RAIL PRIMER:

LEGAL, TECHNICAL AND BUSINESS ASPECTS OF RAIL TRANSPORTATION

WESTERN INTERSTATE ENERGY BOARD

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EXECUTIVE SUMMARY

The Department of Energy (DOE) has not yet reached a decision on which mode(s) to use for shipments of spent fuel and high-level waste to a repository and monitored retrievable storage facility (if one is built). It is likely that some of the shipments will be conducted by rail. The Western Interstate Energy Board High-Level Waste Committee has emphasized the highway mode in its past work on spent fuel and high-level waste transportation. The purpose of this report is to provide background for the Committee's work on rail transportation in order to effectively move toward achieving its goal of developing a safe, publicly acceptable transportation system for spent fuel and high-level waste.

To date, there have been a limited number of rail shipments of high-level radioactive materials and the role of rail transport in DOE's plans for shipping HLW to a repository or MRS is not clearly defined. In spite of uncertainties, the potential exists that, using the Multi-Purpose Canister (MPC), the projected number of rail shipments to the proposed Yucca Mountain repository could exceed 9,000 rail cask shipments. There is also the possibility of inter-modal shipments involving rail transport. This Revised Rail Primer includes summary information on historical commercial spent fuel shipments by rail and estimates of future shipments under different scenarios. As a result of federal legislation and regulations, legal action, DOE analyses, and increased state interest, the potential role for rail transport in shipping high level radioactive material to a repository or MRS continues to evolve. It is the intent of the HLW Committee to make the Rail Primer a working document for updating issues and addressing pertinent new concerns on rail transportation.

The Committee has identified a number of items it believes are particularly important with respect to rail transport of spent fuel and high-level waste. These subjects have been addressed in the Rail Primer and subsequent revision, however, it is propopsed that the Committee focus its future rail related efforts on:

? implementation of the Hazardous Materials Transportation Uniform Safety Act of 1990, including provisions on routing, emergency response training, and inspection;
? the lack of rail data for application in modal analysis - particularly rail accident data;
? the significance of private ownership of railroads and interaction with state/federal/local policy decisions;
? the importance of speed and track classification as safety measures;
? continued analysis of dedicated trains vs. general commerce trains for HLW shipments;
? rail access at origin and destination sites; and
? the role of rail in inter-modal shipments.

The background information in the Rail Primer is relevant to many issues of interest to western states, including: modal mix analyses (truck vs. train, and general commerce trains vs. dedicated trains);

states' roles in rail shipments (including inspection and enforcement, and emergency response); and aspects of the rail transportation system that could be strengthened or improved for shipments of spent fuel and high-level waste.

The Rail Primer provides a basic description of how railroads work -- e.g., the private ownership of the railroads; the mechanics of track, equipment, traffic control and switching; and business arrangements between shippers and carriers. There are significant differences in structure between the rail and trucking industries with regard to operations, regulation, and profitability for shipping. It would be misleading to extrapolate data from highway truck transport to rail transport. The private ownership of railways, coupled with profitability of shipping, could lead to a desirability on the part of railroads to maximize the use of their own rail lines, which in turn, could lead to transport distances that significantly exceed the minimum distance between origin and destination.

Included in the Rail Primer, are detailed discussions of several aspects of rail transportation that are of particular interest to states, including: regulation, inspection and enforcement; emergency preparedness and response; route selection; risk assessment; rail service options (general, special and dedicated trains); and operating provisions that could be applied to spent fuel shipments by rail. These areas are briefly described below.

Regulation, Inspection and Enforcement: Regulation and enforcement of rail safety (e.g., track, equipment) are handled much differently than regulation and enforcement of hazardous materials issues as they apply to rail shipments. The safety program is primarily federal: the Federal Rail Safety Act (FRSA) contains a stronger preemption clause than is found in the Hazardous Materials Transportation Act (HMTA). Consequently, the FRSA does not authorize the dual regulatory structure (state and federal) as is found in the HMTA.

However, the states' role in regulating rail safety is significant. In many states, state inspectors have similar duties as federal inspectors. In December, 1990, the Federal Railroad Administrator indicated that the FRA must change in response to GAO's critical evaluation of FRA's railroad safety program and that state and federal inspectors would be treated as equals in terms of work assignments.

The National Association of Regulatory Utility Commissioners has, in the past, criticized the federal safety program as being ineffective and has urged Congress to give states the funding and authority they need for an effective inspection and enforcement program. Currently, under FRSA, criteria have been established which allow state agencies to have federally certified inspectors, and, as of November 1995, there are a total of 137 state inspectors in 29 states, including California, Texas, Oregon, and Arizona.

In contrast to the safety program, the hazardous materials program has been primarily a state-driven program. The Federal Railroad Administration currently has 45 hazardous materials inspectors. In the past, the General Accounting Office found that it would be more cost-effective to fund expanded state hazardous materials programs, rather than to add additional federal inspectors. Although the FRA

has only recently begun to certify state hazardous materials inspectors, there are currently a total of 19 federally certified state hazardous materials inspectors in 13 states.

State enforcement of federal railroad safety, and hazardous materials violations continue to be an area of particular concern. State inspectors must process all rail safety violations through the FRA and any penalty received as part of a violation must go to the U.S. Treasury. State enforcement is also weakened by a lack of federal funding for state inspection programs, although it has been estimated that state inspectors contribute more than one-third to the combined federal/state enforcement effort. With respect to hazardous materials violations, states are allowed to keep any fines they collect as a result of the enforcement program.

The ability of states to regulate rail operations is also an area of concern. Several court decisions have shed additional light on the issue. A U.S. Appeals Court decision dismissed a March 1990 U.S. District Court ruling that prohibited the Oregon Public Utilities Commission from imposing fees on railroads to recover the costs of rail regulation. In January 1991, the U.S. Supreme Court denied a review of an Appeals Court decision which held that Ohio's statute regulating transportation of hazardous materials is subject to the broad preemption provision in the Federal Railroad Safety Act, although the decision does not totally prohibit states from promulgating rail safety regulations.

Emergency Preparedness and Response: The key to good emergency response to rail accidents appears to be a good working relationship between the railroad and local responders, with advance planning and established lines of communication. Railyard employees and train crews receive some emergency response training, but rely primarily on the Association of American Railroads' hazardous materials emergency response handling guidelines. AAR's existing training does not specifically address radioactive materials. However, under HMTUSA, hazardous materials employers must provide training and certification for all employees on handling of hazardous materials (of which radioactive materials is a subset).

A key issue for accidents occurring en route is likely to be the ability to retrieve a spent fuel cask after a derailment. Most railroads use their own equipment when a derailment occurs in a railyard and rely on contractors when a derailment occurs en route. The railroads believe that the weight of the cask is not likely to cause special retrieval problems because locomotives are often heavier than spent fuel casks. Other potential concerns are the amount of time needed to obtain lifting equipment and arrive at the accident scene and some contractors' unwillingness to retrieve a spent fuel cask before receiving assurance that the cask is not leaking.

Route Selection: No federal rules exist regarding selection of rail routes for spent fuel shipments, comparable to HM-164 for highway shipments. Generally, railroads select routes in such a way as to maximize profits, which can lead to undesirable routes from the shippers' and states' perspectives. Shippers have the authority to designate rail routes for their shipments; this authority has been exercised for several high-visibility radioactive materials shipping campaigns, such as Three Mile Island shipments to the Idaho National Engineering Laboratory. In the past DOE said that it would

consider the need for federal rail routing regulations, and would develop its own rail route-planning criteria for repository shipments. However, in 1996, DOE announced that it would no longer attempt to produce nuclear waste rail routing criteria, but would instead rely on standard railroad practice to determine rail routes. States may be interested in designating rail routes, although there are practical and legal issues to consider. Regardless of who selects the route, there are at least half a dozen computer models available to analyze routes using different criteria. The Hazardous Materials Transportation Uniform Safety Act of 1990 directed DOT to study the need for rail routing criteria for spent fuel and high-level waste shipments, but provided no funding. DOT had until October 1991 to start a study to determine which factors, if any, should be considered by shippers and carriers in selecting modes and routes to enhance safety of spent fuel and high-level waste shipments. DOT issued a draft of this report in December 1993 but has not yet released a final version.

Risk Assessment: A thorough risk assessment is essential in comparing rail to other modes, as well as in making decisions within the rail mode -- e.g., rail service (general, dedicated, or special trains), rail routing, and the use of cabooses. There is not sufficient information to make these comparisons. The accident reporting system has been criticized by the General Accounting Office. A bigger problem is that certain types of statistics are not widely available. For example, accident <u>numbers</u> are available comparing different track classes and trains with and without cabooses. However, these numbers are meaningless without knowing traffic volumes so that accident <u>rates</u> can be calculated. Traffic volumes are not readily available because railroads consider this information to be proprietary, although it may be possible to estimate traffic volumes using the waybill sample. The Rail Primer encountered the same problem that DOE and its contractors have faced in the past -- a thorough analysis of rail issues is impossible because of the lack of data.

Rail Service Options: Railroads have been proponents of the use of special trains for spent fuel shipments, citing safety concerns. However, shippers historically have been opposed to special trains because of the higher costs, as compared to general commerce (regular) trains. (Some of the reasons for this opposition may have decreased since the Staggers Act of 1980 changed the way railroads do business.) The Interstate Commerce Commission has ruled that railroads cannot force spent fuel shippers to use special trains. A 1977 study by the Interstate Commerce Commission predicted that the accident rates (for all levels of accident severity) for special trains would be lower than for general commerce trains. Actual shipping experience is difficult to assess because of the lack of data. The Hazardous Materials Transportation Uniform Safety Act of 1990 directed DOT to conduct a study comparing the safety of dedicated trains and general commerce trains for shipping spent fuel and high-level waste. DOT had until 1991 to complete the study, but was unable to meet this timetable and has not yet released any final study results.

Operating Provisions: Regardless of whether a spent fuel shipment is carried under contract or tariff, special conditions can and have been imposed on a shipment. Conditions that have been advocated by the railroads or other parties, or used in past shipping campaigns, include: identification of all carriers and interchange points; route selection; speed limits lower than those allowed for other shipments; a requirement that a spent fuel train stops while another train is passing it; minimizing the

number and length of stops in railyards; use of cabooses; specifying train crew numbers and qualifications; real-time tracking; special track inspections; requiring escorts; and time-of-day restrictions.

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The Department of Energy has not yet reached a decision on which mode(s) to use for shipments of spent fuel and high-level waste to the repository and monitored retrievable storage facility (if one is built). It is possible that at least some of the shipments will be conducted by rail. According to the strategic plan and schedule developed by the Western Interstate Energy Board's High-Level Waste Committee, the modal mix decision should be made early in the transportation program. Because routes cannot be finalized until a mode is selected, time-consuming route-specific activities (e.g., emergency response training) cannot be completed until the modal mix decision is made.

The Committee has emphasized the highway mode in its past work on spent fuel and high-level waste transportation and is less familiar with rail transportation. The purpose of this report is to give the Committee a background in rail transportation so that it can work more effectively towards its goal of developing a safe, publicly acceptable transportation system for spent fuel and high-level waste. The background information is relevant to many issues of interest to western states, including:

- modal mix decision -- truck vs. train, and general commerce trains vs. special or dedicated trains;

- states' roles in rail shipments, including inspection and enforcement, and emergency response; and

- aspects of the rail transportation system that could be strengthened or improved for shipments of spent fuel and high-level waste.

I. OVERVIEW

The map on the following page shows the rail network in the United States. While the map may give the impression of a national network, it is actually more of an interlocking network of individual railroads. The rail network differs from the highway network, in which the roads are owned by the public, because each railroad owns its own track. While railroads may choose to grant trackage rights to another railroad company (for a price), they will only do so when it is in their best interest. The private ownership of railroads should be kept in mind, because it influences numerous aspects of rail transportation. For example: 1) route selection is complicated by the fact that choosing a route is, in essence, choosing a carrier; 2) railroads are responsible for inspecting and maintaining their track because there is no rail equivalent of state highway departments to perform these tasks; 3) most cross-country shipments cannot be accomplished by a single carrier, but must be interlined to another carrier when the first railroad's track ends; 4) in a shipment involving multiple carriers, each carrier attempts to alter

the route and transfer points to maximize the distance the shipment travels on its railroads (because revenues for a shipment are divided among carriers according to miles travelled); and 5) railroads lose business when their tracks are closed (because they cannot detour as easily as trucks can), and therefore, may have different attitudes than motor carriers towards emergency response and the risks of accepting spent fuel shipments. All of these points are discussed later in this report.

The remainder of the report is organized as follows:

II Historical data and projections for rail shipments of spent nuclear fuel.

III The three rail options: general commerce, dedicated, and special trains.

IV The technical aspects of railroads: how railcars are classified (switched from one train to another) in railyards, safety devices on tracks and trains, traffic control systems, the use of cabooses, tracking systems for determining a train's location, computerized systems to control train movement, and radiation detection and alarm systems.

V Regulation, inspection and enforcement of both rail operation and the transport of hazardous materials, including: the railroad's responsibilities (primarily operational); state and federal roles [including the inspection and enforcement roles of the Federal Railroad Administration, the Department of Transportation's Research and Special Programs Administration, and the Association of American Railroads (an industry group)]; an overview of state enforcement of federal safety and hazardous materials regulations; and state regulation of rail operations.

VI Emergency response to accidents occurring in railyards and en route.

VII The current route selection system for rail shipments, state designation of rail routes, models that can be used for route selection, examples of how routes were selected for previous spent fuel shipments, DOE's repository routing studies, and other routing studies.

VIII Risk assessment, including: a review of the available accident data, a review of information on the potential radiological and non-radiological health risks of shipping spent fuel, the impacts of adverse weather conditions on rail transportation, and the special hazards presented by gas pipelines located in or near the railroads' rights-of-way.

IX The business aspects of railroads (contracts, tariffs and economic regulation) as they may impact DOE's willingness to use the rail mode and as they affect the ability to impose special conditions on spent fuel shipments, and past examples of special provisions used during spent fuel shipments.

II. RAIL SHIPMENTS OF SPENT NUCLEAR FUEL AND HLW: HISTORICAL DATA AND PROJECTIONS

Several studies have presented historical data on rail shipments of spent fuel by year, and in some instances, by origin and destination, for the period 1964 to present. (Nuclear Assurance Corporation (NAC) 1985 and 1990; Brodnick 1987; and Pope 1990) None of these studies is completely satisfactory because of limited availability of data for the 1960s and 1970s and because certain shipments, such as DOE shipments of commercial reactor spent fuel to research facilities, are excluded. One attempt at a comprehensive data compilation, by Ron Pope of Oak Ridge National Laboratories, estimates that there were about 232 rail cask shipments containing about 875 MTUs of spent fuel between 1964 and 1989 (Pope 1990) According to Pope's estimates, rail transport accounted for about 9% of the total shipments and approximately 47% of the total volume of spent fuel shipped (by weight) during this period. (Pope 1990)

The Nevada Nuclear Waste Project Office has reviewed the available data and estimates that there were about 280 rail shipments of spent fuel to off-site locations between 1964 and 1989. These movements can be divided into three groups. First, between 1965 and 1974, there were about 130 rail shipments from four commercial reactors (Dresden 1, Yankee 1, Humboldt Bay, and Big Rock) to the Nuclear Fuel Services reprocessing plant at West Valley, New York. Second, between 1975 and 1982, there were about 90 rail shipments from two reactors to off-site storage facilities -- from Dresden 2 to the General Electric (G.E.) storage facility at Morris, Illinois, and from Carolina Power and Light's Robinson 2 reactor to another of the utility's storage pools at the Brunswick nuclear power station in North Carolina. Third, between 1984 and 1989, there were two major rail shipping campaigns from midwestern reactors (Cooper Station in Nebraska and Monticello in Minnesota) to the G.E. facility at Morris. The two campaigns totalled 64 dedicated train shipments, with each train consisting of two or three IF-300 casks. (Halstead 1991)

For the period 1979 to 1994, virtually complete data on commercial spent fuel shipments by electric utilities and other licensees is available and has been published by the Nuclear Regulatory Commission in <u>Public Information Circular for Shipments of Irradiated Reactor Fuel</u>. (U.S. NRC 1995) The NRC's data for spent fuel shipments by rail and truck is summarized in the table on the following page. The NRC data includes truck shipments of research reactor fuel which is often omitted from other databases. However, only shipments of academic, industrial, and utility spent fuel subject to NRC regulation are included in the data. The NRC data therefore does <u>not</u> include DOE shipments such as the truck shipments of spent fuel from the Surrey reactor in Virginia to the Idaho National Engineering Laboratory (INEL) or the DOE rail shipments of Three Mile Island core debris to INEL.

NRC SUMMARY DATA
HISTORICAL SPENT FUEL SHIPMENTS
1979-94

Year	Number of Highway Shipments	Number of Railway Shipments	Kilograms SNF Shipped by Highway (Thousand)	Kilograms SNF Shipped by Railway (Thousand)	Highway Shipment Miles (Thousand)	Railway Shipment Miles (Thousand)	Highway Kilogram Miles (Million)	Rail Kilogram Miles (Million)
1979	16	11	0.1	30.2	8.0	2.3	0.1	6.2
1980	130	5	10.0	13.6	115.9	1.0	17.2	2.8
1981	81	2	7.9	6.0	38.5	0.4	1.7	1.2
1982	124	0	7.1	0.0	106.8	0.0	1.8	0.0
1983	117	0	36.6	0.0	83.6	0.0	12.7	0.0
1984	245	3	84.5	23.8	181.3	1.6	51.4	12.7
1985	135	18	74.0	119.4	70.9	8.7	28.3	57.8
1986	105	15	40.4	97.5	47.8	8.7	8.8	56.3
1987	107	15	82.3	101.4	41.8	8.4	14.8	56.5
1988	25	7	12.8	41.8	11.4	4.3	2.4	25.7
1989	16	6	0.1	30.8	16.7	1.7	0.1	8.7
1990	2	8	(0.03)*	70.5	1.5	1.6	(0.02)*	12.7
1991	11	10	0.1	98.4	9.6	1.5	0.1	15.0
1992	17	6	0.1	61.3	15.7	0.8	0.1	8.1
1993	16	12	0.1	114.0	23.2	2.3	0.3	21.9
1994	7	10	(0.02)*	84.2	6.6	2.2	(0.01)*	17.4
Total	**1154**	**128**	**356.2**	**892.9**	**779.3**	**45.5**	**139.8**	**303.0**

* Entries in parentheses are rounded to the nearest hundredth. All others are rounded to the nearest tenth.

Source: U.S. Nuclear Regulatory Commission, 1995, Public Information Circular for Shipments of Irradiated Reactor Fuel, NUREG-0725, Revision 10.

Projections of future shipments of spent fuel and HLW by rail to an MRS facility and to a geologic repository have been presented in a number of studies over the past decade and a half. The Nevada Nuclear Waste Project Office has summarized projections of rail shipments to a repository at Yucca Mountain under various scenarios. These projections are presented on the following page. Since the Yucca Mountain site presently lacks rail access, it is possible that all shipments to a repository could be made by truck. If rail access is constructed to Yucca Mountain and the transportation system is optimized (including construction of an MRS facility), about 1,050 dedicated train shipments would take place during the 25-30 year lifetime of the repository.

In its January 1995 paper entitled, *High-Level Nuclear Waste Shipping Route Maps to Yucca Mountain and Shipment Number Estimates—Multi-Purpose Canister Base Case,* the Nevada Nuclear Waste Project office also recently compiled shipment number estimates in the event that DOE utilizes a Multi-Purpose Canister (MPC) for the transportation, storage, and permanent disposal of radioactive waste. Using 1992 projections of spent fuel discharges through the year 2030, the Nuclear Waste Project Office generated route-specific shipment number estimates from each reactor site, and determined that approximately 9,421 total rail cask shipments would occur under a DOE MPC shipping campaign. The chart on the previous page shows the total rail cask shipment miles projected from each nuclear reactor site based on the metric tons of uranium (MTUs) of spent nuclear fuel at each reactor site, the capacity of the MPC used, and the route miles required to transport the spent fuel to a nuclear waste repository at Yucca Mountain, Nevada.

III. RAIL OPTIONS

Three general rail options exist: general commerce, dedicated, and special trains. The Federal Railroad Administration (FRA), within the U.S. Department of Transportation, and the Association of American Railroads (AAR) have established regulations and guidelines, respectively, for carriers to follow for all rail shipments. For dedicated and special trains, railroads have imposed further limitations involving speed, the contents of railcars adjacent to spent fuel casks, and layover frequency.

General commerce trains, also referred to as regular trains, comprise the majority of rail traffic today and travel set routes on one carrier's tracks at a regular schedule. Most regular trains stop at railyards and sidings en route to add or remove railcars. Crew size can be three or five, with three in the locomotive and two in the caboose. Since cabooses are not required by federal law, train crews of three, all in the locomotive, are common. This is discussed in a later section of this report. Radioactive shipments are not allowed to be transported next to any other placarded car (except ones carrying combustible or radioactive material), the locomotive, or occupied caboose, if present; cushion cars containing inert buffer materials often augment segregation from other railcars. Speed limits vary according to track class and range from 10 to 110 miles per hour. Tracks are divided into six classes (with Class 6 being of the highest quality) based on track quality and frequency of inspection and maintenance. Most main lines and branch lines are class 3 or 4, with respective speed limits of 40 and 60 miles per hour. Restrictions frequently lower the speed limit near population centers or crossings.

A shipment being transported by regular train must accommodate the carrier's timetable and may have to switch trains several times to reach its destination. Switching trains is also necessary if more than one carrier's lines are used. Layovers between trains average 12 to 24 hours. The variability in layover length and frequency results in a wide range of travel times for regular train shipments between two points a similar distance apart. Travel time for train shipments can be significantly longer than for truck shipments, which can travel straight through on the public highway system, limited only by weight and clearance restrictions, fuel mileage and storage capacity, and inspection stations. Track class would also affect travel time. As an example of regular train travel

time, coast to coast rail transport -- which requires at least two rail carriers, and thus, at least one stopover for reclassification -- takes between one and two weeks at a minimum. Sandia National Laboratories (1986) determined that the average road haul velocity, or distance divided by all train hours (including layover time), for regular trains is about 20 miles per hour. However, estimating the travel time for a particular route using this generalization would not be appropriate, considering the great variability from route to route.

Dedicated trains transport a particular commodity between fixed points, stopping only for refueling, crew changes, and to change locomotives if more than one railroad is involved. Dedicated trains are commonly used to transport large quantities of raw materials such as coal to manufacturing plants. Since layover time at railyards is minimal, travel time is much shorter than for regular freight rail service. DOE (1986) estimated that cross-country travel time can be reduced by half -- saving three to seven days as compared to regular freight service.

Special trains are dedicated trains with additional requirements, which are summarized by Goodman (1988) and NUREG-0170. A caboose is required, resulting in a five-person crew. Speed is typically limited to 35 miles per hour regardless of the higher speeds normally allowed by the track's class. When a special train passes or is passed by another train, one train must stop while the other passes. Railcars with radioactive materials must be separated by buffer cars containing inert substances. At this time, items requiring excess clearance or having excess weight are often transported in special trains.

The use of special or dedicated trains for spent fuel transportation has been the subject of continuing disagreement between railroads and shippers -- especially DOE. For many years, railroads have attempted to require the use of special trains (at a greater cost to the shipper) for spent fuel shipments. Arguments advanced in favor of special trains include:

- the lower train speeds could limit accident severity;

- in the event of a severe accident, it is less likely that a spent fuel cask would be buried under other cars (because special spent fuel trains are shorter than regular trains);

- the shipment can be kept under observation more easily;

- special trains could avoid railyards where most accidents occur;

- regular trains carry hazardous materials such as explosives or flammables that could endanger the spent fuel cask in the event of an accident; and

- routing to avoid high population areas is possible with special trains. (Goodman 1989)

The Interstate Commerce Commission has ruled that railroads cannot require spent fuel shipments to use special trains, although special trains can be used with the shipper's consent. (For an extremely detailed discussion of the special train issue from the shipper's perspective, see Goodman 1989.)

One of the reasons for shippers' historic reluctance to use special trains may have been that, before 1980, shippers and carriers were prohibited from entering into individual contracts. All rates and terms were set by tariffs -- published rates and terms that were available to all shippers of a particular commodity between a certain origin and destination. (See Section VIII for more details on Contracting, Tariffs, and Economic Regulation.) The tariff was inflexible and offered no opportunity for individual shippers to negotiate terms. The special train tariff defined a specific package of terms and a much higher rate than for general commerce rail. The Staggers Act of 1980 removed the prohibition against negotiating customized rail service contracts. Therefore, today it is possible for a shipper to bargain with a railroad over the rates to be charged for a special train and to incorporate terms favorable to the shipper (e.g., speeding up a shipment by bypassing certain railyards). For example, DOE was successful in negotiating a decrease of over 40% on the special train surcharge for its Three Mile Island shipments. (See Section VI.A.)

