

**Possibility of Transportation Incidents  
Occurring in Lincoln County  
During the Shipment of Spent Nuclear Fuel  
and High-Level Radioactive Waste to  
the Proposed Repository at Yucca Mountain**

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## I. Overview

With Yucca Mountain being confirmed as the national repository for high-level nuclear waste (HLW) and spent nuclear fuel (SNF) by Congress, it is prudent to investigate the potential problems associated with transporting this material from current storage sites around the country to the permanent facility at Yucca Mountain. A concern for many entities may be the potential for incidents that may occur during the handling and transporting of these materials (See definitions for incidents in Appendix A). It is the purpose of this report to analyze the possibilities of incidents occurring in Lincoln County during the 24-year period during which SNF and HLW waste may be transported through the County in route to Yucca Mountain repository site. Considering the uncertainty of actual transportation routes that may be used and given that the Department of Energy's (DOE) Final Environmental Impact Statement (FEIS) for the Yucca Mountain repository did not select specific routes (possible routes have been identified in the EIS and are used in this report for analysis), it is necessary to consider the impacts of several scenarios of the transportation process.

## II. Parameters

Over the years, there have been documented incidents involving the shipment of SNF. Between 1957 and 1964 there were 11 transportation incidents recorded by the U.S. Atomic Energy Commission and its contractors. There is no comparable data for the period from 1964 to 1970. Between 1971 and 1990 there were 47 incidents involving spent fuel cask shipments (DOE,b). Most of the incidents involved excess radioactive contamination on cask surfaces, a result of the "weeping" phenomena on casks loaded and unloaded in wet storage pools (See Appendix A and B for details). Based on this data, DOE has calculated anticipated incident rates for commercial spent fuel shipments to the repository at Yucca Mountain. For truck shipments, DOE calculated 10.5 incidents per million shipment miles and for rail shipments the rate was 19.4 incidents per million shipment miles (DOE,a). The estimate of the number of incidents reported herein that may occur within Lincoln County was arrived at by multiplying the anticipated incident rates with the anticipated cumulative shipment miles within the County.

It is important to note that over the years, the method of reporting and recording these incidents has changed drastically. The responsibility of reporting incidents has passed between the DOE, Nuclear Regulatory Commission (NRC), and the Department of Transportation (DOT). Currently the nuclear incidents are included in the reports of hazardous waste and are not as detailed as they were in the past. Because of these changes, it is prudent to resort to historical data as it impacts the transportation of these materials.

DOE has developed two national transportation scenarios – "mostly legal-weight truck" and "mostly rail" – in order to estimate the number of shipments anticipated under the FEIS Proposed Action (24 years) and under Modules 1 and 2 (38 years). The Proposed Action is to handle up to 70,000 metric tons of SNF and HLW. Modules 1 and 2 were developed to deal with SNF and HLW in excess of 70,000 metric tons that will be

generated in the years to come and require disposal. Therefore, in analyzing the possible risk of nuclear incidents that may occur during the transportation process, it is necessary to project the incident risk for all three scenarios. In all cases, there would be shipments by both modes of transportation, with the key being “mostly”.

The “mostly legal-weight truck” plan would result in the greatest number of shipments with 53,000 over 24 years (about 2,200/year) and 108,900 over 38 years (about 2,870/year). Included in this scenario would be 300 and 355 rail shipments under that Proposed Action and Module 1 and 2 scenarios, respectively. In comparison, over the past 40 years there have been less than 100 shipments by legal weight truck per year in the United States.

The “mostly rail” plan would result in 9,646 shipments over 24 years (402/year) and 18,935 over 38 years (498/year). Included in this scenario would be 1,079 and 3,122 truck shipments under the Proposed Action and Module 1 and 2 scenarios, respectively.

### **III. Possible Routes**

#### **Mostly Rail**

DOE has identified two separate rail scenarios within Lincoln County as potential routes for the shipment of SNF and HLW. The first route, Caliente would use the present rail line that enters the County on the eastern edge of the state and follow a new rail spur called the Caliente Corridor west to Nye County. The second route, Caliente-Chalk Mountain would enter the County at the same place on the eastern edge of the state and would follow the same rail spur for most of the route as the Caliente Corridor until just north of Rachel where it would head south to the Nevada Test Site along what is referred to as the Caliente-Chalk Mountain Corridor. Estimates of the number of incidents under various rail scenarios are summarized in Table 1 and described below.

