiation exposure factor
- Public health risk factor
- Economic consequences factor

The first criterion is the radiation exposure caused by the accident-free transportation of the waste containers on highways. None of the containers used to hold the waste can completely shield the truck driver or nearby motorists from some radiation exposure. The Guidelines argue that since the likelihood of an accident is small, normal radiation exposure is the most significant risk associated with the shipments. The second criterion is the public health risk from accidents. This benchmark measures the health effects of an accident which breeches the container holding the waste. In an accident, radioactive particles can spread in an airborne plume. The Guidelines assume that radioactivity will spread up to ten miles downwind from an accident and will contaminate an area of approximately 25 square miles.

The final criterion for selecting routes is the economic risk of transporting the waste. The economic risk is defined as the “cost of decontamination” for the buildings adjacent to the route. This factor provides an estimate of the total cost to decontaminate areas affected by radiation. This primary factor ignores any economic costs beyond decontamination costs. The Guidelines also designate three secondary factors that are optional and used when the primary factor do not produce a conclusive result. These factors are: emergency response effectiveness, evacuation capabilities, location of special facilities, and traffic fatalities and injuries unrelated to radioactive materials.

The route selection process contained in the Guidelines is performed in the following steps:

1. determine highway route that minimizes impacts
2. identify alternative highway routes available in consultation with affected jurisdictions
3. develop list of route comparison factors
4. evaluate route comparison factors for each alternative highway route
5. select route that best minimizes impacts based on evaluation of route comparison factors
6. document the entire routing analysis to serve as the basis for the routing decision.

In implementing HM-164, different states chose different strategies. For example, California and Ohio made comprehensive designations of large portions of their highway networks. They chose to require permits or reviews for large portions of their highway networks. Other states choose only to restrict very small portions of their networks

Current Status of HM164

The Federal Motor Carrier Safety Administration (FMCSA) maintains a registry of the HM164 routes. There are three types of routes: restricted, preferred, and permit required. The map below highlights the different approaches to routing adopted by various states.

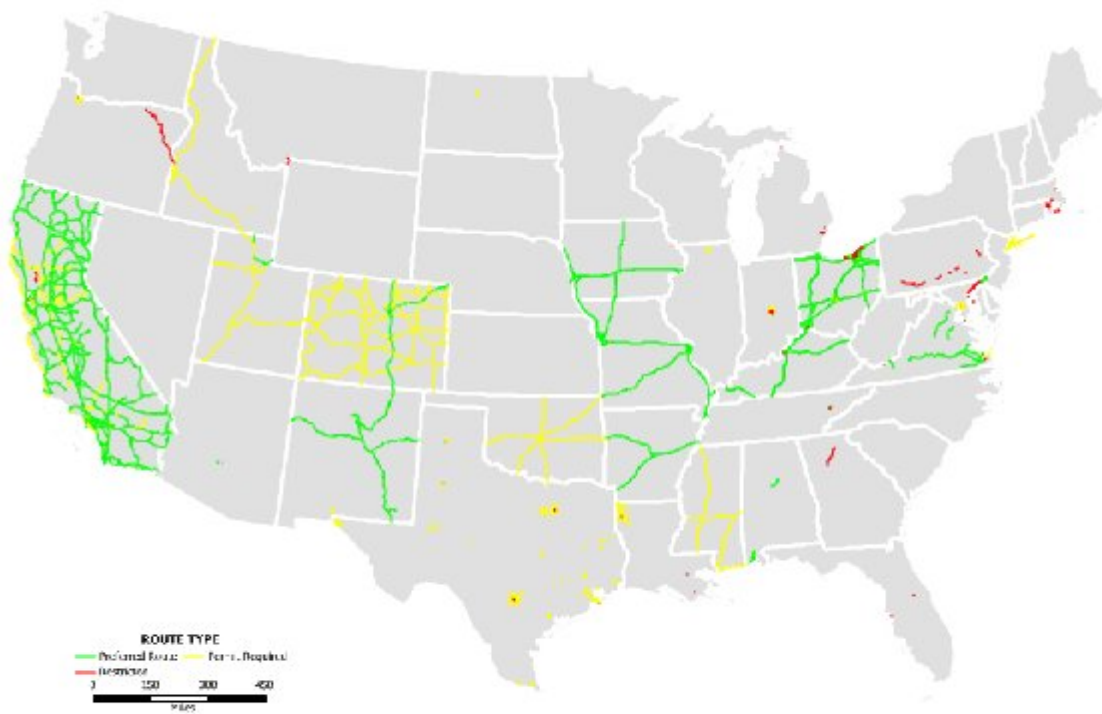


Figure 4 HM-164 Route designation status 2008

The map shows that states have taken different regulatory approaches to the problem of routing. The most recent listing of these routes results is from 2008. There are 42 states with route designations. Eleven states have statewide designations.