The Hazardous Materials Transportation Uniform Safety Act of 1990 required DOT to conduct a study comparing the safety of dedicated and general commerce trains for transporting spent fuel and high-level waste. DOT is to conduct the study in cooperation with DOE, NRC, states, tribes, railroads and shippers. DOT was to complete the study in 1991, but was unable to meet this timetable and has not yet released any final study results. The Act also requires DOT to amend the existing rail regulations, as appropriate, within two years to provide for safe rail (including dedicated train) transportation of spent fuel and high-level waste.

Cost could influence modal decisions in several ways. First, dedicated or special trains can complete a trip faster than general commerce trains because they do not have to wait repeatedly in railyards to be picked up by another train. Therefore, dedicated or special trains can decrease the number of shipping casks needed for the repository/MRS program. It is unknown whether the decreased cask costs would outweigh the increased rates for dedicated or special trains. Second, rail maintenance costs and the cost of constructing new rail spurs could also have an impact. DOE has examined these costs as part of the Near Site Transportation Infrastructure assessment (NSTI) and the Yucca Mountain Project Office's Rail Access Study, which examines conceptual rail spurs into Yucca Mountain. Third, the <u>overall</u> costs of shipping spent fuel and HLW by dedicated or special train, which may be significantly higher than for general commerce trains, could impact DOE's final modal decision.

Utility costs, including spent fuel handling and transfer costs, enhanced safety measures, and other transportation related expenses could also impact modal decisions. Dedicated train shipments of Three Mile Island (TMI) core debris to the Idaho National Engineering Laboratory cost General Public Utilities (GPU) approximately $17 million. Although DOE was the shipper, GPU spent roughly $13.8 million on rail transportation expenses, special handling fees, and additional safety measures, and

another $3.2 million on equipment modifications and other non-transportation expenses. (Conaway 1991)

IV. TECHNICAL ASPECTS

This section discusses railyard activities (classification, safety and security), safety devices, tracking and communication systems, and radiation detection/alarm systems.

A. Railyard Classification, Safety and Security[1]

Classification involves switching railcars from one train to another and organizing the associated records. Computer systems and databases have been used to keep track of shipments since the mid-1960s, when Southern Pacific developed the Total Operating Processing System, or TOPS. Currently most carriers are using similar or more sophisticated computer systems for data processing. When a loaded car enters the railyard, a waybill is written up. The waybill describes the shipment, charges, route, and handling instructions, and accompanies the car to its destination. This information is entered into the computer system, which then assigns the car to a train. The railcar is set aside until its train is put together.

Before a train is assembled, its switch list, which contains the sequence of cars, is generated by the computer system and is distributed to the switch crew in the yard and to the yardmaster. Trains are put together in the classification yard, which is comprised of multiple parallel tracks branching out from a central track and connected by switches. Each of the parallel tracks is designated to receive cars with particular destinations along the route. A special locomotive, or switch engine, transports each car or group of cars to its assigned track. Depending on the sensitivity of the shipment and the type of classification yard, the cars may either be shoved to rest, during which the car remains attached to the engine until it couples with the adjacent car, or humped, where the car is uncoupled at the top of a very gentle incline and allowed to travel freely downhill. The optimal speed for coupling is 4 miles per hour and can be achieved by either method, although shoving to rest is more accurate. When all of the railcars have been classified, the switch engine retrieves and connects them in the order given by the switch list. After the consist (pronounced with the accent on the first syllable), which is the group of railcars comprising the train, is assembled, the locomotive, and caboose if used, are attached and the train is ready for its final inspection before departure. The yardmaster, who is in the tower overlooking the railyard, may double check the switch list with the sequence of cars in a train using binoculars.

Safety is a special concern at railyards because the surrounding community is often densely populated. Minor collisions and derailments can and do occur during switching operations. In addition, special attention must be given to containers of flammable, explosive, or otherwise hazardous materials. Several safety precautions have become standard practice at railyards. Identification of railcars carrying hazardous material is necessary for proper handling and emergency response should

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[1] The reference by Armstrong (1982) served as the primary source of information regarding rail equipment and operations; this is the accepted reference by most within and outside of the rail industry.

there be an accident. Warning placards are required on each end and side of railcars to identify those containing hazardous materials; this is the responsibility of the shipper. The fact that a railcar is carrying hazardous material is also noted on the waybill and switch list, both of which would be accessible from the carrier's computer system to all carrier personnel. Standardized DOT instructions regarding the normal handling and emergency treatment of the shipment are included in the waybill as well. To maximize control of railcars containing hazardous materials during switching operations, these railcars are usually shoved to rest rather than humped in the classification yard.

Railyard security is accomplished by armed patrols and strategically placed video cameras. Current surveillance systems are intended to prevent vandalism and the theft of goods from railcars during layovers, which can last 24 hours or more. During prolonged stopovers, railcars carrying hazardous materials may be set apart, but often they are not. Dedicated trains have shorter stopover times since they remain at railyards only long enough to refuel, change crews, and, if more than one rail carrier is involved, change locomotives. Crew and locomotive switching do not need to occur in a railyard. Security en route is also a potential problem.

Despite precautions, acts of vandalism occur both in railyards and during rail shipments. Railroad vandalism has led to severe derailments and accidents, resulting in millions of dollars of property damage, injuries, and in at least one instance, the death of a rail worker. The statistics on railroad vandalism are alarming. The AAR counted over 54,000 acts of vandalism in 1980, although AAR's Safety and Special Services section has noted the difficulty in obtaining complete information on vandalism when trying to develop comprehensive, accurate information. Vandals are particularly active in the East and Midwest. Acts of railroad vandalism have included: incidents involving multi-level automobile transporters (by far the biggest target in terms of number of vandalism incidents), stonings, obstructions placed on tracks, and shootings. The railroads spend millions of dollars on vandalism; some have beefed up security and many have retrofitted locomotive fleets with shatter-proof glass. Fencing may also be a deterrent to vandalism. (Miller 1980) A 1988 derailment in Bridgewater, Pennsylvania, was caused by vandals who threw a switch by hand. Rail officials said that the switch keys are widely available at flea markets and installed a tamper-proof lock on the switch after the derailment. (GAO 1989a)

Rail shipments are also extremely vulnerable to acts of sabotage. This fact was clearly demonstrated by the recent Amtrak train derailment in Arizona on October 9, 1995 in which one crew member was killed and more than 100 passengers were injured. To cause the derailment, saboteurs unscrewed six heavy bolts and removed a connecting joint between two 39-foot lengths of track in an isolated area. Saboteurs also rewired an electrical signal cable that ran inside the joint bar. This electrical cable flashed a red signal by the side of the track to alert oncoming trains if there was damaged track ahead. The cable in this case was “wired around” the tampered portion of the track, maintaining a green signal for the oncoming train. An Amtrak official said that the tampering required knowledge of railroad signal systems, but that a person acting alone “could have easily lifted away the joint bar and rewired the cable in about ten minutes.”

The potential for vandalism upon spent fuel shipments will likely receive increased attention. During Northern States Power shipments of irradiated spent fuel to the General Electric storage facility in Morris, Illinois, there was an attempt to sabotage one of the shipments in October, 1986. (Earl 1986) To this date, the case has not been resolved. Special security measures have been used during spent fuel shipping campaigns in the past (this is discussed in further detail under the **Special Provisions** section of chapter **IX. Contracting, Tariffs, and Economic Regulation**).

B. Safety Devices

Safety devices in railroad operations include traffic control systems, redesigned railcar parts, detection equipment on tracks and locomotives, and cabooses. Over the years changes have been made to the design and composition of various railcar parts to lessen the probability of severe accidents. A common cause of major derailments in the past occurred when the bearing between a railcar's axle and wheel became overheated and broke apart, allowing the frame to drop to the roadbed, causing what is called a hot box. Sufficient lubrication of the bearing prevents hot boxes, and beginning with 1963 railcar production, roller bearings which remain fully lubricated for ten years were installed instead of journal bearings which required frequent and inconvenient inspections. Roller bearings have also been replacing worn journal bearings, so now almost all railcars contain roller bearings. The disadvantage to the roller bearing is that its design enables failure to occur more suddenly, albeit less often, than with the journal bearings. Roller bearings do, however, get hot as they begin to fail, and devices called hot bearing detectors can warn train crews before the bearings suddenly “burn off.” Although these detectors work well, they are expensive to install, costing nearly $90,000 each. In addition, the detectors cost from between $11,000 and $20,000 per unit for yearly maintenance. (FRA, 1994)

Improvements in technology have reduced hot box accidents to only two percent of all accidents caused by mechanical failure. However, hot box accidents are still very dangerous, accounting for a much larger percentage (about 20 percent) of the damage from those accidents. Railcar parts and coupling devices, which connect adjacent railcars, have been redesigned and added to make rail transport of hazardous materials safer. Headshields were added to tanker cars to prevent puncturing of the tank. Another safety practice initiated by the rail industry, specifically for shipments of radioactive materials, was the routine use of steel (rather than wood) decks to increase the efficiency of decontamination after transport.

Both head-on and rear-end collisions are a concern because single-track lines, which accommodate both directions of traffic on one track, are becoming more popular. Signal systems are intended to prevent collisions of trains traveling on the same track by alerting locomotive engineers of the presence of trains up ahead. Tracks are divided into segments, or blocks, and each block has at least one signal. Signals operate on vital circuits, with a weak current that originates from a battery and travels through the rails within each block. For single-track, only one train is allowed in a block at

a time; for double-line track, which has a separate track for each direction of traffic, only one train traveling in a particular direction is allowed in a block at a time. Signals are similar to highway traffic lights and are spaced such that a train traveling at the maximum speed limit has sufficient stopping distance. To augment the signal lights beside the tracks, an audible signal in the cab of the locomotive, or cab signal, notifies the crew in the cab of the message of an approaching signal. Cab signals are especially useful when visibility is poor. Since the vital circuit supplies power to the block's signal, any discontinuity in the tracks, such as a major crack, breaches the vital circuit and results in a signal that warns approaching trains to stop.

Two methods are used to control signals. With Centralized Traffic Control (CTC), signals are activated by a central dispatcher who monitors rail traffic from a control panel. As a train approaches, occupies, and exits a block, the dispatcher sets the appropriate signals to alert incoming trains, which will slow down or stop as advised. The CTC signals are transmitted by microwave. In addition to preventing collisions, signals are used to instruct trains to slow down for other reasons. For example, when approaching a junction at which a train will divert from one route to another, the train's speed will need to be reduced. Due to the high cost of installation, maintenance, and operation, only heavily traveled single-track lines or congested sections of multi-track routes are usually equipped with CTC.

The Automatic Block System (ABS) is less expensive than CTC since it relies solely on the vital circuit. The signal is triggered when a train enters the block, shunts the current with its wheels, and sets a stop signal for other trains approaching the block. When the train leaves the block, the track circuit resumes and the signal indicates an empty block.

Blind, or dark, track contains no signals and is present where the locomotive engineer can safely operate a train with written and/or oral instructions. Usually only short runs and lines which experience little traffic are included in this category.

The National Transportation Safety Board concluded that a contributing factor to a 1988 head-on collision between two Conrail freight trains was that Conrail's dispatching system was not designed to show that a train has entered a block of track occupied by another train. (GAO 1989a)

Automatic train-stop (ATS) and/or train-control (ATC) systems are often used in conjunction with ABS track. The ATS device is triggered when the train passes a signal warning the train to stop and the brakes are not being applied by the locomotive engineer. The ATS system will stop the train within safe stopping distance unless the locomotive engineer regains control of the brakes within a few seconds. The ATC functions in a similar manner to ATS; however, the former is activated when it encounters a signal instructing the train to reduce its speed as well as stop. Unless the locomotive engineer responds to the warning signal, ATC will apply the brakes until the train stops. ATC equipment is calibrated before installation and cannot be turned off for an extended period of time by the train crew. Settings may be for low and/or medium speeds, 20 and 40 miles per hour, respectively, and also to prevent the train from exceeding a certain speed. The FRA requires trains exceeding speeds of 79 miles per hour to have ATC, ATS, or cab signals.

One limit on the effectiveness of the ATS and ATC systems is that the crew is not necessarily required to take appropriate action in order to prevent the ATS or ATC from stopping the train. For example, on Conrail's ATS system, a whistle sounds when the train is required to stop or slow down. The engineer has eight seconds to respond by pressing an acknowledgement pedal or the ATS will stop the train. In 1988 two Conrail freight trains, at least one of which was equipped with ATS, collided head-on in Pennsylvania, causing four fatalities and millions of dollars in property damages. The National Transportation Safety Board's preliminary finding was that the crew had fallen asleep, and when the ATS whistle sounded, the engineer pushed the acknowledgement pedal in his sleep as a reflex, but did nothing to stop the train. The acknowledgement was sufficient to prevent the ATS from stopping the train. (GAO 1989a)

Several types of safety devices are used on tracks to warn locomotive engineers of potentially dangerous situations. Most will transmit either measurements or warnings to the train crew or to a central dispatcher. Infra-red hot box detectors are placed on tracks at intervals of 20 to 50 miles to detect overheated journal bearings, which can lead to bearing failure and derailment. Hot wheels resulting from stuck or unreleased brakes can be similarly detected. Dragging equipment detectors are used to ensure that equipment such as brake rods and air hoses is not dragging along the track. If such equipment were to lodge between the train's wheels and the track, a derailment could result. These are often placed ahead of major bridges, where a derailment would be exceptionally disastrous. Where necessary, devices that detect rock slides, high water, and earthquake motion can be installed.

To help monitor crew performance and to provide an unbiased, accurate record of train operations prior to a derailment, locomotive event recorders can be used. According to a final rule recently issued by the Federal Rail Administration, locomotive event recorders will be required by May 5, 1995 in the lead locomotive of all trains travelling faster than 30 miles per hour. (FRA, 1994)

The safety value of cabooses at the end of trains has been the subject of debate for many years between rail management, who felt they added personnel (and thus cost) to train operations unnecessarily, and labor unions, who felt they were important for safety. Federal regulations requiring a caboose on every train were relaxed in 1982, and the use of trains without cabooses began in 1984. Several states, including Oregon and Virginia, required cabooses until recently. Contracts between labor unions and carriers now define when cabooses are used. The determining factors are usually train length and track location; a train carrying many cars or a local run that involves frequent switching is more likely to travel with a caboose. In one labor contract, a carrier must use a caboose on a minimum number of trains (or train-miles) or pay a penalty. At present, between 90 and 95 percent of all trains travel *without* cabooses. (Blackwell, 1995)

End-of-train (EOT) telemetry devices are used when cabooses are absent. These are generally "one-way" telemetry devices in the form of two metal boxes, one at the rear of the train (sending unit) and one in the locomotive (receiving unit). The sending unit relays brake line pressure data to the locomotive engineer. This information can warn the engineer if there is a leak in the brake system or if the rear of the train has become uncoupled during travel. The EOT device allows the brakes to be applied from the locomotive. However, the one-way EOT does <u>not</u> allow the locomotive

to verify the status of the sending unit or transmitter in the event of inconsistent readings or apply the train brakes from the rear of the train. Current technology in the form of "two-way" telemetry devices allows the engineer to check the status of the rear telemetry device and engage the brakes from the rear of the train. As a result of an investigation into a derailment incident involving a Montana Rail Link (MRL) freight train, the National Transportation Safety Board recommended that the FRA require the use of two-way EOT telemetry devices on all trains without a caboose. In its conclusions to the MRL incident, the NTSB noted that "A two-way telemetry device would have allowed the road engineer to verify the status of the telemetry device on the rear of the train and to attempt to initiate an emergency application of the train brakes from the rear of the train." (NTSB 1989)

Using the FRA's rail accident records, the frequency and severity of accidents involving trains with and without cabooses between 1984 and 1986 were compared by the National Railway Labor Conference (NRLC), an organization representing rail management. The 1987 study indicated an overall decline in accident frequency over the three year period. Accidents attributed to human error were slightly more frequent for non-caboose trains. The cost of damages to rail equipment per train-mile, which was used as a measure of accident severity, also declined between 1984 and 1986. For both comparisons, however, the difference between caboose and non-caboose operations was considered statistically insignificant.

C. Tracking and Communication Systems

Carriers need to know the exact and relative locations of trains on their rail network for both scheduling and safety purposes. Traditionally, this has been accomplished by two-way radio communication with the crew and instrumentation along the rails. Sophisticated tracking systems are constantly being developed to increase the efficiency and reliability of rail transportation and to provide updated information to shippers as well as carriers. Newer systems involve transponders placed on locomotives or railcars. Recently developed tracking systems are giving more power to central control centers equipped with computers and less autonomy to the locomotive engineer, but it seems unlikely that the latter will become obsolete in the near future.

Communication along the rail network is crucial for safe and efficient train operation. Two-way radio contact between the locomotive and caboose allows the entire train crew to work as a single entity. There is also radio communication between local dispatchers and moving trains on all mainlines and some of the branch lines. Local dispatchers need to be informed of the condition of incoming trains, while locomotive engineers must be alerted of track damage, inclement weather, or other conditions which would require a change in operations. Since signals could be used to advise locomotive engineers to reduce speeds, radio communication is more important in territory that is not equipped with signals.

Three advanced tracking systems have been developed. TRANSCOM was developed by DOE to monitor the movement of unclassified truck and rail shipments of radioactive materials. It will be installed for the shipments to the Waste Isolation Pilot Plant (WIPP) facility in southeastern New Mexico. Using satellites, the exact location of a transponder attached to the shipment is calculated and

transmitted by satellite to the TRANSCOM Control Center (TCC) in Oak Ridge, Tennessee. The TCC was established to maintain the TRANSCOM system as well as to provide support to system users. The types of information available with TRANSCOM include the location of current shipments on computer-generated maps, data regarding past and future shipments, and emergency response instructions. A set of passwords prevents access to all information by every user while allowing parties to access the TRANSCOM database from computer terminals away from the TCC. A CRT screen placed in the cab of the truck or locomotive augments radio communication between the TCC and the shipment.

Burlington Northern Railroad, has discontinued testing on an Advanced Railroad Electronic System (ARES), which was an extremely sophisticated tracking system under which a locomotive's location would be continuously transmitted via Navstar satellite to a central computer. The computer would receive this information and integrate it with a database of the carrier's rail network, including the speed limit and grade along various segments of track.

Currently, however, Burlington Northern Santa Fe, Union Pacific Railroad, and the Federal Railroad Administration have begun a Positive Train Separation (PTS) system demonstration project. The project is now underway on over 800 track miles in Oregon and Washington along the Columbia River and Cascadia Corridor lines.

Railstar, a New Hampshire-based company, is currently marketing a system which is similar to ARES but does not have emergency remote control capabilities. Location and diagnostic information, such as temperature and pressure, are transmitted from devices placed atop locomotives, railcars, and maintenance-of-way vehicles to Railstar's control center via dedicated satellites. Wayside detectors can also be incorporated into the system to transmit vital information. No land-based communication equipment is used, thus avoiding interruptions in transmission caused by topography and other obstructions. In addition to the tracking capabilities of the Railstar system, information management services such as shipment and route summary reports are available.

Union Pacific constructed the Harriman Dispatching Center, a centralized dispatching and tracking system for its entire service territory. Located at UP's headquarters in Omaha, Nebraska, the system replaces individual dispatching/tracking activities for each of its 20 operating divisions. The centralized system utilizes a fully computerized command module which provides dispatch scheduling control of nearly 700 trains per day over UP's 23,000 miles of track. Train tracking occurs through radio contact and remote track "monitors" that indicate passage of trains. The information is relayed to a database. The system also allows for centralized control of train movement over the railroad's mostly single-track routes, and serves as the command post in the event of an en-route emergency. UP has indicated that the system will eventually include real-time satellite tracking. (Tierney 1991)

A 1986 incident involving a flatcar loaded with low-level radioactive waste headed for the disposal facility at Hanford from a nuclear reactor in central Iowa confirmed the need for reliable real-time monitoring of sensitive materials shipments. An apparent error in the classification yard resulted in the railcar becoming attached to the wrong train and travelling through Nebraska and northern Iowa

before being uncoupled at a siding near a small town in Minnesota. Three days after its departure, a computerized car-tracking system located the railcar, which was then successfully routed to Hanford.

D. Radiation Detection and Alarm Systems

The Nuclear Waste Technical Review Board has recommended verifying the radioactive risk estimates predicted by the RADTRAN model developed by Sandia National Laboratories (See Section IV (B) for a description of RADTRAN), although the method of verification has not been specified. Utilization of a remote radiation detection device has potential applications for verifying the model, as well as providing an additional safety measure for spent fuel rail transport, if used in conjunction with an early warning system. Use of some type of automatic radiation detection and alarm system (similar to dragging equipment and hot box detectors) along the rail route leads to concerns for durability, accuracy (calibration), sensitivity, and ability to communicate to some type of control or monitoring center -- all based on remote operations.

The State of Maryland, through the Science and Health Advisory Group (now the Radiological Health Program) within the Department of the Environment, initiated a program entitled "Radioactive Materials Routing Surveillance" in 1983. The program used automatic radiation detection devices along major highways as a means of tracking the movement of radioactive shipments over Maryland's highways. (State of Maryland 1984) The setup included use of a common radiation detection device connected to a printer. The printer was set to run on a timed basis. Calibration was performed roughly once a month. All of the devices operated from standard 110 kv outlets. (State of Maryland 1990)

Initially, the experimental program tested several recorders and detection probes for sensitivity. It was determined that the devices had similar performance capability and the program was put into place. (State of Maryland 1982) The system was used to count radioactive materials shipments at two high volume locations. Results indicated that the system can be utilized at any highway location to detect the passage of radioactive materials at high speeds (50 to 60 m.p.h.), up to a distance of 300 feet. One problem encountered was a difference in the feed rates of the recording devices. Variances of up to four hours between actual shipment time and the time indicated on the recording devices occurred. The overall goal of this project was to determine which sites might need additional observation and characterization for transport of radioactive materials. (State of Maryland 1984) Currently, the technology for radioactivity detection devices is well founded. Based on the Maryland demonstration, the potential for locating automatic radiation detection devices in a remote location along a rail track exists, given a power source, adequate housing and maintenance, calibration procedures, and a communication system.

V. REGULATION, INSPECTION AND ENFORCEMENT

DOT, under the Federal Rail Safety Act, regulates, among other things, state participation in federal rail safety inspections, track safety standards, railroad accident and incident reporting, and

railroad locomotive safety and inspection standards. Radioactive materials transportation by rail is also regulated by DOT under the Hazardous Materials Transportation Act, which addresses such areas as handling and loading procedures, railcar cleanliness, inspections, and incident notification. Because rail regulation under the HMTA is similar to highway regulation under the HMTA, this report focuses on regulation under the Federal Rail Safety Act. The railroads have the primary responsibility for inspecting their equipment and track on a routine basis. Federal inspections are intended to function as oversight programs to ensure that railroads are meeting their responsibility. 49 C.F.R. §212.101 (b) The Federal Rail Safety Act dictates a narrow role for states in safety inspections, but allows more latitude for state inspections for compliance with hazardous materials regulations.

A. Railroad Responsibilities

Railroads are responsible for performing inspections on their locomotives, railcars, and track according to the schedule set by the FRA in 49 CFR 229. Inspections are done at the classification yard by carrier employees who meet FRA requirements, while the FRA oversees the self-inspection program, performing on-site inspections and reviewing records. Repairs are made at the railyard if possible, otherwise the railcar or locomotive is designated to go to a repair facility.

Upon each departure, a train's brakes are checked. Locomotives in regular use are inspected daily. If a defect resulting in non-compliance is detected, it is noted and the locomotive is taken off-line for repairs. Periodic inspections are required at least every 92 days during which the brake gauges, electrical devices, visible insulation, cable connectors between locomotives, and automatic controls are examined. Air brake filters and valves are cleaned, repaired, or replaced during periodic inspections, with the remaining air brake components being checked every two years.

Railcars must be checked visually every 1000 miles, with a more detailed inspection every 100,000 miles. For the shipments of damaged fuel between Three Mile Island and Idaho National Engineering Laboratory, the latter inspection was done prior to every departure from INEL, or about every 5,000 miles. A more comprehensive examination was scheduled for every third departure from INEL.

Track is inspected once or twice per week on main lines and monthly on other track and sidings. Higher class, or better quality, track is inspected more often. Various methods are used to check for track defects. Visual inspections are carried out by locomotive engineers while driving, by track walkers, and by passengers on high rail vehicles, which are automobiles equipped with retractable steel guideways that fit on the track to steer the vehicle while it is powered by its engine and rubber tires.