#### **Caliente Corridor**

The length of the Caliente Corridor within Lincoln County is 92.3 miles and over the 24-year period of the Proposed Action phase, it is estimated that 9,646 rail shipments will pass through the County. This amounts to 890,326 cumulative shipment-miles. At an incident rate of 19.4 incidents/million miles shipped, Lincoln County could expect 17.3 rail incidents to occur within the County over the 24-year period of time. During the time period of Module 1 there could be 32.7 incidents expected based on 18,243 shipments and 1,683,829 cumulative shipment-miles. Module 2 would anticipate 18,935 shipments and 1,747,701 cumulative shipment-miles resulting in approximately 33.9 incidents within Lincoln County.

As indicated earlier, under the mostly-rail scenario there will still be a legal-weight truck factor and under the Proposed Action this amounts to 1,079 shipments and depending on the proposed routing (specific legal weight truck routes are discussed in the next section), could result in route lengths of 99-117 miles and cumulative shipment miles of 106,821-

126-243 over the 24 year period. At an incident rate of 10.5/million shipment miles this would result from 1.1-1.3 incidents in Lincoln County. For both Modules 1 and 2 the number of shipments would rise to 3,122 with 309,078-365,274 cumulative shipment miles. The number of truck incidents within Lincoln county under the “mostly rail” scenario for both Modules would be 3.2-3.8.

#### Caliente-Chalk Mountain Corridor

The Caliente-Chalk Mountain Corridor is slightly longer than the Caliente Corridor through Lincoln County with a total of 98.2 miles. During the Proposed Action phase there would be the same total shipments (9,646) with 947,237 cumulative shipment-miles. This would result in an anticipated 18.4 incidents over the 24-year period of shipment. Module 1 would create 1,791,462 shipment miles with a possibility of 34.8 incidents. Module 2 could possibly see 36.1 incidents within Lincoln County with 1,859,417 shipment miles. Under each of these scenarios, the legal weight truck incident numbers would be the same as the Caliente Corridor as the legal weight truck routes would not change.

**Table 1**  
**Mostly Rail Scenario**  
**Incident Rate @ 19.4 Incidents/Million Shipment Miles for Rail**  
**Incident Rate @ 10.5 Incidents/Million Shipment Miles for Legal-Weight Truck**

Route		Number of Shipments	Length of Route	Number of Shipment Miles	Possible Incidents	
Caliente	Proposed Action	9,646 rail	92.3 miles	890,326	17	
		1,079 truck	99.0 - 117 miles	106,821 - 126,243	1	
	Module 1	18,243 rail	92.3 miles	1,683,829	33	
		3,122 truck	99.0 - 117 miles	309,078 - 365,274	3 – 4	
	Module 2	18,935 rail	92.3 miles	1,747,701	34	
		3,122 truck	99.0 - 117 miles	309,078 - 365,274	3 – 4	
	Caliente-Chalk Mtn	Proposed Action	9,646 rail	98.2 miles	947,237	18
			1,079 truck	99.0 - 117 miles	106,821 - 126,243	1
Module 1		18,243 rail	98.2 miles	1,791,462	35	
		3,122 truck	99.0 - 117 miles	309,078 - 365,274	3 – 4	
Module 2		18,935 rail	98.2 miles	1,859,417	36	
		3,122 truck	99.0 - 117 miles	309,078 - 365,274	3 – 4	

### **Types of Nuclear Incidents Expected In Lincoln County by Rail During the Proposed Action Phase**

It is possible to anticipate the types of nuclear incidents that may occur in Lincoln County by considering historical nationwide transportation incident data from 1949 to 1996. during this time there were 72 incidents involving the transportation of radioactive materials. Descriptions of two of the incidents are not available and will not be considered in this assessment. Therefore, of the 70 remaining incidents, 9 involved shipment by rail. One incident involved radioactive contamination beyond the vehicle (11percent of incidents), one incident involved radioactive contamination confined to the vehicle (11 percent of incidents), six were traffic accidents with no release or contamination (67 percent of incidents) and one incident involved accidental surface contamination (11 percent of incidents). Using these percentages, it is possible to project the type of incidents that may be expected to occur by the rail scenarios in Lincoln County over the period of the Proposed Action (see Table 2). In the Caliente Corridor the contamination expected would be: 2 incidents of radioactive contamination beyond the vehicle; 2 incidents of radioactive contamination confined to the vehicle; 11 incidents of traffic accidents with no release or contamination; and 2 incidents of accidental surface contamination. For the Caliente-Chalk Mountain the figures would be slightly higher with 2 incidents of radioactive contamination beyond the vehicle, 2 incidents of radioactive contamination confined to the vehicle, 12 traffic accidents with no release or contamination, and 2 incidents of accidental surface contamination.

