ENERCON SERVICES, INC.	CALCULATION COVER SHEET	CALC. NO. TXUT-001-ER-3.8-CALC-008
		REV. 1
		PAGE NO. Page 1 of 23
Title:	CPNPP Transportation Analysis	Client: Luminant
		Project: MITS003

Item	Cover Sheet Items	Yes	No
1	Does this calculation contain any open assumptions that require confirmation? If **YES**, identify the assumptions __________	☐	☒
2	Does this calculation serve as an "Alternate Calculation"? If **YES**, identify the design verified calculation. **Design Verified Calculation No.**__________	☐	☒
3	Does this calculation supersede an existing calculation? If **YES**, identify the superseded calculation. **Superseded Calculation No.**__________	☐	☒

Scope of Revision:

The scope of Revision 1 is to add a heat load calculation to determine the amount of decay heat in one spent fuel shipping cask. Also, the number of fuel assemblies per new fuel shipping truck is changed from 28 to 12 to serve as a better estimate of actual shipments of PWR fuel.

Revision Impact on Results:

The dose per reactor year associated with shipments of new fuel increased due to the change in the required number of shipments. See Section 7.1. Also, the decay heat load calculated is added to the results in Sections 2 and 7.

Study Calculation	☐	**Final Calculation**	☒
Safety-Related	☐	**Non-Safety Related**	☒

(Print Name and Sign)

Originator: Jeffrey Head [signature]	**Date:** 3/20/2009
Design Verifier: Marvin Morris [signature]	**Date:** 3/20/2009
Approver: Joanne G. Morris [signature]	**Date:** 3/20/2009

CALCULATION REVISION STATUS

REVISION	DATE	DESCRIPTION
0	4/18/2008	Initial issue.
1		Revision to calculate cask decay heat and to adjust number of new fuel assemblies per truck.

PAGE REVISION STATUS

PAGE NO.	REVISION	PAGE NO.	REVISION
3,8-14,17-19,21	0		
1,2,4,5-7,15-16,20,22,23	1		

APPENDIX REVISION STATUS

APPENDIX NO.	PAGE NO.	REVISION NO.	APPENDIX NO.	PAGE NO.	REVISION NO.
Appendix 1	1 – 4	1	Appendix 2	1	0
Appendix 3	1 – 4	0	Appendix 4	1 – 20	0

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1.0 Purpose and Scope

The purpose of this calculation is to determine the effects (measured in person-rem) of shipping nuclear material to and from the proposed Luminant nuclear plants, Comanche Peak Nuclear Power Plant (CPNPP) Units 3 & 4. The shipments of nuclear material include new fuel to the site, spent fuel away from the site, and radioactive waste away from the site. The results of this calculation will be used to support the Combined License Application (COLA) for the CPNPP to be submitted by Luminant.

This calculation was performed using the RADTRAN computer program, which was developed to calculate the risks of transporting radioactive materials. A NRC analysis of the risks of transporting nuclear materials is provided in NUREG-1817, "Environmental Impact Statement for an Early Site Permit (ESP) at the Grand Gulf ESP Site." NUREG-1817 procedures are largely based on the RADTRAN code.

RADTRAN requires that a route be entered so that the risks of transporting the nuclear materials can be adequately modeled. Routes can be manually entered or acquired using a secondary program, Transportation Routing Analysis Geographic Information System (TRAGIS). TRAGIS uses mapping and population data to output types of areas (rural, suburban, urban) along a route and population densities for those areas around the route. RADTRAN then applies the risks of transporting the nuclear material to the route supplied by TRAGIS. This calculation was performed using outputs from WebTRAGIS, the web based Graphical User Interface (GUI) for the TRAGIS code. The method behind the creation of those inputs is outlined in Calculation TXUT-001-ER-3.8-CALC-009.

A possible transportation accident while transporting spent fuel could lead to a breach of the shipping container and a release of nuclear materials. To calculate the source term inside of the container, this calculation used ORIGEN-ARP, Automatic Rapid Processing for Spent Fuel Depletion, Decay, and Source Term Analysis. ORIGEN-ARP is part of the SCALE package. A simulated US-APWR assembly was irradiated and then decayed to determine the activity of the spent fuel 5 years after a burnup period of 62 GWd/MTU. The results of this computation are in Appendix 1.

Revision 1 of this calculation determines the heat load of one spent fuel shipping container so that a comparison can be made to the heat load presented in Table S-4 of 10 CFR 52.51. In addition, the number of fuel assemblies per new fuel shipment changes from 28 to 12.

2.0 Summary of Results and Conclusions

A transportation accident involving a spent fuel shipping container could lead to a release of nuclear material. The total calculated RADTRAN population dose for such an accident is 4.64E-06 person-rem for a spent fuel cask shipping container containing a single assembly. For a container of four assemblies, the payload evaluated herein, the population dose increases to 1.86E-05 person-rem.

For incident-free transport of spent fuel, Table 2.1 describes the dose risk for various people affected by the shipment of 1 spent fuel container by truck. The route taken starts at the CPNPP site and ends at Yucca Mountain. The crew is defined by the 2 operators of the truck. On link is defined by people in cars in the general area of a spent fuel shipping truck as it approaches its destination. Off link is defined as residents within 800 meters of a spent fuel shipping truck. Public – Around Truck Stop is defined as people that are around a truck when it experiences a planned stop. This analysis assumes eight 30 minute stops on the trip from the CPNPP to Yucca Mountain.

For incident-free transport of new fuel, Table 2.2 describes the dose risk for various people affected by the shipment of 1 new fuel container by truck. The route taken starts at the San Diego port and ends at the CPNPP site. Eight 30 minute stops were also assumed on the trip from San Diego to the CPNPP.

Table 2.1 Proposed Dose to Population as a Result of Incident-Free shipment of 1 spent fuel container by truck

Type of Population	Crew	On Link	Off Link	Public – Around Truck Stop
Dose (person-rem)	1.18E-01	5.43E-02	3.93E-03	5.39E-01

Table 2.2 Proposed Dose to Population as a Result of Incident-Free shipment of 1 new fuel container by truck

Type of Population	Crew	On Link	Off Link	Public – Around Truck Stop
Dose (person-rem)	2.74E-03	6.05E-04	2.84E-05	4.15E-03

Based on the results presented above, the risks associated with the transport of new and spent nuclear fuel are small. The doses to individual members of the public are small because these population doses apply to large populations of people.

The US-APWR is expected to generate 15278 cubic feet of solid radioactive waste every year. Because trucks have the capacity of approximately 1000 cubic feet per shipment, this waste will less than 1 truck per day and the weight limit of these trucks containing radioactive waste will weigh result in less than 33,100 kg (73,000 lb) to comply with 10 CFR 51.52(a).

From Appendix 1, the decay heat load of one spent fuel assembly is 1970 watts. Therefore, the total decay heat of one spent fuel container is 7880 watts (26,888 BTU/hr). This value is less than the limit of 250,000 BTU/hr given in Table S-4 of 10 CFR 51.52. Detailed results are presented in Section 7.

3.0 References

3.1 U.S. Department of Energy (DOE), 2002, "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," DOE/EIS-0250, Office of Civilian Radioactive Waste Management, Washington D.C.

3.2 Mitsubishi Heavy Industries, Ltd., "Design Control Document for the United States Advanced Pressurized Water Reactor," Revision 1.

3.3 National Nuclear Data Center, Brookhaven National Laboratory, "Chart of the Nuclides," <www.nndc.bnl.gov/chart>.

3.4 U.S. Department of Energy (DOE), 2002, "A Resource Handbook on DOE Transportation Risk Assessment," DOE/EM/NTP/HB-01, Washington, D.C.

3.5 U.S. Census Bureau, 2004, "U.S. Interim Projections by Age, Sex, Rate, and Hispanic Origin," 3/24/2008, <http://www.census.gov/ipc/www/usinterimproj/>.

3.6 U.S. Environmental Protection Agency, Federal Guidance Report No. 11, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion," 3/24/2008, <http://homer.ornl.gov/VLAB/FedGR11.html>.

3.7 U.S. Environmental Protection Agency, Federal Guidance Report No. 12, "External Exposures to Radionuclides in Air; Water; and Soil," <http://homer.ornl.gov/VLAB/FedGR12.html>.

3.8 NUREG/CR-6672, "Reexamination of Spent Fuel Shipment Risk Estimates," Volume 1, March 2000.

3.9 NUREG-1817, " Environmental Impact Statement for an Early Site Permit (ESP) at the Grand Gulf ESP Site," Final Report, April 2006.

3.10 Hostick, C.J., J.C. Lavender, and B.H. Wakeman. 1992. Time/Motion Observations and Dose Analysis of Reactor Loading, Transportation, and Dry Unloading of an Overweight Truck Spent Fuel Shipment. PNL-7206, Pacific Northwest Laboratory, Richland, Washington.

3.11 Sandia National Laboratories, "RadCat 2.3 User Guide – A Graphical User Interface for the RADTRAN Code, Version 2.3," September, 2006 (Revised December 2007).

3.12 ENERCON Computer Program Certification: "RADTRAN 5.6 / RadCat 2.3, Code Used for Calculating the Risks for Transporting Nuclear Material," 4/18/2008.

3.13 Calculation TXUT-001-ER-3.8-CALC-009, "Transportation Routing," Revision 0.

3.14 U.S. Bureau of Transportation Services, Table 2-17, "Motor Vehicle Safety Data," 3/24/2008, <http://www.bts.gov/publications/national_transportation_statistics/html/table_02_17.html>.

3.15 SCALE: "A Modular Code System for Performing Standardized Computer Analyses for Licensing Evaluations, ORNL/TM-2005/39, Version 5, Vols. I-III, April 2005. Available from Radiation Safety Information Computational Center at Oak Ridge National Laboratory as CCC-725.

3.16 Comanche Peak Nuclear Power Plant Units 3 & 4, COL Application, Part 3 Environmental Report, Revision 0.

4.0 Assumptions

4.1 Population densities acquired from TRAGIS are from the 2000 census. These values were multiplied by 1.49 to scale these population densities for the year 2050, which is the last year that the census bureau projected population [Reference 3.5]. 1.49 was obtained by dividing the projected United States population in 2050 by the total United States population in 2000.
Basis: The earliest date that fuel could potentially be shipped is around 2021, which is 5 years after the approximate startup date of 2016. Scaling populations to 2050 is conservative because more people will experience the effects of the transportation of spent fuel at later dates.

4.2 The spent fuel shipping container and truck is assumed to abide by DOT regulatory guidance in 49 CFR 173.441 stating that the dose rate at 2 meters away from the container is < 10 mrem/hr. For the purposes of this analysis, the dose rate that RADTRAN sets is 13 mrem at 1 meter away from the container. Also, the dose rate to the drivers of the truck is assumed to be 2 mrem/hr to abide by regulations set forth in 49 CFR 173.441.
Basis: The actual dose rates will be smaller than their maximum allowed values. Setting the dose rates to the highest value possible will lead to more conservative population exposure.

4.3 In the event of an accident involving a spent fuel shipment, all radioactive particles that are released are assumed to be aerosolized and able to deposited in the lungs.
Basis: Based on guidance in the RADTRAN manual, this is conservative because not all particles will be small enough to enter the alveoli of the lungs.

4.4 Accident rates and fatalities due to accidents are taken from the Bureau of Transportation Services website [Reference 3.14]. Accident rates have been decreasing over the years, so the highest accident and fatality rates were used from 1990.
Basis: The bounding accident and fatality rates taken from the year 1990 will provide a conservative limit on accident scenarios.

4.5 Because 2 drivers will be utilized during shipment of fuel, long term stops for sleeping are not necessary. However, based on values in NUREG-1817 [Reference 3.9], the average truck stop time chosen is 30 minutes. For the spent fuel case, 8 stops were assumed to happen during the 2567.5 km long route, and 8 stops were assumed to happen during the 2616.3 km long route for new fuel. These stop amount numbers come from the estimate of .0014 hours of stop time per km of travel [Reference 3.10].
Basis: These conservative stop times overestimate dose to the public at truck stops because actual stop times will be less.

4.6 Spent fuel shipping containers are assumed to have 4 assemblies of PWR fuel [Reference 3.9].
Basis: Even though newer shipping containers could contain upwards of 32 fuel assemblies, this analysis conservatively overestimates the number of shipments per year.

4.7 Because new fuel shipping container dimensions and shipping frequencies are not known, new fuel shipping container dimensions are assumed to be exactly the same as spent fuel shipping dimensions, though 12 assemblies will be assumed per shipment [Reference 3.9].
Basis: New fuel shipments require less shielding and smaller containers. The dose rates due to new fuel shipping are small compared to spent fuel shipping, so slight changes in the shipping container dimensions will not significantly affect population dose.

4.8 In regards to an accident scenario that releases radioactive materials, subsequent cleanup is assumed to happen quickly. Soil that is radioactive (groundshine) and radioactive particles that are released from the soil after deposition (resuspension) will not pose a long term risk. However, the doses from these two pathways are considered in their fullest extent to affect the public.
Basis: This conservative approach maximizes dose from an accident.

4.9 In regards to an accident scenario that releases radioactive materials, subsequent cleanup is assumed to happen quickly. Crops that could possibly be affected are assumed to not be harvested. Thus, ingestion of radioactive materials is assumed to never happen.
Basis: This approach is consistent with NUREG-1817.

5.0 Design Inputs

5.1 TRAGIS Inputs

For the spent fuel shipment, the route goes from the CPNPP to the proposed waste repository in Yucca Mountain, Nevada. For the new fuel shipment, the route goes from the San Diego port to the CPNPP. TRAGIS inputs are outlined in detail in Reference 3.13.