One potential safety problem is the issue of exempt track -- track below class 1. Railroads are allowed to classify any track as exempt, in which case inspections and repairs are not required. However, the speed limit on this track is only 5-10 miles per hour, which creates a disincentive for railroads to exempt their track. Although exempt track is unlikely to be a major problem for cross-country shipments of spent fuel, it is possible that it could present a localized problem near origin and

destination points. Because of the proprietary nature of track classification, the amount and location of exempt track are unknown, although it is believed that railyards (where the 5-10 mph speed limit would not cause significant problems) contain large amounts of exempt track.

Another potential track problem is that the track standards may not be stringent enough. The General Accounting Office, in examining 21 rail accidents in Pennsylvania, found that six accidents were caused, at least in part, by track defects that were within the allowable range of deviation under the FRA's track standards. The 21 accidents the GAO examined were those the FRA selected earlier for investigation, generally because they were the most serious (involving fatalities or serious injuries) or because the accidents have received great public attention (e.g., involving hazardous materials releases). The FRA has several research projects underway to address track geometry problems. For example, the FRA has discovered that track maintenance procedures often leave track vulnerable to extreme temperatures, thus leading to buckling and sun kinks. The FRA has developed revised maintenance procedures to eliminate this problem. The FRA has not required carriers to use the revised procedures, but is relying on educational sessions with the railroads "in an attempt to persuade them to voluntarily employ the new maintenance procedures." (GAO 1989a)

The responsibility for making repairs due to normal usage of tracks, cars, and locomotives belongs to the owner. However, because of the common practice of one carrier's trains travelling on another carrier's track, parties other than the owner often perform needed repairs or maintenance. Billing for this interline activity, for repairs as well as track usage, is usually handled on a monthly basis between carriers. When a railcar is damaged due to causes other than normal usage, the handling line is often held responsible. Arbitration boards are used to settle disagreements.

The railroad's inspections are spot-checked by AAR. As of November 1995, AAR had 12 mechanical inspectors performing inspections at railyards and industry loading facilities. After a train has been inspected by the carrier's inspector, the AAR inspector carries out the same procedure, validating the inspection. AAR also employs 17 hazardous materials inspectors who visit non-railroad AAR membership companies, such as chemical plants, as well as railyards. Both types of inspectors arrive unannounced. When a violation is detected, the railroad is notified and the inspector will return within six months. The purpose of these inspections is to ensure that proper loading, unloading, and inspection procedures are being followed as per FRA regulations. Each inspector, who is a former railroad inspector, is assigned a geographic territory to cover. The inspection frequency of a particular site will vary depending on whether previous violations have been detected. It is estimated that a fairly busy railyard with no violations will be inspected at least every one to two years.

B. Federal/State Role

The Federal Rail Safety Act makes DOT the lead agency for railroad inspections. (45 U.S.C. §§421 et seq.) DOT inspections are carried out through the Federal Railroad Administration (FRA), which conducts inspections on carriers and shippers, and the Research and Special Programs Administration (RSPA), which concentrates on shippers and container manufacturers. States can play a significant role during rail safety inspections and many coordinate with or supplement FRA safety

inspectors. In 1990, rail inspectors in Oregon placed a locomotive "out of service" after they found a potentially severe defect, which could have been in violation of federal codes. On all accounts, the finding may have prevented a potentially severe incident. (Howells 1991) However, until recently, states generally have had a limited role in enforcing the federal rail safety regulations.

This section discusses the FRA and RSPA inspection programs, the states' role regarding safety inspections, state hazardous materials enforcement programs, and independent state regulation of rail operations.

1. FRA Inspections

The FRA inspects for compliance with hazardous materials rail regulations under the Hazardous Materials Transportation Act, and for compliance with general rail safety regulations (such as track standards) under the Federal Rail Safety Act and other statutes. Most of the inspection efforts are directed towards the safety regulations, rather than the hazardous materials inspections.

Safety Inspections

The FRA had 275 rail safety inspectors in Fiscal Year 1986. (The total number of inspectors was fairly similar for Fiscal Year 1989). Currently, the FRA has 235 safety inspectors in four disciplines, as well as 45 hazardous materials inspectors. The following table shows the current distribution of FRA's 280 inspectors by type (track, operating practices, etc.) (Blackwell, 1995) The map following the table depicts FRA's eight regions.

NUMBER OF FRA INSPECTORS FY-95

Hazardous Materials	Track	Motive Power & Equipment	Signal & Train Control	Operating Practices	Total
45	53	72	48	62	**280**

FEDERAL RAILROAD ADMINISTRATION REGIONS

The Hazardous Materials Transportation Uniform Safety Act of 1990 directed DOT to hire 30 additional hazardous materials safety inspectors. Ten of these inspectors -- including at least 3 in the Federal Railroad Administration -- were to focus on radioactive materials transportation. (As of FY-86, the FRA had 35 hazardous materials inspectors in addition to the 275 safety inspectors; as of FY-95 the FRA has 45 hazardous materials inspectors.) The FRA radioactive materials inspectors are to cooperate with the safety inspectors of the NRC and appropriate state and local governments.

The FRA's role is geared primarily to determining whether the railroads are meeting their responsibilities to conduct self-inspections. The FRA has developed its own high-speed track geometry cars for use by its track inspectors as part of its Automated Track Inspection Program to detect deviations from rail standards. Detailed rail inspections are done annually. Switches and crossing devices are examined monthly if used on a regular basis or before use if used less often.

When FRA field inspectors discover a defect, they are granted broad discretion in deciding whether to file a defect notice with the railroad or to propose formal enforcement action and assess a civil penalty. Regional offices submit proposed violations to FRA's Office of Chief Counsel, which reviews them for legal sufficiency. Headquarters then aggregates similar violation reports and submits them to the carrier as a single case with a penalty notice. The FRA then negotiates a settlement with the carriers, generally for about 50-60% of the initial assessments. Under the Rail Safety Improvement Act of 1988, the FRA is authorized to impose penalties of up to $20,000. Before 1988, the limit was $2,500.

The amount of civil fines which FRA collects has greatly increased over past levels. The following chart shows the total amount of civil penalties collected by FRA under all applicable statutes,

from fiscal year 1987, when FRA collected $3.37 million in fines, to fiscal year 1993, when FRA collected over $15.5 million in fines.

FRA Total Civil Penalty Collections	
YEAR	**AMOUNT**
1987	$3,375,115
1988	$2,556,430
1989	$4,622,928
1990	$8,455,674
1991	$10,951,123
1992	$16,659,448
1993	$15,583,915

Source: Federal Railroad Administration, U.S. Department of Transportation, 1994, Forward Through the 90s: Selected Issues in the Transportation by Rail of Hazardous Materials, Report to the Senate Committee on Commerce, Science, and Transportation and the House Committee on Energy and Commerce.

Timely processing of safety violations by FRA has, in the past, been an issue of great concern. According to the GAO, by the end of 1989, the FRA had a backlog of 24,000 safety violations. (GAO 1990) In 1991, the FRA Administrator indicated that this backlog was reduced to about 9,500. Currently, FRA has said that it has "essentially corrected the problem: Inspector's reports received by the Office of Chief Counsel are reviewed and transmitted well within the agency's 120-day internal guideline and, except for certain cases held for thorney interpretive issues or pending the outcome of on-going litigation, cases transmitted before 1992 have been settled and closed." (FRA, 1994)

The FRA inspectors' interpretation of the Federal Rail Safety Act and the FRA regulations creates enforcement problems. For example, FRA inspectors believe they must allow a train to leave the railyard before the inspector can issue a notice of violation. (The rationale is that it is always possible, at least in theory, that the railroad will notice a violation just before the train leaves the yard and will recall the train to fix the defect.) Therefore, the inspector must choose between allowing an unsafe train to leave the yard (when it may be many miles before the problem is fixed) or telling the railroad to fix the problem (in which case no violation has occurred).

Another problem is that if an inspection occurs as a train is entering a railyard, it is difficult to prove that the defects did not occur in transit. If a defect arises between required inspections, no

violation occurs if the railroad fixes the defect at the first opportunity. With some types of defects, it is difficult to tell when they occurred, and therefore, whether they should have been detected in a required inspection. [A similar problem occurs with track defects. For example, a 73-inch split in a rail caused a derailment of a CSX freight train in Pennsylvania. The carrier was not cited for a violation because the FRA could not prove that the violation was present four days before the derailment when the carrier conducted a routine visual inspection or six months earlier, when the carrier conducted the more detailed semi-annual inspection with a track geometry car, as required under the FRA rules. (GAO 1989a)] After the inspector has notified the railroad of a defect, the railroad certifies that it has corrected the defect. The federal and state inspectors spot check the defect notices to determine if the defects have actually been repaired. If they have not, the railroad can be assessed a penalty for falsifying records.

The GAO concluded that the FRA does not process and settle civil penalties in a timely manner. According to a March 1991 report, the FRA took an average of 36 months to settle civil penalties. The procedure involves an inspector identifying a violation and recommending a penalty through a violation report to headquarters in Washington, D.C. According to the GAO, "the settlement of civil penalties with the railroads has historically resulted in settlement amounts lower than the initial assessment amounts." (GAO 1991)

In many cases, the FRA relies on the railroads not merely to enforce the standards, but also to determine what the standards should be. When the FRA defers to the railroads in developing operating practices, it does not enforce these practices because they are not FRA rules. Two examples are rocking of cars with high centers of gravity, and humping of hazardous materials cars. With respect to rocking, the FRA believes that a 1987 derailment was caused by a hopper car with a high center of gravity rocking its wheel off the rail. The carrier restricts cars with high centers of gravity (which may include spent fuel cars) from travelling between 14 and 21 mph because harmonic rocking at these speeds can cause a derailment when a wheel lifts off the track. Therefore, CSX requires high center-of-gravity trains to travel at least 22 mph, or if this is not possible, to reduce speed below 14 mph. Although the FRA believed that the derailment was caused by the train's 21 mph speed, it did not cite the carrier for a violation of the carrier's operating practices. An example of the humping problem is the 1987 Pennsylvania railyard accident causing a release and fire involving white phosphorus which took approximately four months to clean up. Many railroads prohibit humping of hazardous materials cars (coupling trains by letting them coast down a slight hill until they bump into the rest of the train) and require these cars to be shoved to rest (coupled to an engine which pushes the car into the rest of the train). Although the humping of the white phosphorus cars caused the puncture of the tank car and the resulting fire, no violation occurred because, in this case, humping of hazardous materials cars was not prohibited under the FRA's rules. (GAO 1989a)

A major area in which the FRA defers to railroads is in enforcement actions against individual railroad employees. Before 1988, the FRA was able to assess penalties against the carrier, not the individual employee, for an employee's violation of an FRA rule. The FRA generally did not exercise this limited authority, saying that it preferred to allow the carrier to use its discretion in determining whether to discipline an employee. For example, when a 1987 derailment occurred because the train

was travelling at 60 mph in a 30 mph zone, the FRA did not cite the carrier for violating the speed limit, even though the derailment caused a hazardous materials release and the evacuation of 22,000 people. This failure to cite the carrier was consistent with the FRA's general policy not to cite a carrier for speeding violations unless there is a consistent pattern of violations for a given track class. (Even then, the violation technically is not for speeding, but for failing to maintain the track to the level required for the speed travelled.) In another example, the carrier was not cited for a violation when an overheated journal box caused a derailment, even though railroad employees told the FRA that they had not conducted the federally-required predeparture inspection of the journal boxes. FRA inspectors said that they had not observed the violation and that the railroad employees had refused to sign a statement regarding their violation. The 1988 Rail Safety Improvement Act granted the FRA the authority to assess penalties against individual employees who willfully violate an FRA rule; it is not known to what extent the FRA exercises this authority. (GAO 1989a)

Hazardous Materials Inspections

The FRA enforces the hazardous materials rail regulations under the Hazardous Materials Transportation Act. As with the safety regulations, shippers and carriers have the primary responsibility for ensuring compliance with the hazardous materials regulations; FRA's role is to determine whether they are meeting this responsibility. As of November 1995, the FRA had only 45 hazardous materials inspectors nationwide. (Blackwell, 1995) In FY-86, the most recent year for which regional distributions were available, FRA had 35 hazardous materials inspectors, with three each in regions 6, 7, and 8 (see map in previous section) and 6 in region 5. (GAO 1987b) FRA hazardous materials inspectors also have non-inspection duties (such as accident investigations, safety training classes for shippers and carriers, and writing violation reports), which take up about 34% of the inspectors' work time. In addition to the inspections performed by the hazardous materials inspectors, the FRA's general safety inspectors also devote part of their time towards hazardous materials compliance. (GAO 1989c) For example, in 1984, FRA had 34 inspectors devoted full time to hazardous materials inspections, and 166 safety inspectors who, on average, spent slightly less than 10% of their time on hazardous materials inspections. (OTA 1986)

The hazardous materials inspection program is similar to the safety inspection program. Field inspectors determine whether to write up a defect as a notice to the railroad or as a violation for which FRA Headquarters may pursue civil penalties. Relatively few of FRA's hazardous materials inspections result in a penalty being collected from a railroad. For example, in Fiscal Year 1988, FRA collected $396,425 in penalties in 36 hazardous material enforcement cases. (An enforcement case often consolidates multiple similar violations against a single shipper or carrier). The penalties ranged from $500 to $97,000, with an average of $11,012. The four largest penalties (three of which were against the same carrier) accounted for more than half of FRA's collections; when these cases are disregarded, the average penalty was only $6,120. More than half of the penalties collected measured $5000 or less. DOT's penalty report also reveals that collections are decreasing; in FY-85 through FY-87, FRA collected more than $600,000 annually. There is a significant lag time between the initiation of an enforcement case and the collection of a penalty. Of the 36 penalties collected in FY-

88: none had 1987 or 1988 case numbers; only 7 had 1986 case numbers; and the remainder were almost equally divided between 1984 and 1985. (DOT 1989a)

The General Accounting Office (GAO 1989c) has criticized the FRA's hazardous materials inspection program. Its findings and recommendations include:

- The number of hazardous materials violations increased by 600% from 1984 to 1988 even though the number of inspections decreased over this period.

- FRA's 28 inspectors annually inspect approximately 85 railroads, 15,000 shippers and 100,000 hazardous materials tank cars.

- The FRA Hazardous Materials Enforcement Manual is deficient because it is out of date, contradicted by regional goals and guidance, and vague. It provides no criteria for determining who should be inspected and how often inspections should occur.

- Inspectors generally did not understand their enforcement authority over hazardous materials shippers. Most inspectors believed that they could not issue a violation until after a shipper had released a defective hazardous materials car into transportation (i.e., transferred it to the railroad). Therefore, even though the hazardous materials regulations explicitly address loading of hazardous materials, inspectors said they were extremely reluctant to cite shippers for improper loading, even if they personally observed the improper loading procedures, unless there was evidence that the car was still in violation while it was in the railroad's possession.

- Inspectors spend more than half of their time inspecting railroads, although the FRA Headquarters goal is to spend 80% of inspection time at shippers' facilities, where the greatest number of violations arise. The FRA, however, claims that this statement is misleading because many of the cars which the FRA inspects on railroad property are actually shippers cars. (Kelly, 1996)

- Although FRA inspectors spend most of their time inspecting individual rail cars, they can only inspect about 6% of hazardous materials rail shipments. [Spent fuel is an exception. The FRA inspects each spent fuel shipment before it is offered for rail transport.] Inspectors' time would be better spent reviewing shippers' and carriers' safety procedures to identify problems that could affect numerous shipments.

- It would be more cost effective for the FRA to train and certify state rail inspectors than to add more hazardous materials inspectors to FRA's permanent staff. GAO found that the four states it talked to were interested in receiving

> more training from FRA. If this trend holds true after a more comprehensive survey of states, FRA should seek the necessary Congressional authorization to involve states in the federal hazardous materials inspection program, similar to state participation in the rail safety regulations. (See discussion below under 3. State Enforcement of Federal Rail Safety Regulations.)

GAO reiterated its concerns in its November 1989 testimony before the House Energy Subcommittee on Transportation and Hazardous Materials. Because FRA's small hazardous materials inspection staff is charged with inspecting the safety practices of 85 railroads and 15,000 shippers, it is essential that FRA concentrate its resources on the greatest hazards. GAO stated that FRA inspectors are not focusing on the areas with the greatest danger -- shipping docks of hazardous materials manufacturers. Also, the number of inspections has declined annually since 1987. GAO also said that although FRA is supposed to inspect all railroad and shipper facilities annually, in the four regions studied by GAO, only 30% had been inspected in the last year. (NARUC 1989)

2. Research and Special Programs Administration Inspections

DOT's Research and Special Programs Administration also has some responsibility for enforcing hazardous materials regulations. RSPA focuses especially on container manufacturers. None of the 92 penalties collected by RSPA in FY-88 were identified as relating to rail shipments or rail-specific container manufacturers. However, it is possible that some of the violations related to rail shipments. (DOE 1989a)

3. State Enforcement of Federal Safety Regulations

States can conduct independent inspections (without an accompanying FRA inspector) only if they have passed an FRA training/certification program. The regulations state that other education and experience can be substituted for the training program, but as a practical matter, all state inspectors must participate in the FRA apprenticeship program. No set training period has been established; certification of a state inspector can take up to six years. Detailed qualifications for each type of inspector (e.g., track inspector) are specified in FRA's rules. 49 C.F.R. §212.201 - 212.227.

Even after a state inspector has passed the FRA certification program, he or she must process all violations through FRA. After FRA receives the state's investigation report and a request for a civil penalty assessment, the Secretary of Transportation has 60 days to decide whether to act on the potential violation. [The statute states the Secretary makes this decision, but the authority apparently has been delegated to the FRA. 49 C.F.R. §212.115] If the Secretary makes a decision (either for or against pursuing the violation), the state's role is ended. If the Secretary makes no decision, the state may pursue the violation in federal court. Any penalties received from the railroad go to the U.S. Treasury as miscellaneous receipts. This creates a great disincentive for states to use their resources to conduct independent enforcement efforts; few, if any, states have pursued violations after FRA has declined to act. A similar rule exists for obtaining injunctive relief (ordering a violator to stop

committing violations or to take some affirmative action), but the time limit for the FRA's decision on whether to pursue the violation is 15 days. 43 U.S.C. §436.

Another weakness in state enforcement of federal rail safety regulations is the lack of federal funding for state inspection programs. Federal funding is limited by statute to 50% of program costs and federal money cannot be used to replace historic state spending on inspections. Furthermore, the level of funding in the past has decreased from 50% of state program costs in 1985 to 15% by FY-88. The National Association of Regulatory Utility Commissioners blames the FRA and the railroads for these funding cuts and notes that FRA has consistently proposed zero-funding for the state enforcement programs. (NARUC 1988) No funding was provided in FY-89. (Melander)

When funding is available, the FRA rules set forth the minimum number of person-years each state must devote to each type of inspection (track, freight car, and railroad operating practices) to qualify for federal funding. The rules also specify the maximum number FRA will fund, which is merely the minimum person-years rounded up to the next whole number. [For example, if FRA requires a minimum of 1.2 person-years for track inspections in a state, it will provide reimbursement for up to 2 inspector-years, possibly so that the state is not required to hire part-time inspectors.] If a state wants to use more inspectors than the FRA will fund, it is allowed to do so at the state's expense. 49 C.F.R. Part 212 Appendices A, B and C. In establishing the number of inspectors FRA will reimburse for each state, the FRA considers: number of inspection points or miles of track; traffic levels; accident history and accident potential; the number of federal rail safety laws (in addition to the Federal Rail Safety Act) for which the state is providing inspections; and the deployment of FRA inspectors. In western states, the number of inspectors per state authorized for FRA cost-sharing ranges from three to five (with California being the exception with nine inspectors authorized for cost-sharing). The highest levels of authorized inspectors are in the track inspection area, where many western states are authorized for two inspectors. (For comparison purposes, the highest levels of track inspectors outside of the West are in Illinois, with six inspectors, and Texas, with five inspectors.) Few western states are eligible for more than one freight car inspector and one operating practices inspector. (For comparison purposes, the highest levels of authorized freight car inspectors are in Ohio, with five inspectors, and in Pennsylvania and Illinois, with four inspectors each. The highest levels of operating practices inspectors are in Illinois and Pennsylvania, with four inspectors each.)

Under the Federal Rail Safety Act, criteria have been established that allow state agencies to have federally certified rail inspectors. Currently, there are a total of 137 state inspectors in 29 states. (Blackwell, 1995) The following table shows the distribution of these 137 inspectors by type (track, operating practices, etc.) (Blackwell, 1995)

NUMBER OF FEDERALLY CERTIFIED STATE INSPECTORS FY-95

Hazardous Materials	Track	Motive Power & Equipment	Signal & Train Control	Operating Practices	Total
19	51	37	9	21	**137**

It has been estimated that state inspectors provide more than one-third of the combined federal/state enforcement effort. (City & State 1989) However, the National Association of Regulatory Utility Commissioners believes that state enforcement programs are jeopardized because of funding and state enforcement authority problems. At least two states (Alabama and Louisiana) terminated their programs in response to funding cuts. (Melander) Tennessee Public Service Commissioner Keith Bissell recently noted that the rail transportation areas showing the greatest improvements in recent years -- track and equipment -- are the areas in which the states have provided the greatest percentage of inspectors. Bissell, noting that 81.5% of 1988s train collisions were caused by human error, called for increased numbers of operating practices inspectors, who review drug and alcohol control programs, enforce compliance with hours-of-service laws, and act in other areas related to human error. Currently, there are 56 operating practices inspectors, including 18 state inspectors. (NARUC 1990) [Note: there is some disagreement over the percentage of accidents attributable to human error. A House Appropriations Committee report estimated that only 28% of rail accidents are caused by human factors. (Congress 1988) The 1988 Accident/Incident Bulletin attributes 34% of total reportable accidents to human factors, more than any other cause. (FRA 1989)]

In a 1988 resolution, NARUC called on Congress to adopt legislation to strengthen state rail safety enforcement programs by:

1) giving states direct enforcement authority (rather than requiring states to pursue violations through FRA) in all areas in which they have certified inspectors;

2) requiring FRA to establish a training and certification program for state inspectors which requires no more than two years to complete and which uses certified state and federal inspectors as instructors;

3) allowing states with direct enforcement authority to impose and keep the fines they collect for violations of state and federal rail regulations to help fund rail regulation; and

4) clarifying that state fees imposed on rail operations to fund rail regulation are permissible and do not constitute "impermissible discrimination" under the Railroad Revitalization and Regulatory Reform Act (4R Act) of 1976. (NARUC 1988)

A 1987 GAO survey (GAO 1987b) of state rail safety administrators supported NARUC's concern that decreased federal funding of state inspection programs could have a significant impact on the level of state participation. Of 30 states who participated in the federal safety inspection program and responded to GAO's survey, 25 states said that it was possible that the number of state inspectors would decrease if federal funding were eliminated. Thirteen of these 25 states said that the decrease would be "very likely." Fifteen states said that it was possible that their states would eliminate the rail safety programs entirely. Of 28 states which predicted how they would fund their programs if FRA's support were eliminated, 18 states said that they would consider assessments against railroads, while 10 states said they might use general state funds.

At a December 1990 State/Federal Rail Safety Coordination Meeting, state representatives met with Federal Railroad Administrator Gilbert Carmichael on ways to improve the railroad safety partnership between states and the FRA. The Administrator indicated that the FRA must change in response to GAO's recent critical evaluation of FRA's railroad safety inspection program. The FRA Administrator indicated that state and federal inspectors would be treated as equal in terms of work assignments and that FRA would be receptive to state training curriculum development. However, FRA was noncommittal on funding for state rail programs, would not negotiate on the concurrent penalty issue (discussed in **State Regulation of Rail Operations**), and would not abdicate its authority with regard to amending or adopting safety standards to the states. FRA officials indicated that work is underway toward a proposed rulemaking to amend regulations governing state participation in hazardous materials regulations enforcement to conform with Section 28 of HMTUSA. (Smith 1991)

4. State Enforcement of Federal Hazardous Materials Regulations

The state enforcement program for hazardous materials rail transportation regulations differs in several key respects from the safety enforcement program described above. The states are allowed to keep any fines they collect as a result of the enforcement program. The FRA helps train state hazardous materials inspectors, but pays only for travel and training expenses. The FRA does not provide any funding for state enforcement programs. The FRA has only recently begun to certify state hazardous materials inspectors. Currently there are 19 federally certified state hazardous materials inspectors in 13 states including Oregon, Texas, Arizona, and California. (Blackwell, 1995)

As shown in the map on the following page, 21 states have adopted federal hazardous materials regulations for rail shipments, but only 12 of these states have active enforcement programs. In the West, Nevada, Oregon, and Utah have adopted the federal regulations in their entirety. Arizona, California, South Dakota, and Utah adopted the regulations in part. Of the WIEB states which have adopted the regulations, all but South Dakota have enforcement programs. Oregon, Utah and Washington have adopted state regulations in addition to the federal regulations.