**Table 2**  
**Types of Nuclear Incidents Expected In Lincoln County During**  
**The Rail Scenarios of the Proposed Action Phase**

<b>Route</b>	<b>Total Expected Incidents</b>	<b>Contamination Beyond Vehicle</b>	<b>Contamination Contained To Vehicle</b>	<b>Traffic Accidents No Radioactive Release</b>	<b>Accidental Surface Contamination</b>
<b>Caliente Corridor</b>	17	2	2	11	2
<b>Caliente-Chalk Mountain Corridor</b>	18	2	2	12	2

### **Mostly Legal-Weight Truck**

There are four possible routes through Lincoln County that SNF and HLW could be transported. Three routes have been identified because of their direct proximity to the Nevada Test Site and the State of Nevada has identified an alternate route (that would impact Lincoln County) to DOE's choices submitted in the FEIS. Due to the uncertainty of a mostly rail mode of shipment (there is no rail line to Yucca Mountain and many of the existing storage sites are not served by rail) it is possible that the mostly legal-weight

truck scenario will be adopted. Eighty-seven percent of all national legal-weight truck shipments could utilize through this route. Heavy-haul truck shipments are also not likely for the reasons that will be discussed in a following section. Estimates of the number of incidents under various mostly truck scenarios are summarized in Table 3 and described below.

#### Nevada Alternate Route A

This route would bring SNF and HLW south on U.S. 93 from Wendover, west on U.S. 6 to Nevada 318, south on Nevada 318 to U.S. 93 and south to the Clark County Line. This route covers 99 miles in Lincoln County. Under the Proposed Action plan this would result in 45,919 shipments over 24 years with 4,545,981 cumulative shipment miles. With an incident rate of 10.5/million miles there could be as many as 47.7 incidents within Lincoln County. Module 1 would require 91,946 shipments over 38 years with 9,102,654 shipment miles, resulting in the potential for as many as 95.7 incidents. Module 2 calls for 94,433 shipments, 9,348,895 shipment miles, resulting in the potential for as many as 98.2 incidents within the County.

#### Caliente-Chalk Mountain

This scenario would envision bringing SNF and HLW into Caliente by rail on “piggy-back” legal-weight trailers and transferring them to truck transport south on U.S. 93 to Crystal Springs, west on Nevada 375 to Rachel and south on Valley Road to the Nellis Range. This route encompasses approximately 111 miles in Lincoln County. Under the Proposed Action the same number of shipments (45,919) would result in 5,097,009 shipment miles and the potential for 53.5 incidents during the 24-year period. Module 1 would require 91,946 shipments totaling 10,206,000 cumulative shipment miles, resulting in the potential for as many as 107.2 incidents over the 38-year period. Module 2 would result in 94,433 shipments and 10,482,094 cumulative shipment miles, resulting in the potential for up to 110.1 incidents.

Under the mostly legal-weight truck plan there would be a significant rail factor because of the “piggy-backing” concept. In this case, it is reasonable to assume that 100 percent of anticipated legal-weight truck trailers could be “piggy-backed” by rail and therefore total shipments in the Proposed Action plan would be 46,185 entering Lincoln County from the north along 40.2 miles of track to Caliente. This scenario would result in 1,856,637 cumulative shipment miles and the potential for 36 incidents over the 24-year period within Lincoln County. During this same time period, 6,906 shipments would enter Lincoln County from the south over the 65 miles of track to Caliente and result in 448,890 cumulative shipment miles and as many as 8.7 additional incidents. In Module 1 there would be 92,207 shipments, 3,706,719 cumulative shipment miles and the potential for up to 71.9 incidents over the rail route from the north and 13,517 shipments, 878,605 cumulative shipment miles and an the potential for up to 17 additional incidents over the rail route from the south. Module 2 would involve 94,742 shipments from the north and 3,808,634 cumulative shipment miles, resulting in the potential for up to 73.9 incidents. From the south there would be 14,157 shipments and 920,205 cumulative shipment miles, resulting in the potential for as many as 17.8 additional incidents over the 38-year period.