5.2 RADTRAN Inputs for Spent Fuel

RADTRAN inputs are separated by tabs into 9 sections: Title, Package, Radionuclides, Vehicle, Link, Stop, Handling, Accidents, and Parameters. The title section describes the output level, accident options, and health effects output parameters. For spent fuel, both accident and incident free scenarios are considered. The outputs of RADTRAN are set to be in rem and person-rem.

The Radionuclides section is defined to specify the inventory of radioactive materials that could be released in the event of an accident. The name and magnitude of these radionuclides come from the output of ORIGEN-ARP (see Appendix 1) and the 140 $\mu Ci/cm^2$ estimate of CRUD surface activity for PWR rods from NUREG/CR-6672 [Reference 3.8, Section 7.3.6] that uses fuel parameters presented in Chapter 4 of the USAPWR DCD [Reference 3.2]. This method takes the total surface area of all fuel rods (.374" outside diameter * pi * 165.4" total length * 264 rods) and multiplies it by the conservative value of 140 $microcuries/cm^2$ to obtain 4.63E01 curies of total CRUD per assembly. All CRUD is input as co-60, which is consistent with the approach of NUREG/CR-6672 [Reference 3.8, Section 7.3.6].

Rh106 is not included because RADTRAN accounts for it in the ru106 library file. Likewise, pr144 and pr144m are not included because they are accounted for in the ce144 library file. Ba-137m is accounted for in the cs137 library file (See Page 98 of RADTRAN manual [Reference 3.11]).

Library files in RADTRAN contain other information for these radionuclides including half life, photon energy, groundshine, cloudshine, and dose to activity factors. For the nuclides that are not in the RADTRAN library (ag110m and am-242), user defined library files were generated using the chart of the nuclides, FGR 11, and FGR 12 [References 3.3, 3.6, and 3.7]. Note that scaling factors provided in the RADTRAN manual [Reference 3.11] are multiplied by values in FGR11 and FGR12 to acquire the proper units required for RADTRAN. These scaling factors are 3.7E12 for cloudshine, 3.197E11 for groundshine, and 3.7E12 for all other activity to dose factors. These parameters are presented in Table 5.1.

The radionuclides entered into the RADTRAN radionuclides section are presented in Table 5.2. Note that these inventories are for one fuel assembly. Because 4 assemblies will be used in one spent fuel container, the inventory for one container can be acquired by multiplying the values in Table 5.2 by 4.

Table 5.1 RADTRAN 5.6 User Defined Library File for ag-110m and am-242

	Half Life (days)	Photon Energy[1]	Cloudshine	Groundshine	Effective Dose	Gonad (Testes) Inhalation	Lung Inhalation	Marrow Inhalation
ag-110m	249.9	0.112 (MeV)	5.032E-01 (Rem-m^3/Ci-sec)	8.47E-04 (Rem-m^2/microCi-day)	39590 (rem/Ci)	6956 (rem/Ci)	30007 (rem/Ci)	14911 (rem/Ci)
am-242	0.6675	0.192 (MeV)	2.28E-03 (Rem-m^3/Ci-sec)	5.02E-06 (Rem-m^2/microCi-day)	58460 (rem/Ci)	7178 (rem/Ci)	192400 (rem/Ci)	48840 (rem/Ci)
FGR11 and FGR12 ag110m (In SI units)			1.36E-13 (Sv-m^3/Bq-s)	2.65E-15 (Sv-m^2/Bq-s)	1.07E-08 (Sv/Bq)	1.88E-09 (Sv/Bq)	8.11E-09 (Sv/Bq)	4.03E-09 (Sv/Bq)
FGR11 and FGR12 am-242 (In SI units)			6.15E-16 (Sv-m^3/Bq-s)	1.57E-17 (Sv-m^2/Bq-s)	1.58E-08 (Sv/Bq)	1.94E-09 (Sv/Bq)	5.2E-08 (Sv/Bq)	1.32E-08 (Sv/Bq)

[1] Maximum gamma energy is taken to be the average beta energy from the chart of the nuclides. For ag-110m, the average beta energy from the ag110 decay is taken for conservatism.

Table 5.2 RADTRAN 5.6 Radionuclide Input Parameters for Spent Fuel Shipments

Isotope	Ci/assembly	Isotope	Ci/assembly
np239	4.02E+01	rh106	1.33E+04
pu238	5.13E+03	ag110m	2.93E+01
pu239	2.20E+02	cd113m	2.69E+01
pu240	3.76E+02	sb125	1.83E+03
pu241	9.07E+04	te125m	4.48E+02
am241	9.77E+02	cs134	3.46E+04
am242m	1.10E+01	cs137	9.50E+04
am242	1.10E+01	ba137m	8.98E+04
am243	4.02E+01	ce144	7.49E+03
cm242	3.28E+01	pr144	7.49E+03
cm243	3.11E+01	pr144m	1.05E+02
cm244	6.77E+03	pm147	2.79E+04
h 3	3.50E+02	sm151	3.49E+02
kr 85	5.90E+03	eu154	5.55E+03
sr 90	6.46E+04	eu155	1.48E+03
y 90	6.46E+04	co-60	4.63E+01
tc 99	1.26E+01	Total	5.39E+05
ru106	1.33E+04		

Table 5.3 describes the inputs for the package and vehicle link section. Table 5.4 describes the user generated parameters for the link section of RADTRAN. Table 5.5 describes the rest of the input parameters for the link section. The first 3 columns of Table 5.5 come directly from the TRAGIS output file [Reference 3.13]. The Vehicle Density column comes from the Interstate Highway information documented in Appendix D of the RADTRAN manual [Reference 3.11]. Note that because no vehicle density data exists for Nevada and Texas, national average values are used. Note also that the vehicle density values for Arizona, California, and New Mexico are based on rounding to three significant digits in exponential notation (e.g., 2144 is presented as 2.14E02 or 2140).

Table 5.3 RADTRAN Package and Truck Input Parameters for Spent Fuel Shipments

Parameter	Input Value	Source / Reasoning
Long Dimension (Package Length)	5.2 meters	NUREG/CR-6672 [Ref 3.8]
Gamma Fraction	1	Gamma Rays are more likely to escape than neutrons.
Vehicle Dose Rate	13 mrem/hr	NUREG/CR-6672 [Ref 3.8]. Higher values cannot be chosen in RADTRAN due to the 10 mrem/hr limit at 2 meters.
Crew Size	2	2 Truck Drivers are required to minimize stop time.
Shielding Factors	1	All shielding factors for people not in buildings are set to 1 (no shielding) for conservatism.
Crew View (Cask Diameter)	1 meter	Yucca Mountain Final Environmental Impact Statement [Ref 3.1]
Crew Distance	2 meters	Minimum distance away from the cask that the drivers can be from the RADTRAN manual [Ref 3.11]

Table 5.4 RADTRAN Link Input Parameters for Spent Fuel Shipments

Parameter	Input Value	Source / Reasoning
Speed	88 km/h (55mph)	NUREG/CR-6672 [Ref 3.8] and [Ref 3.4]
Persons Per Vehicle	2	The bureau of transportation services suggests a value of 1.2 persons per vehicle. 2 persons per vehicle is chosen for conservatism based on direction in the RADTRAN manual [Ref 3.11]
Accident Rate	1.86E-06 (accidents/veh-km)	Bureau of Transportation Services website [Ref 3.14]
Fatalities Per Accident	7.00E-03	Bureau of Transportation Services website [Ref 3.14]
Farm Fraction	0 (no farms)	The ingestion pathway is not considered. (See Assumption 4.9)

Table 5.5 RADTRAN Link Input Parameters for Specific Segments of the Route for a Spent Fuel Shipment

Link Name	Length (km)	Population Density	Vehicle Density
RURAL_AZ	533.2	7	825
SUBURBN_AZ	37.9	369.9	2140
URBAN_AZ	3.6	2311.5	4210
RURAL_CA	102.1	2.7	1920
SUBURBN_CA	6.6	285	4510
URBAN_CA	0.3	1764.7	7910
RURAL_NV	287.5	5.9	1119
SUBURBN_NV	25.7	252.9	2463
URBAN_NV	1.1	2398.6	5385
RURAL_NM	519.7	7.7	654
SUBURBN_NM	63.5	308.9	1210
URBAN_NM	13.8	2387.3	3350
RURAL_OK	358.1	11.4	1180
SUBURBN_OK	76.4	382.7	1790
URBAN_OK	13	2257.4	2780
RURAL_TX	397.6	9.9	1119
SUBURBN_TX	106.5	355.3	2463
URBAN_TX	20.8	2188.9	5358

The stop input section is described by defining an area around the parked truck. This is done by setting an annular space with an inside radius equal to 1 meter away from the truck and an outside diameter equal to 10 meters away from the truck. The population density in this area is set to 64,300 people/km^2 based on NUREG-1817 [Reference 3.9]. This means approximately 20 people are assumed to stand around the truck for the whole 30 minutes of the stop. There are a total of eight stops on the route for the spent fuel shipment and eight stops on the route for a new fuel shipment (see Assumption 4.5). Note that the NUREG-1817 analysis considers a larger annular region (for distances greater than 10 meters) with a shielding factor of 0.2. This region is neglected because its contribution is limited by both shielding and greater distance.

The handling input section is not used for this calculation. Workers that are involved in the loading and unloading of a truck typically receive the highest dose out of anyone that deals with the spent fuel shipping container. However, container handlers are not considered to be affected by the actual transport of the cask and are therefore not under the scope of this analysis.

The accident input section is described by defining the types of release that would occur in the case of an accident that compromises the shipping container and releases nuclear material. An accident has the potential to release differing amounts of radioactive materials. Each index listed in Table 5.6 corresponds to a particular severity fraction defining the potential severity of the release. The next five columns in Table 5.6 define the release fractions for each particular group of radioactive materials. All of these inputs come directly from Table 7.31 of NUREG/CR-6672 [Reference 3.8].

Table 5.6 RADTRAN Accident input Parameters for Spent Fuel Shipments

Index	Severity Fraction	Gas	Cesium	Particulates	Ruthenium	CRUD
1	1.53E-08	8.0E-01	2.4E-08	6.0E-07	6.0E-07	2.0E-03
2	6.19E-05	1.4E-01	4.1E-09	1.0E-07	1.0E-07	1.4E-03
3	2.81E-07	1.8E-01	5.4E-09	1.3E-07	1.3E-07	1.8E-03
4	6.99E-08	8.4E-01	3.6E-05	3.8E-06	3.8E-06	3.2E-03
5	4.89E-07	4.3E-01	1.3E-08	3.2E-07	3.2E-07	1.8E-03
6	9.22E-11	4.9E-01	1.5E-08	3.7E-07	3.7E-07	2.1E-03
7	3.30E-12	8.5E-01	2.7E-05	2.1E-06	2.1E-06	3.1E-03
8	1.17E-08	8.2E-01	2.4E-08	6.1E-07	6.1E-07	2.0E-03
9	1.90E-12	8.9E-01	2.7E-08	6.7E-07	6.7E-07	2.2E-03
10	0.00E00	9.1E-01	5.9E-06	6.8E-07	6.8E-07	2.5E-03
11	1.49E-10	8.2E-01	2.4E-08	6.1E-07	6.1E-07	2.0E-03
12	2.41E-14	8.9E-01	2.7E-08	6.7E-07	6.7E-07	2.2E-03
13	0.00E00	9.1E-01	5.9E-06	6.8E-07	6.8E-07	2.5E-03
14	6.99E-11	8.4E-01	9.6E-05	1.8E-05	8.4E-05	6.4E-03
15	3.30E-15	8.5E-01	5.5E-05	9.0E-06	5.0E-05	5.9E-03
16	0.00E00	9.1E-01	5.9E-06	6.8E-07	6.4E-06	3.3E-03
17	0.00E00	9.1E-01	5.9E-06	6.8E-07	6.4E-06	3.3E-03
18	5.59E-06	8.4E-01	1.7E-05	6.7E-08	6.7E-08	2.5E-03
19	9.99E-01	0.0E00	0.0E00	0.0E00	0.0E00	0.0E00

The next inputs in the accident section are deposition velocity, aerosol fraction, and respirable fraction. Gases have a deposition velocity of 0 because they do not deposit on anything. All other particles have a deposition velocity of .01 m/sec per guidance from the RADTRAN manual [Reference 3.11]. The aerosol fraction and respirable fractions are both chosen to be 1 for conservatism.

RADTRAN also gives the option of generating user defined population densities to determine the people that will experience the fallout from an accident. For the purposes of this analysis, the default value of taking population densities within an 800 meter (.5 mile) distance from the road is used.

The last input parameter for the accident section is the weather specification. This evaluation uses the default method of specifying increasing isopleths area sizes around the accident along with decreasing time integrated constant (χ/Q) values for those isopleths. These default parameters can be seen in the RADTRAN manual [Reference 3.11].

The final section of input values is the parameters section. This parameters section contains all other variables that must be set for RADTRAN to run properly. These variables are shown in Table 5.7. No values were changed from their default values. Explanation for these values are in the RADTRAN user manual [Reference 3.11].

