Risk Insights Associated with Incident-Free Transportation of Spent Nuclear Fuel To Yucca Mountain Using RADTRAN 5.5

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ABSTRACT

The Yucca Mountain Final Environmental Impact Statement (YM EIS)[1] included an analysis of the environmental impacts associated with the transport of spent nuclear fuel (SNF) from multiple locations across the US to Yucca Mountain for incident-free and accident conditions. While the radiological risks contained in the YM EIS were calculated to be small, it is important to recognize the many conservatisms that were utilized to calculate these risks. This paper identifies conservative assumptions associated with the YM EIS calculation of incident free transportation risk, and provides an estimate of incident free transportation risk using more realistic assumptions. While it is important to use conservative assumptions in the evaluation of the environmental impacts associated with the proposed repository, it is equally important that the public and decision makers understand the conservative nature of the results presented. This paper will provide that perspective regarding the incident free transportation impacts and summarizes the results of a more detailed EPRI report on this subject, “*Assessment of Incident Free Transport Risk for Transport of Spent Nuclear Fuel to Yucca Mountain Using RADTRAN 5.5*.”[2]

INTRODUCTION

This paper describes the results of a re-evaluation of the incident free radiological impacts for the Mostly Legal-Weight Truck and the Mostly Rail scenarios evaluated in the YM EIS for transport of SNF to Yucca Mountain using the RADTRAN 5.5 computer code developed by Sandia National Laboratories. [3,4] The objectives of the EPRI report were to examine the RADTRAN input parameters used in the YM EIS to determine which parameters: (1) are not consistent with the standard input parameters recommended in the RADTRAN User Guide [5] and RADTRAN 5 Technical Manual [3], (2) utilize conservative assumptions that result in an over-prediction of radiological incident-free transportation risks and (3) to recommend alternative assumptions to use in the development of a more “best estimate” approach to assessing incident-free risk. The analysis examines the effects of changing RADTRAN input parameter assumptions on the calculation of incident-free risk and compares the results to the results in the YM EIS.

APPROACH TO REASSESSMENT OF INCIDENT-FREE TRANSPORT RISK

The YM EIS and its supporting calculational package[6], the YM EIS transportation database and RADTRAN files were reviewed to become familiar with the assumptions used to calculate incident-free risks in the YM EIS. RADTRAN 5 and, later, RADTRAN 5.5 were used to confirm that using the same RADTRAN input parameters would result in the calculation of the same incident-free unit risk factors and dose-risk that were calculated to support the YM EIS. Once it was determined that the RADTRAN 5.5 results were the same as the results in the YM EIS, the assumptions used for a range of RADTRAN parameters were changed from those in the YM EIS, and the effects on the incident-free transportation dose risk were determined.

The risk importance of the input parameters to RADTRAN 5.5 was examined through varying parameters one at a time to determine the relative importance of the parameters on calculation of the incident-free dose to workers and the public in the YM EIS. Input parameters evaluated include: cask external dose rate; crew dose; shielding factors associated with buildings along the routes; vehicle velocity; and distance over which dose to the public along the routes is integrated.

A realistic set of RADTRAN input parameters was then identified to use as the basis for determining a realistic assessment of incident-free radiological risks for the transport of spent fuel to the proposed repository.

REVIEW OF YM EIS METHODOLOGY FOR CALCULATING INCIDENT-FREE TRANSPORT RISK

The YM EIS incident-free transportation risk assessment used RADTRAN 5 to calculate what it refers to as “radiological unit risk factors. Appendix J of the YM EIS explains how these unit risk factors were used to calculate incident-free dose as follows: [1]

- The off-link unit risk factors represent the dose that would be received by a population adjacent to the route (hence, “off-link”) with a population density of one person per square kilometer for one shipment that travels a distance of one kilometer in the population density zone.
- The on-link unit risk factors are the doses that would be received by persons occupying vehicles that are on the same transport route as the SNF and HLW casks.
- The YM EIS analysis included two unit risk factors for stop doses – that is doses that occur during stops made by the vehicle along the route while the vehicle is in transit. The first stop dose risk factor is for residents near stops and it is based on a population density of one person per square kilometer. The second stop dose risk factor is for calculating the dose to the public at rest and refueling stops and it is not dependent on the population density.