#### Caliente-Rachel-Nye County Line

This route is almost identical to the above route with the exception of the last section where instead of going south on Valley Road to the Nellis Range, the route would continue west through Rachel to the Nye County Line. The difference between the two routes is about 2 miles and would be negligible in the number of incidents expected in relation to the previous route.

#### Caliente-Crystal Springs-Clark County Line

This route would also envision bringing SNF and HLW to Caliente by rail on “piggy-back” trailers, transferring to truck then traveling on U.S. 93 south to Crystal Springs and continuing south to the Clark County Line. The length of this route in Lincoln County is 117 miles. Under the Proposed Plan this would involve 45,919 shipments and 5,372,523 shipment miles that could result in up to 56.4 incidents over the 24-year period. The Module 1 plan would create 91,946 shipments and generate 10,757,676 cumulative shipment miles, resulting in the potential for up to 113 incidents. Module 2 would generate 94,433 shipments and 11,048,694 cumulative shipment miles, resulting in as many as 116 incidents.

#### **Types of Nuclear Incidents Expected In Lincoln County by Legal-Weight Truck During the Proposed Action Phase**

As in the case of rail shipments, it is possible to project the types of nuclear incidents that may occur in Lincoln County during the Proposed Action phase by using historical nuclear incident history from 1949 – 1996. During this time there were 61 reported cases of legal-weight truck incidents, broken into the following statistics: 3 incidents involving radioactive contamination beyond the vehicle (5 percent of incidents); 3 incidents involving radioactive contamination confined to the vehicle (5 percent of incidents); 7 traffic accidents with no release or contamination (11 percent) of incidents; and 48 incidents of accidental surface contamination (79 percent of incidents).

Using these percentages, the type of incidents that may be expected to occur by the legal-weight truck scenarios in Lincoln County over the period of the Proposed Action (shown in Table 4) are: In the Nevada Alternate Route A scenario the contamination expected would be: 2 incidents of radioactive contamination beyond the vehicle; 2 incidents of radioactive contamination confined to the vehicle; 5 incidents of traffic accidents with no release or contamination; and 39 incidents of accidental surface contamination. For the Caliente- Chalk Mountain and Caliente-Rachel-Nye County Line scenarios the figures would be slightly higher with 3 incidents of radioactive contamination beyond the vehicle, 3 incidents of radioactive contamination confined to the vehicle, 6 traffic accidents with no release or contamination, and 42 incidents of accidental surface contamination. For the Caliente-Crystal Springs-Clark County Line scenario the projections would be 3 incidents of radioactive contamination beyond the vehicle; 3 incidents of radioactive contamination confined to the vehicle; 6 incidents of traffic accidents with no release or contamination; and 44 incidents of accidental surface contamination.

**Table 3**  
**Mostly Truck Scenario**  
**Incident Rate @ 10.5/Million Shipment Miles for Truck**  
**Incident Rate @ 19.4/Million Shipment Miles for Rail**

Route		Number of Shipments	Length of Route	Number of Shipment Miles	Possible Incidents
Nevada Alternate Route A	Proposed Action	45,919 truck	99 miles	4,545,981	48
	Module 1	91,946 truck	99 miles	9,102,654	96
	Module 2	94,433 truck	99 miles	9,348,895	98
Caliente- Rachel- Valley Road- Nellis Range/ Nye Co. Line	Proposed Action	45,919 truck 53,086 rail	111 miles 105.2 miles*	5,097,009 2,305,527	54 45
	Module 1	91,946 truck 105,985 rail	111 miles 105.2 miles*	10,206,000 4,585,324	107 89
	Module 2	94,433 truck 108,899 rail	111 miles 105.2 miles*	10,482,094 4,728,839	110 92
Caliente- Crystal Springs- Clark Co. Line	Proposed Action	45,919 truck 53,086 rail	117 miles 105.2 miles*	5,372,523 2,305,527	56 45
	Module 1	91,946 truck 105,985 rail	117 miles 105.2 miles*	10,757,676 4,585,324	113 89
	Module 2	94,433 truck 108,899 rail	117 miles 105.2 miles*	11,048,694 4,728,839	116 92

\*Assumes all possible rail shipments from the north and south.