Four types of inspections are possible: trackside, railyards (including railcar inspections without opening the rail car), shipper, and railcar right of entry. Not all states perform all types of inspections:

Arizona -- railyard only
California -- all four
Nevada -- railyard and shipper only
Oregon -- railyard only
Utah -- all four
Washington -- railyard and vehicle right of entry only

HAZARDOUS MATERIALS RAIL PENALTIES IMPOSED BY WESTERN STATES

	Civil	Criminal	Administrative
Arizona	X		
California	X	X	X
Nevada		X	X
Oregon	X	X	X
Utah	X	X	X
Washington	X		

State penalties can be criminal, civil or administrative. Criminal penalties can include imprisonment, unlike civil or administrative penalties, but require enforcement officials to meet a higher burden of proof. Criminal and civil penalties must be pursued through the courts, unlike administrative penalties, which can be assessed by the state agency that enforces the rail regulations. The box shows the types of penalties that each state is authorized to impose.

The number of state rail inspectors ranges from 1-19 per state (with California having 19 inspectors). Most states have three or fewer inspectors, who are responsible for enforcing the rail safety regulations in addition to the hazardous materials regulations. (NGA 1989)

5. State Regulation of Rail Operations

Several courts have addressed the permissible extent of state regulation of rail operations and imposition of fees.

Railroads have filed lawsuits in several states challenging the legality of state fees assessed against railroads. A U.S. Appeals Court overturned a U.S. District Court ruling that prohibited the Oregon Public Utilities Commission from imposing fees on the railroads to recover the costs of rail regulation. Union Pacific Railroad Company, et. al v. Public Utilities Commission of Oregon; State of Oregon, 874211 D.C. CV86778 OMP (March 28, 1990) The Court found that such fees are legal. However, three other funding issues were left in the lower court. Union Pacific decided not to take the case to the Supreme Court. In 1988, NARUC testified before a Congressional committee that 17 states could be in the same position as Ohio; finding their fees challenged by the railroads.

In 1988, a U.S. District Court found that Ohio's hazardous (including radioactive) materials transportation regulations, as they applied to rail operations, were preempted by the Federal Railroad Safety Act of 1979 (FRSA). CSX Transportation, Inc. v. Ohio Public Utilities Commission (S.D. Ohio, Dec. 12, 1988) [The court allowed the Ohio laws to stand as they apply to other transportation modes.] The Ohio law required carrier registration (with fees ranging from $5 to $250 annually), with

the proceeds to be used to fund emergency response training. The Public Utilities Commission was authorized to require carriers of certain hazardous materials (not including radioactive materials) to conduct route assessments and to require shippers of those materials to provide prenotification. Penalties of up to $10,000 were authorized for certain safety violations. The Court applied the preemption clause in the FRSA rather than the less stringent preemption provision of the Hazardous Materials Transportation Act. Under the FRSA, a state law related to any DOT-regulated area of railroad safety is preempted unless it is necessary to address a local safety hazard. The U.S. Sixth Circuit Court of Appeals subsequently upheld the District Court decision.

On January 22, 1991, the U.S. Supreme Court denied to review this decision, letting stand the Appeals Court holding that Ohio's statute regulating transportation of hazardous materials is subject to the broad preemption provision in the Federal Railroad Safety Act (U.S. Law Week 1991). The Appeals Court's opinion does not totally prohibit states from promulgating rail safety regulations. The FRSA allows states to adopt or continue to enforce any regulations relating to railroad safety until the Federal Railroad Administration has adopted or has declined to adopt regulations covering the subject matter of the state requirement.

Courts have, in the past, been more lenient regarding state regulation of railyard operations than of rail transportation. Following the U.S. Supreme Court's recent reversal of a District Court decision upholding a state's right to regulate railyard operations, however, this may be changing. On July 18, 1990, the Supreme Court held that the District Court failed to give sufficient weight to the DOT's ruling that the regulations of the state of Nevada were inconsistent with federal provisions of the Hazardous Materials Transportation Act (HMTA) and DOT regulations promulgated thereto (HMR). Thus the Supreme Court upheld the DOT's ruling that the state regulations were redundant and unduly burdensome, and therefore preempted by federal regulations. (Southern Pacific Transportation Co. v. Public Service Commission of Nevada, 909 Federal Reporter 2d 352)

Several states (in addition to Ohio, discussed above) have statutes specifically regulating hazardous materials transportation by rail. California, in particular, has been a pioneer in establishing state regulations governing rail operations. California has found that states have three major tools to use in ensuring the safety of rail shipments: (1) states can participate in enforcing federal regulations (currently, the California Public Utilities Commission (CA-PUC) has 20 FRA-certified rail inspectors who write violations when railroads do not comply with federal regulations); (2) as the CA-PUC has done, states can issues regulations in areas where the federal government has not “occupied the field” with federal regulations; and (3) states can adopt regulations to mitigate “local safety hazard sites.” (Well, 1995)

In 1991, two major rail accidents occurred which helped spur the development of increased state legislative and regulatory involvement over rail operations in California. The first accident was a derailment at Dunsmuir, California which resulted in the spilling of a chemical weed killer that killed all aquatic life in the Sacramento River for several miles. The second accident occurred two weeks later at Seacliff, California, and caused the closure of a major California freeway for five days.

In response to the public outcry over these two derailments, the California legislature passed a series of bills in an attempt to prevent such spills from occurring in the future. In addition, on August 7, 1991, the CA-PUC promulgated General Order 161 governing the transportation of hazardous materials. General Order 161 contains several requirements, including: (1) railroads must notify local emergency response agencies when any rail incident occurs; (2) railroads must provide local emergency response agencies with the railroad's current emergency telephone number; (3) within 60 days of a written request by an emergency response agency, railroads must provide a list of the hazardous materials which passed through or within the jurisdiction of the requesting emergency response agency for the most recent 12-month period available; (4) railroads transporting hazardous materials must have an "emergency preparedness plan," which must include procedures for notifying the appropriate emergency response agency in the event of a rail incident, procedures for mitigation of release, and training procedures for railroad personnel; and (5) all trains transporting hazardous materials must be equipped with at least two radio transceivers in good working order. (Well, 1995)

The CA-PUC also adopted rules for both the Pantera Loop, where the Dunsmuir accident occurred, and for the Seacliff accident site. The Pantera Loop was established as a "local safety hazard site," which allowed the CA-PUC to establish both length and weight limits for trains traveling over the site. At Seacliff, a rule was established that hot box detectors must be placed every 20 miles. The CA-PUC was able to implement this rule because the federal government had no regulations governing hot box detectors, and thus had not "occupied the field" in this area. (Well, 1995)

The bills passed by the California legislature impose further requirements. For example, railroads are required to pay a user fee to the CA-PUC to defray the added costs of state regulatory activities in the rail area. In addition, the CA-PUC is required to inspect all tracks at least once per year, as well as identify local safety hazard sites throughout the state. Following the passage of this legislation, the CA-PUC identified 38 local safety hazard sites. Currently the agency is in the process of establishing mitigating measures for 33 of the 38 sites. (Well, 1995)

California presently also has the power regulate rail walkways. This state regulatory authority withstood legal challenges and was affirmed by an appellate court. However, it should be noted that a similar regulatory provision in Texas concerning walkways was struck down by another appellate court. Unfortunately, this issue has not been completely resolved since the Supreme Court refused to rule on the conflicting appellate court decisions. (Well, 1995)

Other states, such as Oregon, also have statutes authorizing the adoption of hazardous materials rail safety regulations, and inspection, prenotification, and accident reporting requirements. (See: Ore. Rev. Stat. Ann. §761.110). Non-western states which regulate hazardous materials transportation by rail include: Illinois (Ill. Rev. Stat. Ann. §95 1/2 §18c-7404); Iowa (Iowa Code Ann. §307.26); Massachusetts (Mass. Gen. Laws Ann. ch. 25 §5c); and Michigan (Mich. Division of Radiological Health Regulation 325.5801). (Battelle 1989)

VI. EMERGENCY PREPAREDNESS/RESPONSE

The emergency preparedness and response actions associated with rail transport differ from those associated with the highway mode. Rail carriers must focus their efforts on potential hazards at railyards, the site of short-term storage and switching activities, as well as those involving trains en route. Access to an accident site by emergency equipment is another concern regarding emergency preparedness plans. Both aspects require educating railroad personnel and coordinating response plans with local responders.

A. Railyards

Risks associated with railyards include the release of dangerous materials stemming from the collision of railcars and derailments during switching activities, vandalism or sabotage of standing railcars, fire, or an explosion of explosive materials. The presence of most railyards in or near populated areas increases the danger. However, the risk at railyards can be minimized through good emergency preparedness policies or through the use of special or dedicated trains, which do not need to stop as often.

1. Emergency Planning

Past experience has shown that several factors are key to effective emergency response efforts at railyards. Most important seem to be good working relationships among the carrier, local government, and the surrounding community. An emergency response plan which includes input from all parties should be established before any emergency occurs. This plan should outline the assignment of responsibilities and sequence of notification during an emergency. Local emergency response agencies should have a scale map showing the layout of the tracks and structures at railyards in their territory. Sufficient communication equipment at the railyard would enable the early transmittal of vital information. Lastly, many concerned citizens and public officials contend that advance notification of local agencies by railroads regarding pending hazardous materials shipments would allow for adequate preparation by emergency management organizations.

To help railroads plan for accidents involving radioactive materials, AAR published a report, "Nuclear Emergency Response Planning for Railroads," in 1984. The report emphasized many of the factors mentioned earlier, such as the importance of an established response plan prior to any emergency and concise communication, and also provided descriptions of many radioactive materials commonly transported by rail.

Good working relationships between the rail industry and local governments are being fostered by local emergency response personnel attending AAR training courses held in Pueblo, Colorado. Also, a few major cities such as Houston and Atlanta have established emergency response plans with communities and industry, and others are being developed. For instance, Houston recently started a pilot program called Operation Respond. As part of this program, the Houston Fire and Police Departments and the Harris County Sheriff's Department have on-line computer access to the

hazardous cargo files of the Port Terminal Railroad, and the Southern Pacific Railroad. Also, the police and fire dispatching centers of Pasadena and Galena Park, Texas, are being connected to this information via a dedicated fax machine. According to the FRA, "[t]his pilot program may ultimately provide the model for hazardous materials emergency response partnerships for communities throughout the United States." (FRA, 1994)

The Union Pacific Railroad has training programs in the form of films and slide presentations available for use by local emergency response personnel. They include programs for recognizing and identifying hazardous materials as well as the basics of tanker car and intermodal tank container design.

2. Training, Standards, and Certification

Railyard employees and train crews receive limited emergency response training and depend on the hazardous materials emergency handling guidelines published by the AAR to provide appropriate response instructions in case of an accident. According to a 1985 NTSB study, erroneous instructions in the AAR publication seriously hampered the initial response actions to the April 1983 nitric acid spill in Denver. According to AAR, improvements have been made to increase the accuracy of the guidelines. (Conlon, 1995) While there is no national curriculum, most major carriers have training programs that cover general handling and emergency treatment of hazardous materials. Four hazardous material emergency response training courses are offered several times per year at AAR's Transportation Technology Center in Pueblo, Colorado. Since 1985, there have been approximately 20,000 participants in these courses, including representatives from chemical companies (40%), rail carriers (20%), and local fire departments (25%). The radiological portion of the training is sponsored by DOE. In October 1990, the Hazardous Materials Transportation Uniform Safety Act (HMTUSA) reauthorized and amended the Hazardous Materials Transportation Act. A portion of the amended act focuses on testing and certification for hazardous materials employees upon completion of hazardous materials training. Radiological training programs offered at the Transportation Technology Center are transportation-oriented to both rail and highway transportation.

Under Section 106 (b) of HMTUSA, the Secretary of Energy, within 18 months of enactment of the amendments, must issue requirements for hazardous materials employers to provide training for all hazardous materials employees regarding "the safe loading, unloading, handling, storage, and transportation of hazardous materials" and "emergency preparedness for responding to accidents or incidents involving the transportation of hazardous materials." Section 106 (b) (6) addresses certification. Upon completion of a hazardous materials training course, each employer must certify, with appropriate documentation, that the employee has received transportation-related training and has been appropriately tested in one or more of several areas, including: the DOT's hazardous materials classification system; DOT's placarding and marking systems; general handling procedures (loading and unloading); health, safety, and risk factors; appropriate emergency response and communication procedures; use of DOT's Emergency Response Guidebook; other hazardous materials transportation regulations; personal protection techniques; and preparation of shipping documents for transportation of hazardous materials.

A key issue may arise from the AAR radiological training and the certification for training required under HMTUSA -- Should the railroad employees be required to meet the same level of certification as local or State emergency responders who have completed radioactive materials training courses? The standards for certification under HMTUSA may or may not equate with local and State training standards. Inconsistencies in levels of training for rail transport workers (potential emergency responders) could result in concerns over several issues, such as: conflicts with standards and requirements that are already in-place, whether certification levels should be a criterion for route selection, and addressing public opinion on the adequacy of radiological safety training. Train crews and/or railyard workers would certainly play a significant role in radioactive material handling and any emergency scenario that could arise. Issues related to testing or certification for radiological training of railroad employees are likely to receive additional attention.

B. En-Route Emergencies

Train crews provide the initial line of response to an emergency situation while en route. DOT requires that emergency response information be kept on-board, and the AAR guidelines fulfill this requirement and enable the crew to determine the appropriate action to take. In the event of an emergency, the crew radios the nearest dispatcher who would notify the railyard's safety officer, who is in charge of coordinating the response actions and alerting the appropriate government agencies. Safety officers have been trained to handle hazardous materials and other emergency situations.

The promptness and methods used in retrieving derailed railcars loaded with hazardous materials are major concerns for the carrier, shipper, and general public. The ultimate concern for everyone is the potential environmental, safety, and health hazard associated with the release of hazardous substances into the environment. In addition, a top priority for carriers is clearing the track for later rail traffic. In contrast to highway vehicles, detouring trains is a major undertaking. A carrier may not own an alternate route and may have to negotiate with a competing railroad for use of the latter's tracks. Carriers are obligated to deliver goods on schedule or pay a penalty often equal to the value of the goods. These factors provide added incentive for the prompt clean-up of an accident site. With respect to urgency of cask retrieval as compared to locomotive recovery, some carriers mentioned an informal policy that would give priority to retrieving a high-level waste package, assuming that the locomotive and cask were equally accessible.

1. Derailment

In retrieving derailed railcars, a carrier will utilize either its own resources or those of a contractor, depending on the location and severity of the accident. Historically, the railroad industry has used its own equipment and personnel for recovery operations. This is still the case with minor derailments (e.g., when a wheel or two slips off the track at low speeds), and most railyards are equipped with cranes for this purpose. However, the high equipment cost and the vastness of many carriers' territories have advanced the use of contractors for retrieving railcars following severe derailments. A few major contracting companies that specialize in rerailing operate throughout the

Midwestern, Southeastern, and Eastern U.S., where rail traffic is heaviest. In some parts of the country, carriers may have agreements with construction contractors regarding use of heavy equipment for a train rerailment. Several types of equipment are used to rerail railcars. The most common are side booms, which are Caterpillar tractors with mounted moving cranes. These can be transported by truck or rail car and can also be equipped with padded tracks for use on streets. Usually at least two side booms are used to lift a railcar from either side onto the tracks; four are used for heavy railcars and locomotives. Sixty and 100 ton "hyrail" equipped (road or rail transport capability) cranes have also been used in rerailment operations. Derricks, which are railcars with mounted cranes that have a capacity of up to 250 tons, may also be used. Several carriers own their own derricks. Since locomotives often weigh more than 100 tons, the weight of a spent fuel cask is not seen as a limiting factor. Of greater concern is the shape of the cask and the configuration of trunnions, by which retrieval equipment would grab hold of the cask with a sling or hook. In response to suggestions by AAR, one of DOE's cask designers has added extra trunnions to facilitate cask retrieval. Such trunnions are also included in the design of the multi-purpose canister (MPC).

With respect to the location of equipment, a few rail carriers with operations in the West indicated that some equipment is strategically located for use in the more difficult Western terrain. For the most part, rail carriers store their heavy equipment at the regional hubs with relatively equal dispersion throughout their service territories. Derailment contractors indicated that each divisional headquarters had roughly the same equipment available, but that certain heavy equipment was strategically located for use in more difficult terrain. Response time generally depends on the distance and route to the accident. Both contractors and railroad response personnel strive to be en route within an hour and at the site in less than ten hours. Several labor contracts require a certain level of participation by railroad employees whether or not a contractor is involved. Hazardous materials specialists from the carrier and/or contractor may become involved if needed. At least one major rail carrier has its own hazardous materials response vehicle.

2. Accident Response in Difficult Terrain

To date, there has been a limited number of rail shipments of high-level radioactive materials in the West. Accordingly, few accidents involving high-level radioactive materials or spent fuel casks have occurred. Further analysis of potential complications resulting from a rail accident involving high-level radioactive materials must rely on speculation by rail carriers and contractors, whose judgment is based on past experience with derailments or rail accidents.

The fact that a number of potentially limiting topographical characteristics exist in the western States raises the possibility that an accident could occur in which cask retrieval may be especially difficult. In comparison to cask recovery on a level, relatively obstacle-free area (e.g., plains) or a railroad's operational terminal, steep canyons, wetlands, rivers, and mountain passes present conditions that would likely make rail car, locomotive and/or cask recovery complex. The remoteness of many of these areas would presumably result in an increase in response time. With regard to cask recovery, rail carriers and contractors generally believe that there are no surface or landform characteristics that are so limiting that they would prevent recovery of spent fuel casks with equipment that is commonly

available for derailments, assuming that there is no release and trunnions are in place. For example, one carrier recalled the recovery of a locomotive from a crater lake in Montana with cranes and another made reference to the use of pulleys and winches in a steep canyon to aid in recovery of railroad cars. Use of barge-mounted cranes was mentioned as a possibility for cask recovery on or near a waterway. If circumstances arise in which common equipment may not be able to perform a recovery operation, rail carriers and/or contractors feel that they can get whatever equipment may be necessary. A variety of contingency options exist for a difficult recovery scenario, including tying into DOE or DOD facilities. In general, most echoed a common belief that, based on cost, operational efficiency, and opportunities for use, the effort to catalog or strategically locate any special equipment is beyond the scope of response planning.

3. DOE Radiological Response Assistance

Several contractors have stated they would be unwilling to respond to a rail accident involving radioactive shipments until the possibility of leakage had been ruled out. This responsibility could be assumed by DOE's specially-trained Radiological Assistance Teams, or RATs, (now known as Radiological Assistance Program teams, or RAP teams) who were on call for the Three Mile Island-INEL shipments and would probably be available to provide support for other radioactive materials shipments. The emergency response contingency plan for this shipping campaign calls for the train crew to report to the nearest local dispatcher, who would call DOE's Warning Command Center. The center would notify DOE's emergency response personnel, and officials of the state and adjacent states. DOE has eight regional offices and 26 RAP teams which can mobilize within two hours and be on the scene in six to eight hours.

The western region comprises all or part of five of the eight Regional Coordinating Offices, which are located in Albuquerque, Idaho Falls, Oakland, Chicago, and Richland Falls (WA). Within each regional office are Area and Project Offices which are responsible for supporting Radiological Assistance Program activities. The purpose of the RAP and the RATs is to make DOE resources (facility contractor expertise and equipment) available to state and local agencies in a consistent manner. The Radiological Assistance Program does not keep special staff and equipment assigned to specific regions. However, the RAP teams have agreements with the Department of Defense, and the Accident Response Group (ARG) within the Department of Energy for the use of specialized equipment. An example of the former would be the use of heavy equipment from Kirtland Air Force Base in New Mexico [Region Four]. An example of utilization of the ARG would be use of a field deployable, air transportable x-ray diagnostics device developed at Los Alamos National Laboratories (LANL), which allows x-ray examination of damaged items such as radioactive materials packages. In addition, one Regional or Area Office may request the resources of other DOE Offices or facilities if the need exists. Requests would be made through a 24-hour hotline. RAP equipment operators must be trained emergency response personnel. (SAIC 1989)

4. Access

Access may be a distinct problem for response to a difficult derailment situation, both physically and legally. Rail, truck, and direct transport to the scene would be the likely methods. Rail transport may be the only option in certain areas (e.g., steep canyons) for both responders and equipment. For less limiting areas, trucks may provide the optimal transport method. Direct transport refers to the possibility of straddling the track with a side-boom tractor or "padding" tractor tracks for direct road access. From a legal aspect, much is contingent upon the railroad's attitude toward use of its privately owned right-of-way. In the past, railroads have sometimes performed derailment cleanup operations without notifying state or local officials. If an accident involving high-level radioactive materials occurred in a difficult or remote access area, a site assessment would initially be performed (by trained local, State, or Federal emergency responders) to determine if a release occurred and the basis for the subsequent response activities. In general, a greater level of cooperation is probable due to the nature of the materials and the likelihood of using some type of tracking/detection system which would alert local/State/Federal responders in the event of an accident or release.

VII. ROUTING

No federal agency is required to select rail routes, nor has any federal agency adopted rules requiring shippers and carriers to use certain guidelines in selecting rail routes. Under the existing system, an individual railroad generally selects routes so as to maximize the distance a shipment spends on that railroad's track, thus maximizing the railroad's share of the shipping revenue (because when a shipment uses more than one carrier, the carriers divide the revenue according to the miles travelled on each railroad). (DOT 1989b) This does not necessarily lead to the most desirable routes from the states' perspective because it sometimes leads to circuitous routing, use of lower quality track, increased number of switches, or undesirable switching points.

The Hazardous Materials Transportation Uniform Safety Act of 1990 requires DOT to conduct a study on which factors, if any, should be considered by shippers and carriers when selecting modes and routes for high-level waste and spent fuel to enhance overall public safety. At a minimum, DOT must assess the impact of the following factors on overall public safety: population densities, types and conditions of modal infrastructures (such as highways, railbeds, and waterways), quantities of high-level waste and spent fuel, emergency response capabilities, exposure and other risk factors, terrain considerations, continuity of routes, available alternative routes, and potential environmental impact factors.

The Department of Transportation has not yet completed this study. However, in December 1993, DOT released a draft report entitled, *Identification of Factors for Selecting Modes and Routes for Shipping High-Level Radioactive Waste and Spent Nuclear Fuel*. (Battelle, 1993) This draft report provides an overall assessment of the primary mode/route factors identified in the study. The study identified eight primary mode/route selection factors, including: (1) general population

exposure; (2) occupational population exposure; (3) environmental exposure; (4) accident rate; (5) shipment duration; (6) trip length; (7) emergency response; and (8) amount of material.

The draft report also outlines a framework for conducting an overall evaluation of the primary mode/route factors it identified. This framework included four main criteria: (1) the nature and degree of impact on public safety; (2) the degree of variability from mode to mode and route to route; (3) the ability to measure; and (4) the feasibility of implementation. The draft report defines *ability to measure* as "the degree of confidence in the representativeness of the factor, its degree of accuracy, and the difficulty of obtaining the required information and the related institiutional and political considerations."

WIEB's High-Level Waste Committee found the draft report to be useful in contributing to a better understanding of how shippers and carriers could select modes and routes for spent fuel and high-level waste shipments in order to enhance safety. The Committee found that the report:

? Acknowledged for the first time, that mode and route decisions historically have not been based on safety criteria.

? Correctly acknowledged that "no federal, state, Indian, or local regulations that require the use of a particular mode for hazardous materials could be identified."

? Identified the importance of adequate emergency response capabilities in contributing to safety.

? Acknowledged the need to protect sensitive environmental areas from potential releases.

? Identified the importance of differences between the voluntary and involuntary assumption of risk by parties potentially at risk.

? Highlighted the difficulty of securing accurate accident rates for rail shipments.

? Acknowledged the need for tradeoff studies as part of selecting modes and routes for a shipping campaign.

Despite the report's positive attributes, however, the Committee also found that the conclusion of the report appeared to reach an overall conclusion that there are a limited number of factors which can be used to effectively distinguish the safety of shipments using different modes and routes, and that the many other factors affecting the safety of modes and routes must be left to the analysis of specific shipping campaigns. Although this approach may contribute to a baseline level of mode and route planning for shipments, the Committee found that it failed to fulfill the mandate of Section 15 of HMTUSA which requires DOT to "...determine which factors, if any, should be taken into consideration by shippers and carriers in order to select routes and modes which, in combination, would enhance overall public safety..." Among the Committee's other findings were that the report "fails to contribute answers to many of the key questions about how modes and routes should be

selected to enhance safety" and also that the report does not provide any clear guidelines on the process shippers and carriers should follow when deciding upon modes and routes for specific shipping campaigns.