- Unit risk factors were also calculated for workers during classification stops (stops in rail yards during which rail cars may be reassembled), in-transit rail stops, in moving vehicles, and during walk-around inspections.

As described in YM EIS Appendix J, the incident-free dose from transporting a single shipment was determined by multiplying the unit risk factors by the distances in each population zone along the shipment route and by the population density for each zone along the route. The collective incident-free dose for all shipments from a specific site was calculated by multiplying the dose calculated for a single shipment by the total number of shipments necessary to transport spent fuel from a given site to the site of the proposed Yucca Mountain repository. DOE’s YM EIS converted collective dose to an estimated number of latent cancer fatalities by using a dose conversion factor of 0.0004 latent cancer fatalities per person-rem for radiation workers and 0.0005 latent cancer fatalities per person-rem for the public, as recommended by the International Committee on Radiological Protection.[1]

National radiological impacts were calculated as part of the assessment of transportation impacts for the transport of SNF and HLW to Yucca Mountain from nuclear power plant sites and DOE facilities. The YM EIS evaluated the transportation impacts for two national transportation scenarios, a Mostly Legal-Weight Truck scenario and a Mostly Rail scenario. The EPRI report evaluated the same scenarios with more realistic RADTRAN 5.5 input parameters utilizing the route specific information contained YM EIS and supporting YM EIS transportation database. [1]

CONSERVATISMS IN YM EIS AND EFFECT OF CHANGING ASSUMPTIONS ON INCIDENT FREE TRANSPORT RISK

The YM EIS utilizes a number of conservative assumptions as input parameters to the RADTRAN 5 model for calculation of incident-free and accident dose, as summarized below. In addition, there are also conservative assumptions related to cask dose rate and worker dose that EPRI examined as part of a more realistic analysis of the potential radiological impacts associated with transporting spent fuel to the proposed repository. There are also additional conservative assumptions that are hardwired into the RADTRAN model, over which a user has no control – these assumptions were also identified.

Urban and Suburban Shielding Factors

The YM EIS assumes that buildings along the transportation routes provide no shielding to workers or the public. That is, the YM EIS assumed that building shielding factors (RR, RS, and RU) in RADTRAN equal 1.0. This assumption was made in the YM EIS despite the fact that the standard values from the RADTRAN User Manual for building shielding factors indicate that at least some credit for shielding should be included in the calculation of incident free dose. The RADTRAN User Manual recommends a standard value for the rural shielding factor, RR, equal to 1.0 (which results in no shielding provided by rural buildings) in order to account for the fact that many rural economies have a large fraction of outdoor employment such as farming. [3] This is a conservative assumption since most individuals spend at least some time indoors. Since the standard value of RR is 1.0, EPRI’s realistic analysis will utilize the standard value.

The standard RADTRAN value for the suburban shielding factor, RS, is 0.87, and the standard value for the urban shielding factor, RU, is 0.018. [3] These shielding factors are based on assumptions regarding shielding provided by typical building materials in urban and suburban buildings. Use of the recommended shielding factors will result in the calculation of lower off-link dose for the off-link populations in suburban and urban locations along the transportation routes for the Mostly Legal Weight Truck scenario and the Mostly Rail scenario than that presented in the YM EIS. The off-link doses for suburban populations decrease to 87% of the YM EIS value, proportional to a decrease in dose associated with the shielding factor of 0.87. The off-link unit risk factors for urban populations decrease to less than 2% of the original unit risk factors. This is proportional to the decrease in dose that would be expected with a shielding factor of 0.018. Table I compares the resulting off-link public doses assuming the standard building shielding factors recommended in the RADTRAN Technical Manual to those calculated in the YM EIS that assume no shielding is provided.

Table I. Comparison of YM EIS Off-Link Dose to Dose Using Standard RADTRAN Urban and Suburban Shielding Factors [2]

Description	YM EIS (Person-Rem)			Standard RADTRAN Building Shielding Factors (Person-Rem)		
	Shielding Factor	Mostly Legal-Weight Truck	Mostly Rail	Shielding Factor	Mostly Legal-Weight Truck	Mostly Rail
Rural	1.0	48	12	1.0	48	12
Suburban	1.0	470	237	0.87	408	207
Urban	1.0	364	323	0.018	7	6
Total Off-Link Dose		882	572		463	225