Because the last two scenarios involve the “piggy-back” mode of rail transport coupled with legal-weight truck shipments, it is necessary to factor in the rail incident portion of the scenario. In this case the incidents for the rail portion of the process would add an additional 5 incidents of radioactive contamination beyond the vehicle, 5 incidents of radioactive contamination confined to the vehicle, 30 traffic accidents with no release or contamination, and 5 incidents of accidental surface contamination.

**Table 4**  
**Types of Nuclear Incidents Expected In Lincoln County During**  
**The Legal-Weight Truck Scenarios of the Proposed Action Phase**

<b>Route</b>	<b>Total Expected Incidents</b>	<b>Contamination Beyond Vehicle</b>	<b>Contamination Contained To Vehicle</b>	<b>Traffic Accidents No Radioactive Release</b>	<b>Accidental Surface Contamination</b>
<b>Nevada Alternate Route A</b>	48 truck	2	2	5	39
<b>Caliente-Rachael-Nellis/ Nye Co. Line</b>	54 truck	3	3	6	42
	45 rail	5	5	30	5
<b>Caliente-Crystal Springs-Clark Co. Line</b>	56 truck	<b>3</b>	<b>3</b>	<b>6</b>	<b>44</b>
	45 rail	5	5	30	5

### **Heavy-Haul Truck**

In the FEIS, DOE has proposed that part of the solution to the problem of the transporting of SNF and HLW to the Yucca Mountain repository could be solved by the use of a heavy-haul truck (HHT) scenario. Several alternatives have been proposed, but under each, HLW and SNF would be transported by rail to an intermodal facility where it would be transferred to heavy-haul vehicles capable of carrying the very large casks that are envisioned to be used in the mostly rail scenario. These vehicles would be 220 ft. long; are accompanied by escort support; are limited to 20-50 mph; and are only allowed to travel during daylight hours. The 100-mile route within Lincoln County would take 4-6.5 hours under the most favorable conditions. Much of the route involves steep grades and sharp curves through high-mountain passes. Because this type of vehicle has not been developed on a large scale and has never been used systematically for the transportation of SNF and HLW, there are no statistics to indicate an incident rate. For the purpose of this report, it will be assumed that heavy-haul truck transportation would have similar incident reports and ratios as legal weight truck transportation. The FEIS has identified two possible routes through Lincoln County that shipments of HLW and SNF via the heavy-haul scenario might utilize. In one alternative, 10,815 shipments would be made by rail to an intermodal facility in Caliente where they would be loaded

on heavy-haul vehicles and transported via the Caliente-Chalk Mountain/Caliente-Rachael-Nye County Line (92 road miles/105 rail miles) or the Caliente-Crystal Springs-Clark County Line (93 road miles/105 rail miles) to the proposed repository at Yucca Mountain.

Under the Proposed Action using the Caliente-Rachel-Chalk Mountain route, the 10,815 shipments would generate 994,980 road shipment miles and 1,135,575 rail shipment miles. As many as 10 heavy-haul and 22 rail incidents could occur under this scenario. The Caliente-Crystal Springs-Clark County Line Route would involve 1,005,795 shipment miles by heavy-haul truck and 1,135,575 shipment miles by rail. Under this alternative, as many as 11 heavy-haul and 22 rail incidents might occur. A summary of possible incidents for heavy-haul transport within Lincoln County is provided in Table 5.

**Table 5**  
**Heavy-Haul Truck Scenario**  
**Incident Rate @ 10.5/Million Shipment Miles for Truck**  
**Incident Rate @ 19.4/Million Shipment Miles for Rail**

Route		Number of Shipments	Length of Route	Number of Shipment Miles	Possible Incidents
Caliente-Chalk Mountain-Nye Co. Line	Proposed Action	10,815 truck	92 miles	994,980	10
		10,815 rail	105 miles*	1,135,575	22
Caliente-Crystal Springs-Clark Co. Line	Proposed Action	10,815 truck	93 miles	1,005,795	11
		10,815 rail	105 miles*	1,135,575	22

\*Assumes all possible rail shipments from the north and south.