Table 5.7 Default Parameters for RADTRAN

Parameter	Value
Shielding factor for rural residents	1.00E00
Shielding factor for suburban residents	8.70E-01
Shielding factor for urban residents	1.80E-02
Fraction of outside air in urban buildings	5.00E-02
Fraction of urban population occupying the sidewalk	4.80E-01
Fraction of urban population inside buildings	5.20E-01
Ratio of pedestrians/km² to residential population/km²	6.00E00
Minimum small package dimension for handling (m)	5.00E-01
Distance from shipment for maximum exposure (m)	3.00E01
Vehicle speed for maximum exposure (km/hr)	2.40E01
Imposed regulatory limit on vehicle external dose	Yes
Average breathing rate (m³/sec)	3.30E-04
Cleanup Level (microcuries/m²)	2.00E-01
Interdiction Threshold	4.00E01
Evacuation time for groundshine (days)	1.00E00
Survey interval for groudshine (days)	1.00E01
Occupational latent cancer fatalities per person-rem	4.00E-04
Public latent cancer fatalities per person-rem	5.00E-04
Genetic effects per person-rem (public)	1.00E-04
Campaign (year)	8.33E-02
Iodine	I131
Rem per curie thyroid via inhalation (Rem/Ci)	1.27E06
Distance of freeway vehicle carrying radioactive cargo to pedestrians (m)	3.00E01
Distance of freeway vehicle carrying radioactive cargo to right-of-way edge (m)	3.00E01
Distance of freeway vehicle carrying radioactive cargo to maximum exposure distance (m)	8.00E02
Distance of non-freeway vehicle carrying radioactive cargo to pedestrians (m)	2.70E01
Distance of non-freeway vehicle carrying radioactive cargo to right-of-way edge (m)	3.00E01
Distance of non-freeway vehicle carrying radioactive cargo to maximum exposure distance (m)	8.00E02
Distance of city street vehicle carrying radioactive cargo to pedestrians (m)	5.00E00
Distance of city street vehicle carrying radioactive cargo to right-of-way edge (m)	8.00E00
Distance of city street vehicle carrying radioactive cargo to maximum exposure distance (m)	8.00E02
Perpendicular distance to freeway vehicle going in opposite direction (m)	1.50E01
Perpendicular distance to non-freeway vehicle going in opposite direction (m)	3.00E00
Perpendicular distance to city vehicle going in opposite direction (m)	3.00E00
Perpendicular distance to all vehicles going in same direction (m)	4.00E00

5.3 RADTRAN Inputs for New Fuel

RADTRAN inputs for new fuel are exactly the same as RADTRAN inputs for spent fuel except for differences in the link section and differences in the dose rate. The dose rate is decreased from 13 mrem/hour for spent fuel to .1 mrem/hour for new fuel based on NUREG-1817 [Reference 3.9]. Table 5.8 describes the link inputs for new fuel. Note that the vehicle density values for Arizona, California, and New Mexico are based on rounding to three significant digits in exponential notation (e.g., 2144 is presented as 2.14E02 or 2140).

Table 5.8 Link Inputs for New Fuel

Link Name	Length (km)	Population Density	Vehicle Density
RURAL_AZ	503.2	9.2	825
SUBURBN_AZ	81.7	324.1	2140
URBAN_AZ	10	2341.5	4210
RURAL_CA	201.1	8.8	1920
SUBURBN_CA	46.3	351.5	4510
URBAN_CA	26.9	2848	7910
RURAL_NM	230.7	8.9	6540
SUBURBN_NM	29.8	309.1	1210
URBAN_NM	3.3	2080.3	3350
RURAL_TX	819.5	8.1	1119
SUBURBN_TX	151	339.3	2463
URBAN_TX	20	2395.5	5385

Also, an accident scenario involving a new fuel shipping container is not considered to release enough airborne radioactive material to pose a significant health hazard. Thus, accident scenarios for new fuel are not considered in the RADTRAN calculation.

Initial and reload cores for the US-APWR are anticipated to operate up to 24 months assuming a cycle burnup of 23,000 MWd/MTU and refueling outage length of a half of a month [Reference 3.2, Section 4.3.2]. The core loading is 257 assemblies [Reference 3.2]. Also note that Chapter 15 of the US-APWR DCD calculates source terms based off of 55,000 MWd/MTU while Section 3.2 of the Comanche Peak Environmental Report lists the maximum burnup as 54,200 MWd/MTU [Reference 3.16]. This calculation will use a burnup of 62,000 MWd/MTU to generate a bounding decay heat load and source term.

5.4 Transportation of Radioactive Waste

The Solid Waste Management System (SWMS) for collecting, packaging, and shipping solid waste is outlined in Section 11.4 of the US-APWR DCD [Reference 3.2]. This system prepares all solid waste for transport to offsite storage facilities. The SWMS is designed to use DOT-approved containers for the packaging of radioactive wastes. These containers include drums, high-integrity containers, B-25 boxes, and others that are DOT-approved and accepted by waste disposal facilities. The packaging and shipment of radioactive solid waste for disposal complies with 10 CFR 20 Appendix G and 49 CFR 173 Subpart I. The estimated annual volumes of solid waste come from the US-APWR DCD [Reference 3.2] and are outlined in Table 5.9.

Table 5.9 Annual Estimated Solid Waste Inventory

Waste Type	Shipped Volume (ft^3)	Waste Classification
Low Activity Spent Resin	250	A
High Activity Spent Resin	290	B
High Activity Spent Filter	17	B
Low Activity Spent Filter	35	A
Spent Carbon	14	A
Sludge	42	A
High Activity Dry Active Waste	1430	B
Low Activity Dry Active Waste	13200	A

10 CFR 51.52 states that all radwaste must be shipped in solid form. As stated in chapter 11 of the US-APWR DCD [Reference 3.2], any "wet" waste will have absorbing material added to it so that the form will be solid.

Truck shipments of radwaste are evaluated with a capacity of approximately 1000 cubic feet per shipment for consistency with NUREG-1817 [Reference 3.9].

6.0 Methodology

The methodology used in this calculation is based on NUREG-1817 [Reference 3.9] and the RADTRAN code manual [Reference 3.11]. Verification of the RADTRAN computer code [Reference 3.12] was performed in accordance with the ENERCON corporate procedure for control of computer software.

6.1 Regulatory Limits

10 CFR 51.52 lists the following requirements for shipping nuclear materials.

(a)(1) The reactor has a core thermal power level not exceeding 3,800 megawatts;

(2) The reactor fuel is in the form of sintered uranium dioxide pellets having a uranium-235 enrichment not exceeding 4% by weight, and the pellets are encapsulated in zircaloy rods;

(3) The average level of irradiation of the irradiated fuel from the reactor does not exceed 33,000 megawatt-days per metric ton, and no irradiated fuel assembly is shipped until at least 90 days after it is discharged from the reactor;

(4) With the exception of irradiated fuel, all radioactive waste shipped from the reactor is packaged and in a solid form;

(5) Unirradiated fuel is shipped to the reactor by truck; irradiated fuel is shipped from the reactor by truck, rail, or barge; and radioactive waste other than irradiated fuel is shipped from the reactor by truck or rail; and

(6) The environmental impacts of transportation of fuel and waste to and from the reactor, with respect to normal conditions of transport and possible accidents in transport, are as set forth in Summary Table S-4 in paragraph (c) of this section; and the values in the table represent the contribution of the transportation to the environmental costs of licensing the reactor.

(b) For reactors not meeting the conditions of paragraph (a) of this section, the statement shall contain a full description and detailed analysis of the environmental effects of transportation of fuel and wastes to and from the reactor, including values for the environmental impact under normal conditions of transport and for the environmental risk from accidents in transport. The statement shall indicate that the values determined by the analysis represent the contribution of such effects to the environmental costs of licensing the reactor.

Environmental impacts of transportation are defined by Table S-4 of 10 CFR 51.52, shown as follows.

Summary Table S-4--Environmental Impact of Transportation of Fuel and Waste To and From One Light-Water-Cooled Nuclear Power Reactor [1]

Normal Conditions of Transport

	Environmental Impact
Heat (per irradiated fuel cask in transit)	250,000 Btu/hr.
Weight (governed by Federal or State restrictions)	73,000 lbs. Per truck; 100 tons per cask per rail car.
Traffic density:	
Truck	Less than 1 per day.
Rail	Less than 3 per month.

Exposed Population	Estimated Number of Persons Exposed	Range of Doses to Exposed Individuals[2] (per reactor year)	Cumulative Dose to Exposed Population (per reactor year)[3]
Transportation workers	200	0.01 to 300 millirem	4 man-rem.
General public:			
Onlookers	1,100	0.003 to 1.3 millirem	3 man-rem.
Along Route	600,000	0.0001 to 0.06 millirem	

Accidents in Transport

Types of Effects	Environmental Risk
Radiological effects	Small[4]
Common (nonradiological) causes	1 fatal injury in 100 reactor years; 1 nonfatal injury in 10 reactor years; $475 property damage per reactor year.

[49 FR 9381, Mar. 12, 1984; 49 FR 10922, Mar. 23, 1984, as amended at 53 FR 43420, Oct. 27, 1988; 72 FR 49512, Aug. 28, 2007]

[1]Data supporting this table are given in the Commission's "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants," WASH-1238, December 1972 , and Supp. 1 NUREG-75/038 April 1975. Both documents are available for inspection and copying at the Commission's Public Document Room, 2120 L Street NW., Washington, DC and may be obtained from the National Technical Information Service, Springfield, VA 22161 . WASH-1238 is available form NTIS at a cost of $5.45 (microfiche, $2.25) and NUREG-75/038 is available at a cost of $3.25 (microfiche $2.25).

[2]The Federal Radiation Council has recommended that the radiation doses from all sources of radiation other than natural background and medical exposures should be limited to 5,000 millirem per year for individuals as a result of occupational exposure and should be limited to 500 millirem per year for individuals in the general population. The dose to individuals due to average natural background radiation is about 130 millirem per year.

[3]Man-rem is an expression for the summation of whole body doses to individuals in a group. Thus, if each member of a population group of 1,000 people were to receive a dose of 0.001 rem (1 millirem), or if 2 people were to receive a dose of 0.5 rem (500 millirem) each, the total man-rem dose in each case would be 1 man-rem.

[4]Athough the environmental risk of radiological effects stemming from transportation accidents is currently incapable of being numerically quantified, the risk remains small regardless of whether it is being appiled to a single reactor or a multireactor site.

6.2 RADTRAN Methodology

The RADTRAN code can either be used with the RadCat Graphical User Interface or with a traditional text file input. This calculation uses version 2.3 of RadCat to generate input files for version 5.6 of RADTRAN. RADTRAN can calculate both an accident scenario and an incident free scenario in one run. However, some parameters such as radionuclides and weather only factor into the accident analysis. This calculation requires two RADTRAN runs. One run is for an incident free shipment of new fuel. The other run considers both an incident free and an accident scenario for a shipment of spent fuel.

The first set of inputs involves specification of the package (container). The length of the package and dose rate of the package are entered along with the fraction of gamma rays and neutrons.

The second set of inputs involves specification of the source term. The source term name, type, and activity in curies are required. There are 5 types of radionuclides: Gas, Particulate, Cesium, Ruthenium, and CRUD. The gas type includes krypton and tritium. Cesium and ruthenium contain their respective isotopes. CRUD is composed of cobalt that is assumed to be deposited on the cladding. Particulates are other fission products and actinides that are contained in the fuel rod.

The next set of inputs is the vehicle specification. The dimensions of the truck, crew size, and vehicle dose rate are all inputs for this section. Also, the gamma and neutron fractions are specified here as well as in the package section.

The link section input comes from some user entered parameters and route parameters imported directly from TRAGIS. TRAGIS inputs are described in Reference 3.13.

The stop section defines the risk associated with parking the truck for a period of time. An area around the truck is defined and the population density relating to that area is entered. The average stop time and shielding factor for people around the truck are also defined.

The next input section used is the accident definition section. Severity fractions, deposition velocities, release fractions, aerosol fractions, respirable fractions, population densities, and weather parameters are all inputs in this section. The population and weather parameters are set to defaults and the rest of the inputs come directly from NUREG/CR-6672, “Reexamination of Spent Fuel Shipment Risk Estimates” [Reference 3.8].

The final section of RADTRAN inputs are various parameters that are needed for the analysis, but come as default parameters in the RadCat GUI. There are a total of 35 parameters in this section. They are explained more in depth in the RadCat/RADTRAN manual [Reference 3.11].

Outputs of interest are the dose rates for incident-free transport and the dose rates for an accident scenario. These dose rates are reported in person-rem.

7.0 Calculations

7.1 Risks of Transporting New Fuel

Transporting new fuel on the proposed route leads to the in-transit population exposure in person-rem reported in Table 7.1 below.

Table 7.1 New Fuel In-Transit Incident Free Population Exposure in Person-Rem for One New Fuel Shipment

	CREW	OFF LINK	ON LINK	TOTALS
RURAL_AZ	6.48E-04	1.22E-06	5.72E-05	7.07E-04
SUBURBN_AZ	1.05E-04	6.07E-06	2.41E-05	1.35E-04
URBAN_AZ	1.29E-05	1.11E-07	5.80E-06	1.88E-05
RURAL_CA	2.59E-04	4.66E-07	5.32E-05	3.13E-04
SUBURBN_CA	5.97E-05	3.73E-06	2.88E-05	9.22E-05
URBAN_CA	3.47E-05	3.63E-07	2.93E-05	6.44E-05
RURAL_NM	2.97E-04	5.41E-07	2.08E-04	5.06E-04
SUBURBN_NM	3.84E-05	2.11E-06	4.97E-06	4.55E-05
URBAN_NM	4.25E-06	3.25E-08	1.52E-06	5.81E-06
RURAL_TX	1.06E-03	1.75E-06	1.26E-04	1.18E-03
SUBURBN_TX	1.95E-04	1.17E-05	5.13E-05	2.58E-04
URBAN_TX	2.58E-05	2.27E-07	1.48E-05	4.08E-05
RURAL	2.26E-03	3.97E-06	4.45E-04	2.71E-03
SUBURB	3.98E-04	2.36E-05	1.09E-04	5.31E-04
URBAN	7.76E-05	7.34E-07	5.15E-05	1.30E-04
TOTALS:	2.74E-03	2.84E-05	6.05E-04	3.37E-03

Table S-4 of 10 CFR 51.52 lists environmental impacts for transportation of fuel and waste to and from one light-water-cooled nuclear power reactor for one reactor year. The CPNPP fuel loading scheme requires an initial fuel loading of 257 fuel assemblies along with approximately 129 fuel assemblies needed every 24 months for reload operations (based on replacing half the core with fresh fuel). Because 12 assemblies per vehicle are assumed, the total amount of shipments for one unit per reactor year after the first reactor year is approximately 6 (rounded up). The total radiation exposure to the public is presented in Table 7.2. Note that the public around a truck stop dose of 4.15E-03 person-rem/shipment is added to the on-link dose.