In planning for spent fuel and high-level waste shipments to a nuclear waste repository, the Department of Energy stated for years that it would consider the need for federal rail routing regulations, and that it would develop rail route-planning criteria. At a minimum, the criteria was to limit costs and transit time, avoid population centers (where possible) and avoid adverse seasonal weather conditions. (DOE 1986b) However, in February 1996 OCRWM announced that it was abandoning its attempt to develop guidelines for selecting either highway or rail routes for transporting spent nuclear fuel and high-level waste. In a letter to stakeholders, OCRWM stated that, "After considering this issue, OCRWM has decided that the existing Federal guidelines are sufficient...Standard railroad practice will be used for rail routing." (DOE 1996)

Prior to the release of this letter, OCRWM had made little progress in establishing rail routing criteria. OCRWM's last attempt at formulating such criteria occurred in January 1995 when OCRWM released a draft discussion paper entitled: *Rail Route Selection for DOE Unclassified HRCQ Shipments.* (DOE, 1994) In this paper, DOE described an initial proposal for a process to develop rail route selection criteria and a methodology by which to apply these criteria for its unclassified Highway Route Controlled Quantity (HRCQ) shipments of radioactive material (primarily spent nuclear fuel, high-level radioactive waste, and certain large source radioisotopes).

However, WIEB's High-Level Waste Committee's analysis of this *Discussion Paper* was that it appeared merely to be aimed at selecting the same routes which railroads would select on their own in order to increase DOE's chances of reaching route agreements with railroads shipping nuclear waste. An obvious result of such a strategy would be to lessen the likelihood that DOE would have to use dedicated or special trains for NWPA shipments. In its comments to the *Discussion Paper*, however, the Committee stated its strong belief that the primary goal in establishing a routing strategy should be to produce the safest route possible regardless of whether it is likely to match the route which railroads would currently choose.

The Committee's analysis highlighted other important areas which the *Discussion Paper* failed to address, including:

?Minimizing time in transit;
?Maximizing the use of the highest track class;
?Minimizing the number of grade crossings;
?Minimizing accident rates measured by type of track, location or carrier;
?Minimizing emergency response time;
?Minimizing the potential property exposure;
?Minimizing the transit through environmentally sensitive areas;
?Minimizing the transit through culturally sensitive areas;
?Considering class of railroad; or

?Advance notification of states of selected routes.

These aspects of rail routing will likely remain unexplored since DOE has ceased efforts at producing a rail routing methodology.

There also appears to be little progess made towards developing a better understanding of the decisional criteria to use for determining whether general commerce or dedicated trains will be used for NWPA shipments. Such decisions should play a part in determining the appropriate route to use. For example, if spent fuel is to be shipped by general commerce trains — trains which can spend days sitting in rail marshaling yards during a cross country trip — then time in transit could become a very important routing criterion. If dedicated trains are used, the differences in transit times among competing routes are likely to be smaller and thus other factors, such as population exposure should take on relatively greater importance.

This section discusses: State designation of rail routes; computer models for rail route analysis and/or selection; examples of how rail routes were selected for past shipping campaigns; DOE's repository rail routing (the Yucca Mountain Project Office's Rail Access Study); and point-of-origin feasibility studies (including the Facility Interface Capability Assessment (FICA) and the Near Site Transportation Infrastructure (NSTI) study), and other repository routing studies, including efforts undertaken by the University of Las Vegas at Nevada's Transportation Research Center.

A. State Designation of Rail Routes

With DOE now absent from any process of providing route selection guidance or criteria, some states may be interested in designating rail routes for shipments of spent fuel and high-level waste. There are several legal and practical problems these states need to consider before adopting rail routing regulations. First, there is a possibility that state designation of rail routes has been preempted by the federal government. Federal law does not contain an explicit state role in rail routing, comparable to HM-164 for highway routing of highway route controlled quantities of radioactive materials. On the other hand, no federal agency has adopted regulations specifying how rail routes shall be selected. An analysis of the preemption issue is beyond the scope of this report, but one key issue is whether the federal law's silence on rail routing means that this is an area open for state regulation or that the federal government has determined that rail routing regulation by the federal or state governments is undesirable. The Hazardous Materials Transportation Uniform Safety Act of 1990 may have an impact on this issue. HMTUSA directs DOT to study the need for rail routing regulations for spent fuel and high-level waste shipments. RSPA has been designated the lead agency for this study, although no funds were appropriated and an anticipated completion date has not yet been identified.

States that designate rail routes could also be faced challenges by the railroads. Because railroads own their track, choosing a rail route is, in essence, choosing the carrier, although the railroad owning the designated route may choose to sell trackage rights to another carrier. Challenges could come from the carrier whose track was rejected or from the carrier whose track was designated (or both) -- depending on whether the individual railroad views spent fuel shipments as a desirable revenue source or an undesirable risk.

DOE could also challenge the route designation because limiting spent fuel shipments to a single route (between a certain origin and destination) could put DOE in a poor bargaining position when it negotiates rates and terms with the railroad. In the absence of designated routes, the shipper has the ability to select another carrier if the first carrier will not agree to terms the shipper believes are reasonable. This is possible even when the origin or destination is served by a single carrier. For example, the Three Mile Island nuclear powerplant is served only by Conrail. When DOE was negotiating with Conrail regarding shipments of core debris from Three Mile Island to the Idaho National Engineering Laboratory, Conrail insisted on imposing a speed limit of 35 mile per hour. This could be accomplished only by using local service, rather than through-train service (doubling the transit time from Three Mile Island to East St. Louis from 7 to 14 days) or by using special trains (with a surcharge of $42 per train-mile added to the base cost of $10 per cask-mile for regular train service). Neither of these options was acceptable to DOE. DOE considered "short-hauling" Conrail (using Conrail only long enough to transfer the shipments to another nearby carrier), and began negotiating with CSX to accept the shipments in Maryland. After DOE started the negotiations, Conrail lowered its special train surcharge from $42 per train-mile to $24 per train-mile, and DOE agreed to use Conrail. [Note: DOE eventually shipped three casks per train, which decreased the per-cask cost of special train service to about $65,000, as compared to a per-cask cost of approximately $50,000 for regular train service.] Although Conrail's willingness to lower the rate, in this case, was not necessarily a result of DOE's negotiations with CSX, this case is an example of how a short-hauling strategy can be used to improve a captive shipper's negotiating position. (DOT 1989b)

Even if states resolve any potential legal problems with rail route designation, practical problems may prevent selection of an "ideal" route. States may not have sufficient route-specific information regarding factors that influence route desirability. For example, railroads believe that the quality of individual sections of their track is proprietary information, and are extremely reluctant to reveal this data. Track class information is not even readily available to the Federal Railroad Administration, the agency that regulates the railroads, although a shipper can request the information for a specific route proposed by a prospective carrier. (DOT 1989b) Even if states could obtain track class data, it would be of limited value because there is insufficient evidence that the highest quality track has the lowest overall accident rate or the lowest rate of severe accidents. More information is needed on whether the high quality of the track (which would tend to reduce accidents) is outweighed by the higher speed limits (which would tend to increase the number and severity of accidents) allowed on the higher quality track. [This would not necessarily be an issue with special trains, which could use the higher quality track, but with lower speed limits.] It may be possible to estimate accident rates by track class by using the waybill sample to estimate traffic volume by track class. However, there are no known examples of this type of information being assembled and used to make routing

decisions. Another problem with directing shipments to high quality track is that the best track is often found in or near urban areas -- thus requiring a tradeoff between population avoidance and track quality. Finally, even if a state is willing to use lower quality track, it will not always be possible to avoid urban areas because: 1) the railroad network lacks urban bypasses comparable to interstate highway beltways; and 2) railyards (which the train must enter for refueling, crew changes, and interchanges between carriers) are often located in urban areas.

A 1990 report prepared for the Department of Transportation concludes that additional research is needed before establishing guidelines for rail route selection for hazardous materials. At a minimum:

> 1) existing models for estimating the probabilities and consequences of average-severity and high-severity accidents need to be reviewed and, if necessary, modified or replaced;
>
> 2) the relationship between operating speeds and accident frequency must be better understood; and
>
> 3) a method for estimating the economic effects of routing regulations needs to be established.

In addition, other data must be gathered -- either for the entire rail network (if the goal is to designate a national network of preferred routes) or on a more limited basis for specific routes under consideration (if the goal is to establish national route selection <u>criteria</u>). These additional data requirements are:

> 1) a rail network model that is accurate and detailed enough to show important variations in population exposure and operating conditions, rather than aggregating the data over relatively long, varied stretches of the rail network;
>
> 2) a widely-available database on route-specific track class (or similar measure of track condition); and
>
> 3) improved methods of determining population exposure, including a practical way to account for time-of-day variations.

The report suggested that time-of-day restrictions and reduced speed limits be considered as a substitute for route designation. (Glickman 1990)

If a state chooses to designate rail routes, there are several existing computer models that will assist in analyzing and selecting routes.

B. Computer Models for Routing

Several computer models have been developed to evaluate transportation routes for shipments of sensitive materials. Most can be used for both highway and rail routing since they include parameters applicable to both transport modes such as travel time, length of route, and population densities. Some of the models use characteristics unique to rail, such as track class and private ownership of rail lines.

INTERLINE was developed by Oak Ridge National Laboratory as a tool to predict the rail routes that would likely be proposed by carriers. The model's database consists of rail lines classified by owner and traffic volume (using a different FRA classification for main lines versus branch lines), and can therefore take into consideration the tendency by carriers to maximize the distance traveled on their own lines rather than choose the shortest route. INTERLINE includes options to delete or ignore certain segments of track based on track class, ownership, or location, but otherwise does not have the capability to compare routes using multiple criteria simultaneously. This model was used to provide information on potential routes for the shipments of damaged fuel from Three Mile Island to INEL. Although INTERLINE has no risk assessment capabilities, it is often used in association with RADTRAN.

RADTRAN was developed by Sandia National Laboratories for DOE to assess the risks of transporting radioactive materials by highway, rail, or air by combining meteorological, demographic, health physics, transportation, packaging, and payload factors. The output describes the radiological and non-radiological risks of accidents and of incident-free shipments.

The ALK & Associates computer model, **Railroad Hazardous Materials Routing Package**, is an enhanced version of the FRA's Network model developed at Princeton University. A network of rail lines is divided into junctions, where railcars can switch carriers, and links which connect junctions. The model's algorithm enables optimal routes to be determined by minimizing "impedance." Impedance is a function of the population density within a quarter-mile of each link, the length and track class (track quality) of each link, and the estimated time delays associated with different types of junctions. The impedance of a route can be reduced by avoiding areas of high population density, improving track quality (i.e., upgrading to better quality track), and minimizing the distance traveled and length of time spent at junctions. The ALK model can also be used to select the minimum accident route. This model was used to provide information on potential routes between Three Mile Island and INEL.

Turnquist and Werk of Cornell University developed a route assessment model that identifies a set of "efficient" alternatives using multiple criteria. A route is said to "dominate" another if it is preferable on at least one criteria and no worse on any of the others. A set of all efficient routes includes those that are not dominated by any other route, but at least one route in the efficient set dominates any route not in the set. This approach is justified since there is usually no single route or schedule for a given shipment that is superior in every criterion when many factors are considered. In this model, a network of nodes and links, representing junctions and roads or rail lines, respectively, is established, and parameter values are assigned to each link. When criteria such as cost and distance

are used, a set of potential routes results. Scheduling alternatives for a particular route can be compared with the use of time-of-day-specific criteria such as travel restrictions, travel time, and population exposure.

The **DANTRAN** model is similar to the Turnquist and Werk model, but uses a time/place network that allows simultaneous scheduling and routing analysis and can indicate optimal departure times. It was written when Texas was being evaluated as a potential site for a geologic repository for high level radioactive waste. DANTRAN was tested on the state's interstate highway system but can also be used for evaluation of rail routes.

StateGEN was developed by Sandia National Laboratories to allow individual states to assess potential rail and highway routes for hazardous shipments. It can be run on the user's IBM PC or compatible machine, and Sandia provides support as needed. The user inputs a network of roads or rail lines, and assigns values for up to 30 parameters (such as population density, traffic and road characteristics, and accident rates) to various points or segments throughout the network. The program determines the route in which a particular parameter is maximized or minimized. Comparing multiple criteria can be accomplished by further processing of StateGEN data by Sandia's TRANSNET system. The State of Nevada used StateGen and TRANSNET to develop plans for highway shipments of radioactive materials.

System Technology Laboratory, Inc. of Arlington, Virginia, developed a routing model with FRA funding, which calculates the radiation exposure risk associated with a particular route during normal transportation conditions and during accidents of varying severity, given stopover times, travel time, and estimated time spent in zones of varying population density. The sensitivity of the overall risk to changes in each parameter can be determined as well. The costs and benefits associated with various routes can be compared. The initial paper discussing this model concluded that the high economic cost of rerouting to minimize population exposure often outweighed the advantage of reduced exposure levels.

Dames & Moore, Inc. developed a mathematical algorithm to determine the composite population dose (CPD) of radiation associated with each highway or rail route following an accident during which there is a release of radiation. The CPD is based on separate dilution factors in air and water to account for the different exposure pathways. Route-specific meteorologic and hydrologic data, such as wind direction and stream flow, are required for accurate results.

C. Historical Route Selection

This section describes the route selection process used for two past shipping campaigns: shipments of core debris from the failed Three Mile Island nuclear powerplant to the Idaho National Engineering Laboratory and shipments of spent fuel from a Minnesota powerplant to Morris, Illinois, for storage.

1. TMI Rail Study

In 1986, DOE started shipping debris by rail from the failed Three Mile Island nuclear powerplant in Pennsylvania to the Idaho National Engineering Laboratory. A 1988 switchyard incident caused Sen. John Danforth of Missouri to ask DOE to seek an analysis of the rail route from the Department of Transportation. [When a buffer car was taken out of service because of equipment problems, it was replaced by a hopper car of lime. Lime is a non-hazardous substance, but the car was erroneously placarded as a flammable solid. Placing a flammable solid car next to a radioactive materials car is a violation of federal regulations.] In 1989, DOT concluded its analysis. (DOT 1989b) Because of the way DOE's request was worded, DOT did not evaluate the appropriateness of DOE's route selection criteria, nor did it compare the route DOE selected with other possible routes. DOT analyzed the route selection process and the extent to which the route selected by DOE satisfied the route selection criteria DOE chose to use.

DOT found it difficult to reconstruct DOE's route selection process because it was not documented. Therefore, DOT was forced to rely on correspondence and personal recollection to determine how DOE selected the route. DOT found that DOE did not have well-developed route selection guidelines while it was selecting the Three Mile Island route, and that the criteria evolved during the selection process. DOT concluded:

> DOE relied upon independent technical analyses and NRC certification that the cask would provide an acceptable level of public safety and consequently handled route selection in a manner similar to that for routine DOE shipments.

Based on DOT's analysis, the following table shows the factors DOE considered in selecting the Three Mile Island route.

THREE MILE ISLAND SHIPMENTS
DOE'S ROUTE SELECTION CRITERIA
(AS RECONSTRUCTED BY DOT)

Safety

High quality track

Routing through relatively low population areas and avoiding high population areas, where possible

Low accident rate

Carriers that

- *have extensive experience handling hazardous materials and*
- *have earned industry recognition for safety of operations and maintenance of track*

"Schedular" Efficiency

Minimum time in transit

Fewest carrier changes

Fewest switching delays

Cost Effectiveness

Commercial through-train service

Shortest distance

Most economic/lowest cost service

DOT concluded that the route selected by DOE was a reasonable one, in light of the criteria DOE used. On the positive side, the track quality was high, accident rates were low, transit times were minimal, the distance was almost minimal, there were few switching delays, and one of the carriers had a significantly better than average safety record in handling hazardous materials. On the negative side, one of the carriers was "somewhat below the industry norm" for hazardous materials safety, and population exposure was more than twice the exposure of the minimum-exposure route. [DOT cited a General Accounting Office report that noted that DOE officials did not consider population exposure to be a critical factor because the cask was designed to provide adequate protection against releases. At Congressman Jack Buechner's request, DOE agreed to reconsider the importance of population density, but had not reported the results of the reexamination by the time the DOT analysis was concluded.]

As a final note, two years after the Three Mile Island route was selected, DOE adopted written guidelines for traffic managers to use in route selection. In describing DOE's new guidelines, DOT said: "the level of definition remains as it was during TMI planning (i.e., topical listings only), and no rationale or ranking in order of importance is provided to facilitate the inevitable tradeoffs among criteria." The 1988 guidelines are shown in the box.

DOE 1988 ROUTING GUIDELINES

Rail shipments of unclassified SNF [spent nuclear fuel] and HLW are the responsibility of the traffic manager of the field office having program authority for [their] transport. Actual routes selected will be a joint effort among the DOE, its contractors, and the origin and destination carriers.

Because of the sensitivity of routing SNF and HLW through population centers, it is necessary for DOE, its contractors, and its carriers to consider additional specific route selection criteria prior to route finalization:

1) Minimize time, distance, number of carriers, and interchange points in transit.

2) Maximize use of best track class considering that maximum safe [speed] for each track class is regulated by the Federal Railroad Administration.

3) Apply lowest through rates and accessorial charges consistent with service requirements.

4) Obtain computer run from ORNL's [Oak Ridge National Laboratory] INTERLINE (rail routing model) of the final alternate rail routes being considered -- retain as part of the permanent route selection record.

5) Coordinate final route selection with Transportation Management Division (DP-121).

2. Northern States Power Shipments

In 1984, ALK & Associates analyzed potential rail routes for spent fuel shipments from Northern States Power's Monticello plant in Minnesota to a spent fuel storage facility in Morris, Illinois. ALK used its routing model, described earlier, to analyze six specified rail routes and to compare these routes with all possible routes that might have a more direct path, lower accident indexes, or lower population density. No route evaluated by ALK was optimal in all respects. The recommended route was the most direct route, with a high proportion of high quality mainline track, and had the lowest total accident index. However, the recommended route had twice the population of the minimum-population route and two other routes had slightly lower populations than the recommended route. These three routes were rejected because they were much longer than the recommended route or contained a lower proportion of A Mainline track, which experiences the greatest traffic volume and is thus the best maintained. The analysis concluded that "[n]either security nor radiological concerns would be diminished by selecting the low population-longer transit time routes." (DeLong 1984)

A Wisconsin interagency working group objected to the route selected by Northern States Power. State officials noted that more than three-quarters of the 210-mile route within Wisconsin was either within or immediately adjacent to the Mississippi River or its wetlands. Approximately 190 miles of the route was within a National Wildlife Refuge, which includes habitat for more than a dozen endangered and threatened species. The state was also concerned about topographic features (e.g., steep slopes and bluffs, heavy forestation, proximity to shallow wetlands, and absence of highway access) that could hinder emergency response in the event of an accident. Track conditions were highly variable along the chosen route. Some route segments seemed especially vulnerable to sabotage. In 1984, Northern States Power started making shipments along the route despite Wisconsin's objections. The Wisconsin Department of Natural Resources sought to enjoin further shipments until the utility complied with the state's request to prepare a spill prevention and mitigation plan, but the state court denied the injunction on the grounds that the state's activities were preempted by the Atomic Energy Act and the Hazardous Materials Transportation Act. The state then petitioned the Nuclear Regulatory Commission for a rulemaking to expand the NRC's authority over route selection. NRC denied the petition. (Halstead 1987)

D. DOE's Repository Routing Studies

Three DOE studies examine feasibility of rail access to the potential repository site and utility reactor locations. The *Preliminary Rail Access Study* (DOE/YMP 1990) was undertaken as part of DOE activities to evaluate options for rail transport to the Yucca Mountain repository site, which currently lacks both rail service and a right-of-way. The report summarizes potential options from major rail routes in the region to Yucca Mountain. The *Facility Interface Capability Assessment*

(FICA) and the *Near Site Transportation Infrastructure Study* (NSTI), examine constraints upon routine spent fuel shipping cask handling at specific reactor sites, and potential rail, road, and barge access corridors for nuclear reactor sites, respectively. Following is an overview of the results of the Preliminary Rail Access Study and current status of the FICA and NSTI studies.

Unlike the route selection examples discussed above, the *Preliminary Rail Access Study* addressed possible locations for the <u>construction</u> of new rail routes. Therefore, some of the factors considered above, such as accident rates and track quality, are irrelevant. The *Preliminary Rail Access Study* examines ten rail options previously identified by DOE in preliminary rail investigations and three additional alternative alignments proposed by Lincoln County (NV) and the City of Caliente, Nevada. The ten options were screened for conformity to standard railroad engineering practices, access to any of three regional rail carriers, maximizing use of federal land, and avoidance of obvious land use conflicts. Each option was then evaluated further for other potential land use conflicts, and potential access to regional rail carriers. Three routes were recommended for further study. (See map) Although different criteria were used in selection of the alignments identified by Lincoln County and the City of Caliente, they were subject to the same analysis in the Access Study. Of the alternatives proposed by Lincoln County and the City of Caliente, two were found to have land use conflicts and the third does not provide direct access to the site. (DOE/YMP 1990)

The three recommended routes are Jean, Carlin, and Caliente. For the **<u>Jean</u>** route, Clark and Nye Counties would be affected. The proposed route, which would branch from a Union Pacific rail line, would require construction of a bridge and 121 miles of track. The **<u>Carlin</u>** option provides access to Yucca Mountain from a paired Southern Pacific and Union Pacific rail route. The greater portion of the rugged terrain is BLM land. Five counties would be impacted under this option, which would require 365 miles of additional track. Because the mountain ranges in Nevada are predominantly north-south, this route would have more favorable topography than east-west routes. The **<u>Caliente</u>**

option consists of a base route, and five alternatives. Initial analysis by DOE indicates that the Caliente route has the most favorable land use compatibility of the three, but would incur significant costs due to complex engineering and construction required to traverse rough terrain in order to avoid contact with private lands. Two counties, Lincoln and Nye would be affected. The Caliente spur would stem from a Southern Pacific line and require 406 miles of additional track (the five alternatives to the base route significantly impact track length and cost estimates). (DOE/YMP 1990)

The Yucca Mountain Project Office has focused its attention upon the Caliente route and has completed a detailed study. The city is very interested in the economic benefits of sharing a rail spur, which DOE has tentatively approved. Estimates indicate that it would take three years to construct the Caliente route, if funding was provided. (Standish, 1991) More recently, a fourth route option has emerged in the Yucca Mountain EIS scoping process. This fourth option, called the Modfied Valley route, would extend from northwestern Las Vegas to Yucca Mountain (see map on previous page). (Strolin, 1995)

Option costs for the three recommended routes, based on capital outlay (approximately $1.5 million per mile of track) and operating and maintenance costs, are summarized in the following table.

Summary of Option Costs

Option	Total Length	Capital Cost	Annual Oper. & Maint. Cost (In $ millions)
Jean	121	183	0.89
Caliente (Base)	406	692	2.90
Carlin	365	661	2.90

Based on DOE's evaluation criteria, Jean and Caliente would have no land use conflicts, while the Carlin option has potential for conflict, but "probability exists that conflict could be abated, or may be resolved, due to external, non-DOE activities." (DOE/YMP 1990) The Carlin route is the only one of the three recommended routes that would have direct access to more than one regional carrier.

Building a new rail line is a multi-phased process, sometimes requiring more time for planning than for construction. Before construction can begin, the exact alignment of the track must be determined. Factors that are considered during planning include acquiring land for the right-of-way, responding to environmental concerns, and engineering feasibility and design. The length of the planning stage varies depending on the complexity of each issue. For example, the type (private or public) and number of landowners involved and level of opposition shown by each will affect the time it takes to attain the right-of-way. Railroads, unless given special authority by Congress to condemn the land they need, must negotiate with private landowners. Acquiring the right-of-way on public land

may be less of a problem; however, an environmental impact statement (EIS) would be required if federal land were involved. Were a government agency to build a rail line, it would have the authority to condemn the land it required for a right-of-way and would need to submit an EIS. In either case, the amount of compensation received by each landowner would be determined through negotiation or litigation. Opposition may also be encountered from non-landowners concerned with the environmental impact associated with construction and the presence of rail traffic, especially if the trains would be transporting potentially hazardous shipments. From an engineering perspective, the optimal rail route would have few curves, tunnels, and bridges, and call for little grading. Trains can safely travel on tracks with a limited gradient and degree of curvature. If a new rail line is going to have a signalling system such as CTC, an average of one year in lead time is usually required for design. A railroad's engineering department usually designs the system's software and purchases the necessary hardware from manufacturers.

Based on a number of limitations, building a new rail route is a relatively rare occurrence now. In particular, the time required for planning and constructing a new railway can vary according to a variety of circumstances, including: the complexity of the terrain (e.g., requiring many new bridges and/or tunnels, extensive or difficult grading, major obstacles, etc.); seasonal conditions, since final ballasting cannot be done on frozen ground; the amount of resources, both human and financial, that are available; and the extent of opposition to a proposed route. A recent example of complications arising from a proposed route is Burlington Northern's rail spur into Wyoming's Powder River Basin. Actual planning and construction of the route took three years (construction taking two years), although completion of the spur was held up for nearly five years due to legal action. The Bureau of Land Management issued a coal lease to a private company in the Powder River Basin. The Sierra Club subsequently filed suit against BLM, although Burlington Northern had already received permission from the Interstate Commerce Commission to construct a 120-mile rail spur to an existing coal mine (not covered in the suit) that passed through a portion of the area being contested. Burlington built the first 10 miles of the route, however, construction was held up due to the litigation. The decision eventually went in favor of the BLM and construction of the spur was completed, although the estimated time for construction more than doubled initial estimates. In addition to the lengthy delay, BN indicated that a high level of resources (human and financial) were expended on the project.