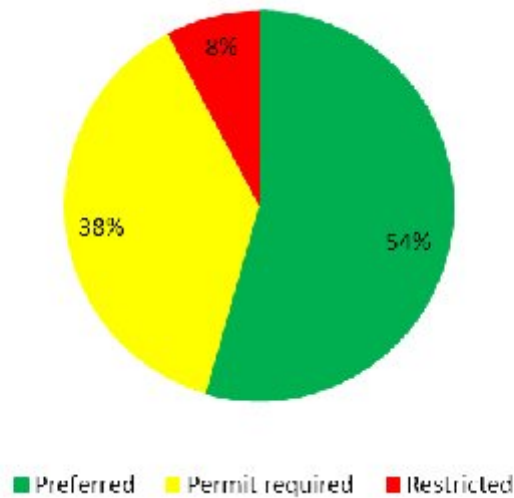


Figure 5 Percentage of HM164 route designations by length

The main shortcomings of HM164 are that the rules relate to only a single transportation mode, shipment by truck. There are no equivalent regulations for rail shipments, which became problematic when the Department of Energy's 1999 Draft Environmental Impact Statement (DEIS) for Yucca Mountain identified potential routes for mostly truck and mostly rail shipment scenarios. Secondly, HM-164 does not provide a method that makes it possible to distinguish between alternatives when population densities are high, or low. The New York City case provides a roadmap for legal challenge to HM-164. That will inevitably follow when a large-scale shipping campaign takes place.

WIEB Straw man (1988)

Although HM-164 remains largely unchanged since 1984, the issue of route selection has continued to provoke interest and discussion. In 1988, the Western Interstate Energy Board, expressing the desires of the Western Governor's Association proposed a recursive route selection methodology that would be suitable for spent nuclear fuel shipments. The method is illustrated below (Western Interstate Energy Board, 1988):

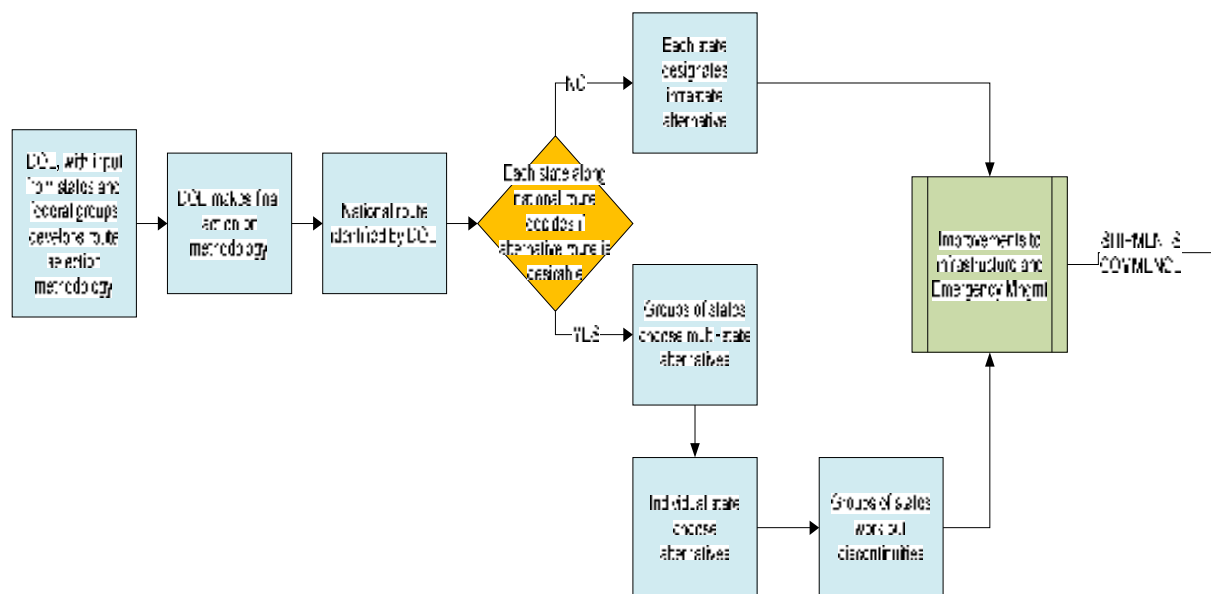


Figure 6 WIEB straw man process

Other regional organizations have also made efforts related to route designation selection. The NAS recommended a similar process in its report. They said: “DOE should identify and make public its suite of preferred highway and rail routes for transporting spent fuel and high-level waste to a federal repository” (National Academy of Sciences, 2006).