Table 7.2 New Fuel In-Transit Incident Free Population Exposure for One Unit per Reactor Year

	On Link	Off Link	Crew
Dose/reactor year (person-rem)	2.85E-02	1.70E-04	1.64E-02

7.2 Risks of Transporting Spent Fuel

7.2.1 Incident Free Transport of Spent Fuel

Transporting spent fuel on the proposed route leads to the in-transit population exposure in person-rem reported in Table 7.3.

Table 7.3 Spent Fuel In-Transit Incident Free Population Exposure in Person-Rem for One Spent Fuel Shipment

	CREW	OFF LINK	ON LINK	TOTALS
RURAL_AZ	2.44E-02	1.28E-04	7.88E-03	3.24E-02
SUBURBN_AZ	1.74E-03	4.17E-04	1.45E-03	3.61E-03
URBAN_AZ	1.65E-04	5.13E-06	2.72E-04	4.42E-04
RURAL_CA	4.68E-03	9.44E-06	3.51E-03	8.20E-03
SUBURBN_CA	3.02E-04	5.60E-05	5.33E-04	8.92E-04
URBAN_CA	1.37E-05	3.26E-07	4.25E-05	5.66E-05
RURAL_NV	1.32E-02	5.81E-05	5.76E-03	1.90E-02
SUBURBN_NV	1.18E-03	1.94E-04	1.13E-03	2.51E-03
URBAN_NV	5.04E-05	1.63E-06	1.06E-04	1.58E-04
RURAL_NM	2.38E-02	1.37E-04	6.09E-03	3.00E-02
SUBURBN_NM	2.91E-03	5.84E-04	1.38E-03	4.87E-03
URBAN_NM	6.32E-04	2.03E-05	8.28E-04	1.48E-03
RURAL_OK	1.64E-02	1.40E-04	7.57E-03	2.41E-02
SUBURBN_OK	3.50E-03	8.71E-04	2.45E-03	6.82E-03
URBAN_OK	5.96E-04	1.81E-05	6.47E-04	1.26E-03
RURAL_TX	1.82E-02	1.35E-04	7.97E-03	2.63E-02
SUBURBN_TX	4.88E-03	1.13E-03	4.70E-03	1.07E-02
URBAN_TX	9.53E-04	2.81E-05	2.01E-03	2.99E-03
RURAL	1.01E-01	6.07E-04	3.88E-02	1.40E-01
SUBURB	1.45E-02	3.25E-03	1.16E-02	2.94E-02
URBAN	2.41E-03	7.35E-05	3.90E-03	6.39E-03
TOTALS:	1.18E-01	3.93E-03	5.43E-02	1.76E-01

Because 4 spent fuel assemblies are assumed per truck, it would take approximately 32 shipments every 2 years to completely dispose of the spent fuel from one refueling outage. This equates to 16 shipments per year. The total radiation exposure to the public is presented in Table 7.4. Note that the public around a truck stop dose of 5.39E-01 person-rem/shipment is added to the on-link dose.

Table 7.4 Spent Fuel In-Transit Incident Free Population Exposure for One Unit per Reactor Year

	On Link	Off Link	Crew
Dose/reactor year (person-rem)	9.49	6.29E-02	1.89

7.2.2 Accident Scenario for a Spent Fuel Shipment

An accident scenario regarding shipments of spent fuel could potentially compromise the integrity of the shipping container and release radioactive material. There are 5 different scenarios in which radioactive material can enter the body. The first method is radioactive material depositing on the ground with the ground then becoming a radiation source (groundshine). The next scenario is when radioactive materials are suspended in air with the air becoming a radiation source (cloudshine). Inhaled particles may deposit inside of the body and then affect the internal organs (inhalation). The next scenario is when particles are deposited on the ground and then suspended in air after a certain period of time (resuspension). The last scenario is radioactive material depositing on crops and then ingested through a food pathway (ingestion). The population doses from these scenarios, except for ingestion (See Assumption 4.9), are quantified in Table 7.5.

Table 7.5 Spent Fuel Accident Scenario Population Exposure in Person-Rem for Single Assembly Spent Fuel Shipment

	GROUND	INHALED	RESUSPD	CLOUDSH	TOTAL
RURAL_AZ	3.36E-08	2.90E-09	2.15E-11	3.79E-11	3.66E-08
SUBURBN_AZ	1.26E-07	1.09E-08	8.08E-11	1.42E-10	1.37E-07
URBAN_AZ	2.18E-07	1.88E-08	1.39E-10	2.45E-10	2.37E-07
RURAL_CA	2.48E-09	2.14E-10	1.59E-12	2.80E-12	2.70E-09
SUBURBN_CA	1.70E-08	1.46E-09	1.08E-11	1.91E-11	1.84E-08
URBAN_CA	1.39E-08	1.19E-09	8.87E-12	1.56E-11	1.51E-08
RURAL_NV	1.53E-08	1.32E-09	9.78E-12	1.72E-11	1.66E-08
SUBURBN_NV	5.86E-08	5.04E-09	3.75E-11	6.60E-11	6.37E-08
URBAN_NV	6.91E-08	5.95E-09	4.42E-11	7.78E-11	7.52E-08
RURAL_NM	3.61E-08	3.11E-09	2.31E-11	4.06E-11	3.92E-08
SUBURBN_NM	1.77E-07	1.52E-08	1.13E-10	1.99E-10	1.92E-07
URBAN_NM	8.63E-07	7.43E-08	5.52E-10	9.72E-10	9.39E-07
RURAL_OK	3.68E-08	3.17E-09	2.35E-11	4.14E-11	4.00E-08
SUBURBN_OK	2.64E-07	2.27E-08	1.69E-10	2.97E-10	2.87E-07
URBAN_OK	7.69E-07	6.62E-08	4.92E-10	8.66E-10	8.36E-07
RURAL_TX	3.55E-08	3.05E-09	2.27E-11	4.00E-11	3.86E-08
SUBURBN_TX	3.41E-07	2.94E-08	2.18E-10	3.84E-10	3.71E-07
URBAN_TX	1.19E-06	1.03E-07	7.63E-10	1.34E-09	1.30E-06
RURAL	1.60E-07	1.38E-08	1.02E-10	1.80E-10	1.74E-07
SUBURB	9.83E-07	8.47E-08	6.29E-10	1.11E-09	1.07E-06
URBAN	3.13E-06	2.69E-07	2.00E-09	3.52E-09	3.40E-06
TOTALS:	4.27E-06	3.67E-07	2.73E-09	4.81E-09	4.64E-06

The values in Table 7.5 are for one spent fuel assembly. Because the shipping cask is assumed to have 4 spent fuel assemblies, any breach of one assembly is assumed to breach all assemblies. This means that the total population dose for an accident scenario affecting a spent fuel shipping truck is 1.86E-05 person-rem.

From Appendix 1, the decay heat load of one spent fuel assembly is 1970 watts. Therefore, the total decay heat of one spent fuel container is 7880 watts (26,888 BTU/hr). This value is less than the limit of 250,000 BTU/hr given in Table S-4 of 10 CFR 51.52.

7.3 Transportation of Radioactive Waste

The total amount of radioactive waste in Table 5.9 is summed to obtain a waste value of 15278 cubic feet per unit per reactor year. Because trucks have the capacity of approximately 1000 cubic feet per shipment (Section 5.4), there will need to be approximately 16 shipments of radioactive waste per year. This means that the waste will require less than 1 truck per day to comply with 10 CFR 51.52 (Section 6.1). To comply with the weight limit of less than 33,100 kg (73,000 lb) per shipment, more shipments may have to be made than 16 per year, but this number of shipments will never require more than 1 shipment per day.

8.0 Appendices

Appendix 1: Source Term and Decay Heat Load Generation Using ORIGEN-ARP

RADTRAN requires a listing of nuclides along with their respective activities to calculate the effects of an accident scenario that could potentially release radioactive material. Oak Ridge Isotope Generation Automatic Rapid Processing (ORIGEN-ARP) is a program in the Standardized Computer Analyses for Licensing Evaluation (SCALE) package of code issued by the Radiation Safety Information Computational Center (RSICC) at Oak Ridge National Laboratory. ORIGEN-ARP evaluates source terms contained in fuel assemblies for a specified reactor core. This source term is used to calculate the effects of an accident involving a spent fuel transportation vehicle in which radioactive material is released.

Assumptions

1) The lattice parameters from the default 17X17 cross section library are assumed to apply to the source term generation calculation using ORIGEN-ARP.
Basis: The 17X17 Westinghouse fuel parameters used to generate the cross sections are nearly identical to the 17X17 Mitsubishi Heavy Industries fuel parameters. The major parameters including pitch, pellet outside diameter, clad thickness, and number of rods are all identical to 3 significant figures and are presented in Table A1-1.

Table A1-1 Comparison of Fuel Parameters

Assembly Type	Pitch (inch)	Pellet Outside Diameter (inch)	Fuel Rod Outside Diameter (inch)	Clad Thickness (cm)	Number of Rods
Westinghouse 17X17	0.496	0.3225	0.374	0.0224	264
Mitsubishi 17X17	0.496	0.322	0.374	0.0224	264

2) The material temperatures from the default 17X17 cross section library are assumed to apply to the source term generation calculation using ORIGEN-ARP.
Basis: The 17X17 Westinghouse temperature parameters and the 17X17 Mitsubishi Heavy Industries temperature parameters are assumed to be generic PWR temperatures. The fuel temperature of 811 K and moderator temperature of 570 K are typical for PWRs.

3) Materials such as clad and fuel hardware are not considered in this source term analysis.
Basis: For a transportation accident that could potentially release nuclear material from a spent fuel shipping container, these components will not be composed of materials that could potentially deposit in the air, on the ground, or in the body.

4) Fuel rods containing gadolinium are not considered in this source term analysis.
Basis: For the high burnup achieved by the US-APWR, the gadolinium will burn out well before the time the assembly is discharged from the reactor (approximately 10 GWd/MTU vs. the 62 GWd/MTU modeled herein). The significance of gadolinium activation products to the source term is therefore negligible.

Design Input

The 17X17 cross section library was chosen along with the 238 Group ENDF5 neutron energy group structure. The 44 Group ENDF5 gamma group structure was chosen to model the gamma energies in the core. The composition of fuel in the core is outlined in Table A1-2. The total amount of uranium in one assembly is approximately 5.40E-01 MTU based on the value of 1350 pounds of UO_2 per assembly from Chapter 4 of the US-APWR DCD.

$$1350\text{lbs} \times \frac{\text{kg}}{2.2\text{lbs}} \times 0.88 \frac{\text{gU}}{\text{gUO}_2} \times \frac{\text{MTU}}{1000\text{kg}} = 0.54\text{MTU}$$

Table A1-2 ORIGEN-ARP Elemental Compositions*

Element/Isotope	Amount (grams)
U-234	2.40E02
U-235	2.70E04
U-236	1.24E02
U-238	5.12E05
O	7.26E04

To model the irradiation and decay of the fuel, time steps of 95 days each were entered up to 1900 days of total irradiation at 17.67 MW total thermal power for one assembly (4451 MW × 1.02 / 257). This is equivalent to 62,000 MWd/MTU of burnup. Then, the fuel is allowed to decay for 5 years. The ORIGEN-S file generated by ORIGEN-ARP is altered to output more isotopes than set as default. The ORIGEN-S file is also altered so that the final output is in curies and not grams. The detailed ORIGEN-S input file is provided in Appendix 2.

Methodology

After installation of the SCALE5 code package, a verification case was run to ensure that the ORIGEN-ARP program was properly installed and ran as intended. The sample cases supplied with the code were entered, and the outputs were compared to the ORIGEN-S input files supplied with the code. The ORIGEN-S files generated by ORIGEN-ARP were determined to match the ORIGEN-S files provided in the SCALE5 code manual. Validation of one aspect of the ORIGEN-ARP module can be found in Oak Ridge National Laboratory Document ORNL/TM-13584, "ARP: Automatic Rapid Process for the Generation of Problem-Dependent SAS2H/ORIGEN-S Cross-Section Libraries." Validations for other SCALE modules can be found on the SCALE website (http://www.ornl.gov/sci/scale/validation.htm).