Truck Crew Shielding Factors

Within the vehicle description input for RADTRAN is a "crew modification factor" that can be used to account for shielding provided by the vehicle to the crew. As this factor will be specific to the vehicle being used, there is no standard value recommended for this parameter. The YM EIS assumed a crew modification factor equal to 1.0, meaning that no shielding is provided by the vehicle. [6] Some shielding would be provided by the truck cab and personnel barrier that would cover the spent fuel cask on its shipping skid, but this is not expected to be significant shielding (unless the truck cab was specifically designed with shielding features). Therefore, crew modification factors of 0.95 or 0.97 that account for a small amount of shielding are considered by EPRI to be reasonable. The results presented in Table II show that crew dose for the Mostly Truck scenario decreases proportionally to the crew modification factor – decreasing by approximately 3% using a crew modification factor of 0.97 and by approximately 5% using a crew modification factor of 0.95. RADTRAN does not calculate a crew dose for the rail crew during transport, therefore only the Mostly Legal-Weight Truck scenario is shown.

Table II. Mostly Legal Weight Truck Crew Dose – Comparison of YM EIS Results To Dose Assuming Crew Modification Factors of 0.97 and 0.95 [2]

Route Segment	YM EIS Results		Crew Modification Factor Case 1		Crew Modification Factor Case 2	
	Crew Modification Factor	Dose Person-Rem	Crew Modification Factor	Dose Person-Rem	Crew Modification Factor	Dose Person-Rem
Rural	1.0	7,210	0.97	6,993	0.95	6,849
Suburban	1.0	1,194	0.97	1,158	0.95	1,134
Urban	1.0	158	0.97	153	0.95	150
Total Dose		8,562		8,304		8,133
Note that the crew dose identified only represents dose to crews during transport. Total truck crew dose calculated in the YM EIS includes doses to workers at stops and escort dose. These portions of worker dose are not included in the results above.						

Cask External Dose Rate

The YM EIS assumed that all spent fuel casks will have an external dose that is equal to the regulatory maximum permitted dose – 14 mrem/hour at 1 meter (10 mrem/hour at 2 meters) from the cask surface.[7] This is a conservative assumption as not all spent fuel transport casks will be loaded with fuel with characteristics (burnup, enrichment and cooling time) that would result in the cask external dose rate being at the regulatory limit. While it can be expected that some portion of the casks may have doses that are equal to the regulatory limit, industry practice has always been to ensure that external doses are lower than the regulatory limits. The external dose will be highly dependent upon the fuel age and burnup at the time of transport. Much of the fuel that will be shipped to a repository at Yucca Mountain will be older fuel that does not have as high a radiation source term as younger fuel and will, therefore, have cask external dose rates that are much lower than the regulatory limit. As an example, there are more than 35,000 metric tons (MTU) of spent fuel with burnups of 40 GWD/MTU or lower in spent fuel inventories today. By the time spent fuel transport begins, this inventory will have an average cooling time of at least 26 years, with some fuel cooled for longer than 40 years. Regarding the 50,000 MTU of spent fuel in storage at commercial nuclear plants today, this fuel will have an average cooling time of 24 years by the time spent fuel transport begins resulting in package dose rates lower than the regulatory limit. Over the range of possible shipping strategies evaluated by DOE’s Management and Operating (M&O) contractor, more than 40% of fuel shipped is likely to have cooling times greater than 20 years. [8]

EPRI examined a range of external cask dose rates to determine the effect of external dose rate on the unit risk factors and resulting public and worker dose calculated by RADTRAN. Table III compares the public and worker doses that result from applying unit risk factors for external cask dose rates (at 1 meter from the cask surface) that range from 14 mrem/hour at one meter (YM EIS assumption) to 7 mrem/hour at one meter. Table III summarizes the calculated doses for the public and workers for two cases from the EPRI report [2]: External Dose Case 2 (10 mrem/hour at 1 meter) and External Dose Case 4 (7 mrem/hour at 1 meter). The results for these two cases are compared to the results of those contained in the YM EIS (14 mrem/hour at 1 meter). Assuming an external dose rate of 10 mrem/hour, the total public dose is reduced to 3,596 person-rem for the Mostly-Legal Weight Truck scenario and to 1,185 person-rem for the Mostly Rail scenario – approximately 28% lower than the YM EIS dose of 5,029 person-rem. Worker doses for the Mostly Rail scenario are reduced to 2,869 person-rem – approximately 74% of the YM EIS dose. Assuming an external dose rate of 7 mrem/hour, public doses are reduced to approximately 50% of the YM EIS dose.