WIPP (1990’s)

The DOE began shipping transuranic wastes to the Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico in March 1999, and by the end of September 2011, more than 10,000 shipments had been completed (Franco, 2012). The successful transportation of transuranic wastes to the WIPP in New Mexico provides important lessons for national transportation of spent fuel and high-level waste. These lessons include the need for advance planning (particularly early selection of shipment routes), intergovernmental cooperation (especially DOE cooperative activities with state regional groups), extra-regulatory safety measures to prevent accidents, full-scale testing of transport packages, and sustained Federal funding to support law enforcement and emergency response activities.

Although most of the WIPP shipments have not been Highway Route Controlled Quantity (HRCQ) shipments as defined by the DOT regulations for highway routing, the DOE Carlsbad Field Office (DOE-CBFO) made a commitment before the commencement of shipments to use HRCQ guidelines in selecting routes, use state-designated alternative routes, and/or use routes selected through negotiations with the affected states. In the West, the States of California, Colorado, and New Mexico formally designated alternative routes, and the State of Nevada negotiated alternative routes with DOE-CBFO. From the standpoint of the states, this resulted in selection of routes which were safer and more acceptable to the public. In addition to reducing both radiological and non-radiological risks, this approach has allowed DOE to consolidate shipments on fewer routes, reducing the number of affected States and Indian tribes (Western

Governor's Association, 2008). The highway routes used for shipments to WIPP are shown in Figure 7 below.



Figure 7 Highway Routes for DOE Transuranic Waste Shipments to WIPP

As successful as it has been to date, the WIPP transportation planning model may not be fully applicable to spent fuel and high-level radioactive waste. Transuranic waste, even the remote-handled portion, is considerably less dangerous than spent nuclear fuel; the wastes shipped to WIPP are owned by DOE and shipped from sites managed by DOE; and to date, trucks have been used for all WIPP shipments. Additionally, public acceptance of WIPP shipments is influenced by attitudes towards national defense and environmental remediation of nuclear weapons facilities. However, the cooperative approach to selection of highway routes to WIPP has been highly successful, and should be considered in the planning for any future repository transportation planning.

Volpe Study (1998)

A study of spent fuel transportation risks was undertaken by the DOT's Volpe Center in 1998 (US DOT Volpe National Transportation Systems Center, 1998). This study was prepared at the behest of Congress to provide better information about dangers of shipping these materials. The study is important because it identified the primary factors for transporting spent fuel and then assessed their contribution to total risk through a sensitivity analysis. The risk factors are:

- General population exposed
- Occupational population exposed
- Shipment duration
- Accident rate
- Trip length

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- Sensitive environment
- Emergency response
- Amount of material

Any route selection process for future shipments will likely have to do the same thing.

DOE Environmental Impact Reports for Yucca Mountain (1986-2008)

The U.S. Department of Energy (DOE) and some potential repository host states began detailed transportation studies even before passage of the Nuclear Waste Policy Act (NWPA) in 1982. The NWPA created the DOE Office of Civilian Radioactive Waste Management (OCRWM), and directed OCRWM to begin planning for two geologic repositories, a monitored retrievable storage (MRS) facility and the associated transportation system. OCRWM contractors at Oak Ridge and Sandia National Laboratories had already begun developing transportation logistics and routing models for use in the environmental impact assessments (EAs) that DOE would be required to prepare under the site selection provisions of the NWPA.

OCRWM recognized the potential national significance of repository shipments in its 1986 Transportation Institutional Plan, and included mode and route specific transportation analyses in the 1986 Final EAs for Yucca Mountain and the other candidate sites for the first geologic repository. After the Nuclear Waste Policy Amendments Act (NWPAA) of 1987 directed OCRWM to plan for one repository only, located at Yucca Mountain in Nevada, OCRWM prepared mode and route specific transportation analyses for Yucca Mountain in a 1999 Draft Environmental Impact Statement (DEIS), a 2002 Final Environmental Impact Statement (FEIS), a 2007 Draft Supplemental Environmental Impact Statement (DSEIS), and a 2008 Final Supplemental Environmental Impact Statement (FSEIS) (Department of Energy, 1999).