The use of ORIGEN-ARP involves setting parameters regarding fuel burnup and decay to acquire a source term for the RADTRAN model. The first step is setting the uranium enrichment, amount of fuel, and reactor geometry. The neutron and gamma libraries were chosen and then the irradiation and decay cases were set up. Origen-ARP creates an ORIGEN-S input file and then runs it through the SCALE program. Outputs of the ORIGEN-S run are given in curies per isotope. All isotopes with non-negligible activities after 5 years are then entered into the RADTRAN radionuclides input section. Less than .5% of the total activity is not considered (26.35 Ci vs. 5.39E+05 Ci) after important isotopes are extracted.

To calculate decay heat load instead of the radioactivity of the isotopes, the 65$$ input line is changed so that the output is in watts and not curies.

* Calculated by ORIGEN-ARP based on MTU and ^{235}U enrichment.

Calculations

The ORIGEN-ARP calculation yielded the source term presented in Table A1-3 . This source term is used directly as an input to the RADTRAN spent fuel accident scenario analysis. The detailed ORIGEN-S output from the source term decay case is presented in Appendix 3.

The decay heat load for one assembly is shown in Table A1-4. Note that h3 (tritium) is listed twice because it is both a light element and a fission product.

Table A1-3 Spent Fuel Source Term for a Single US-APWR Fuel Assembly (Curies)

np239	4.02E+01	ru106	1.33E+04
pu238	5.13E+03	rh106	1.33E+04
pu239	2.20E+02	ag110m	2.93E+01
pu240	3.76E+02	cd113m	2.69E+01
pu241	9.07E+04	sb125	1.83E+03
am241	9.77E+02	te125m	4.48E+02
am242m	1.10E+01	cs134	3.46E+04
am242	1.10E+01	cs137	9.50E+04
am243	4.02E+01	ba137m	8.98E+04
cm242	3.28E+01	ce144	7.49E+03
cm243	3.11E+01	pr144	7.49E+03
cm244	6.77E+03	pr144m	1.05E+02
h 3	3.50E+02	pm147	2.79E+04
kr 85	5.90E+03	sm151	3.49E+02
sr 90	6.46E+04	eu154	5.55E+03
y 90	6.46E+04	eu155	1.48E+03
tc 99	1.26E+01	Total	5.39E+05

Table A1-4 Spent Fuel Decay Heat Load for a Single US-APWR Fuel Assembly (Watts)

h3	2.58E-10	pu240	1.17E+01	ag110m	4.89E-01
be10	4.98E-09	pu241	2.88E+00	cd113m	2.93E-02
c14	2.34E-05	pu242	7.19E-02	sn119m	5.78E-04
tl208	2.62E-04	am241	3.26E+01	sn121	1.16E-03
pb212	5.90E-05	am242m	4.45E-03	sn121m	5.08E-04
bi212	5.23E-04	am242	1.26E-02	sb125	5.80E+00
po212	1.06E-03	am243	1.30E+00	te125m	3.77E-01
po216	1.28E-03	cm242	1.20E+00	sn126	8.72E-04
rn220	1.19E-03	cm243	1.14E+00	sb126	1.45E-03
ra224	1.07E-03	cm244	2.37E+02	sb126m	7.25E-03
th228	1.02E-03	cm245	2.88E-02	te127	9.58E-05
th234	6.81E-05	cm246	1.08E-02	cs134	3.53E+02
pa233	9.77E-04	cf250	5.34E-05	cs135	1.86E-04
pa234m	8.06E-04	cf252	1.22E-04	cs137	1.06E+02
u232	1.34E-03	h3	1.18E-02	ba137m	3.53E+02
u234	2.02E-02	se79	2.10E-04	ce144	4.90E+00
u235	2.28E-04	kr85	8.85E+00	pr144	5.49E+01
u236	6.80E-03	sr90	7.50E+01	pr144m	3.60E-02
u237	4.20E-03	y90	3.58E+02	pm146	1.16E-02
u238	4.16E-03	zr93	1.30E-04	pm147	1.03E+01
np237	1.10E-02	tc99	6.33E-03	sm151	4.10E-02
np238	2.47E-04	rh102	8.02E-03	eu152	3.80E-02
np239	1.02E-01	ru106	7.92E-01	gd153	9.80E-05
pu236	8.72E-03	rh106	1.28E+02	eu154	5.04E+01
pu238	1.70E+02	ag108m	1.35E-04	eu155	1.15E+00
pu239	6.85E+00	ag110	2.86E-03	Total	1.97E+03

Appendix 2: Discussion of Alternate Sites

This analysis compares the risks of transporting radioactive materials between proposed sites for the Luminant COLA. The only change between the sites is in the link section of RADTRAN. Alternate Site B is at a further distance away from Yucca Mountain than the other sites so an additional stop is needed. Different sites' transportation routes traverse through different areas that may or may not increase the risk of transporting nuclear materials. Table A2-1 shows the risks of incident free transport of new fuel. Table A2-2 shows the risks of incident free transport of spent fuel. Table A2-3 shows the comparison of accident scenario risk.

Table A2-1 Incident Free Risk of Transporting 1 New Fuel Shipping Container by Site in Person-Rem

	Crew	On-Link	Off-Link	Public – Around Truck Stop	Total Link Length (km)
CPNPP	2.74E-03	6.05E-04	2.84E-05	4.15E-03	2123.5
Alternate Site A	2.91E-03	6.32E-04	2.96E-05	4.15E-03	2254.4
Alternate Site B	3.32E-03	7.09E-04	3.93E-05	4.15E-03	2574.6
Alternate Site C	2.83E-03	6.21E-04	2.98E-05	4.15E-03	2198.1

Table A2-2 Incident Free Risk of Transporting 1 Spent Fuel Shipping Container by Site in Person-Rem

	Crew	On-Link	Off-Link	Public – Around Truck Stop	Total Link Length (km)
CPNPP	1.18E-01	5.43E-02	3.93E-03	5.39E-01	2567.4
Alternate Site A	1.31E-01	6.01E-02	3.96E-03	5.39E-01	2848.3
Alternate Site B	1.42E-01	7.30E-02	6.42E-03	6.06E-01	3095
Alternate Site C	1.19E-01	5.54E-02	3.99E-03	5.39E-01	2605.2

Table A2-3 Accident Risks of Transporting 1 Spent Fuel Shipping Container by Site in Person-Rem

	CPNPP	Alternate Site A	Alternate Site B	Alternate Site C
Total Dose	4.64E-06	4.79E-06	9.18E-06	4.74E-06

Appendix 3: ORIGEN-S Input and Output Summary

ORIGEN-S Input

```
'This SCALE input file was generated by
'OrigenArp Version  5.00  May 21, 2004
=arp
17x17
4.9999993
2
950
950
32.73217
32.73217
1
1
0.7295
ft33f001
end
#origens
0$$ a4 33 a11 71 e t
17x17 library, interpolated to 4.999999 wt% -- ft33f001
3$$ 33 a3 1 238 a16 2 a33 44 e t
35$$ 0 t
56$$ 10 10 a6 3 a10 0 a13 5 a15 3 a18 1 e
57** 0 a3 1e-05 0.5 e t
Case 1
0.54 MTU
58** 17.67 17.67 17.67 17.67 17.67 17.67 17.67 17.67
 17.67 17.67
60** 95 190 285 380 475 570 665 760 855 950
66$$ a1 2 a5 2 a9 2 e
73$$ 922340 922350 922360 922380 80000
74** 240.182 26986.75 124.139 512384 72615
75$$ 2 2 2 2 4
t
17x17 library, interpolated to 4.999999 wt% -- ft33f001
3$$ 33 a3 2 238 a33 44 e t
35$$ 0 t
56$$ 10 10 a10 10 a15 3 a18 1 e
57** 950 a3 1e-05 0.5 e t
Case 1
0.54 MTU
58** 17.67 17.67 17.67 17.67 17.67 17.67 17.67 17.67
 17.67 17.67
60** 1045 1140 1235 1330 1425 1520 1615 1710 1805 1900
66$$ a1 2 a5 2 a9 2 e t
54$$ a8 1 a11 0 e
56$$ a2 1 a10 10 a14 5 a15 3 a17 4 e
57** 0 a3 1e-05 e
95$$ 0 t
Case 3
```

```
0.54 MTU
60** 5
61** f0.000005
65$$
'Gram-Atoms   Grams   Curies   Watts-All   Watts-Gamma
 3z   3z   1   0   0   3z   3z   6z
 3z   3z   1   0   0   3z   3z   6z
 3z   3z   1   0   0   3z   3z   6z
t
56$$ f0 t
end
```

Total Activity in Curies for all Isotopes after 5 Year Cooling Period from ORIGEN-S Output

light elements	h 3	7.65E-06
	be 10	4.15E-06
	c 14	7.98E-02
actinides	tl208	1.12E-02
	pb212	3.12E-02
	bi212	3.12E-02
	po212	2.00E-02
	po216	3.12E-02
	rn220	3.12E-02
	ra224	3.12E-02
	th228	3.12E-02
	th231	8.24E-03
	th234	1.65E-01
	pa233	3.85E-01
	pa234m	1.65E-01
	u232	4.17E-02
	u234	7.03E-01
	u235	8.24E-03
	u236	2.51E-01
	u237	2.17E+00
	u238	1.65E-01
	np237	3.85E-01
	np238	4.95E-02
	np239	4.02E+01
	pu236	2.51E-01
	pu238	5.13E+03
	pu239	2.20E+02
	pu240	3.76E+02
	pu241	9.07E+04
	pu242	2.44E+00

	am241	9.77E+02
	am242m	1.10E+01
	am242	1.10E+01
	am243	4.02E+01
	cm242	3.28E+01
	cm243	3.11E+01
	cm244	6.77E+03
	cm245	8.67E-01
	cm246	3.30E-01
fission products	h 3	3.50E+02
	se 79	6.68E-01
	kr 85	5.90E+03
	sr 90	6.46E+04
	y 90	6.46E+04
	zr 93	1.16E+00
	nb 93m	3.29E-01
	tc 99	1.26E+01
	rh102	6.25E-01
	ru106	1.33E+04
	rh106	1.33E+04
	pd107	1.23E-01
	ag110	3.99E-01
	ag110m	2.93E+01
	cd113m	2.69E+01
	sn119m	1.12E+00
	sn121	1.70E+00
	sn121m	2.20E+00
	sb125	1.83E+03
	te125m	4.48E+02
	sn126	5.59E-01
	sb126	7.83E-02
	sb126m	5.59E-01
	te127	7.05E-02
	te127m	7.20E-02
	i129	3.18E-02
	cs134	3.46E+04
	cs135	5.57E-01
	cs137	9.50E+04
	ba137m	8.98E+04
	ce144	7.49E+03
	pr144	7.49E+03

pr144m	1.05E+02
pm146	2.33E+00
pm147	2.79E+04
sm151	3.49E+02
eu152	4.98E+00
gd153	1.12E-01
eu154	5.55E+03
eu155	1.48E+03
Total	5.39E+05