### **Types of Nuclear Incidents Expected In Lincoln County by Heavy-Haul Truck Scenario During the Proposed Action Phase**

As with legal-weight truck shipments, one can anticipate the types of nuclear incidents that could occur in Lincoln County during the Proposed Action phase by using nationwide historical transportation incident data from 1949 – 1996. During this time there were 61 reported cases of legal-weight truck incidents including: 3 incidents involving radioactive contamination beyond the vehicle (5 percent of incidents); 3 incidents involving radioactive contamination confined to the vehicle (5 percent of incidents); 7 traffic accidents with no release or contamination (11 percent) of incidents; and 48 incidents of accidental surface contamination (79 percent of incidents). The lack of current information involving heavy-haul truck shipments requires using historical

statistics for legal-weight truck shipments. The types of rail incidents would be identical to those used above.

For the first heavy-haul transportation scenario (Caliente-Chalk Mountain) the types of incidents that could be expected within Lincoln County are: 3 incidents of radioactive contamination beyond the vehicle (1 heavy-haul truck/2 rail); 3 incidents of radioactive contamination confined to the vehicle (1 heavy-haul truck/2 rail); 16 incidents of traffic accidents with no release or contamination (1 heavy-haul truck/ 15 rail); and 10 incidents of accidental surface contamination (7 heavy-haul truck/3 rail). In the second scenario (Caliente-Crystal Springs-Clark County Line) the anticipated incidents could include: 3 incidents of radioactive contamination beyond the vehicle (1 heavy-haul truck/2 rail); 3 incidents of radioactive contamination confined to the vehicle (1 heavy-haul truck/2 rail); 16 incidents of traffic accidents with no release or contamination (1 heavy-haul truck/ 15 rail); and 11 incidents of accidental surface contamination (8 heavy-haul truck/3 rail). A summary of these incidents is provided in Table 6.

**Table 6**  
**Types of Nuclear Incidents Expected In Lincoln County During**  
**The Heavy-Haul Truck Scenarios of the Proposed Action Phase**

<b>Route</b>	<b>Total Expected Incidents</b>	<b>Contamination Beyond Vehicle</b>	<b>Contamination Contained To Vehicle</b>	<b>Traffic Accidents No Radioactive Release</b>	<b>Accidental Surface Contamination</b>
<b>Caliente-Chalk Mtn. Nye Co. Line</b>	10 truck	1	1	1	7
	22 rail	2	2	15	3
<b>Caliente-Crystal Springs-Clark Co. Line</b>	11 truck	1	1	1	8
	22 rail	2	2	15	3

#### IV. References

Clark County, Comments on Transportation Sections of the U.S. Department of Energy's Draft Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High Level Radioactive Waste at Yucca Mountain, Nye County, Nevada, Department of Comprehensive Planning, Nuclear Waste Division, February 24, 2000.

Nuclear Regulatory Commission, NUREG-0770.

Science Applications International Corporation, Nevada Spent Fuel Transportation Experience, n.d.

State of Nevada, Transportation of Spent Nuclear Fuel and High-Level Radioactive Waste to a Repository, Agency for Nuclear Projects, Nuclear Waste Projects Office, n.d.

United States, Code of Federal Regulations, 10 CFR 71.

U.S. Department of Energy, Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada, Office of Civilian Radioactive Waste Management, DOE/EIS-0250, February 2002.

U.S. Department of Energy, Transportation Accidents and Incidents Involving Radioactive Materials (1971-1998), Office of Civilian Radioactive Waste Management, n.d.

## **Appendix A**

### **Definitions for Release and Contamination As Used In Transportation Incident or Events Reports**

#### **Release**

An official definition for release from a cask is not found in NRC's 10 CFR 71 (i.e., the Definitions section 71.4). However, an NRC definition of release as it pertains to transportation can be inferred from 10 CFR 71 as follows:

[10 CFR 71.4, Definitions] "Containment System means the components of a packaging intended to retain the radioactive material during transport."

[10 CFR 71.5 1, Additional requirements for Type B packages.] Paragraph (a)(1) prohibits loss or dispersal of radioactive contents for Normal Condition of Transport. Paragraph (a)(2) restricts escape of krypton or other radioactive materials for Hypothetical Accident Conditions. Finally, the word release is used in paragraph (b) which states: "Compliance, with the permitted activity release limits of paragraph (a) of this section must not depend upon filters or upon a mechanical cooling system."

From the above 10 CFR 71 material we can develop a definition that is consistent with NRC's rules and regulations. Release means loss, dispersal, or escape of radioactive material from the package's containment system.

#### **Contamination:**

[10 CFR 71.87(1)(1) and (1)(2), Routine determinations.] refer to. non-fixed (removable) radioactive contamination on external surfaces. These paragraphs prescribe specific limits for transport of radioactive materials. However, a formal definition is not provided.