With sufficient personnel and funding, construction can occur at more than one site along the route at a time. Work on bridges usually begins first. The low-end industry estimate for a new rail spur is six to 18 months for route planning (inception to construction), two years construction per 100 miles of track, and a $1 million per-mile rail line cost (excluding land costs).

Summary of FICA
Number of Facilities Able to Handle FICA Cask
(Out of 122 Facilities)

	Currently	With License Revision	With Plant Modification
Legal Weight Truck	73	105	121
Overweight Truck	68	98	119
100-Ton Rail/Barge	50	76	99
125-Ton Rail/Barge	26	52	79

Rail routing to a repository is also influenced by the ability of reactor sites to handle rail shipments. The FICA study is a systematic assessment of each nuclear generation site and their ability to handle and process four types of spent fuel casks. A Draft Report was published for comment in May 1990, and a final summary report was issued in May 1992. The FICA Study evaluated a variety of potential cask handling constraints, such as cask weight and length capability, crane capacity, impediments to physical handling, modal access to the site, and rail siding to accommodate multiple railcar shipments. The cask dimensions used in FICA are not the same as those currently being designed. The box summarizes the final data for the 122 sites included in the assessment. (NAC, 1992(a)) The main conclusion derived from the assessment was that current facility capabilities would not allow handling of any of the FICA casks at 49 of the 122 facilities. However, with plant modifications, all but one of the 122 facilities could be adapted to handle at least one FICA cask. The final report states, however, that "[i]t is important to recognize that the project did not include any of the detailed technical analyses that would be required for implementing the potential changes identified. Therefore, there is no certainty that the assessed changes can be achieved. Demonstration that the potential changes could be achieved would have required technical analyses and the evaluation of licensing requirements that were beyond the scope of this project." (NAC, 1992(a))

The NSTI study evaluated potential rail, road, and barge access for 76 reactor sites in order to determine travel restrictions and infrastructure limitations (e.g., bridge limits) for spent fuel shipments. The potential for upgrades was also assessed. The NSTI Final Report was released in February 1992. For the survey of rail spurs, the items examined include: the owner of the rail line to which the spur connects, spur usage (present and future), spur maintenance, number of tracks, rail weight, clearance restrictions, development along spur, and care facilities. Findings for the 76 sites are summarized in the box. (NAC 1992(b)) It should be noted that according to the report, "the ability to move heavy loads by rail only relates to the shipment capability from the site. It does not imply that a rail/barge cask could be handled and loaded within the facility but only that the local transportation infrastructure could accomodate such a load." (NAC, 1992(b))

NSTI Findings For 76 Reactor Sites

Number of sites with the *potential* to use onsite rail for cask transport	Number of sites *currently able* to use onsite rail for cask transport	Number of sites currently able to use onsite rail for cask transport which have rail access to the cask receiving area	Number of sites that have onsite rail systems requiring an average of $65,000 in upgrades *before* they can be used.
53	**36**	**24***	**17**

*For those sites which have no rail access to the cask receiving area, transferral from a heavy haul truck to a railcar would be required.

Other Findings:

? The continuing abandonment of track by railroads can adversely impact future prospects for rail srvice to reactor sites.

? All sites were assessed as having the transportation infrastructure capability to ship "rail/barge" casks weighing 100 tons or more

E. Other Repository Routing Studies

In a study for the Nevada Agency for Nuclear Projects, the University of Nevada at Las Vegas (UNLV) Transportation Research Center (TRC) characterized transportation routes to Yucca Mountain, including DOE's three proposed rail spurs and access routes, Jean, Caliente, and Carlin, in Yucca Mountain Transportation Routes: Preliminary Characterization and Risk Analysis (Souleyrette and Sathisan 1990) This characterization allows for three types of impact analyses: comparative study; limited worst-case assessment; and traditional probabilistic risk assessment. Characterization of the three rail routes is primarily based upon "probability" and "consequence" measures. Probability measures include distance, anticipated accident rates, and hazardous shipments/inventories (including an examination of the location of natural gas pipelines). Eight consequence measures are examined: resident and non-resident population, ecologically sensitive areas, land use, property value, difficult/dangerous to evacuate locations, meteorological conditions, and infrastructure characteristics. Both relative and absolute Nevada-specific data were used, however, a lack of certain rail data was limiting. The Draft Report notes:

> A significant limitation was the lack of more detailed data on hazardous materials shipments. The commodity report provided a listing of the average number of shipments and the tonnage. However, it did not provide any information on the frequency or consequences of accidents. The Hazardous Materials Pipeline Atlas showed the physical location of pipelines in Nevada, but provided no detail on the amounts of hazardous materials being transported through the pipelines. (Souleyrette and Sathisan 1990)

Summary tables allow for comparative analysis of the potential impacts of the three proposed rail routes on corridor widths of 0.5, 1, 2, 6, 10, and 20 miles.

The TRC characterization study identifies potentially critical locations for rail accidents on the proposed rail routes, thus allowing for a limited worst-case risk assessment. For each spur, this analysis is based on potential population impacts, cost and difficulty of accident cleanup, environmental impacts, and the potential impacts the proposed spur could have on accident severity. The data compiled for characterization and comparison may also be used, in conjunction with the RADTRAN computer risk assessment model, as part of a probabilistic risk assessment for the population along a proposed route. In a preliminary draft of the study, this was done for highway routes only, primarily due to the lack of complete and accurate rail data. The Transportation Research Center's characterization study, which uses a wide variety of input parameters and allows for direct comparison between routes, could have implications upon rail route selection to Yucca Mountain. However, the analyses likely to be facilitated by the study are limited because impact measures are restricted to identification of potential areas or persons affected. There was no attempt made to quantify the magnitude of these impacts. (Souleyrette and Sathisan 1990) The usefulness of the data compiled in this effort clearly has implications as part of the TRC's routing systems model described above.

VIII. RISK ASSESSMENT

A. Review of Accident Data

The most comprehensive source of train accident data is the FRA's annual Accident/Incident Bulletin, a compilation of accident statistics for the previous year broken down by cause, type, state, damage cost, and carrier. The bulletin is based on standard reports that carriers must submit each month. The initial report sent to FRA is usually filled out at the accident scene and then revised when final information is available regarding the cost of the damage incurred and lost person-hours. Carriers must report accidents resulting in damages costing more than the FRA's reporting threshold, which was $6300 in 1994 and which usually increases yearly to account for inflation. Incidents resulting in damages below the threshold do not need to be reported unless they occurred at a rail-highway crossing or resulted in death or significant injury.

In 1988, the Accident/Incident Bulletin indicated that after eight years of decline, the accident rate increased in every category. Of the 3,051 train accidents occurring in 1988, 1031 were attributed to human error, 952 to track defects, 512 to equipment failure, and 556 to other factors. In earlier years, accidents attributed to track defects outnumbered those due to human error. Almost all of the accidents due to track defects and equipment failure resulted in derailments while the majority of collisions were attributed to human error. In 1988 there were 2,054 derailments, 315 collisions, and 682 other types of accidents. This translated into an overall accident rate of 5.01 accidents per million train-miles, or 3.37, 0.52, and 1.12 accidents per million train-miles attributable to derailments, collisions, and other factors, respectively. There were 475 accidents involving trains carrying hazardous materials, and 349 (or 73%) were derailments.

In 1988, there were 197 accidents and 2,258 incidents at rail-highway crossings, resulting in a total of 689 fatalities and 2,589 injuries. Of these, 25 accidents involved trains carrying hazardous materials. No hazardous materials were released, although 100 people were evacuated as a precaution. No details regarding the circumstances of the accidents are included in the annual accident/incident bulletins. In 1981, the NTSB studied collisions at rail-highway crossings involving trains and trucks, primarily tanker trucks, in which the truck was carrying bulk quantities of hazardous materials. The study estimated that 100 such accidents and 750 near collisions take place each year. Relatively few accidents occurred west of the Mississippi River, while many took place near the truck shipment's origin or destination, such as an oil refinery or chemical plant. The NTSB also concluded that train/truck collisions were less frequent at crossings protected by active rather than passive traffic control devices.

According to a September 1994 FRA report entitled, *Forward Through the 90s: Selected Issues in the Transportation by Rail of Hazardous Materials*, the number of train accidents involving hazardous materials releases now appears to be declining. According to FRA, in 1980, 173 train accidents occurred involving hazardous materials releases. In 1989, only 56 such accidents occurred, resulting in the evacuation of almost 12,000 people and causing damages of approximately $16.8 million. In 1990, 36 such accidents occurred causing the evacuation of approximately 2,434

people and resulting in $9.7 million in damages. In 1991, there were 47 accidents involving hazardous material release, causing 1,488 people to be evacuated and $17.0 million in damages, and in 1992, 27 such accidents occurred, causing 20,430 people to be evacuated and $5.9 million in damages. It should be noted that the sudden increase in evacuations in 1992 is the result of a single accident on June 30, 1992 in Minnesota. The charts on the following pages summarize the data on railroad accidents involving hazardous materials releases between 1989 and 1992. (FRA, 1994)

Location and Railroad	**Date of Acciden t**	**Commodity Released**	**Probable Cause**	**Persons Evacuate d**	**Person s Injured**	**Damages: Equipmen t/Way & Structure**
Fredericksburg, VA RF & Potomac	1/4/89	Ethyl Alcohol	Interactioin of lateral/vertical forces	0	0	$15,000/ $4,281
Gurdon, AR Union Pacific	1/14/89	Not Available (N/A)	Shoving Movement, man on or at leading end of movement, failure to control	0	0	$16,000/ $1,900
Goffre, NM ATSF RY	1/15/89	N/A	Truck, stiff, improper lateral or swivelling	0	0	$145,300/ $28,500
East St. Louis, IL Chicago, Missouri & Western	1/16/89	Ammonium Nitrate Fert.	Switch Point worn or broken	0	0	$36,500/ $0
Natchez, MS Illinois Central	1/19/89	Caustic Soda	Wide Gage (defective or missing crossties)	0	0	$17,570/ $500
Strang, TX	1/27/89	Vinyl Acetate	Switch Damaged or out of adjustment	0	0	$2,625/ $3,800
Helena, MT Montana Rail Link	2/2/89	Hydrogen Peroxide & Isopropanol	Failure to apply sufficient handbrakes	3500	2	$802,500/ $118,000

Pando, CO Denver & Rio Grande RY	2/7/89	Sulfuric Acid	Speed & failure to apply sufficient no. of hand brakes	0	2	$3,000,000/ $60,000
Starnes, VA CSX Trans.	2/10/89	N/A	Head & web separation (outside joint bar limits)	0	0	$195,700/ $80,000
Location and Railroad	**Date of Accident**	**Commodity Released**	**Probable Cause**	**Persons Evacuated**	**Persons Injured**	**Damages: Equipment/ Way & Structure**
Bordulac, ND Soo Line	2/20/89	Anhydrous Ammonia	Vertical split rail head	50	2	$643,503/ $17,500
Akron, OH CSX Teans.	2/2 6/89	Butane	Truck components: side bearing clearance improper	1500	0	$521,000/ $0
Jal, NM Union Pacific	3/11/89	Molten Sulfur	Cross level of track irregular (not at joints)	0	0	$50,000/ $2,600
Denison, TX Union Pacific	3/11/89	*	Switch point worn or broken	0	0	$42,681/ $4,500
Houston, TX Houston Belt Terminal RY	3/25/89	*	Worn flange	0	1	$222,092/ $33,123
Douglasville GA Soutnern RY	3/25/89	*	Derail, failure to apply or remove	0	0	$62,871/ $1500
Galva, Il Burlington Northern	4/1/89	*	Rigging down or dragging	0	0	$441,000/ $32,000
Sand Hill, TX Union Pacific	4/3/89	*	Track profile improper	0	0	$163,640/ $113,000
Crockett, TX Union Pacific	4/6/89	*	Side bearing clearance improper	0	0	$9,000/ $27,000

Englewood, TX Southern Pacific	4/13/89	*	Malfunction of hump retarder	0	0	$25,000/ $50,000
Clearing yard, IL Belt Railway of Chicago	4/23/89	Butadiene	Retarder did not slow car sufficiently	0	0	$122,000/ $0
Solsberry, IN Indiana RR Co.	4/24/89	*	Track Alignment irregular (buckled)	0	0	$160,000/ $45,000
Location and Railroad	**Date of Accident**	**Commodity Released**	**Probable Cause**	**Persons Evacuated**	**Persons Injured**	**Damages: Equipment/ Way & Structure**
Highland, MI CSX Trans.	4/25/89	*	Center plate disengaged from truck (car off center)	25	0	$150,000/ $2000
Willard, OH CSX Trans.	4/29/89	*	Overloaded car	0	0	$10,000/ $1,600
Cassville, WI Burlington Northern	4/30/89	*	Interaction of lateral/vertical force-rock off	0	0	$771,000/ $100,000
Livonia, LA Union Pacific	5/10/89	*	Truck Components	0	0	$193,578/ $24,000
Meehan, MS Midsouth Rail Corp.	5/11/89	Caustic Soda	Joint bar broken, noninsulated	100	0	$1,000,000/ $60,000
Milpitas, CA Union Pacific	5/26/89	*	Switch movement excessive	0	0	$29,400/ $5,000
Nelson, LA Midsouth Rail Corp.	6/19/89	Sodium Hydroxide	Journal (plain) failure from overheating	200	0	$263,000/ $12,000
Columbus, OH CSX Trans.	6/26/89	*	Wide gage (defective or missing crossties)	0	0	$14,725/ $0
Ruth, PA Conrail	7/14/89	*	Journal (plain) failure from overheating	0	0	$25,880/ $19,648

Location and Railroad	Date of Accident	Commodity Released	Probable Cause	Persons Evacuated	Persons Injured	Damages: Equipment/ Way & Structure
Freeland, MI CSX Trans.	7/22/89	Multiple flammable and corrosive materials	Wheel lift	1000	0	$390,000/ $19,000
Vista, MT Burlington Northern	7/31//89	Fuel oil	Center plate broken or defective & truck, stiff, improper lateral or swivelling	0	0	$500,000/ $57,000
Location and Railroad	**Date of Accident**	**Commodity Released**	**Probable Cause**	**Persons Evacuated**	**Persons Injured**	**Damages: Equipment/ Way & Structure**
Aalberg, MO Burlington Northern	8/7/89	Calcium Carbide	Roadbed settled or soft	0	0	$22,000/ $500
Duluth, MN Burlington Northern	8/19/89	*	Switch damaged or out of adjustment	0	0	$22,100/ $3000
Camden, NJ Conrail	8/22/89	Vinyl Chloride	Passed couplers	40	0	$6,000/ $250
Tucson, AZ Southern Pacific	8/22/89	*	Wide gage (defective or missing crossties)	800	0	$61,700/ $22,000
Reduction, PA CSX Trans8/23/89	8/23/89	*	Forces of nature	0	0	$391,000/ $0 Two reports
Cypress, FL CSX Trans.	9/4/89	*	Journal (plain) failure from overheating	350	0	$317,000/ $25,000
Rison, A.R. St. Louis Southwestern RY.	9/6/89	*	Excessive Speed	600	1	$516,000/ $750,000
Bristol, V.A. Norfolk & Western	9/10/89	*	Switch not latched or locked	0	0	$13,100/ $250

Byron, CA. Southern Pacific	9/13/89	*	Broken wheel rim	0	0	$323,000/ $850.000
Hume, IL. CSX Trans.	9/14/89	*	Switch rod worn, bent, broken, or disconnected	150	0	$451,500/ $5,600
Louisville, K.Y. Paducah & Louisville	9/15/89	Calcium Carbide	Muptiple potential causes	35	1	$28,000/ $0
Ontario, OR. Union Pacific	9/23/89	*	Excessive speed	0	0	$33,940/ $60,078
Location and Railroad	**Date of Accident**	**Commodity Released**	**Probable Cause**	**Persons Evacuated**	**Persons Injured**	**Damages: Equipment/ Way & Structure**
Jamesburg, N.J. Conrail	10/2/89	*	Derail, failure to apply or remove	0	0	$9,000/ $0
Rotterdamn Jct., NY. Springfield Terminal RY.	10/12/89	Hexane	Load Shifted	3500	0	$65,000/ $8,971
Pulga, CA Union Pacific	10/23/89	*	Focuses of Nature	0	0	$207,000/ $295,985
Towanda, KS. Union Pacific	11/7/89	Sodium Hydroxide	Transverse/ compound fissure in rail	0	0	$188,010/ $25,544
Payne, VA. Norfolk & Western	11/9/89	Hexamethyl-enediamine	Wide gage (defective or missing crossities	0	0	$95,550/ $500
Cowan PA. Buffalo & Pittsburgh	11/19/89	Methyl-methacrylate	Track geometry fects defects	30	0	$57,000/ $19,253
Salix, LA. Southern Pacific	12/1/89	*	Showing movement, absent man on or at leading end of movement	75	0	$81,725/ $60,000

Brooks Avenue, NY. Rochester Southern RR.	12/3/89	*	Wide page	0	0	$56,000/ $5,238
Lawrenceburg TN. Tennesse Southern RR.	12/12/89	*	Transverse/ compound fissure in rail	40	0	$75,000/ $25,000
Addis, LA. Union Pacific	12/21/89	*	Wide gage (defective or missing spikes or other rail fastners	0	0	$22,800/ $2,000
C&M Junction PA. Buffalo & Pittsburgh RR.	12/27/89	*	Journal (roller bearing) failure from over heating	0	0	$65,000/ $5,342
Location and Railroad	**Date of Accident**	**Commodity Released**	**Probable Cause**	**Persons Evacuated**	**Persons Injured**	**Damages: Equipment/ Way & Structure**
Vanderbilt, TX. Union Pacific	1/8/90	Muptiple products, incl. Hexamethyl enediamine, monoethanol-aine	Journal (roller bearing) failure from overheating	0	0	$409,623/ $20,000
Paskwood, AL. CSX Trans.	1/22/90	*	Other acts of God	0	4	$508,300/ $3,000
Page, WA. Union Pacific	2/9/90	Methyl alchol	Journal (plain failure from overheating	9	0	$434,600/ $293,914
Bardwell, TX. Burlington Northern	2/17/90	Sodium chlorate	Truck bolster broken	15	0	$420,000/ $47,328
Ottawa, IL. CSX	2/23/90	*	Bolt hole crack or break in rail	0	0	$25,000/ $0
Valley, Jct., TX, Union Pacific	3/15/90	*	Shoving movement, absent man on or at leading end of movement	0	0	$13,500/ $0

Gibson, TN. CSX Trans.	3/17/90	Styrene Monomer	Improper train makeup	100	0	$301,000/ $15,000
East St. Louis, Il. Gateway Western RY.	3/26/90	*	Wide gage (defective or missing crossties)	0	0	$15,000/ $2,500
Oliver, GA. Central of GA. RR.	4/20/90	Calcium Hypochlorate	Collision with highway user at grade crossing	0	0	$112,000/ $7,500
Craigsville, PA. Buffalo & Pittsburg RR.	4/22/90	Sodium hydroxide, Crude Oil	Side bearing clearance improper	200	0	$569,000/ $184,000
Pedernal, NM. ATSFRY	4/25/90	*	Truck, stiff, improper latcral or improper swivelling	0	0	$113,600/ $45,000
Location and Railroad	**Date of Accident**	**Commodity Released**	**Probable Cause**	**Persons Evacuated**	**Persons Injured**	**Damages: Equipment/ Way & Structure**
Pee Dec. NC. CSX Trans.	4/28/90	*	Object on or fouling track	200	0	$389,000/ $195,000
Ashland, KY. CSX Trans.	5/7/90	*	Head and web separation (within joint bar limits)	0	0	$61,700/ $500
Englewood Yard, TX. Southern Pacific	5/15/90	*	Retarder, improper manual operation	0	0	$30,000/ $2,400
Stockton, CA. Union Pacific	5/19/90	*	Switched improperly lined	0	0	$12,000/ $10,451
Covington, TN. Illinois Central RR.	5/24/90	*	Journal (roller bearing failure from overheating	1000	0	$368,000/ $60,000
Dunbar, AK. Alaska RR.	5/28/90	Fuel oil	Switch point worn or broken	0	0	$360,000/ $70,000
Spofford, TX. Southern Pacific	6/16/90	*	Air hose uncoupled or burst	0	0	$188,200/ $75,000

Commerce City, CO Denver Rio Grande & Western	7/26/90	Caustic soda	Brake valve malfunction stuck brake and other brake components damaged, etc.	40	0	$15,000 $1,000
Tucson, AZ. Southern Pacific	8/5/90	Sulfuric Acid	Hand brake (including gear) broken or defective	50	2	$68,300/ $0
Englewood, TX. Southern Pacific	9/10/90	*	Failure to properly secure engine(s)	0	0	$55,000/ $0
Fontana, KS. Burlington Northern	9/15/90	*	Cross level of track irregular (not at joints)	0	0	$284,200/ $130,573
Location and Railroad	**Date of Accident**	**Commodity Released**	**Probable Cause**	**Persons Evacuated**	**Persons Injured**	**Damages: Equipment/ Way & Structure**
Chidester, AR. Union Pacific	9/17/90	Nitric acid & Ammonium nitric fertilizer	Side bearing clearance improper and truck stiff, improper latcral or improper swivelling	200	4	$159,013/ $238,976
Columbus, OH. CSX Trans.	9/24/90	*	Transverse/ compound fissure in rail	0	0	$47,200/ $5,000
St. Louis, MO. Burlington Northern	10/2/90	Ammonium nitratc fertilizer	Car(s) shoved out and left out of clear	0	0	$10,000/ $250
Sevier Yard, TN. Southern RY.	10/9/90	*	Retarder did not slow car sufficiently	0	0	$26,000 $0

Marshville, NC. CXS Trans.	10/10/90	*	Washout/rain/slide/flood/snow/ice damage to track	0	0	$38,300/ $65,000
Lewisburg, TN. CSX Trans.	10/15/90	Chloroform	Interaction of lateral/vertical force-rock off	20	0	$732,000/ $14,800
McCormick, SC. CSX Trans.	10/19/90	Xylene & Toluene	Journal (roller bearing) failure from overheating	600	0	$358,400/ $13,000
Washington, IL. Toledo, Peoria & Western	10/20/90	Diesel Fuel	Collision with highway user at grade crossing	0	0	$650,000/ $10,000
Whiting, IN. Elgin, Joliet & Eastern RY.	11/8/90	Corrosive liquids	Wide gage (worn rail)	0	0	$8,000/ $2,000
Essex, CA. ATSFRY	11/26/90	Combustible liquid, nos & Methyl-ethyl-ketone	Special operating instruction. failure to comply	0	0	$690,662/ $80,000
Location and Railroad	**Date of Accident**	**Commodity Released**	**Probable Cause**	**Persons Evacuated**	**Persons Injured**	**Damages: Equipment/ Way & Structure**
Keith, NE. Union Pacific	12/9/90	*	Broken flange	0	0	$220,407/ $100,994
Quitman, GA CXS Trans.	12/12/90	*	Improper operations of train air brake system	0	0	$232,499/ $10,000 2 reports
Alvarado, TX. ATSFRY	12/14/90	*	Use of brakes and special operating instruction, failure to comply	0	0	$88,400/ $19,000
Broadview, MT. Burlington Nothern	1/2/91	*	Load fell from car	0	0	$176,700/ $14,600

Memphis, TN Burlington Northern	1/31/91	Ammonium nitratc fertilizer	Knuckle broken or defective	0	0	$64,000/ $0
Wickliffe, KY, Illinois Central RR.	2/9/91	Petroleum oil	Rigging down or dragging	0	0	$295,000/ $70,000
Diboll, TX. Southern Pacific	2/11/91	*	Collision with highway user at grade crossing	30	0	$251,250/ $63,000
Navasota, TX, Southern Pacific	2/19/91	*	Dynamic Brake, improper	0	0	$504,728/ $51,000
Woolbridge, MO. Union Pacific	2/20/91	White phosphorous	Broken wheel flange	200	0	$485,276/ $224,311
Copperhill, TN. CSX Trans.	3/5/91	*	Horizontal split head	0	0	$41,000/ $4,000
Sudden, CA. Southern Pacific	3/19/91	*	Washout/ rain/slide/flood/s now/ice damage to track	0	0	$1,4000,00/ 0/ $150,000
Alberg, MO Burlington Northern	3/29/91	Combustible liquid	Buffing or slack action excessive	0	0	$489,800/ $85,400
Location and Railroad	**Date of Accident**	**Commodity Released**	**Probable Cause**	**Persons Evacuated**	**Persons Injured**	**Damages: Equipment/ Way & Structure**
Stang, TX. Southern Pacific	4/7/91	*	Interaction of lateral/vertical force-rock off	0	0	$62,100/ $22,000
Homly, OR. Union Pacific	4/12/91	Phosphoric acid	Buffing or slack action excessive and dynamic brake, improper use	0	2	$379,592/ $190,865
Edgewood, IL. Illinois Central	4/13/91	Caustic soda	Detail fracture from shelling or head check	50	0	$635,200/ $100,000