Appendix 4: Sample RADTRAN Input/Output Files

Comanche Peak to Yucca Mountain Input/Output

```
                    RUN DATE: [ 15-APR-08 AT 08:59:26 ]          PAGE    1

  RRRR    AAA   DDDD   TTTTT  RRRR    AAA   N   N  55555        6
  R   R  A   A  D   D    T    R   R  A   A  NN  N  5            6
  R   R  A   A  D   D    T    R   R  A   A  N N N  5            6
  RRRR   A   A  D   D    T    RRRR   A   A  N  NN  5555         6666
  R R    AAAAA  D   D    T    R R    AAAAA  N   N      5        6   6
  R  R   A   A  D   D    T    R  R   A   A  N   N  5   5        6   6
  R   R  A   A  DDDD     T    R   R  A   A  N   N  5555     *    666

                           RADTRAN 5.6   February 20, 2006

                                   INPUT ECHO
                                   ----------


 TITLE CPNPP Spent Fuel to Yucca Mountain
 INPUT STANDARD
STD: 0 10 18                              && DIMEN=NSEV NRAD NAREAS
STD: 1 3 3 0                              && PARM=IRNKC IANA ISEN IPSQSB
STD: .TRUE. .FALSE.                       && FORM = UNIT, SI-UNITS?
STD: 2.3E12                               && NEVAL FOR CF252
STD: 9.25E5 5.77E6 1.27E6                 && RPCTHY FOR I125, I129, I131
STD: 0.0 0.0 0.0 0.0 0.0                  && TRANSFER GAMMA
STD: 7.42E-3 2.02E-2 6.17E-5 3.17E-8 0.0  && TRANSFER NEUTRON
STD: 30  24                               && MITDDIST  MITDVEL
STD: 1  2   .0018                         && ITRAIN FMINCL DDRWEF
STD:    33    68    105   244   369               && CENTER LINE
STD:   561  1018   1628  2308  4269               && DISTANCES
STD:  5468 11136  13097 21334 40502               && FOR AVERAGE
STD: 69986 89860 120878 0 0 0 0 0 0 0 0 0 0 0 0   && US CLOUD
STD: 4.59E+02 1.53E+03 3.94E+03 1.25E+04 3.04E+04 6.85E+04 1.76E+05 4.45E+05
STD: 8.59E+05 2.55E+06 4.45E+06 1.03E+07 2.16E+07 5.52E+07 1.77E+08 4.89E+08
STD: 8.12E+08 1.35E+09 0 0 0 0 0 0 0 0 0 0 0 0     && AREADA
STD: 3.42E-03 1.72E-03 8.58E-04 3.42E-04 1.72E-04 8.58E-05 3.42E-05 1.72E-05
STD:  8.58E-06 3.42E-06 1.72E-06 8.58E-07 3.42E-07 1.72E-07 8.58E-08 5.42E-08
STD:  4.30E-08 3.42E-08 0 0 0 0 0 0 0 0 0 0 0 0     && DFLEV
STD: 3 6 9 12 15 30 61 91 152 305 0 0 0 0 0
STD: 3 6 9 12 15 30 61 91 152 305 0 0 0 0 0
STD: 3 6 9 12 15 30 61 91 152 305 0 0 0 0 0 && RADIST
STD: 0.5                              && SMLPKG
STD: 1.0  0.87  0.018                 && SHIELDING FACTORS RR  RS  RU
STD:  30  30  800                     && OFFLINK {FREEWAY}
STD:  27  30  800                     && OFFLINK {NON-FREEWAY}
STD:   5   8  800                     && OFFLINK {CITY STREETS}
STD:  30  30  800                     && OFFLINK {RAILWAY}
STD: 200 200 1000                     && OFFLINK {WATERWAY}
STD: 15  3  3  3  4                   && ONLINK {FWAY NONFWY STREET RAIL ADJ}
STD: 6.0  4  40.0                     && RPD FNOATT INTERDICT
STD: 0.05   0.2   3.3E-4              && BDF CULVL BRATE
STD: 0.9   0.1                        && UBF USWF
STD: 1.0  10.0 1.0                    && EVACUATION SURVEY CAMPAIGN
```

```
                    RUN DATE: [ 15-APR-08 AT 08:59:26 ]          PAGE     2

                      CPNPP Spent Fuel to Yucca Mountain

STD: 0.0  0.0     1.5E-8  5.3E-8      && HIGHWAY - RURAL - NONRAD
STD: 0.0  0.0     3.7E-9  1.3E-8      && HIGHWAY - SUBURBAN - NONRAD
STD: 0.0  0.0     2.1E-9  7.5E-9      && HIGHWAY - URBAN - NONRAD
STD: 0.0  0.0    1.81E-9  2.64E-8     && GENERAL FREIGHT - R - NONRAD
STD: 0.0  0.0    1.81E-9  2.64E-8     && GENERAL FREIGHT - S - NONRAD
STD: 0.0  0.0    1.81E-9  2.64E-8     && GENERAL FREIGHT - U - NONRAD
STD: 0.0  0.0    1.27E-7  1.85E-6     && DEDICATED RAIL - R - NONRAD
STD: 0.0  0.0    1.27E-7  1.85E-6     && DEDICATED RAIL - S - NONRAD
STD: 0.0  0.0    1.27E-7  1.85E-6     && DEDICATED RAIL - U - NONRAD
STD: 0.0 0.0 0.0 0.0 0.0 0.0          && PSPROB
STD: 0.67  0.67  0.42                 && TIMENDE NON-DISPERSAL EVAC TIME (LCF&EARLY)
STD: 2 2 1                            && FLAGS=IUOPT IACC REGCHECK
STD: 5E-4, 4E-4, 1.0E-4               && LCFCON(1), LCFCON(2), GECON
STD: R5INGEST.BIN                     && INGESTION FILE
 OUTPUT CI_REM
 FORM UNIT
 DIMEN 19 10 18
 PARM 1 3 1 0
 SEVERITY
    NPOP=1
       NMODE=1
        1.53E-8
  6.19E-5 2.81E-7 6.99E-8 4.89E-7 9.22E-11
  3.3E-12 1.17E-8 1.9E-12 0.0 1.49E-10
  2.41E-14 0.0 6.99E-11 3.3E-15 0.0
  0.0 5.59E-6 0.9994
    NPOP=2
       NMODE=1
        1.53E-8
  6.19E-5 2.81E-7 6.99E-8 4.89E-7 9.22E-11
  3.3E-12 1.17E-8 1.9E-12 0.0 1.49E-10
  2.41E-14 0.0 6.99E-11 3.3E-15 0.0
  0.0 5.59E-6 0.9994
    NPOP=3
       NMODE=1
        1.53E-8
  6.19E-5 2.81E-7 6.99E-8 4.89E-7 9.22E-11
  3.3E-12 1.17E-8 1.9E-12 0.0 1.49E-10
  2.41E-14 0.0 6.99E-11 3.3E-15 0.0
  0.0 5.59E-6 0.9994
 RELEASE
    GROUP=Particul
       RFRAC
          6.0E-7
  1.0E-7 1.3E-7 3.8E-6 3.2E-7 3.7E-7
  2.1E-6 6.1E-7 6.7E-7 6.8E-7 6.1E-7
  6.7E-7 6.8E-7 1.8E-5 9.0E-6 6.8E-7
  6.8E-7 6.7E-8 0.0
       AERSOL
          1.0
```

```
1.0 1.0 1.0 1.0 1.0
1.0 1.0 1.0 1.0 1.0
1.0 1.0 1.0 1.0 1.0
1.0 1.0 1.0
     RESP
        1.0
1.0 1.0 1.0 1.0 1.0
1.0 1.0 1.0 1.0 1.0
1.0 1.0 1.0 1.0 1.0
1.0 1.0 1.0
     LOS
        0.0
0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0
     DEPVEL 0.01
  GROUP=CRUD
     RFRAC
        0.0020
0.0014 0.0018 0.0032 0.0018 0.0021
0.0031 0.0020 0.0022 0.0025 0.0020
0.0022 0.0025 0.0064 0.0059 0.0033
0.0033 0.0025 0.0
     AERSOL
        1.0
1.0 1.0 1.0 1.0 1.0
1.0 1.0 1.0 1.0 1.0
1.0 1.0 1.0 1.0 1.0
1.0 1.0 1.0
     RESP
        1.0
1.0 1.0 1.0 1.0 1.0
1.0 1.0 1.0 1.0 1.0
1.0 1.0 1.0 1.0 1.0
1.0 1.0 1.0
     LOS
        0.0
0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0
     DEPVEL 0.01
  GROUP=Krypton
     RFRAC
        0.8
0.14 0.18 0.84 0.43 0.49
0.85 0.82 0.89 0.91 0.82
0.89 0.91 0.84 0.85 0.91
0.91 0.84 0.0
     AERSOL
        1.0
1.0 1.0 1.0 1.0 1.0
```

```
1.0 1.0 1.0 1.0 1.0
1.0 1.0 1.0 1.0 1.0
1.0 1.0 1.0
     RESP
        1.0
1.0 1.0 1.0 1.0 1.0
1.0 1.0 1.0 1.0 1.0
1.0 1.0 1.0 1.0 1.0
1.0 1.0 1.0
     LOS
        0.0
0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0
     DEPVEL 0.0
  GROUP=Cesium
     RFRAC
        2.4E-8
4.1E-9 5.4E-9 3.6E-5 1.3E-8 1.5E-8
2.7E-5 2.4E-8 2.7E-8 5.9E-6 2.4E-8
2.7E-8 5.9E-6 9.6E-5 5.5E-5 5.9E-6
5.9E-6 1.7E-5 0.0
     AERSOL
        1.0
1.0 1.0 1.0 1.0 1.0
1.0 1.0 1.0 1.0 1.0
1.0 1.0 1.0 1.0 1.0
1.0 1.0 1.0
     RESP
        1.0
1.0 1.0 1.0 1.0 1.0
1.0 1.0 1.0 1.0 1.0
1.0 1.0 1.0 1.0 1.0
1.0 1.0 1.0
     LOS
        0.0
0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0
     DEPVEL 0.01
  GROUP=Rutheniu
     RFRAC
        6.0E-7
1.0E-7 1.3E-7 3.8E-6 3.2E-7 3.7E-7
2.1E-6 6.1E-7 6.7E-7 6.8E-7 6.1E-7
6.7E-7 6.8E-7 8.4E-5 5.0E-5 6.4E-6
6.4E-6 6.7E-8 0.0
     AERSOL
        1.0
1.0 1.0 1.0 1.0 1.0
1.0 1.0 1.0 1.0 1.0
```

```
                    RUN DATE: [ 15-APR-08 AT 08:59:26 ]          PAGE    5

                      CPNPP Spent Fuel to Yucca Mountain

  1.0 1.0 1.0 1.0 1.0
  1.0 1.0 1.0
       RESP
          1.0
  1.0 1.0 1.0 1.0 1.0
  1.0 1.0 1.0 1.0 1.0
  1.0 1.0 1.0 1.0 1.0
  1.0 1.0 1.0
       LOS
          0.0
  0.0 0.0 0.0 0.0 0.0
  0.0 0.0 0.0 0.0 0.0
  0.0 0.0 0.0 0.0 0.0
  0.0 0.0 0.0
       DEPVEL 0.01
DEFINE se79
   2.37E7 0.0558 1.13E-6 6.62E-9 6549.0
  2512.0 3134.0 2512.0
   NONE
DEFINE sn121
   1.13 0.116 8.78E-6 3.36E-8 335.0
  16.2 862.0 181.0
   NONE
DEFINE am242
   0.6675 0.192 0.00228 5.02E-6 58460.0
  7178.0 192400.0 48840.0
   NONE
DEFINE nb93m
   4964.0 0.0308 1.64E-5 3.0E-7 29230.0
  573.5 238650.0 421.8
   NONE
DEFINE ag110m
   249.9 0.112 0.5032 8.47E-4 39590.0
  6956.0 30007.0 14911.0
   NONE
PACKAGE SpentFuelContainer 13.9 1.0 0.0 5.2
   SR90 64600.0 Particul
   SB125 1830.0 Particul
   TE125M 448.0 Particul
   EU154 5540.0 Particul
   EU155 1480.0 Particul
   NP239 40.2 Particul
   PU238 5130.0 Particul
   PU239 220.0 Particul
   PU240 379.0 Particul
   PU241 90700.0 Particul
   AM242M 11.0 Particul
   AM243 40.2 Particul
   CM242 32.8 Particul
   CM243 31.1 Particul
   TC99 12.6 Particul
   CE144 7490.0 Particul
   PM147 27900.0 Particul
```

```
   SM151 349.0 Particul
   Y90 64600.0 Particul
   ag110m 29.3 Particul
   CM244 6770.0 Particul
   CD113M 26.9 Particul
   am242 11.0 Particul
   CO60 46.3 CRUD
   KR85 5900.0 Krypton
   H3GAS 349.0 Krypton
   CS134 34600.0 Cesium
   CS137 95000.0 Cesium
   RU106 13300.0 Rutheniu
   AM241 977.0 Particul
END
VEHICLE -1 Shipping_Truck 1.39E01 1.0 0.0 5.2 1.0 2.0 2.0 1.0 1.0
      SpentFuelContainer 1.0
FLAGS
   IACC 2
   IUOPT 2
   REGCHECK 1
MODSTD
   DISTOFF FREEWAY 3.00E01 3.00E01 8.00E02
   DISTOFF SECONDARY 2.70E01 3.00E01 8.00E02
   DISTOFF STREET 5.00E00 8.00E00 8.00E02
   DISTON
      FREEWAY 1.50E01
      SECONDARY 3.00E00
      STREET 3.00E00
      ADJACENT 4.00E00
   BDF 5.00E-02
   BRATE 3.30E-04
   CULVL 2.00E-01
   EVACUATION 1.00E00
   GECON 1.00E-04
   INTERDICT 4.00E01
   LCFCON 5.00E-04 4.00E-04
   SURVEY 1.00E01
   UBF 5.20E-01
   USWF 4.80E-01
   CAMPAIGN 8.33E-02
   MITDDIST 3.00E01
   MITDVEL 2.40E01
   RPD 6.00E00
   RR 1.00E00
   RU 1.80E-02
   RS 8.70E-01
   SMALLPKG 5.00E-01
   RPCTHYROID
      I131   1.27E06
EOF
LINK RURAL_AZ Shipping_Truck 533.2 88.0 2.0 7.0 825.0 1.86E-6 0.0070 R 1 0.0
LINK SUBURBN_AZ Shipping_Truck 37.9 88.0 2.0 369.9 2140.0 1.86E-6 0.0070 S 1 0.0
LINK URBAN_AZ Shipping_Truck 3.6 88.0 2.0 2311.5 4210.0 1.86E-6 0.0070 U 1 0.0
LINK RURAL_CA Shipping_Truck 102.1 88.0 2.0 2.7 1920.0 1.86E-6 0.0070 R 1 0.0
LINK SUBURBN_CA Shipping_Truck 6.6 88.0 2.0 285.0 4510.0 1.86E-6 0.0070 S 1 0.0
LINK URBAN_CA Shipping_Truck 0.3 88.0 2.0 1764.7 7910.0 1.86E-6 0.0070 U 1 0.0
LINK RURAL_NV Shipping_Truck 287.5 88.0 2.0 5.9 1119.0 1.86E-6 0.0070 R 1 0.0
LINK SUBURBN_NV Shipping_Truck 25.7 88.0 2.0 252.9 2463.0 1.86E-6 0.0070 S 1 0.0
LINK URBAN_NV Shipping_Truck 1.1 88.0 2.0 2398.6 5385.0 1.86E-6 0.0070 U 1 0.0
LINK RURAL_NM Shipping_Truck 519.7 88.0 2.0 7.7 654.0 1.86E-6 0.0070 R 1 0.0
LINK SUBURBN_NM Shipping_Truck 63.5 88.0 2.0 308.9 1210.0 1.86E-6 0.0070 S 1 0.0
```

```
LINK URBAN_NM Shipping_Truck 13.8 88.0 2.0 2387.3 3350.0 1.86E-6 0.0070 U 1 0.0
LINK RURAL_OK Shipping_Truck 358.1 88.0 2.0 11.4 1180.0 1.86E-6 0.0070 R 1 0.0
LINK SUBURBN_OK Shipping_Truck 76.4 88.0 2.0 382.7 1790.0 1.86E-6 0.0070 S 1 0.0
LINK URBAN_OK Shipping_Truck 13.0 88.0 2.0 2257.4 2780.0 1.86E-6 0.0070 U 1 0.0
LINK RURAL_TX Shipping_Truck 397.6 88.0 2.0 9.9 1119.0 1.86E-6 0.0070 R 1 0.0
LINK SUBURBN_TX Shipping_Truck 106.5 88.0 2.0 355.3 2463.0 1.86E-6 0.0070 S 1 0.0
LINK URBAN_TX Shipping_Truck 20.8 88.0 2.0 2188.9 5385.0 1.86E-6 0.0070 U 1 0.0

STOP STOP_1 Shipping_Truck 64300.0 1.0 10.0 1.0 0.5
STOP STOP_2 Shipping_Truck 64300.0 1.0 10.0 1.0 0.5
STOP STOP_3 Shipping_Truck 64300.0 1.0 10.0 1.0 0.5
STOP STOP_4 Shipping_Truck 64300.0 1.0 10.0 1.0 0.5
STOP STOP_5 Shipping_Truck 64300.0 1.0 10.0 1.0 0.5
STOP STOP_6 Shipping_Truck 64300.0 1.0 10.0 1.0 0.5
STOP STOP_7 Shipping_Truck 64300.0 1.0 10.0 1.0 0.5
STOP STOP_8 Shipping_Truck 64300.0 1.0 10.0 1.0 0.5

EOF
```