Although the NRC's regulations do not provide a definition for contamination in 10 CFR 71, a definition is provided in NUREG-0770 (U.S. Nuclear Regulatory Commission, Glossary of Terms Nuclear Power and radiation, NUREG-0770, Washington, DC 20555, June 1981). Contamination: "The deposition of unwanted radioactive material on the surface of structures, areas objects, or personnel."

#### **Definitions of Incidents**

Train *incidents* are defined as "events involving on-track railroad equipment [and non-train incidents arising from the operation of a railroad] that result in the reportable death and/or injury or illness of one or more persons, but do not result in damage at or beyond the damage threshold" (49 CFR 225.11). Because damage to casks containing spent nuclear fuel will necessarily involve severe accidents (hence, substantial damage),

DIRS 152476-Sprung et al. (2000, all) used only train accidents to form the basis for developing the conditional probabilities of accident severities.

Hazardous materials transportation regulations (49 CFR 171) contain no distinction between an *accident* and an *incident*, and *incident* is the term used to describe situations that must be reported. Hazardous materials regulations (49 CFR 171.15) require the reporting of incidents if:

- A person is killed
- A person receives injuries requiring hospitalization
- The estimated property damage is greater than \$50,000
- An evacuation of the public occurs lasting one or more hours
- One or more major transportation arteries are closed or shutdown for one or more hours
- The operational flight pattern or routine of an aircraft is altered
- Fire, breakage, spillage, or suspected radioactive contamination occurs involving shipment of radioactive material
- Fire, breakage, spillage, or suspected contamination occurs involving shipment of infectious agents
- There has been a release of a marine pollutant in a quantity exceeding 450 liters (about 120 gallons) for liquids or 400 kilograms (about 880 pounds) for solids
- There is a situation that, in the judgment of the carrier, should be reported to the U.S. Department of Transportation even though it does not meet the above criteria

## Appendix B

### Reported Incidents Involving Spent Nuclear Fuel Shipments 1949 to 1996

**There have been 72 reported incidents involving spent nuclear fuel shipments from 1949 to present.**

- From 1949 to 1970 14 incidents were reported in a series of U.S. Atomic Energy Commission reports. They were either traffic accidents with no releases or non-traffic accident events with minor leaks suspected from the casks which resulted in small amounts of observed contamination.
- From 1971 to present, 58 incidents have been reported in the Radioactive Material Incident Report database operated by Sandia National Laboratories. 49 of the 58 incidents involve minor surface contamination.

**The 72 incidents can be characterized as follows:**

- 4 incidents of accidental radioactive material contamination beyond the vehicle
- 4 incidents of accidental radioactive material contamination confined to the vehicle
- 13 incidents of traffic accidents, resulting in no release or contamination
- 49 incidents of accidental surface contamination
- 2 other incidents were mentioned in papers but descriptions are not available.

Eight incidents of radioactive material contamination (between 1960-1984) involved leaks of water, liquid, or (reported as) coolant/moderator from casks that were discovered during shipping. Description of the events and equipment are insufficient to evaluate the failure mechanisms or sources of contamination. However, the abbreviated information provided seems to indicate contributing factors may include the absence of regulations for design and use of transport casks, inadequate procedures, or not following the procedures. Some of the earlier incidents occurred prior to the establishment of formal transportation regulations (1966).

## 72 Incidents By Type

Date	Mode	Incident Description
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### Radioactive material contamination beyond vehicle (4 of 72 incidents)

6/2/60	Rail	Leak from cask, small areas at three rail yards contaminated, no runoff or aerial dispersion.
8/21/62	Truck	Cask leakage, trailer and small portion of road contaminated.
11/11/64	Truck	Cask leakage-, trailer, packages, and terminal contaminated.
1/27/84	Truck	Slow drip from bottom front end of empty cask while stored in transportation terminal

### Radioactive material contamination confined to vehicle (4 of 72 incidents):

11/20/60	Truck	Small leak from cask onto trailer floor, result, of shifting cask, contamination confined to vehicle.
9/22/61	Truck	Leak from cask onto trailer floor, result of shifting, contamination confined to vehicle.
12/10/63	Rail	Cask leakage, cask contaminated, contamination confined to trailer.
7/4/76	Truck	Pinhole leak of, reported as, coolant/moderator on outside jacket of cask. Shipment continued without risk to public.