Note that RADTRAN assumes crew dose during truck transport to be the regulatory maximum of 2 mrem per hour. Changes to the cask external dose, summarized in Table III, do not reflect a change the crew dose assumption; hence the unit risk factor and the resulting worker transport dose for truck transport does not change. While crew dose does not change, the reduced external cask dose will result in a decreased escort dose and worker stop dose. The effect of a lower crew dose during transport will be examined in the next section.

Since more than 40% of fuel shipped is likely to have been cooled for times greater than 20 years over the range of possible shipping scenarios evaluated by the M&O contractor (e.g., hottest fuel first, coldest fuel first, etc), a cask dose rate of 10 mrem/hour at 1 meter (approximately 70% of the regulatory limit) was selected by EPRI as being a reasonable average cask external dose rate that could occur over the range of possible shipping strategies.[8]

Table III. Comparison of Incident-free Population Doses Associated with Reduced (i.e., more realistic) Cask External Dose Rates to YM EIS Results [2]

Description		YM EIS Results TI=14mrem/hr@ 1m		External Dose Case 2 TI=10 mrem/hr @1 m		External Dose Case 4 TI=7 mrem/hr @1 m	
		Mostly Legal-Weight Truck	**Mostly Rail**	**Mostly Legal-Weight Truck**	**Mostly Rail**	**Mostly Legal-Weight Truck**	**Mostly Rail**
Public	**Off-Link (person-rem)**	882	572	630	411	440	287
	On-link (person-rem)	2,509	210	1,794	153	1,254	105
	Stop (person-rem)	1,638	862	1,172	621	820	435
Total Public		5,029	1,644	3,596	1,185	2,514	827
Workers (a) (person-rem)		14,123	3,884	13,447	2,869	12,936	2,101
Total:		19,152	5,528	17,043	4,054	15,450	2,928

(a) RADTRAN assumes crew dose during truck transport to be the regulatory maximum of 2 mrem per hour. Changes to the cask external dose do not change the crew dose assumption; hence the unit risk factor and the resulting worker transport dose does not change. While crew dose does not change, the reduced external cask dose will result in a decreased escort dose and worker stop dose. The effect of a lower crew dose during transport will be examined later in the report.

Crew Dose Assumptions for Truck Transport

RADTRAN assumes that the dose to truck crews during transport is 2 mrem/hour, the regulatory maximum [6] – an assumption that is hardwired into the RADTRAN model. Both nuclear industry and DOE ALARA practices would most certainly result in worker doses being lower than the maximum dose permitted by regulations.[9,10] Cask external dose rates are expected to vary depending upon the age and burnup of the fuel being transported; hence, the crew dose (which is a function of the cask external dose) would also vary. It is reasonable to assume that crew doses will vary proportionally to the cask external dose rate.

If it is assumed that the truck crew dose decreases proportionally to the cask external dose rate, then any assumed decrease in the cask external dose rate (compared to the regulatory limit) should result in a proportional decrease in the crew dose. Table IV summarizes the calculated crew dose for a range of cask external dose rates, assuming that the crew dose rate would be proportionally lower than the regulatory limit of 2 mrem/hour. Crew doses evaluated range from 2 mrem/hour (the regulatory limit) to 1 mrem/hour – consistent with the range of cask external dose rates discussed previously. As the crew dose of 2 mrem/hour is hardwired into the RADTRAN model, the adjustments to the crew dose were not accounted for in the analyses of the cask external dose rate presented in Table III. A reduction in crew dose (consistent with reduced cask external dose rate) must be accounted for by the user in the development of the unit risk factors that are used to calculate crew dose. Crew dose may be further reduced by applying a crew modification factor to account for shielding that might be provided from the truck as discussed earlier.