The Yucca Mountain repository project is now terminated. However, the transportation analyses contained in the 2008 FSEIS for the Yucca Mountain project document the potential scope of route selection impacts for any future national repository or centralized interim storage facilities. Accepting OCRWM assumptions – one repository, no new reactors, license extensions for all operating reactors, a total spent nuclear fuel (SNF) and high-level radioactive waste (HLW) inventory of about 150,000 MTU, mostly rail (95 percent) transportation of commercial SNF, and all rail transportation of DOE SNF and HLW - there would likely be about 7,000 train shipments (3-5 casks per train) and 5,000 truck shipments (one cask per truck) over about 50 years. On an annual basis, there would about 100-150 train-load shipments and 100 truck shipments, compared to about 10-15 train-loads and 10-15 truck shipments per year currently. The number of rail shipments could be substantially reduced by use of larger capacity casks; the number of truck shipments could be four times greater if 20 percent of the inventory were to be moved by truck (Halstead & Dilger , 2011).

The routing analyses contained in the 2008 FSEIS further document the potential national scope of impacts for future spent fuel and nuclear waste shipment campaigns. An extraordinary number of people, communities, and political jurisdictions would have been impacted by shipments to Yucca Mountain. Most of the nation's spent fuel and high-level waste is currently stored at 76 sites in 34 states. The "representative routes" identified by DOE (shown in Figure 7),

from these sites to Yucca Mountain, would have traveled 22,000 miles of railways and 7,000 miles of highways, traversing 44 states, the District of Columbia, 33 Indian nations, and about 836 counties with a population of about 161 million (2005 Census estimates).



Figure 8 DOE FEIS Rail and Truck Routes

Between 10 and 12 million people live within one-half mile (800 meters) of these rail and highway routes. And these routes would have affected most of the nation's congressional districts (330 in the 110th Congress) (Halstead & Dilger , 2011).

Railroad Preference (2004)

As part of DOE's engagement with its stakeholders, major railroads were invited to provide some input about the best routes to use, from their point of view, for shipments to the proposed Yucca Mountain repository. The Union Pacific Railroad (UPRR) made a presentation of their preferred routes at a DOE TEC meeting. The UPRR primary route for shipments through the Midwest differed significantly from the route identified by DOE in its 2002 FEIS. The essential contribution made by the UPRR routing scheme was that it revealed the importance of gateways. These major rail interchanges were identified by UPRR as the FIRST destination of spent fuel en route from east to west. The gateways identified by UPRR are:



Figure 9 Union Pacific Railroad Gateways

National Academy of Sciences (2006)

In 2003, the National Academies of Sciences and Engineering appointed a Committee on Transportation of Radioactive Waste to conduct “an independent, objective, and authoritative analysis” of SNF and HLW transportation. The NAS report, “Going the Distance?”, published in 2006, thoroughly examined the history of spent nuclear fuel transportation in the United States, including recent DOE spent fuel shipments to federal facilities, the current DOE transuranic waste shipments to WIPP, and the proposed Yucca Mountain transportation system.

The NAS report’s findings on transportation safety, and the report’s specific recommendations for management of technical and social risks, provide a template for resolving public concerns about SNF and HLW transportation safety, in a manner that could achieve stakeholder confidence. The NAS report’s principal finding on transportation safety:

The Committee could identify no fundamental technical barriers to the safe transport of spent nuclear fuel and high-level radioactive waste in the United States. Transport by highway (for small-quantity shipments) and by rail (for large quantity shipments) is, from a technical viewpoint, a low-radiological-risk activity with manageable safety, health and

environmental consequences when conducted in strict adherence to existing regulations. However, there are a number of social and institutional challenges to the successful initial implementation of large-quantity shipping programs that will require expeditious resolution as described in this report. Moreover, the challenges of sustained implementation should not be underestimated.

The NAS report qualified its findings on risk:

- The radiological risks associated with the transportation of spent fuel and high-level waste are well understood and are generally low, with the possible exception of risks from releases in extreme accidents involving very-long-duration, fully engulfing fires.
- The finding that spent fuel transportation risks are “generally low” at present does not necessarily mean that such risks will continue to be low in the future. Future risks depend on a number of factors (e.g., the care taken in fabricating transport packages and executing transportation operations).
- The social risks ... which can result in lower property values along transportation routes, reductions in tourism, and increased anxiety, have received substantially less attention than health and safety risks, and some are difficult to characterize.