Exeter, NE. Burlington Northern	4/23/91	Ferrous chloride	Journal (roller bearing failure from overheating	0	0	$404,000/ $367,391
Tacosa, TX. Burlington Northern	4/29/91	Methanol	Detail fracture from shelling or head check	0	0	$866,700/ $98,674
Geismar, LA, Illionois Central RR	5/4/91	*	Vertical split head	0	0	$128,300/ $3,500
Tulsa, OK. Burlington Northern	5/6/91	*	Buffing or slack action excessive	0	0	$27,000/ $250
Vanderbilt, TX.Union Pacific	5/16/91	Liquefied petroleum gas	Truck componets and roadbed settled or soft	0	0	$289,000/ $130,393
Englewood, TX, Southern Pacific	5/25/91	*	Other frog, switch or track appliance causes	0	0	$14,500/ $7,000
Carrier, OK, Burlington Northern	5/26/91	*	Journal (plain) failure from overheating	125	0	$426,600/ $81,200
Ingle, IN. CSX Trans.	6/12/91	Anhydrous ammonia	Interaction of lateral/vertical force-rock off	0	0	$131,500/ $25,750
Location and Railroad	**Date of Accident**	**Commodity Released**	**Probable Cause**	**Persons Evacuated**	**Persons Injured**	**Damages: Equipment/ Way & Structure**
Potomac Yard, VA. RF & Potomac	6/23/91	Potassium hydroxide	Worn flange	0	0	$85,400/ $6,000
Heagy, MO. Union Pacific	6/23/91	Corrosive liquids	Defective snubbing	450	0	$462,724/ $0
Willbridge, OR. Burlington Northern	7/8/91	*	Instruction to train/yard crew improper	0	0	$4,800/ $2,500
Bovina, TX, ATSFRY.	7/14/91	*	Broken locomotive axle	0	0	$1,300,000/ $120,000

Dunsmuir, CA. Southern Pacific	7/14/91	Metam sodium	Interaction of lateral/ vertical force rock off	0	53	$274,280/ $5,000
Walcott, WY. Union Pacific	7/14/91	Naphtha	Object on or fouling track	0	0	$355,750/ $180,000
Butler, PA. Buffalo & Pittsburg RR.	7/17/91	Methl-methacrylate	Side bearing clearance improper	100	0	$52,190/ $29,220
Manchester, TX Port Terminal RR.	7/26/91	Sulfuric acid	Passed couplers	0	0	$12,000/ $0
Seacliff, CA. Southern Pacific	7/28/91	Hydrazine hydrated	Journal (roller bearing failure from overheating	300	0	$826,500/ $37,910
Karen, TX Burlington Northen	7/30/91	Methanol	Train order or timetable authority, failure to comply	0	3	$1,900,000/ $35,229
Evansville, IN.	7/31/91	*	Track profile improper	70	0	$46,500/ $0
Beaver Jct., KY CSX Trans.	8/6/91	*	Side bearing clearance improper	0	0	$39,000/ $5,000
Location and Railroad	**Date of Accident**	**Commodity Released**	**Probable Cause**	**Persons Evacuated**	**Persons Injured**	**Damages: Equipment/ Way & Structure**
Bellefonte Yard, PA, Nittany & Bald Eagle	8/15/91	*	Truck, stiff, improper swivelling	0	0	$3,000/ $200/ $30,000 cleanup
Granite City, IL. Norfolk & Western	8/18/91	*	Super elevation improper, excessive or insufficient	0	0	$40,030/ $0

Gilmer, TX, St. Louis Southwestern RY.	8/24/91	*	Dynamic brake, improper use	16	0	$133,250/ $56,000
Bucklim, MO. Burlington Northern	8/28/91	Denatured alcohol	Rigging down or dragging	15	0	$652,000/ $178,613
Joliet, IL. Southern Pacific	9/5/91	Phosphoric acid	Guard rail loose/broken or mislocated	0	0	$19,000/ $28,835
Knox, IN. Norfolk & Western	9/17/91	Molten sulfur	Block signal, failure to comply	12	3	$419,162/ $0
Orchard, ID, Union Pacific	9/22/91	Argon	Other rail and joint bar	0	0	$127,000/ $170,000
Western, AL, CSX Trans.	10/27/91	Fluorosilicic acid	Combination of track geometry violations and slight overspeed	20	0	$35,000/ $500
Capa, SD. Dakota , Minnesota & Eastern RR.	10/31/91	*	Cross level of track irregular (not at joints	0	0	$47,500/ $16,500
Oil City, PA. Conrail	12/17/91	*	Transverse/ compound fissure in rail	0	0	$9,950/ $3,000
Location and Railroad	**Date of Accident**	**Commodity Released**	**Probable Cause**	**Persons Evacuated**	**Persons Injured**	**Damages: Equipment/ Way & Structure**
Kenton, OH, Conrail	12/19/91	*	Wide gage (defective or missing crossties	0	0	$8,500/ $450
Cottondale FL, CXS Trans.	12/20/91	Ammonium nitrate	Failure to properly secure handbrake on car(s)	0	0	$800,000/ $10,000

English, WA. Burlington Northern	12/25/91	*	Journal (roller bearing) failure from overheating	100	2	$240,000/ $112,454
Ekhart, IN. Conrail	12/28/91	*	Use of brakes	0	0	$27,400/ $0
Bates City, MO, Gateway Western	12/30/91	Flammable liquid, nos	Rail and joint bar defects	0	0	$225,000/ $11,500
Dragon, MS. Norfolk Southern	1/18/92	Liquerfied petroleum gas	Other body defects, (car)	0	0	$113,000/ $6,250
Harwood, IN, CSX Trans.	3/1/92	Isopropanol	Side bearing clearance insuffient	45	0	$306,500/ $28,000
Mullins, KY, CSX Trans.	3/7/92	Ammonium nitrate	Vandalism of on-track eqipment, e.g., brakes released	0	0	$20,000/
Good Hope, LA. Illinois Central Gulf	3/14/92	Molten Sulfur	Switch damaged or out of adjustment	0	0	$49,150/ $1,500
East Brighton, VT St. Lawrence & Alantic	3/14/92	Sodium hydroxide	Broken base of rail	0	0	$527,909/ $80,000
Ashland, NE. Burlington Northern	3/26/92	*	Hand signal, failure to comply	0	0	$40,000/ $1,000
Location and Railroad	**Date of Accident**	**Commodity Released**	**Probable Cause**	**Persons Evacuated**	**Persons Injured**	**Damages: Equipment/ Way & Structure**
Whitefish, MT. Burlington Northern	4/17/92	*	Coupling speed excessive	0	0	$61,500/ $1,400
Maxwell, SC, CSX Trans.	4/23/92	*	Failure to apply sufficient number of handbrakes on car(s)	0	0	$15,000/

Avondale, LA. Southern Pacific	5/5/92	*	Automatic Brake insufficient	0	1	$415,487/ $15,000
Willisland NE Union Pacific	5/18/92	Hazardous substance, nos	Improper train inspection	0	0	$279,688/ $104,500
Marccline, MO ATSFRY,	5/19/92	*	Car body defect	0	0	$192,895/ $152,900
Pembine, WI, Wisconsin Central	5/20/92	Sodium chlorate	Wide gage (due to defective or missing crosstics)	0	0	$41,500/ $1,981
Rosenburg, TX, ATSFRY	6/1/92	Acrylic acid	Derail, failure to apply or remove	300	0	$6,000/
Superior, WI, Burlington Northern	6/30/92	Flammable liquid	Derail fracture from shelling or head check	20000	0	$253,300/ $271,000
Julliard, TX. ATSFRY	7/7/92	*	Improper train make-up at initial terminal	0	0	$233,080/ $13,000
Evanston, WY, Union Pacific	7/26/92	Petroleum naphtha	Other coupler and draft system defects (locomotive)	0	0	$424,300/ $178,224
Bosler, WY, Union Pacific	8/8/92	Corrisive liquid	Improperly loaded car	0	0	$182,400/ $105,000
Brooklyn, WV CSX Trans.	8/25/92	*	Failure to apply sufficient number of handbrakes on car(s)	0	0	$12,000/
Location and Railroad	**Date of Accident**	**Commodity Released**	**Probable Cause**	**Persons Evacuated**	**Persons Injured**	**Damages: Equipment/ Way & Structure**
Towanda, PA. Conrail	9/13/92	*	Interaction of lateral/vertical forces	0	0	$73,500/ $9,231
Omar, WV, CSX Trans.	10/7/92	*	Derail, failure to apply or remove	0	0	$11,000/

Mattawamkeag, ME Springfield Terminal	10/7/92	Sodium chlorate	Load shifted	0	0	$96,714/ $4,546
Lucerne, WY, Burlington Northern	10/16/92	Methanol	Transverse/ compound fissure in rail	35	0	$90,000/ $25,000
Alden Bridge, LA. St. Louis Southwestern	11/5/92	*	Derail fracture from shelling or head check in rail	0	0	$899,363/ $150,000
Idafalls, Il). Union Pacific	11/19/92	Diesel fuel	Damaged wheel flange	0	0	$3,000/ $45,000
Hybart, AL Burlington Northern	12/1/92	*	Highway user inattentiveness	50	3	$221,500/ $23,400
Strang, TX Southern Pacific	12/7/92	*	Failure to apply hand brakes on car(s)	0	0	$10,000/
Enampa, ID, Union Pacific	12/15/92	Ethyl acrylate, inhibited	Improper train make-up	0	1	$67,000

Accidents involving the release of a hazardous material occurred on 35 different rail carriers and were reported from 40 different states. The leading states were Texas (26), Illinois (10), Pennsylvania (9), and California and Missouri (8 each). It is important to note that these states are also among the top origins and destinations for hazardous materials. (FRA, 1994)

Separate federal regulations cover the reporting requirements for hazardous materials transportation incidents. All occurrences of a suspected release of radioactivity must be reported. In addition, according to RSPA's reporting regulations (CFR 171.16), any release of hazardous materials involving fatalities, injuries, evacuations, blockage of a transportation artery or flight pattern, or damages exceeding $50,000, must be reported immediately and followed up with a more detailed, written report. (FRA, 1994)

The Nuclear Regulatory Commission (NRC) also collects data on transportation incidents involving radioactive materials. Data regarding incidents with suspected releases of radioactivity have been compiled into the Radioactive Materials Transportation Accident/Incident Database, or RAM-AIDB, at Sandia National Laboratories for DOE. For the years 1971 through 1982, data published by Sandia National Laboratories (1984b) from the RAM-AIDB, revealed that there were 906 incidents involving radioactive materials. Of the 906 incidents, 123 were transportation accidents, 167 were a result of handling, and the remaining 616 were not related to accident conditions. Of the 123 transportation accidents, eight involved aircraft, nine involved rail, 105 involved trucks, and one involved a courier's vehicle. However, accurate comparisons of these figures cannot be made unless the total number of shipments for each mode is taken into consideration. This information is unavailable.

In more recent years, the number of hazardous materials releases from railroad cars has hovered around 1,100 to 1,200 annually, even though the number of train accidents has declined. (FRA 1994)

Track class can be used to further evaluate accident frequency and severity statistics. Based on a review of data from 1980 to 1985, Battelle found that the number of track-caused accidents per mile of track generally decreased with higher class track, probably because as track class increases, rail standards become more stringent. However, since lower maximum speeds are permitted on lower class track, accidents tend to be less costly and less severe on lower class track. While there are twice as many track-caused accidents per track-mile on Class 1 track, which has a maximum speed limit of 10 miles per hour, the average cost of damages per accident associated with Class 1 track was less than any other class of track. Regarding accidents attributed to human factors, there were twice as many accidents per mile of Class 1 track than any other class. It must be noted that most Class 1 track is located at railyards, where there is a high incidence of minor accidents caused by human error during switching operations. Concerning accidents attributed to equipment failure, there were twice as many accidents per mile of Class 4 track, which has a maximum speed limit of 60 miles per hour, than the other classes of track. Limited significance can be given to these statistics without consideration of traffic volume and density on each class of track. At this time such data is unavailable. (Battelle 1988a)

The FRA accident/incident database was found to be inaccurate by a GAO investigation (1989b). After comparing the FRA database with the records of five carriers, including two large freight railroads, two regional carriers, and Amtrak, GAO found that accident data was commonly underreported to the FRA. One carrier's records matched the FRA's database fairly closely, while for the other four carriers, company records indicated up to 14% more reportable injuries, up to 360% more workdays lost, up to 43% more reportable accidents, and up to 69% more damages. The size of the discrepancies varied among carriers. The underlying cause of the disparity cited by GAO was that the preliminary appraisal done at the scene of the accident usually underestimated the extent of the damages, in terms of cost and injuries. These estimates are submitted to the FRA to comply with federal regulations. When the final figures were known, usually within a month following the accident, many carriers did not forward the new numbers to the FRA since a different department was often responsible for FRA reporting than for processing workmen's compensation claims and invoices for repair work. The recommendations made by GAO included: 1) that the FRA ensure that carriers establish internal control procedures for reporting, 2) that the FRA periodically review carriers' reporting procedures, and 3) that carriers maintain complete records in one place.

Except for research reports by government contractors on specific subjects, the annual accident/incident bulletins provide the only comprehensive source of rail accident statistics. Information not in the bulletins is often not available from other sources. Additional types of information that would be helpful in evaluating the rail industry include accident rates by track-mile (although it may be possible to estimate these rates using the waybill sample to estimate traffic volumes), train-mile, geographic area, track class, and for regular, special, and dedicated trains, as well as for trains carrying hazardous and radioactive materials.

B. Health Impacts

Both radiological and non-radiological health impacts of rail transportation of radioactive material need to be considered and compared with the hazards associated with trucks. When evaluating the radiological risks associated with transportation accidents, one must consider the probability of an accident occurring that is severe enough to cause a breach in the fuel rod cladding, shielding, and shell. Until recently, a Type B package had never been breached during a transportation accident; this accident did not involve a spent fuel cask. This

section is divided into three parts: 1. Radiological Accident Risk; 2. Radiological Incident-Free Risk; and 3. Non-Radiological Risk.

1. Radiological Accident Risk

Lawrence Livermore National Laboratory's (LLNL) "Modal Study," released as NUREG/BR-0111 and NUREG/CR-4829, estimated how increased strain and temperature affected the integrity of a spent fuel container, possibly causing a radiation release, and then compared these data with the conditions that occurred in actual transportation accidents involving non-radioactive materials. The Modal Study used a "reference cask" design that differs from the cask designs currently under development for the repository program. It is unclear how the cask differences may affect the Study's conclusions.

Strain measures a material's response to an impact; it can be defined as the change in dimension of any segment of the steel shell in a given direction divided by the original length of the segment. LLNL predicted that no radiological hazards would be expected from less than 0.2% strain, that 10% of the fuel rod cladding would fail with strain values between 0.2% and 2.0%, and that strain greater than 2% would cause failure of all of the fuel rod cladding. Extensive structural cask damage that LLNL could not accurately predict was expected at strain values exceeding 30%. Cask responses were estimated from analytical techniques, not experiments or tests performed on actual casks. In addition, an uncertainty analysis was not performed and the results do not include confidence limits.

LLNL determined that the temperature measured at the centerline of the gamma shielding would provide the best indication of the amount of heat absorbed from external sources. No functional damage or radiological hazard was expected at temperatures less than 500°F, while at temperatures between 500°F and 600°F certain cask seals could degrade, allowing the release of gaseous and volatile materials that had previously escaped from the fuel rods (up to 3% of a shipment). At temperatures greater than 621°F, the lead gamma shielding could melt, resulting in the loss of the shielding's containment function. As temperatures increase beyond 650°F, more fuel rod cladding failures would be expected, further intensifying the radiological hazards outside the cask. Above 1050°F, it was presumed that all gaseous radioactive materials would be released.

The probability of various abnormally high strain and temperature conditions occurring during past truck and rail accidents is displayed, attempting to predict the likelihood of radiation releases during past accidents had there been casks of radioactive materials on board. After reviewing the accident records for trains and trucks, LLNL determined that the vast majority (99.4%) of rail and truck accidents would have posed no radiological hazard. Two-thirds of the remaining 0.6%, or 0.4% of all rail and truck accidents, would have resulted in a radiation release to the environment equal to maximum allowable levels, and one-third of the 0.6%, or 0.2% of all transportation accidents, could have resulted in external radiation levels exceeding compliance values by a factor of four or less. Based on historical data, only a very small percentage of rail and truck accidents (1 per 10,000 and 1 per 100,000, respectively) were expected by LLNL to have experienced sufficient strain and/or temperatures to potentially result in fractures or ruptures of the cask. In general, the overall radiological risk from transportation accidents was nearly the same for trucks and trains; however, it was found that high strain environments were more likely with truck accidents while rail accidents were associated with high temperatures.

LLNL chose four severe transportation accidents, two truck collisions and two train derailments, as potential accident scenarios. The temperature and strain conditions resulting from these accidents were calculated. Of the four scenarios, three would have resulted in superficial cask damage and no radiological hazard. The fourth, the September 1982 train derailment in Livingston, Louisiana involving several combustible and explosive materials, resulted in prolonged high temperatures possibly sufficient to melt the gamma shielding and result in external radiation levels of up to four times the regulatory limit.

The Modal Study results can be compared with those from NUREG-0170, which in 1977 evaluated the environmental impacts caused by transporting radioactive materials by aircraft, truck, rail, and barge. As shown in the table, the LLNL study found that the radiological risk associated with transporting

COMPARISON OF NUREG-0170 AND LLNL RISK RESULTS

	NUREG-0170	LLNL STUDY
Fraction of Transportation Accidents Involving Spent Fuel Shipments Causing Any Radiological Hazard	0.09 (Truck) 0.20 (Rail)	0.006 (Truck) 0.006 (Rail)
Fraction of Transportation Accidents Involving Spent Fuel Shipments Causing Largest Estimated Radiological Hazard	0.004 (Truck) 0.002 (Rail)	0.00001 (Truck) 0.00013 (Rail)
Overall Annual Risk From Transportation Accidents	0.004 LCF	Less Than 1/3 of 0.004 LCF

spent fuel is much less than what was established by NUREG-0170; however, there were several differences between the two studies that may account for the discrepancy. In contrast to LLNL's study, which focused on spent fuel containers, NUREG-0170 evaluated the performance of both Type A and B packages of various types of radioactive materials. NUREG-0170 categorized transportation accidents based on the speed of impact onto an unyielding surface and the duration of a 1300°K (1880°F) fire. While these properties are similar to the strain and temperature conditions used by LLNL, they concentrate on external conditions, rather than the specific reaction by a spent fuel container, which was the focus of LLNL's study. NUREG-0170 used two models to evaluate the risk associated with the release of radiation from Type A and B packages following a transportation accident. The first model assumed that once the conditions allowed by federal regulations were exceeded, there would be a complete release of radiation; since this is not what really happens, the first model would provide a result much higher than what would actually occur. A conservative estimate was also expected from the second model, which increased the amount of radiation released as accident severity increased; reasons for the conservatism include the assumption that most containers would fail just beyond the accident conditions at which they were tested, and aspects of the dispersion model which would tend to overestimate exposure values.

Upon examination of the assumptions used for analysis, the Modal Study results may not be directly applicable to rail shipments. Several truck/highway accident data assumptions were applied to rail transport, largely due to a lack of certain rail-specific data. For example, it was assumed that all rail and highway accidents involved the same: percent of incidents of falling off a bridge or embankment; percent of incidents that involve impacting soft soil, rock, or a roadway; percent of incidents impacting columns, abutments, or other large structures; and cask velocity in a fall off a bridge or embankment. In addition, highway data were used to estimate the distance a cask was likely to fall in a rail accident. Statistics for rail accident fires are also limited. Very little useful data exists for occurrence, duration, and properties of rail accident fires. Results of a 1977 Sandia National Laboratories Study, *Severities of Transportation Accidents* (SAND 1977), were used for estimating fire duration and probability of a train fire occurring. The Modal Study assumed that flame temperatures for train fires are the same as those for truck fires. Statistical techniques were used to generate a prediction of fire duration for various types of rail accidents and scenarios, based on "reasonable assumptions from sensitivity study results, or conservative assumptions."

The Modal Study does not closely examine the possibilities for crushing a cask in a rail transport scenario. The Study considered the 200-ton weight of a locomotive resting on-end against a cask, as the worst case and found it did not yield significant damage. Major derailments can result, however, in greater weights being piled upon one railcar. An NRC study concluded the bounding value in such an instance was 550 tons, nearly three times the case considered by LLNL. (NRC 1980; Audin 1990) As previously mentioned, the reference cask in the Modal Study differs from cask designs currently under development. The study casks incorporated design principles and materials used in casks previously licensed by the NRC. In addition, the truck cask's (capacity - 1 PWR fuel assembly) gamma shield was assumed to be thicker than the rail cask's (capacity - 21 PWR assemblies) to allow for the possibility of highway shipments of spent fuel younger than five years old. (LLNL 1987)

The assumptions described above demonstrate potential weaknesses in relying on the Modal Study results for rail accident scenarios. Using truck and highway statistics and data assumptions for rail transport, while permitting use of a common analysis scheme, introduces further uncertainties into the Study. The Modal Study may or may not accurately reflect rail accident conditions; however, the use of highway/truck accident assumptions, failure to recognize the unique characteristics of rail transport, and lack of an uncertainty analysis must be recognized as potential limitations upon the reliability of the Study results. [For additional information on the applicability of the Modal Study to the Office of Civilian Radioactive Waste Management transportation program, see Nuclear Waste Shipping Container Response to Severe Accident Conditions: A Brief Critique of the Modal Study, prepared by Lindsay Audin for the State of Nevada (Audin 1990).]

The radiological risk associated with special and regular trains can be evaluated in terms of the probability and severity of accidents for each type of operation. A 1977 study by the Interstate Commerce Commission (ICC) found that the accident rate per mile for special trains was lower at all levels of severity, which was measured by fire duration and velocity of impact experienced during past accidents. One factor contributing to the lower accident rate may be the slower speeds required of special trains, which lessen the likelihood of a high-speed impact accident; the possibility of such an accident cannot be eliminated entirely (for example if a loaded railcar falls from a high bridge or collides with another train). Another factor may be the possibility of regular trains carrying tank cars of flammable material, increasing the possibility of an intense fire. The ICC concluded that approximately ten times more latent cancer fatalities would result from accidents involving regular trains than from special trains, using worst-case scenarios. The disparity was reduced by half when a more realistic model was used. Another 1987 study, NUREG-0170, described some of the same potential advantages of special trains and noted that a special train is less likely to have a serious derailment because of the shorter train length (as compared to regular trains). The NRC study also noted that the decreased switching needed for special trains would lower the radiological exposure of railroad employees.

2. Radiological Incident-Free Risk

Under incident-free conditions, some radiation is emitted and could result in a health hazard. The NRC currently limits the radiation level on the surface of a spent fuel cask to 200 mrems per hour (note: NRC regulations allow this limit to be exceeded at the cask surface during shipping, allowing up to 1000 mrems per hour, provided the shipment is made in a closed vehicle, secured in a fixed position throughout transport, with no loading or unloading between origin and final destination. 10 CFR 1, Sec. 71.47 (a)). Measurements taken during the Three Mile Island-INEL shipping campaign did not exceed 4 mrems per hour. The level of radiation exposure received by an individual or population is a function of the amount of radiation being released, the period of exposure, and the distance from the source.

The ICC study also estimated the radiological risks associated with regular and special trains carrying shipments of unspecified radioactive materials during normal conditions assuming the maximum allowable leakage of radiation. It was assumed that, as compared to regular trains, special

trains would travel at a slower speed, have shorter layover periods, and have closer proximity of crew members to a loaded railcar, since only a buffer car would separate the railcar from the locomotive or caboose. After accounting for these assumptions, the exposure levels experienced by railyard workers and the general population within one-half mile of the route were found to be the same for special and regular trains, while the exposure received by special train crews was more than ten times that received by their counterparts on regular trains.

3. Non-Radiological Risk

Rao, et. al. (1982), evaluated two factors associated with non-radiological health effects of transportation: accident severity and frequency, and the types and quantity of air pollutants generated. The study compared these parameters for one truck and one railcar.