Table IV. Comparison of Crew Dose During Transport Associated With Decrease to Crew Dose Rate [2]

Description		Mostly Legal Weight Truck		
Cask External Dose Rate (mrem/hour)		**14.0**	**10.0**	**7.0**
Crew Dose Rate (mrem/hour)		**2.0**	**1.43**	**1.0**
Crew Dose (Person Rem)	Rural	7,210	5,155	3,605
	Suburban	1,194	854	597
	Urban	158	113	79
	Total	8,562	6,122	4,281

Off-Link Maximum Perpendicular Distance

The RADTRAN input variable, DISTOFF, specifies a set of three distances, in meters, used in off-link dose calculations for highway, rail, and barge modes. The three distances are: (1) the minimum perpendicular distance over which the off-link dose calculation will be integrated; (2) the minimum pedestrian-walkway width, for instances in which dose to pedestrians beside the link is calculated; and (3) the maximum perpendicular distance over which the off-link dose calculation will be integrated.

The maximum perpendicular distance over which the off-link dose is calculated (800 meters) is a conservative value. While dose rates can be *calculated* out to 800 meters, dose rates would generally fall well below measurable levels before a distance of 800 meters from the source. Decreasing the value of the maximum distance over which the off-link dose is integrated to less than 800 m will decrease the calculated off-link dose since the integrated dose would be calculated over a smaller area. The RADTRAN technical manual notes that the "*value (800 meters) is not tied to any analytical results indicating that it is appropriate; indeed, dose rates generally fall below detectable levels well before a distance of 800 meters from the source*."[3] The extremely low dose rates out to 800 meters is demonstrated by plotting the dose versus distance from a cask with an external dose at the regulatory limit of 14 mrem/hour at 1 meter (10 mrem/hour at 2 meters) as shown in Fig. 1.[11] The calculated dose rate at 800 meters is less than 0.000002 mrem/hour – a rate that would not be distinguishable from natural background radiation (~0.03 mrem/hr). A decrease in the value of the maximum distance over which the off-link dose is integrated (800 m) will decrease the calculated off-link dose since the integrated dose would be calculated over a shorter distance. EPRI examined the effect of two alternative maximum perpendicular distances – 500 meters and 600 meters. As shown in Fig. 1, the dose rate at 500 meters is an order of magnitude higher (2 x 10^{-5} mrem/hour) than the dose at 800 meters, but still less than 1% of the average natural background.

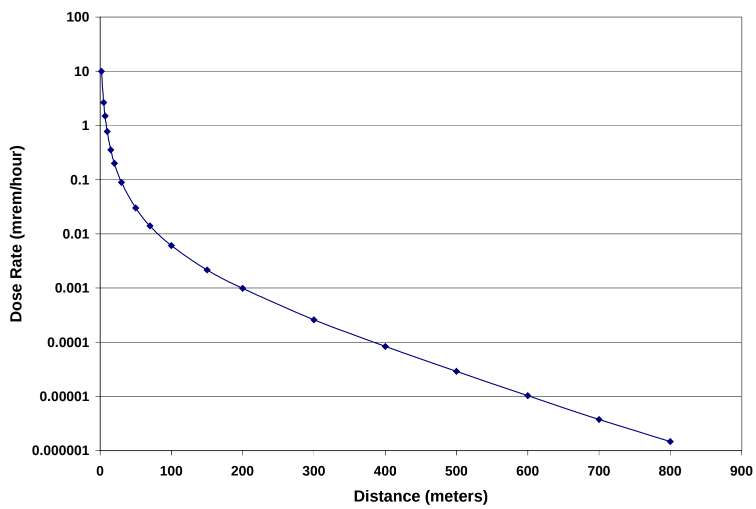

Fig. 1. Dose rate as a function of distance from a spent fuel transport cask [2]

Table V summarizes the impact on the off-link dose of decreasing the maximum perpendicular distance from 800 meters to 600 meters and 500 meters, decreasing the distance over which the off-link dose is integrated to 75% and 62.5% of the original distance, respectively. When the maximum perpendicular distance is decreased to 600 meters, the off-link dose for the Mostly Legal-Weight Truck scenario decreases to approximately 95% of the off-link dose integrated to a distance of 800 meters. When the maximum perpendicular distance is decreased to 500 meters, the off-link dose for the Mostly Legal-Weight Truck and the Mostly Rail scenario decreases to approximately 92% of the off-link dose integrated to a distance of 800 meters. Changes to the maximum perpendicular distance have a relatively minor impact on the calculation of off-link dose due to the fact that the dose rate decreases inversely to the square of the distance from the source resulting in very small (10^{-5} to 10^{-6} mrem/hour) dose rates at distances of 500 to 800 meters.