Several of the recommendations of the NAS report specifically apply to route selection, route-specific risk evaluations, and risk management in affected communities:

- Undertake detailed surveys of transportation routes to identify potential hazards that could lead to or exacerbate extreme accidents involving very-long-duration, fully engulfing fires, and mitigate such hazards before the commencement of shipments
- Continue involvement of states and tribal governments in routing and scheduling of foreign and DOE research reactor spent fuel shipments
- Ensure state designation of highway routes are supported by sound risk assessments, and affected states fulfill their regulatory responsibilities
- Implement mostly rail option, using intermodal transportation to allow the shipment of rail packages from plants that do not have direct rail access, and avoid extended truck transportation program
- Publicly identify DOE suite of preferred highway and rail routes to a federal repository as soon as practicable, with involvement by states and tribes
- Immediately begin to execute DOE emergency preparedness responsibilities defined in section 180© of the NWPA, and include emergency responders in program planning and communication with affected communities

HM232 (2008)

A major potential limitation on the state role in selection of rail routes may come in the form of preexisting federal rules. The Department of Homeland Security (DHS) issued rules regarding the transportation of hazardous materials by rail in 2008 (HM232). Because of the novelty of these rules, it is unclear how they will affect any potential routing agreements among stakeholders (Allen & Fonczak, 2007). The Federal rules may preempt state efforts to arrive at a

negotiated route selection. This could trigger litigation and create delays in shipping. The 27 route selection factors are listed in Table 1.

1. Volume of hazmat	2. Venues along route
3. Rail traffic density	4. Emergency response capabilities
5. Trip length	6. Areas of high consequence
7. Railroad facilities	8. Passenger traffic
9. Track type and class	10. Speed of train operations
11. Track grade and curvature	12. Proximity to en route storage or repair facilities
13. Signals and train control	14. Known threats
15. Wayside detectors	16. Measures in place to address safety and security risks
17. Number and types of grade crossings	18. Availability of alternative routes
19. Single vs. double track	20. Past incidents
21. Frequency and locations of track turnouts	22. Overall time in transit
23. Proximity to iconic targets	24. Training and skill level of crews
25. Environmentally Sensitive areas	26. Impact on rail network traffic and operations
27. Population density	

Table 1 Routing factors identified in DHS rules

However, a major reason why the HM232 rules will not prove to be sufficient for routing High-Level radioactive waste and spent nuclear fuel to a repository is because the new rules do not consider the nature of the hazard. Spent nuclear fuel and high-level radioactive waste are unlike any other hazardous material because the hazard is actually manifested during transportation. The containers cannot contain all the radioactivity during transportation. As a result, routing rules that do not consider this aspect of the hazard may not be appropriate.

BRC Final Report Recommendations

The BRC recommended a cooperative process for storage and disposal facility site selection (Blue Ribbon Commission on America’s Nuclear Future, 2012). Implicit in this recommendation is the idea that routes to a repository site will also be selected in a cooperative manner. Moreover, the BRC called for full implementation of the NAS 2006 transportation recommendations, specifically including those regarding route selection and route-specific risk evaluations, and specifically endorsed the cooperative Federal-State-Regional Group process used to develop the DOE WIPP transportation program.

“In particular, DOE has for many years supported cooperative agreements with state regional groups, or SRGs, to partner with local authorities through whose jurisdictions radioactive materials will be transported. Collaboration through the SRGs has proved

important, not only because states have primary responsibility for protecting the health and safety of their citizens, but because they share (and sometimes disagree about) common concerns. Bringing corridor jurisdictions together under the auspices of these groups allows issues to be identified and resolved by all parties. It also means the shipper and carrier do not have to negotiate individually with jurisdictions that may have inconsistent or even conflicting priorities. States have extensive experience with transportation issues and important roles to fulfill with respect to issues such as routing, inspections, training, emergency preparedness, communications, public information, and security for radioactive materials and other hazardous shipments.” (p.85)

CONCLUSION

The routing guidance for SNF and HLRW was developed during a period of crisis for the nuclear industry and in an expedient fashion. This paper argues that the routing guideless (HM-164) that grew out of the controversy in New York City in the 1970's will not be adequate for a large-scale shipping campaign. The messy litigation surrounding the HM-164 rules was not actually finalized. The DOT rules were upheld in court, but barge shipments were ultimately used. The process to select routes for spent nuclear fuel has never been adequately resolved. The western states have proposed a cooperative process for selection of routes, but the process has never been applied. The DOE, despite years of study, never actually proposed a route selection process. New rules developed in the wake of 9/11 do not consider the unique hazard of spent nuclear fuel. The HM-164 Guidelines should be viewed as an interim measure that was hastily developed and adopted. The process used in the Guidelines has been supplanted by new technology. Ultimately, the United States will need a route selection process for a variety of modes that considers the federal nature of our political system and a wide geographic area.

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