RUN DATE: [15-APR-08 AT 08:59:26]   PAGE 7

CPNPP Spent Fuel to Yucca Mountain

NON-RADIOLOGICAL DATA (ACCIDENTS and FATALITIES)
****

HIGHWAY

	ACCIDENT RATE	ACCIDENTS	FATALITIES
RURAL_AZ	1.86E-06	9.92E-04	6.94E-06
SUBURBN_AZ	1.86E-06	7.05E-05	4.93E-07
URBAN_AZ	1.86E-06	6.70E-06	4.69E-08
RURAL_CA	1.86E-06	1.90E-04	1.33E-06
SUBURBN_CA	1.86E-06	1.23E-05	8.59E-08
URBAN_CA	1.86E-06	5.58E-07	3.91E-09
RURAL_NV	1.86E-06	5.35E-04	3.74E-06
SUBURBN_NV	1.86E-06	4.78E-05	3.35E-07
URBAN_NV	1.86E-06	2.05E-06	1.43E-08
RURAL_NM	1.86E-06	9.67E-04	6.77E-06
SUBURBN_NM	1.86E-06	1.18E-04	8.27E-07
URBAN_NM	1.86E-06	2.57E-05	1.80E-07
RURAL_OK	1.86E-06	6.66E-04	4.66E-06
SUBURBN_OK	1.86E-06	1.42E-04	9.95E-07
URBAN_OK	1.86E-06	2.42E-05	1.69E-07
RURAL_TX	1.86E-06	7.40E-04	5.18E-06
SUBURBN_TX	1.86E-06	1.98E-04	1.39E-06
URBAN_TX	1.86E-06	3.87E-05	2.71E-07
TOTALS:	3.35E-05	4.78E-03	3.34E-05

RUN DATE: [15-APR-08 AT 08:59:26] PAGE 8

CPNPP Spent Fuel to Yucca Mountain

REGULATORY CHECKS

FOR Shipping_T THE DOSE RATE AT 2 METERS COULD EXCEED 10 MREM/HR
THE VEHICLE DOSE RATE HAS BEEN RESET TO EQUAL 13.00 MREM/HR

FOR THE SHIPMENT BY Shipping_T
THE DOSE RATE IN THE CREW COMPARTMENT COULD EXCEED 2 MREM/HR
THE DOSE RATE HAS BEEN RESET FROM 7.82 TO 2 FOR CREW CALCULATIONS

CPNPP Spent Fuel to Yucca Mountain

CALCULATIONAL INFORMATION

FOR Shipping_T AREAS WITH TOTAL CONTAMINATION RATIO GREATER THAN 40.000
(THE AREAS MARKED WITH AN 'X' ARE INTERDICTED AND HAVE
NO 50 YEAR GROUNDSHINE DOSE AND NO INGESTION DOSE.)

AREA/SEVERITY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	X	-	-	X	-	-	X	X	X	X	X	X	X	X	X	X	X	X	-
2	-	-	-	X	-	-	X	-	-	X	-	-	X	X	X	X	X	X	-
3	-	-	-	X	-	-	X	-	-	X	-	-	X	X	X	X	X	X	-
4	-	-	-	X	-	-	X	-	-	-	-	-	-	X	X	-	-	-	-
5	-	-	-	X	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

RUN DATE: [15-APR-08 AT 08:59:26]   PAGE 10

CPNPP Spent Fuel to Yucca Mountain

INCIDENT-FREE SUMMARY
******** **** *******

IN-TRANSIT POPULATION EXPOSURE IN PERSON-REM
*INPUT DATA WERE ALTERED WITH REGULATORY CHECKS

	PASSENGER	CREW	OFF LINK	ON LINK	TOTALS
RURAL_AZ	0.00E+00	2.44E-02	1.28E-04	7.88E-03	3.24E-02
SUBURBN_AZ	0.00E+00	1.74E-03	4.17E-04	1.45E-03	3.61E-03
URBAN_AZ	0.00E+00	1.65E-04	5.13E-06	2.72E-04	4.42E-04
RURAL_CA	0.00E+00	4.68E-03	9.44E-06	3.51E-03	8.20E-03
SUBURBN_CA	0.00E+00	3.02E-04	5.60E-05	5.33E-04	8.92E-04
URBAN_CA	0.00E+00	1.37E-05	3.26E-07	4.25E-05	5.66E-05
RURAL_NV	0.00E+00	1.32E-02	5.81E-05	5.76E-03	1.90E-02
SUBURBN_NV	0.00E+00	1.18E-03	1.94E-04	1.13E-03	2.51E-03
URBAN_NV	0.00E+00	5.04E-05	1.63E-06	1.06E-04	1.58E-04
RURAL_NM	0.00E+00	2.38E-02	1.37E-04	6.09E-03	3.00E-02
SUBURBN_NM	0.00E+00	2.91E-03	5.84E-04	1.38E-03	4.87E-03
URBAN_NM	0.00E+00	6.32E-04	2.03E-05	8.28E-04	1.48E-03
RURAL_OK	0.00E+00	1.64E-02	1.40E-04	7.57E-03	2.41E-02
SUBURBN_OK	0.00E+00	3.50E-03	8.71E-04	2.45E-03	6.82E-03
URBAN_OK	0.00E+00	5.96E-04	1.81E-05	6.47E-04	1.26E-03
RURAL_TX	0.00E+00	1.82E-02	1.35E-04	7.97E-03	2.63E-02
SUBURBN_TX	0.00E+00	4.88E-03	1.13E-03	4.70E-03	1.07E-02
URBAN_TX	0.00E+00	9.53E-04	2.81E-05	2.01E-03	2.99E-03
RURAL	0.00E+00	1.01E-01	6.07E-04	3.88E-02	1.40E-01
SUBURB	0.00E+00	1.45E-02	3.25E-03	1.16E-02	2.94E-02
URBAN	0.00E+00	2.41E-03	7.35E-05	3.90E-03	6.39E-03
TOTALS:	0.00E+00	1.18E-01	3.93E-03	5.43E-02	1.76E-01

MAXIMUM INDIVIDUAL IN-TRANSIT DOSE

Shipping_T 5.92E-07 REM

STOP EXPOSURE IN PERSON-REM

ANNULAR AREA	STOP_1	6.74E-02
ANNULAR AREA	STOP_2	6.74E-02
ANNULAR AREA	STOP_3	6.74E-02
ANNULAR AREA	STOP_4	6.74E-02
ANNULAR AREA	STOP_5	6.74E-02
ANNULAR AREA	STOP_6	6.74E-02
ANNULAR AREA	STOP_7	6.74E-02
ANNULAR AREA	STOP_8	6.74E-02
	TOTAL:	5.39E-01

CPNPP Spent Fuel to Yucca Mountain

ACCIDENT SUMMARY
******** *******
EXPECTED VALUES OF POPULATION RISK IN PERSON-REM

	GROUND	INHALED	RESUSPD	CLOUDSH	TOTAL
RURAL_AZ	3.36E-08	2.90E-09	2.15E-11	3.79E-11	3.66E-08
SUBURBN_AZ	1.26E-07	1.09E-08	8.08E-11	1.42E-10	1.37E-07
URBAN_AZ	2.18E-07	1.88E-08	1.39E-10	2.45E-10	2.37E-07
RURAL_CA	2.48E-09	2.14E-10	1.59E-12	2.80E-12	2.70E-09
SUBURBN_CA	1.70E-08	1.46E-09	1.08E-11	1.91E-11	1.84E-08
URBAN_CA	1.39E-08	1.19E-09	8.87E-12	1.56E-11	1.51E-08
RURAL_NV	1.53E-08	1.32E-09	9.78E-12	1.72E-11	1.66E-08
SUBURBN_NV	5.86E-08	5.04E-09	3.75E-11	6.60E-11	6.37E-08
URBAN_NV	6.91E-08	5.95E-09	4.42E-11	7.78E-11	7.52E-08
RURAL_NM	3.61E-08	3.11E-09	2.31E-11	4.06E-11	3.92E-08
SUBURBN_NM	1.77E-07	1.52E-08	1.13E-10	1.99E-10	1.92E-07
URBAN_NM	8.63E-07	7.43E-08	5.52E-10	9.72E-10	9.39E-07
RURAL_OK	3.68E-08	3.17E-09	2.35E-11	4.14E-11	4.00E-08
SUBURBN_OK	2.64E-07	2.27E-08	1.69E-10	2.97E-10	2.87E-07
URBAN_OK	7.69E-07	6.62E-08	4.92E-10	8.66E-10	8.36E-07
RURAL_TX	3.55E-08	3.05E-09	2.27E-11	4.00E-11	3.86E-08
SUBURBN_TX	3.41E-07	2.94E-08	2.18E-10	3.84E-10	3.71E-07
URBAN_TX	1.19E-06	1.03E-07	7.63E-10	1.34E-09	1.30E-06
RURAL	1.60E-07	1.38E-08	1.02E-10	1.80E-10	1.74E-07
SUBURB	9.83E-07	8.47E-08	6.29E-10	1.11E-09	1.07E-06
URBAN	3.13E-06	2.69E-07	2.00E-09	3.52E-09	3.40E-06
TOTALS:	4.27E-06	3.67E-07	2.73E-09	4.81E-09	4.64E-06

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CPNPP Spent Fuel to Yucca Mountain

SOCIETAL INGESTION RISK - PERSON-REM

LINK	GONADS	EFFECTIVE
RURAL_AZ	0.00E+00	0.00E+00
RURAL_CA	0.00E+00	0.00E+00
RURAL_NV	0.00E+00	0.00E+00
RURAL_NM	0.00E+00	0.00E+00
RURAL_OK	0.00E+00	0.00E+00
RURAL_TX	0.00E+00	0.00E+00
TOTAL	0.00E+00	0.00E+00

SOCIETAL INGESTION RISK BY ORGAN - PERSON-REM

LINK	BREAST	LUNGS	RED MARR	BONE SUR	THYROID	REMAINDER
RURAL_AZ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RURAL_CA	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RURAL_NV	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RURAL_NM	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RURAL_OK	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RURAL_TX	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TOTAL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

CPNPP Spent Fuel to Yucca Mountain

EXPECTED RISK VALUES - OTHER

LINK	EARLY FATALITY	EARLY MORBIDITY
RURAL_AZ	0.00E+00	0.00E+00
SUBURBN_AZ	0.00E+00	0.00E+00
URBAN_AZ	0.00E+00	0.00E+00
RURAL_CA	0.00E+00	0.00E+00
SUBURBN_CA	0.00E+00	0.00E+00
URBAN_CA	0.00E+00	0.00E+00
RURAL_NV	0.00E+00	0.00E+00
SUBURBN_NV	0.00E+00	0.00E+00
URBAN_NV	0.00E+00	0.00E+00
RURAL_NM	0.00E+00	0.00E+00
SUBURBN_NM	0.00E+00	0.00E+00
URBAN_NM	0.00E+00	0.00E+00
RURAL_OK	0.00E+00	0.00E+00
SUBURBN_OK	0.00E+00	0.00E+00
URBAN_OK	0.00E+00	0.00E+00
RURAL_TX	0.00E+00	0.00E+00
SUBURBN_TX	0.00E+00	0.00E+00
URBAN_TX	0.00E+00	0.00E+00
TOTAL	0.00E+00	0.00E+00