Table V. Off-Link Dose – Effect of Changes to DISTOFF Maximum Perpendicular Distance [2]

	YM EIS **Max Distance = 800 m**	**Alternative 1** **Max Distance = 600 m**	**Alternative 2** **Max Distance = 500 m**
	(Person Rem)		
Mostly Legal Weight Truck	882	832	801
Mostly Rail	572	545	526

Other Considerations

As many of the calculations of public and worker dose in the RADTRAN model are hardwired into the model, there are, by default, many conservative assumptions built into the model over which the user has no control. Examples of conservative assumptions that are built into the model include:

- The off-link population residing adjacent to a transportation route is modeled “*as being uniformly distributed on an infinite flat plane at some user-defined density*.”[3] It is somewhat conservative to assume that the population is uniformly distributed since the actual population distribution along any one route segment may vary considerably. It is also conservative to assume that the dose is calculated over a flat plane, since the natural rises and falls in terrain along the route would result in the calculated dose being lower.
- The passing vehicle model assumes that the passing vehicle space is “*always filled by a vehicle for the duration of the trip, but not always the same vehicle*.”[3] The RADTRAN 5 Technical Manual notes that this represents a conservative population dose estimate because the passing space would not always be occupied in a real-world situation.
- “All route segments are modeled as straight lines without grade or curves… yielding slightly conservative dose estimates.”[5]

It would be difficult to quantify the dose impact that these conservatisms have on the calculation of incident-free transportation risk due to the complexity of the YM EIS transportation assessment with spent fuel being shipped from many locations across the US along a range of highway and rail routes to Yucca Mountain. However, it is clear that, given these multiple conservatisms, at least some of which would be applicable in virtually all situations, the result would be dose levels further reduced from those calculated with EPRI’s more realistic values.

INCIDENT-FREE TRANSPORTATION RISK – COMBINED REALISTIC ASSUMPTIONS

In addition to examining the effect of changing a single parameter at a time on worker and public dose for incident-free transport as described above, a “best estimate” case that combines a number of realistic assumptions for RADTRAN input parameters was also analyzed by EPRI. The results of this best estimate case are compared to the incident-free public and worker dose estimates from the YM EIS.

Description of Changes to RADTRAN Input Parameters

As discussed previously, a number of conservative assumptions were made in the selection of RADTRAN input parameters that were used by DOE to calculate incident-free transportation risks in the YM EIS. These conservative assumptions include:

- Assuming that all spent fuel casks that are shipped to the repository would have a cask dose rate at the regulatory limit of 14 mrem/hour at 1 meter.
- Assuming that no shielding is provided by buildings for urban and suburban populations. Standard RADTRAN input parameters include recommendations for the urban and suburban building shielding factors that assume that some shielding is provided by these structures.
- Assuming that no shielding is provided by the transport vehicles to the crew.
- Assuming that the crew dose for truck transport would be at the regulatory limit of 2 mrem/hour for all shipments.
- Assuming a maximum perpendicular distance of 800 meters over which the off-link population dose is integrated.

In addition to the above conservative assumptions that have been evaluated by EPRI, there are also other RADTRAN model assumptions whose impact on transportation risk cannot be easily quantified. These include: an off-link population model that assumes that the population is uniformly distributed along the route segment; a passing vehicles model that assumes that the passing vehicle space is always filled by a vehicle (but not always the same vehicle) for the duration of the trip, and modeling route segments as straight lines without grade or curves and terrain along the routes as infinite flat planes, etc.

As shown above, changes to any one of the above conservative parameters would result in lowering the incident-free worker and/or public dose to varying degrees. In order to understand how a combination of more realistic assumptions would affect the resulting incident-free radiological transport risk, a "realistic" scenario has been developed by EPRI that combined changes to several RADTRAN input parameters in one scenario. That scenario is discussed below.

As more than 40% of fuel shipped is likely to have cooling times greater than 20 years over the range of possible shipping scenarios evaluated by the M&O contractor (e.g., hottest fuel first, coldest fuel first, etc), it is overly conservative to assume that all spent fuel casks that are shipped will have an external dose that is at the regulatory limit of 14 mrem/hour at 1 meter. The EPRI analysis presented here assumes that package dose rates will have an average external dose rate of 10 mrem/hour at 1 meter.