Injuries and fatalities unrelated to the radioactive properties of the cargo may result from vehicle accidents. These deaths and injuries occur immediately and can be attributed to a specific shipment. Using 1976 truck and train accident data, Rao, et. al., calculated the risks associated with one kilometer travelled by one train and truck in both rural and urban areas. As shown by the following data, there are slightly more injuries but slightly fewer fatalities involved with truck transport than with rail.

NON-RADIOLOGICAL RISKS BY MODE

Mode	Injuries/km	Fatalities/km
Truck	5.1×10^{-7}	3.0×10^{-8}
Rail	4.6×10^{-7}	3.4×10^{-8}

Several air pollutants are emitted by trains and/or highway vehicles. Rao, et al., compared the emission rates from trains and trucks and found that trucks generated more tire particulates and fugitive dust (dust that is suspended by a passing vehicle), while train emissions were higher in sulfur dioxide, nitrogen oxides, hydrocarbons, and particulates. The amount of carbon monoxide emitted by trucks and trains was found to be similar. This study also found that in a typical urban area, the incremental sulfur dioxide and particulates would lead to 1.0×10^{-7} and 1.3×10^{-7} deaths per kilometer travelled by a truck or railcar, respectively. The adverse health effects of the other air pollutants have not been determined.

C. Seasonal Transportation Hazards

Adverse weather conditions impact rail and highway transportation differently. The major concerns regarding rail traffic are decreased visibility due to fog, snow, or dust, and the effects of extreme temperatures on equipment and human performance.

Signal systems aid train operation during periods of diminished visibility, but speeds must often be reduced as well. The FRA sets speed limits according to track class, but carriers are responsible

for reducing speeds as conditions dictate. The locomotive engineer may receive instructions from local superintendents or use personal judgment to decide a safe operating speed.

Severe cold affects the physical properties of lubricants, metal, and rubber. Contraction of metal in temperatures below freezing can result in "pull-aparts," which are separations of the rail up to an inch wide. As mentioned in the discussion on signals, a pull-apart would interrupt the vital circuit and result in a warning to approaching trains, reducing the chance of a derailment. Extremely low temperatures have also been tentatively linked to the failure of air brakes. For example, brake failure in combination with human error resulted in a collision and derailment west of Helena, Montana, in February 1989. A Montana Rail Link train consisting of six locomotives and 49 railcars departed Helena for a short 30-mile run in -40^{o}F weather. Less than ten miles from Helena, an electrical short-circuit caused the motor and cab heater in the lead locomotive to go out. The locomotive engineer, who did not want to travel without a heater in such cold weather, decided to pull off at a siding in order to switch lead locomotives even though the train could have proceeded under the power of the remaining five locomotives. The automatic air brake was applied from the inside of the cab. However, the emergency hand brake, which must be set from the outside, was not applied, probably because of the bitter cold. During the switching operation, the automatic air brake released and the 49 railcars slid downhill to Helena until they crashed into a locomotive and railcars containing hazardous materials in a railyard. The NTSB cited a combination of weather-related factors behind the accident: 1) the engineer would have continued without a functioning heater had it not been so cold, 2) the emergency hand brake may have been applied, and 3) the air brake leakage was exacerbated due to thickening of lubricants, the hardening of rubber seals, and the shrinkage of air valves in the cold. There have been other occurrences of automatic air brakes failing and engines quitting in such cold weather.

Extremely high temperatures may have an effect on rail operations as well. Prolonged temperatures over 100^{o}F may cause the rail to loop outward instantaneously and form a "sun-kink." Sun-kinks cannot be detected and are described as rare by AAR. Some locomotive cabs are now air-conditioned. (Kelly, 1996) However, as with extreme cold, uncomfortable working conditions, such as high temperatures, may lead to poor judgment.

Accidents, particularly derailments, can occur in ice, snow, or mud if allowed to accumulate on the tracks. In small amounts the hazards are minimal, since trains are guided by rails and only a loss of traction and reduction of speed would result. On-board sanders, located at the rear of the locomotive, can distribute sand on the underlying track. Locomotives can be equipped with any of a variety of snow plows or snow blowers as needed. High snow drifts can also be cleared from the track before any trains are allowed to travel through a hazardous area.

Train derailments caused by high crosswinds are not uncommon, especially in southern Wyoming, western Nebraska, and the western edge of the Wasatch Mountains in Utah. Especially at risk are trains carrying piggyback trailers or other relatively light and high profile units. Most carriers have installed wind indicators along routes in problem areas to monitor wind conditions. Rail carriers often shut down or limit operations when steady winds of 45 to 50 miles per hour are present.

In response to potentially hazardous weather conditions, carriers often enforce special restrictions in extremely hot or cold weather. Below -10°F and above 90°F, speed restrictions are enforced to look out for temperature-related track defects. In addition, when temperatures dip below 0°F, special tests are done to ensure the reliability of the air brakes.

D. Hazards Presented by Gas Pipelines

A potential risk exists where rail lines are located near pipelines transporting gas and other chemicals under pressure. Concerns were exacerbated after two 1989 incidents, one in the Soviet Union and one in Southern California. The Soviet Union incident involved an explosion and subsequent train derailment. A spark from a passing train ignited gas vapors escaping from a leak in an above-surface pipeline and caused a violent explosion. The train derailed, and there were several fatalities. The probability of this type of incident occurring in this country is slight since the vast majority of pipelines in the United States are buried; an exception is Alaska, where permafrost conditions discourage shallow burial.

1. San Bernardino Accident

The Southern California accident occurred in San Bernardino and involved a freight train derailment and a gas pipeline explosion 13 days later. The freight train consisted of a four-unit locomotive at the head of the train, 69 hopper cars loaded with ore, and a two-unit helper locomotive at the rear of the train. The train had been mistakenly assembled with insufficient braking power for its weight of 9,000 tons and was travelling out of control down a hill at nearly three times the allowable speed of 35 miles per hour. The train was unable to negotiate a curve at the bottom of the hill and derailed. The entire train was destroyed as a result of the derailment. Seven homes in the vicinity were destroyed and four others were extensively damaged. Two crew members and two residents were killed. Causes of the derailment resulted from dispatching the locomotive without adequate operable dynamic brakes and a lack of communication between the road (lead) and helper (rear) engineers regarding the operation of the train and the number of operable brakes. (NTSB 1990)

Thirteen days later, a 14-inch steel and fiberglass pipeline transporting high octane gasoline buried four feet beneath the accident site ruptured and then exploded. Two residents were killed and 19 were injured in the explosion and subsequent fire. The rupture and explosion resulted from inadequate testing and inspection of the pipeline that failed to detect damage to the pipe by earth-moving equipment during clean-up operations. The 248-mile pipeline between Colton, California, and Las Vegas, Nevada, was constructed during 1969-70. (NTSB 1990) At that time, there were no Federal regulations in effect that addressed the operation, inspection, and maintenance of liquid pipelines. However, testing prior to the wreckage indicated that the pipeline exceeded minimum requirements for operation established in the Natural Gas Pipeline Safety Act of 1968. The Act established the Office of Pipeline Safety (OPS) within the Department of Transportation to develop safety standards for pipelines (the new regulations did not apply to pipelines already under construction). The California-Nevada pipeline was used for a number of petroleum products including: gasolines, jet fuels, and No. 2 diesel fuel. (NTSB 1990) As a result of the San Bernardino wreckage

and subsequent explosion, an "informal policy" has been developed by the OPS. In the event of a rail accident upon or near a gas or petroleum products pipeline, the pipe must be fully excavated and checked for visible damage. If the visual inspection proves satisfactory, the pipe must be tested for structural capability prior to backfilling. (NTSB 1990) In an unrelated derailment involving a pipeline near Las Vegas, this procedure was followed and the pipe was determined to be safe.

2. Pipeline Maps

There are over 450,000 miles of pipelines in the United States, consisting of crude oil, petroleum products (e.g., gasolines) and natural gas pipelines. Detailed maps of all three types of pipelines are available from at least one publishing company [PennWell Books, P.O. Box 21288, Tulsa, OK 74121; 1-800-752-9764] The maps, in a scale of 1:3,600,000 or 1 inch = 56.7 miles, include both the United States and Canada. A variety of specific characteristics are provided on the maps such as pipeline diameter, and location of pump stations, refineries, and storage locations, as well as jurisdictional boundaries (counties, states) and principal drainage basins. The maps do not show the location of rail routes nor do they provide any information on depth of pipeline burial. Presently, the OPS does not require pipeline companies to provide detailed pipeline maps. The OPS is in the process of initiating pipeline company mapping requirements to make it possible for individual states or local entities to request pipeline information. The requirements do not require inclusion of rail routes.

The San Bernardino and Las Vegas incidents have focused attention on the potential safety problem associated with locating gas and petroleum product pipelines along railroad rights-of-way. In the Las Vegas derailment, a pipeline was buried only 12 - 30 inches deep. One car length away from where the soil was compressed 30 inches by the derailment, the pipeline was buried only 12 inches deep. The fact that information on the co-location of rail routes and gas or petroleum product pipelines is limited and the impact of the San Bernardino incident may lead to further safety analysis of locating pipelines near rail routes. In addition, specific detailed information on existing pipelines may need to be compiled and would be particularly useful for rail route planning.

IV. CONTRACTING, TARIFFS, AND ECONOMIC REGULATION

The business aspects of rail operations are relevant to two issues involving spent fuel and high-level waste shipments -- DOE's willingness to use the rail mode because of its ability (or lack of ability) to obtain acceptable rates and terms, and the special conditions (escorts, speed limits, etc.) that can be placed on these shipments.

Before 1980, rail rates were set by tariff -- published rates and terms that were available to all shippers of a particular commodity between a certain origin and destination. Rail tariffs were similar to today's air fares for passenger service. Railroads were generally prohibited from negotiating individual contracts with shippers. The Interstate Commerce Commission exercised regulatory authority over the reasonableness of the rates established in the railroads' tariffs. All of this changed when the Staggers Act passed in 1980. Railroads were encouraged to enter into individual contracts

with shippers. The terms of the contract are generally kept secret (as proprietary information that could affect the shipper's or carrier's competitive position), can vary widely for similar shipments by different shippers and carriers, and can impose any special conditions agreed upon by the shipper and carrier. The Staggers Act also limited the ICC's rate regulation authority to cases where the railroad had market dominance -- where a captive (or almost-captive) shipper has no access to other railroads or other transportation modes for a specific commodity. (Sandia 1984a)

A. Economic Regulation

DOE has expressed an unwillingness to commit itself to the rail mode too early in the repository program because this may put it in a weak bargaining position with the railroads -- especially for reactor, repository or monitored retrievable storage sites that are served by a single railroad. A 1984 report prepared for DOE on the effect of rail economic deregulation on radioactive materials shipments recommends that shippers avoid high rail rates by "maintain[ing] a credible option open to ship by different modes." (Sandia 1984a) It is debatable, and unresolved, whether DOE could appeal to the ICC if it believed a railroad was attempting to charge an unreasonable rate to ship spent fuel. The Staggers Act limited the ICC's rate regulation authority to cases of captive shippers. Whether DOE could be considered a captive shipper depends on whether the commodity is considered to be spent fuel assemblies (which can be shipped by truck, so that DOE is not captive to the railroad) or a rail cask full of spent fuel (which would be too heavy to ship by truck, so that DOE would be captive to the railroad). In either case, DOE probably cannot rely on the ICC to protect it from unreasonably high rail rates because the ICC has rarely, if ever, found that it had jurisdiction to protect a captive shipper under the Staggers Act. However, DOE is not totally at the mercy of the railroads, even where a point of origin or destination is served by a single railroad, because DOE has the option of "short-hauling" a railroad that will not offer DOE acceptable rates and terms. (An example of how this could work was discussed in the Routing section.)

B. Special Provisions

The contract vs. tariff issue has often been linked to the special train issue and to the shipper's or carrier's ability to dictate special conditions for a shipment. It is sometimes assumed that contracts require the use of dedicated or special trains, allow greater flexibility for the shipper to specify certain conditions, and result in railroads imposing unreasonable rates and terms on the shipper. On the other hand, tariffs are sometimes viewed as relating only to general commerce trains, and leaving the shipper and carrier with little or no flexibility to impose special terms on shipments. In reality, although contracts and tariffs are different business mechanisms, there is probably very little practical difference between the two, particularly for spent fuel shipments. (Because there are relatively few spent fuel shippers, a spent fuel tariff would not have to be as generic and inflexible as a tariff for shipping a more common commodity where there may be tens of thousands of shippers, all in different circumstances with different needs.) Although most dedicated trains are under contract, there is a special train tariff that can be used. Although most general commerce trains proceed under tariff, one-third of these trains use contracts. (Kerr) Another blurring of the distinction between contracts and tariffs is that tariffs are not necessarily unilateral statements by the railroads; some tariffs are

developed in cooperation between shippers and carriers (making them very similar to contracts). The bottom line is that either a contract or tariff is probably flexible enough to accommodate any terms the shipper or carrier wants to impose on this shipments.

Numerous special conditions, limited only by the shipper's and carrier's willingness, could be required for spent fuel and high-level waste shipments. These conditions have the potential to improve safety and increase public acceptance of these shipments, but could increase transportation costs and cause other problems. Some of the conditions could be imposed on general commerce shipments, where a spent fuel cask is just one car on a regular train, while others are impractical except on dedicated trains which carry no cargo other than the spent fuel. Some examples of possible restrictions are discussed below.

Identification of all carriers and interchange points. Few cross-country shipments can be accomplished without using at least two carriers. A shipper can simply deliver a shipment to the originating carrier, allowing the carrier to decide where (and to which carrier) to deliver the shipment to finish the trip. However, the shipper has the right to determine which carriers to use for the entire trip and where the transfers from one railroad to another will take place. The shipper and carrier are likely to use different criteria in determining where the transfer points should be. When the decision is left to the originating carrier, the railroad generally keeps the shipment on its track as long as possible before transferring it to another carrier, because this maximizes the originating carrier's share of the shipment revenues. The shipper may base the decision on the safety records of the various carriers, the impact on route selection, or the desirability of avoiding equipment changes in certain railyards. (The next section discusses an example of where the Federal Railroad Administration recommended changing the location of the transfer from one railroad to another, without changing the route or carriers.)

Route selection. The shipper has the ability to dictate the route that will be used. There is some overlap between route selection and identifying carriers and interchange points. In some cases, identifying the carriers and interchange points may be a de facto designation of the route. In other cases, a carrier may have more than one set of tracks between two points. The shipper could use its route designation authority, for example, to use the best maintained track, to avoid populated areas (where possible), to minimize transit time, or to avoid routes with high accident rates.

Speed limit. The FRA establishes speed limits of 10 - 110 mph, based on track class. All other factors being equal, the faster a train is travelling at the time of a collision or a derailment, the greater the potential for severe damage to a spent fuel cask resulting in a possible release. There are several ways to limit the speed of a spent fuel shipment. As was discussed earlier, under State Designation of Rail Routes, a spent fuel cask can be placed on a local train (which does not travel very fast because it makes frequent stops), although this greatly increases the transit time. Another option is to use dedicated trains, which do not carry any freight other than the spent fuel, and impose a lower speed limit on these trains. By placing the spent fuel casks on a dedicated train, some of the time lost by the lower speed limit could be regained by avoiding the railyard layovers (which average 12 to 24 hours) the regular trains face while waiting for their connecting train.

Stop when another train passes. Many mainline tracks are double tracks -- two tracks very close to each other, used for traffic moving in opposite directions. Some special trains include a provision that one of the trains stop while the other train passes. The train that is required to stop could be the one carrying the spent fuel, or the spent fuel train could be given priority, with the other train required to stop. It is not clear whether this provision would be feasible if the spent fuel were placed on a general commerce train -- i.e., how practical it would be to make the crew on a regular train aware of this special provision when it is carrying a spent fuel car.

Minimize number and length of railyard stops. A spent fuel cask stopped in a railyard increases the railyard crew's occupational exposure, increases the risk of the cask being in a yard accident, delays shipments, and could present security risks. On general commerce trains, careful route selection and scheduling could eliminate the need for some stops and reduce the length of other stops. However, many stops are unavoidable on a general commerce train because the cars are all going to different destinations and have to be dropped off in railyards along the way to wait for the train going to the next point along their route. More significant decreases in rail stops are possible with dedicated trains, which are not repeatedly taken apart and reassembled in railyards because all of the cars have the same destination.

Use of a caboose. Some special trains require the use of a caboose. The safety benefits of a caboose have been debated and are unresolved. (This was discussed earlier under Technical Aspects.) In addition to possible safety benefits, a caboose might increase public confidence in the shipments if the public believes that an occupied caboose promotes safety. One potential problem with requiring the use of a caboose is that it could interfere with contracts negotiated between railroad labor and management regarding the use of cabooses, although the relatively small number of spent fuel shipments might not have a significant impact on the quotas established by labor and management for use of cabooses. Another factor to consider is that a caboose, occupied by two crew members, adds to the occupational risk, especially on a dedicated train where only one car would act as a buffer between the crew and the spent fuel cask.

Train crew numbers and qualifications. It may be desirable to specify the number of crew members (e.g., require a five-person crew, with two crew members in the caboose, rather than a three-person crew, as is becoming more common). Additional qualifications could be imposed on the train crew (as was done, for example, with driver qualifications for shipments to the Waste Isolation Pilot Plant). Qualifications could relate to education, experience, accident record, and special radioactive materials training. Dictating crew numbers and qualifications could conflict with railroad labor/management agreements. For example, management may be unwilling to place more crew members on a train than they are required to under their collective bargaining agreements, and the labor unions may object to additional training and experience requirements.

Real-time tracking. Real-time tracking would allow the shipper to determine the location of a spent fuel casks at all times. This would provide security benefits, preventing a shipment from being lost. Lost shipments would be a greater potential problem on regular trains than on dedicated trains, because the frequent switching on regular trains increases the opportunities for a spent fuel car to be

placed on the wrong train. (A 1986 incident involving a lost low-level radioactive waste shipment was discussed under Technical Aspects.) Safety could be enhanced, particularly if the system allowed for two-way communication between the train crew and the shipper. Public confidence probably would be increased if the public knew that the shipper was constantly aware of the shipment's location. DOE plans to use real-time tracking for its highway shipments to the Waste Isolation Pilot Plant.

Special track inspections. Special track inspections, in addition to those normally conducted by the railroads and FRA, could promote safety by reducing the likelihood of a track-caused derailment.

Time-of-day restrictions. Time-of-day restrictions could be used to avoid high populations -- e.g., downtown areas during business hours when the population peaks, or urban areas during rush hours. As discussed below, shipping schedules for the Three Mile Island shipments were adjusted to avoid St. Louis during rush hour. This is probably practical for dedicated trains only. The switching and railyard delays that general commerce trains encounter would probably make this type of scheduling logistically difficult, if not impossible.

C. Past Examples of Special Provisions

Past examples of special provisions in rail contracts or tariffs are difficult to obtain because of the railroads' protection of proprietary information. Information is available on three shipping campaigns of radioactive materials.

1. Three Mile Island Shipments

Shipments of core debris from the failed Three Mile Island nuclear powerplant to the Idaho National Engineering Laboratory were conducted by dedicated train, after negotiations between DOE and the carriers. [This was discussed in detail in the Routing section.] The shipping campaign took 46 months; from July 20, 1986 to April 15, 1990. Several special operating provisions were undertaken for the 40 shipments, by both GPU and DOE. For example, a caboose was used; speed limits were identified (35 m.p.h. on Conrail route to East St. Louis -- 55 m.p.h. on the Union Pacific route [as long as gravel cars were used for ballast] from East St. Louis to INEL); DOE tracked the train shipments, through contact with dispatchers as the train progressed across the nation; and, DOE encouraged state and local agencies to conduct their own inspections along the route. (Conaway 1991) In addition, DOE agreed to pre-notify all state and local officials of the shipments. In Nebraska, State Police

followed the shipments along parallel roads throughout the State. Radiological experts also rode the train to monitor external radiation, although this was discontinued after the first three shipments showed consistently even measurements. (GAO 1987a)

After shipments had started, an operational incident in East St. Louis, Illinois, focused attention on the shipping campaign. [A car placarded as a flammable solid (although it actually contained a non-hazardous material) was substituted for the regular buffer car on the Three Mile Island train.] In response to public concern, DOE and the carriers agreed to make the following mid-campaign modifications to their operating procedures:

- Adjust shipment schedules to avoid the St. Louis rush hour;
- Limit mid-shipment equipment changes to the locomotive change required when interlining between Conrail and Union Pacific;
- Assign a hazardous materials inspector from the railroad to the East St. Louis railyard;
- Ensure that DOE and FRA personnel ride the train to monitor speed, track and equipment; and
- Bring DOE's emergency response training course to Missouri to train local responders.

The FRA later investigated the incident and recommended that the equipment switch from Conrail to Union Pacific be made in Indianapolis, rather than East St. Louis, because additional layover time was already scheduled for the Indianapolis yard, which would allow for less-hurried inspections of the train. DOE and the carriers followed this recommendation. Other recommendations made by the FRA called for: increased hazardous materials training for the railroads involved in the incident and the shipper who misplacarded the lime car that caused the operational incident; permanent assignment of buffer cars to the Three Mile Island train; consideration of changing the interchange from Conrail to Union Pacific to eliminate handling by the Alton & Southern Railway, which handles the switch in East St. Louis); ensuring that hazardous materials inspectors are present at all interchange sites; and establishment of clearly-defined lines of communication among state, local, federal and carrier officials.

Another result of the operational incident was a DOT evaluation of the route DOE used for the Three Mile Island shipments, and DOE's process for selecting this route. [This was discussed in the Routing section.] (GAO 1987a) In the end, all 40 shipments were made on dedicated trains, instead of switching to general commerce after the first three, as originally planned.

2. Northern States Power Shipments to Morris, Illinois

Starting in 1984, Northern States Power (NSP) moved 30 shipments of spent fuel from its powerplant in Monticello, Minnesota, to Morris, Illinois, for storage. The shipments were made by special train, which carried no other freight and had a maximum speed limit of 35 miles per hour. The trains were accompanied by armed guards. State escort teams of health physicists accompanied the train on highways near the rail line, and a health physicist was aboard the train. Wisconsin, through the Section of Radiation Protection, monitored the NSP shipments by use of the State's Mobile

Radiological Laboratory. Minnesota's State Patrol and Health Department, and the State of Illinois Department of Nuclear Safety and State Patrol also monitored the shipments. (McDonnel 1987)

One reason for these extra precautions was that Nebraska Power & Light had used special trains for an earlier shipping campaign, and Northern States Power believed that the public would have been concerned if it had adopted different procedures. Another special provision was that Northern States Power selected the route for these shipments, using the ALK routing model. [This was discussed in the Routing section.] (Aerospace 1987; Battelle 1988b)

In addition to concerns over route selection, Wisconsin was also concerned about the way in which NSP and the Nuclear Regulatory Commission reacted to an instance of attempted sabotage during one of the shipments to Morris in October, 1986. (Earl 1986)

3. Nebraska Public Power Shipments to Morris, Illinois

The Nebraska Public Power shipments from Cooper Nuclear Station started shortly before the similar shipments from Northern States Power, discussed above. In response to public concern, the utility agreed to use dedicated trains and to provide a highway escort (to travel as close as possible to the rail lines) of people trained in health physics and communications. The train had two cabooses -- one for the crew and one for the escorts. The utility also agreed to accept the escorts provided by Nebraska, Iowa and Illinois (only Illinois inspected each shipment throughout the entire campaign) and to pay Illinois's escort fees of $2000 per rail cask. (Aerospace 1987; Battelle 1988b)

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LIST OF ACRONYMS AND ABBREVIATIONS USED

AAR	Association of American Railroads, an industry organization
ABS	Automatic Block System
ARES	Advanced Railroad Electronic System
ATC	Automatic Train Control
ATS	Automatic Train Stop
ABS	Automatic Block System
CTC	Centralized Traffic Control
FRA	Federal Railroad Administration, U.S. Department of Transportation
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EOT	End-of-train
FRSA	Federal Rail Safety Act
GAO	General Accounting Office
HMTUSA	Hazardous Materials Uniform Safety Act Amendments of 1990
ICC	Interstate Commerce Commission
INEL	Idaho National Engineering Laboratory
LLNL	Lawrence Livermore National Laboratory
NARUC	National Association of Regulatory Utility Commissioners
NRC	Nuclear Regulatory Commission
NRLC	National Rail Labor Conference, an organization representing management
NSP	Northern States Power
NTSB	U.S. National Transportation Safety Board
OCRWM	Office of Civilian Radioactive Waste Management
OPS	Office of Pipeline Safety
RSPA	Research and Special Programs Administration, U.S. Department of Transportation
TMI	Three Mile Island Nuclear Reactor, Middletown, PA
TRC	Transportation Research Center at the University of Nevada at Las Vegas
UNLV	University of Nevada at Las Vegas

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