### Transportation accident - no release or contamination (13 of 72 incidents):

12/1/56	Truck	Slid off icy road and overturned, 2 casks, 1 fell off trailer, no damage, no release.
1/29/57	Rail	Uncoupling, damage from debris, no release.
4/15/60	Truck	Trailer unhitched from tractor at 5 mph, no release.
11115160	Truck	Truck jackknifed, struck station wagon, no release.
12/7/60	Rail	Engine backed into cask car ' on siding, no release.
7/14/61	Rail	Minor derailment at 10-12 mph, no release.
12/8/71	Truck	Truck left 'road and cask thrown off, no release.
3/29/74	Rail	Derailed tank car struck cask car in yard, empty cask, no release.
2/9/78	Truck	Trailer buckled from weight, no release.
8/13/78	Truck	Empty cask broke through trailer bed, no release.
12/9/83	Truck	Tractor separated from intermediate set of axles, remained connected to trailer, no release.
3/24/87	Rail	Train struck automobile at rail crossing, no release.'
1/9/88	Rail	One set of rail car wheels derailed when switching tracks, empty cask, no release.

**Surface contamination (49 of 72 incidents):**

1/24/74 Truck Surface contamination on shipping pallet.

2/26/74 Truck Surface contamination on pallet and truck, empty cask.

4/29/74 Truck Surface contamination on pallet.

12/11/74 Truck Surface contamination on pallet.

12/23/74 Truck Surface contamination on pallet.

1/13/75 Truck Surface contamination on cask.

2/27/77 Truck Surface contamination on lifting yoke, empty cask.

4/13/77 Truck Surface contamination on trailer, empty cask.

5/3/77 Truck Surface contamination on empty cask.

5/12/77 Truck Surface contamination on empty cask.

5/16/77 Truck Surface contamination caused by small crack in impact limiter.

7/26/77 Truck Surface contamination on empty cask.

8/3/77 Truck Surface contamination.

8/23/77 Truck Surface contamination on cask.

2/16/78 Truck Surface contamination caused by open drain valve, empty cask.

2/27/78 Truck Surface contamination on empty cask.

5/16/78 Truck Surface contamination on empty cask.

7/24/78 Truck Surface contamination on empty cask.

7/29/78 Truck Surface contamination on cask.

8/1/78 Truck Surface contamination on cask.

8/7/78 Truck Surface contamination on cask.

11/27/78 Rail Surface contamination on empty cask, yoke, and rail car caused by defective valve or closure.

3/28/79 Truck Surface contamination on empty cask and trailer.

4/2/79 Truck Surface contamination on cask.

4/2/79 Truck Surface contamination on empty cask.

4/3/79 Truck Surface contamination on tire chains, hold-down chains, and tighteners caused by loading or unloading cask from trailer.

4/4/79 Truck Surface contamination on empty cask.

4/5/79 Truck Surface contamination on trailer, empty cask.

7/23/80 Truck Surface contamination on empty cask

8/25/80 Truck Surface contamination on cask.

2/2/81 Truck Surface contamination on empty cask and trailer

5/30/81 Truck Surface contamination on cask and trailer.

5/31/81	Truck	Surface contamination on empty cask.
6/2/81	Truck	Surface contamination on cask. Third consecutive instance of surface contamination, NRC suspends further shipments.
8/25/83	Truck	Surface contamination on. empty cask.
9/30/83	Truck	Surface contamination on empty cask.
10/21/83	Truck	Surface contamination on empty cask.
1/7/84	Truck	Surface contamination on empty cask.
1/25/84	Truck	Surface contamination on empty cask.
2/24/84	Truck	Surface contamination on cask.
1/11/85	Truck	Surface contamination on trailer, empty cask.
2/3/85	Truck	Surface contamination on cask.
7/8/85	Truck	Surface contamination on empty cask.
2/28/86	Truck	Surface contamination on empty cask.
7/29/86	Truck	Surface contamination on cask.
7/29/86	Truck	Surface contamination on empty cask and trailer
8/19/86	Truck	Surface contamination on cask.
10115191	Truck	Surface contamination on empty cask.
8/14/92	Truck	Surface contamination on cask.

**Unknown (2 of 72):**

1965- One incident, details not available.  
1967

1968- One incident, details not available.  
1970