RADTRAN standard input parameters assume that shielding is provided by buildings to populations residing in urban and suburban environments. The YM EIS assumed that no shielding was provided by such structures. A suburban shielding factor of 0.87 and an urban shielding factor of 0.018 is assumed by EPRI in the presented analysis. A rural shielding factor of 1.0 (no shielding) is assumed by EPRI, the same factor that is used by DOE in the YM EIS, even though this assumption is somewhat conservative as well.

The EPRI analysis assumes that the design of the transport vehicles will provide some minimal shielding to workers. As a result, a crew modification factor of 0.97 is used instead of the factor of 1.0 (no shielding) assumed in the YM EIS.

The EPRI analysis also assumes that crew dose during truck transport will be lower than the regulatory limit of 2 mrem/hour. As it is conservative to assume that the cask external dose rate will be at the regulatory limit for 100% of the packages transported and as the crew dose is dependent, in large part, on the dose rate at the cask surface, it is also conservative to assume that the crew dose will be at the regulatory limit for 100% of the casks transported. The crew dose was adjusted to be consistent with the reduction in cask external dose – a dose rate of 1.43 mrem/hour (2 mrem/hour multiplied by 10 mrem/hour divided by 14 mrem/hour).

The EPRI analysis further assumes that the maximum perpendicular distance over which the off-link dose is integrated is 500 meters instead of the 800 meter distance used in the YM EIS.

Incident-free Transportation Risk – Reevaluated

EPRI recalculated the unit risk factors using the RADTRAN 5 input parameters described above and applied these unit risk factors to the route specific information developed in the YM EIS transportation database and described in the YM EIS calculation package. [6] The resulting incident-free radiological risks (in person-rem) for the public and workers were calculated for the Mostly Legal-Weight Truck and the Mostly Rail scenarios. The resulting dose risk is compared to the dose risk calculated in the YM EIS as shown in Table VI. The results show that the off-link public dose associated with the Mostly Legal Weight Truck scenario for the realistic scenario are reduced from 882 person-rem to 300 person-rem – 34% of the YM EIS results. This is due primarily to the reduction in cask external dose rate and to the application of the urban and suburban building shielding factors that are used to calculate off-link dose. Other doses to the public associated with on-link populations and populations in the vicinity of stops are reduced to approximately 72% of the YM EIS results. This decrease is proportional to the decrease in the cask external dose from 14 mrem/hour to 10 mrem/hour at 1 meter from the cask. Similar results were calculated for the Mostly-Rail scenario – a reduction in the off-link dose to 26% of the YM EIS results and reduction in other doses to the public (on-link and stop) to approximately 72% of the YM EIS results.

Worker doses associated with incident-free transportation were reduced from the YM EIS results of 14,123 person-rem to 10,089 person-rem for the Mostly Legal-Weight Truck scenario and from 3,884 person-rem to 2,780 person-rem for the Mostly Rail scenario. The Realistic scenario results are 72% of the YM EIS results and are directly proportional to the reduction in cask external dose rate and crew dose rate.

Table VI. Comparison of Incident-free Risks Associated with Realistic Scenario

Description		YM EIS Results (a)		Realistic Scenario Results (a)	
		Mostly Legal-Weight Truck	Mostly Rail	Mostly Legal-Weight Truck	Mostly Rail
Public	Off-Link (person-rem)	882	572	300	147
	On-link (person-rem)	2,509	210	1,794	150
	Stop (person-rem)	1,638	862	1,172	620
Total Public		5,029	1,644	3,266	917
Workers (b)	(person-rem)	14,123	3,884	10,089	2,780
Total:		19,152	5,528	13,355	3,697

(a) The YM EIS evaluated ten different rail routing alternatives in NV. For comparison purposes, the results presented represent the route alternative that was evaluated to have the highest incident-free transportation impacts.

(b) Worker doses are only those associated with transportation. Doses associated with loading are not included above.

It should be noted that the public and worker incident-free transportation risk summarized in this section that result from utilizing more realistic assumptions for cask external dose rate, shielding factors, and crew dose are still considered to be conservative due to the many conservative assumptions that are built into the RADTRAN model as discussed in Section 4.5. These include conservatisms regarding the modeling of terrain along the routes for the off-link and on-link populations; the uniform distribution of off-link populations along the routes; and on-link assumptions regarding passing vehicles.

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