EOI
END OF RUN

SUCCESSFUL COMPLETION

San Diego to Comanche Peak Input/Output

```
                    RUN DATE: [ 11-APR-08 AT 16:47:23 ]          PAGE    1

 RRRR    AAA   DDDD   TTTTT  RRRR    AAA   N   N  55555        6
 R   R  A   A  D   D    T    R   R  A   A  NN  N  5            6
 R   R  A   A  D   D    T    R   R  A   A  N N N  5            6
 RRRR   A   A  D   D    T    RRRR   A   A  N  NN  5555         6666
 R R    AAAAA  D   D    T    R R    AAAAA  N   N      5        6   6
 R  R   A   A  D   D    T    R  R   A   A  N   N  5   5        6   6
 R   R  A   A  DDDD     T    R   R  A   A  N   N  5555     *    666

                         RADTRAN 5.6   February 20, 2006

                                 INPUT ECHO
                                 ----------

  TITLE New Fuel from San Diego to CPNPP
  INPUT STANDARD
 STD: 0 10 18                                 && DIMEN=NSEV NRAD NAREAS
 STD: 1 3 3 0                                 && PARM=IRNKC IANA ISEN IPSQSB
 STD: .TRUE. .FALSE.                          && FORM = UNIT, SI-UNITS?
 STD: 2.3E12                                  && NEVAL FOR CF252
 STD: 9.25E5 5.77E6 1.27E6                    && RPCTHY FOR I125, I129, I131
 STD: 0.0 0.0 0.0 0.0 0.0                     && TRANSFER GAMMA
 STD: 7.42E-3 2.02E-2 6.17E-5 3.17E-8 0.0     && TRANSFER NEUTRON
 STD: 30  24                                  && MITDDIST  MITDVEL
 STD: 1  2   .0018                            && ITRAIN FMINCL DDRWEF
 STD:    33     68     105    244    369              && CENTER LINE
 STD:   561   1018    1628   2308   4269              && DISTANCES
 STD:  5468  11136   13097  21334  40502              && FOR AVERAGE
 STD: 69986 89860 120878 0 0 0 0 0 0 0 0 0 0 0 0      && US CLOUD
 STD: 4.59E+02 1.53E+03 3.94E+03 1.25E+04 3.04E+04 6.85E+04 1.76E+05 4.45E+05
 STD: 8.59E+05 2.55E+06 4.45E+06 1.03E+07 2.16E+07 5.52E+07 1.77E+08 4.89E+08
 STD: 8.12E+08 1.35E+09 0 0 0 0 0 0 0 0 0 0 0 0       && AREADA
 STD: 3.42E-03 1.72E-03 8.58E-04 3.42E-04 1.72E-04 8.58E-05 3.42E-05 1.72E-05
 STD:  8.58E-06 3.42E-06 1.72E-06 8.58E-07 3.42E-07 1.72E-07 8.58E-08 5.42E-08
 STD:  4.30E-08 3.42E-08 0 0 0 0 0 0 0 0 0 0 0 0      && DFLEV
 STD: 3 6 9 12 15 30 61 91 152 305 0 0 0 0 0
 STD: 3 6 9 12 15 30 61 91 152 305 0 0 0 0 0
 STD: 3 6 9 12 15 30 61 91 152 305 0 0 0 0 0 && RADIST
 STD: 0.5                                 && SMLPKG
 STD: 1.0  0.87  0.018                    && SHIELDING FACTORS RR  RS  RU
 STD:  30  30  800                        && OFFLINK {FREEWAY}
 STD:  27  30  800                        && OFFLINK {NON-FREEWAY}
 STD:   5   8  800                        && OFFLINK {CITY STREETS}
 STD:  30  30  800                        && OFFLINK {RAILWAY}
 STD: 200 200 1000                        && OFFLINK {WATERWAY}
 STD: 15  3  3  3  4                      && ONLINK {FWAY NONFWY STREET RAIL ADJ}
 STD: 6.0  4  40.0                        && RPD FNOATT INTERDICT
 STD: 0.05   0.2   3.3E-4                 && BDF CULVL BRATE
 STD: 0.9   0.1                           && UBF USWF
 STD: 1.0  10.0 1.0                       && EVACUATION SURVEY CAMPAIGN
```

```
                    RUN DATE: [ 11-APR-08 AT 16:47:23 ]            PAGE     2

                       New Fuel from San Diego to CPNPP

STD: 0.0  0.0     1.5E-8  5.3E-8      && HIGHWAY - RURAL - NONRAD
STD: 0.0  0.0     3.7E-9  1.3E-8      && HIGHWAY - SUBURBAN - NONRAD
STD: 0.0  0.0     2.1E-9  7.5E-9      && HIGHWAY - URBAN - NONRAD
STD: 0.0  0.0    1.81E-9  2.64E-8     && GENERAL FREIGHT - R - NONRAD
STD: 0.0  0.0    1.81E-9  2.64E-8     && GENERAL FREIGHT - S - NONRAD
STD: 0.0  0.0    1.81E-9  2.64E-8     && GENERAL FREIGHT - U - NONRAD
STD: 0.0  0.0    1.27E-7  1.85E-6     && DEDICATED RAIL - R - NONRAD
STD: 0.0  0.0    1.27E-7  1.85E-6     && DEDICATED RAIL - S - NONRAD
STD: 0.0  0.0    1.27E-7  1.85E-6     && DEDICATED RAIL - U - NONRAD
STD: 0.0 0.0 0.0 0.0 0.0 0.0          && PSPROB
STD: 0.67  0.67  0.42                 && TIMENDE NON-DISPERSAL EVAC TIME (LCF&EARLY)
STD: 2 2 1                            && FLAGS=IUOPT IACC REGCHECK
STD: 5E-4, 4E-4, 1.0E-4               && LCFCON(1), LCFCON(2), GECON
STD: R5INGEST.BIN                     && INGESTION FILE
 OUTPUT CI_REM
 FORM UNIT
 DIMEN 0 10 18
 PARM 1 1 1 0
 SEVERITY
    NPOP=1
       NMODE=1

    NPOP=2
       NMODE=1

    NPOP=3
       NMODE=1

 RELEASE
 PACKAGE NewFuelContainer 0.1 1.0 0.0 5.2
 END
 VEHICLE -1 Shipping_Truck 1.00E-01 1.0 0.0 5.2 1.0 2.0 2.0 1.0 1.0
       NewFuelContainer 1.0
 FLAGS
    IACC 2
    IUOPT 2
    REGCHECK 1
 MODSTD
    DISTOFF FREEWAY 3.00E01 3.00E01 8.00E02
    DISTOFF SECONDARY 2.70E01 3.00E01 8.00E02
    DISTOFF STREET 5.00E00 8.00E00 8.00E02
    DISTON
        FREEWAY 1.50E01
        SECONDARY 3.00E00
        STREET 3.00E00
        ADJACENT 4.00E00
    BDF 5.00E-02
    BRATE 3.30E-04
    CULVL 2.00E-01
    EVACUATION 1.00E00
```

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                RUN DATE: [ 11-APR-08 AT 16:47:23 ]          PAGE    3

                   New Fuel from San Diego to CPNPP

   GECON 1.00E-04
   INTERDICT 4.00E01
   LCFCON 5.00E-04 4.00E-04
   SURVEY 1.00E01
   UBF 5.20E-01
   USWF 4.80E-01
   CAMPAIGN 8.33E-02
   MITDDIST 3.00E01
   MITDVEL 2.40E01
   RPD 6.00E00
   RR 1.00E00
   RU 1.80E-02
   RS 8.70E-01
   SMALLPKG 5.00E-01
   RPCTHYROID
      I131    1.27E06
EOF
LINK RURAL_AZ Shipping_Truck 503.2 88.0 2.0 9.2 825.0 1.86E-6 0.0070 R 1 0.0
LINK SUBURBN_AZ Shipping_Truck 81.7 88.0 2.0 324.1 2140.0 1.86E-6 0.0070 S 1 0.0
LINK URBAN_AZ Shipping_Truck 10.0 88.0 2.0 2341.5 4210.0 1.86E-6 0.0070 U 1 0.0
LINK RURAL_CA Shipping_Truck 201.1 88.0 2.0 8.8 1920.0 1.86E-6 0.0070 R 1 0.0
LINK SUBURBN_CA Shipping_Truck 46.3 88.0 2.0 351.5 4510.0 1.86E-6 0.0070 S 1 0.0
LINK URBAN_CA Shipping_Truck 26.9 88.0 2.0 2848.0 7910.0 1.86E-6 0.0070 U 1 0.0
LINK RURAL_NM Shipping_Truck 230.7 88.0 2.0 8.9 6540.0 1.86E-6 0.0070 R 1 0.0
LINK SUBURBN_NM Shipping_Truck 29.8 88.0 2.0 309.1 1210.0 1.86E-6 0.0070 S 1 0.0
LINK URBAN_NM Shipping_Truck 3.3 88.0 2.0 2080.3 3350.0 1.86E-6 0.0070 U 1 0.0
LINK RURAL_TX Shipping_Truck 819.5 88.0 2.0 8.1 1119.0 1.86E-6 0.0070 R 1 0.0
LINK SUBURBN_TX Shipping_Truck 151.0 88.0 2.0 339.3 2463.0 1.86E-6 0.0070 S 1 0.0
LINK URBAN_TX Shipping_Truck 20.0 88.0 2.0 2395.5 5385.0 1.86E-6 0.0070 U 1 0.0

STOP STOP_1 Shipping_Truck 64300.0 1.0 10.0 1.0 0.5
STOP STOP_2 Shipping_Truck 64300.0 1.0 10.0 1.0 0.5
STOP STOP_3 Shipping_Truck 64300.0 1.0 10.0 1.0 0.5
STOP STOP_4 Shipping_Truck 64300.0 1.0 10.0 1.0 0.5
STOP STOP_5 Shipping_Truck 64300.0 1.0 10.0 1.0 0.5
STOP STOP_6 Shipping_Truck 64300.0 1.0 10.0 1.0 0.5
STOP STOP_7 Shipping_Truck 64300.0 1.0 10.0 1.0 0.5
STOP STOP_8 Shipping_Truck 64300.0 1.0 10.0 1.0 0.5


EOF
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RUN DATE: [11-APR-08 AT 16:47:23] PAGE 4

New Fuel from San Diego to CPNPP

NON-RADIOLOGICAL DATA (ACCIDENTS and FATALITIES)
****

HIGHWAY

	ACCIDENT RATE	ACCIDENTS	FATALITIES
RURAL_AZ	1.86E-06	9.36E-04	6.55E-06
SUBURBN_AZ	1.86E-06	1.52E-04	1.06E-06
URBAN_AZ	1.86E-06	1.86E-05	1.30E-07
RURAL_CA	1.86E-06	3.74E-04	2.62E-06
SUBURBN_CA	1.86E-06	8.61E-05	6.03E-07
URBAN_CA	1.86E-06	5.00E-05	3.50E-07
RURAL_NM	1.86E-06	4.29E-04	3.00E-06
SUBURBN_NM	1.86E-06	5.54E-05	3.88E-07
URBAN_NM	1.86E-06	6.14E-06	4.30E-08
RURAL_TX	1.86E-06	1.52E-03	1.07E-05
SUBURBN_TX	1.86E-06	2.81E-04	1.97E-06
URBAN_TX	1.86E-06	3.72E-05	2.60E-07
TOTALS:	2.23E-05	3.95E-03	2.76E-05

New Fuel from San Diego to CPNPP

REGULATORY CHECKS

THE SHIPMENT BY Shipping_T IS DESIGNATED AS EXCLUSIVE USE
BUT IS NOT REQUIRED TO BE SO DESIGNATED BY REGULATIONS

RUN DATE: [11-APR-08 AT 16:47:23] PAGE 6

New Fuel from San Diego to CPNPP

INCIDENT-FREE SUMMARY
******** **** *******

IN-TRANSIT POPULATION EXPOSURE IN PERSON-REM

	PASSENGER	CREW	OFF LINK	ON LINK	TOTALS
RURAL_AZ	0.00E+00	6.48E-04	1.22E-06	5.72E-05	7.07E-04
SUBURBN_AZ	0.00E+00	1.05E-04	6.07E-06	2.41E-05	1.35E-04
URBAN_AZ	0.00E+00	1.29E-05	1.11E-07	5.80E-06	1.88E-05
RURAL_CA	0.00E+00	2.59E-04	4.66E-07	5.32E-05	3.13E-04
SUBURBN_CA	0.00E+00	5.97E-05	3.73E-06	2.88E-05	9.22E-05
URBAN_CA	0.00E+00	3.47E-05	3.63E-07	2.93E-05	6.44E-05
RURAL_NM	0.00E+00	2.97E-04	5.41E-07	2.08E-04	5.06E-04
SUBURBN_NM	0.00E+00	3.84E-05	2.11E-06	4.97E-06	4.55E-05
URBAN_NM	0.00E+00	4.25E-06	3.25E-08	1.52E-06	5.81E-06
RURAL_TX	0.00E+00	1.06E-03	1.75E-06	1.26E-04	1.18E-03
SUBURBN_TX	0.00E+00	1.95E-04	1.17E-05	5.13E-05	2.58E-04
URBAN_TX	0.00E+00	2.58E-05	2.27E-07	1.48E-05	4.08E-05
RURAL	0.00E+00	2.26E-03	3.97E-06	4.45E-04	2.71E-03
SUBURB	0.00E+00	3.98E-04	2.36E-05	1.09E-04	5.31E-04
URBAN	0.00E+00	7.76E-05	7.34E-07	5.15E-05	1.30E-04
TOTALS:	0.00E+00	2.74E-03	2.84E-05	6.05E-04	3.37E-03

MAXIMUM INDIVIDUAL IN-TRANSIT DOSE

Shipping_T 4.26E-09 REM

STOP EXPOSURE IN PERSON-REM

ANNULAR AREA	STOP_1	5.18E-04
ANNULAR AREA	STOP_2	5.18E-04
ANNULAR AREA	STOP_3	5.18E-04
ANNULAR AREA	STOP_4	5.18E-04
ANNULAR AREA	STOP_5	5.18E-04
ANNULAR AREA	STOP_6	5.18E-04
ANNULAR AREA	STOP_7	5.18E-04
ANNULAR AREA	STOP_8	5.18E-04
	TOTAL:	4.15E-03

EOI
END OF RUN
SUCCESSFUL COMPLETION